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Transition metals in organic synthesis. Annual Survey covering the year 1992 *

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Contents

1. General comments

This Annual Survey covers the literature for 1992 dealing with the use of transition metal intermediates for organic synthetic transformations. It is not a comprehensive review but is limited to reports of discrete systems that lead to at least moderate yields of organic compounds, or that allow unique organic transformations, even if low yields are obtained. Catalytic reactions that lead cleanly to a major product and do not involve extreme conditions are also included. This is not a critical review, but rather a listing of the papers published in the title area.

The papers in this survey are grouped primarily by reaction type rather than by organometallic reagent,

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* Reprints are not available. For previous Annual Survey see *J. Organomet. Chem.*, *457* (1993) 167.

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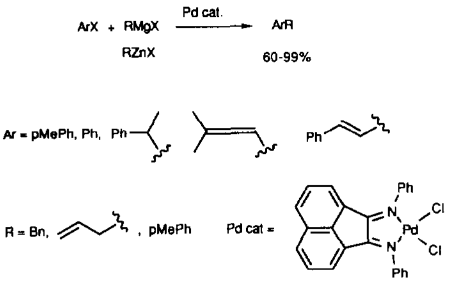
since the reader is likely to be more interested in the organic transformation effected than the metal causing it. Oxidation, reduction, and hydroformylation reactions are specifically excluded, and will be covered in a different annual survey. Also excluded are structural and mechanistic studies of organometallic systems unless they present data useful for synthetic application. Finally, reports from the patent literature have not been surveyed since patents are rarely sufficiently detailed to allow reproduction of the reported results.

2. Carbon–carbon bond-forming reactions

2.1. Alkylations

2.1.1. Alkylation of organic halides, tosylates, triflates, acetates and epoxides

Metal-catalyzed Grignard reactions continue to be developed and applied in organic synthesis. A review entitled "Carbon–carbon bond formation in heterocycles using nickel and palladium-catalyzed reactions" has appeared [1], and deals with metal-catalyzed Grignard reactions as well as the Castro–Stevens reaction. Palladium diazine complexes catalyzed the coupling of aryl halides with Grignard and organozinc derivatives (eqn. (1) [2]). Nickel phosphine complexes catalyzed the coupling of 1,8-dibromo-naphthalene with thiophene Grignard reagents (eqn. (2) [3]). Chromium complexes of optically active aryl aminophosphines catalyzed the asymmetric coupling of phenethyl Grignard reagents with vinyl halides (eqn. (3) [4]).



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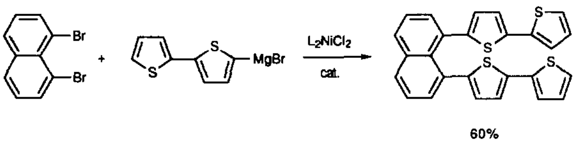

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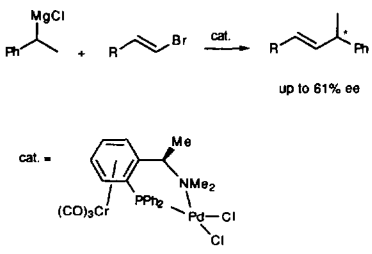

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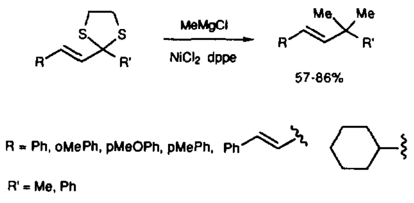
Nickel phosphine complexes catalyzed the alkylation of allylic dithianes (eqn. (4) [5]), benzylic dithianes (eqn. (5) [6] and eqn. (6) [7]), the coupling of tetrathiomethanes (eqn. (7) [8]) and the alkylation of 1,3-dioxep-4-enes by Grignard reagent (eqn. (8) [9]). Acid anhydrides were alkylated by halides in the presence of reduced nickel salts (eqn. (9) [10]).



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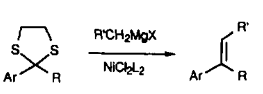

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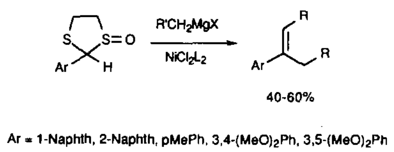

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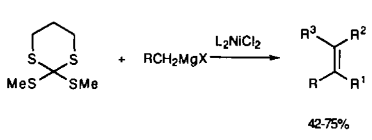
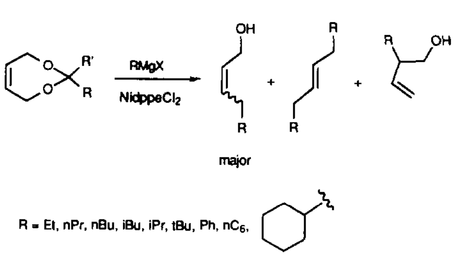


R	R¹	R²	R³
Me	Me	H	H
Bu	Bu	H	H
C_6	C_6	-$(CH_2)_5$-	H
$tBuCH_2$	$tBuCH_2$	tBu	H
$TMSCH_2$	$TMSCH_2$	TMS	H
Ph	H	Me	H
Bu	Me	H	H

(7)



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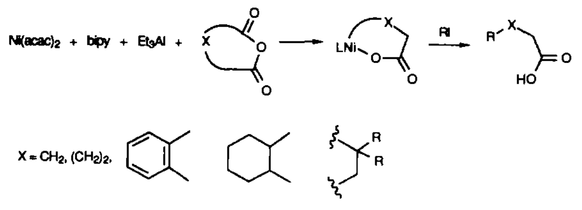
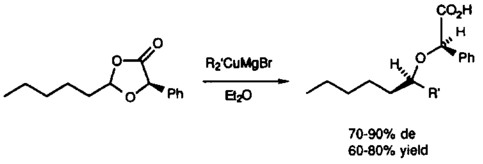


(9)

Copper catalyzed the alkylation of acetals (eqn. (10) [11]) and α-iodoepoxides (eqn. (11) [12]). Titanocene dichloride catalyzed the alkylation of gem dihaloalkanes by Grignard reagents [13].



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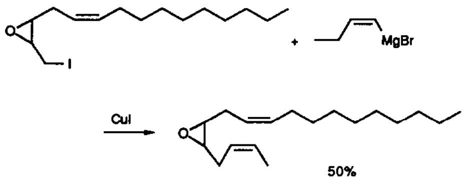
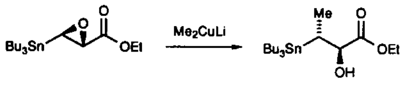


(11)

Organocuprates efficiently alkylated epoxides (eqn. (12) [14], eqn. (13) [15], eqn. (14) [16], eqn. 15 [17]) and vinyl triflates (eqn. (16) [18]). Trienes were synthesized by the coupling of chlorodienes with vinylcuprates from carbocupration of alkynes (eqn. (17) [19]). The arylation of an α-haloketone by a vinylcuprate was a key step in the synthesis of cannabidiol (eqn. (18) [20]). α-Haloallylic esters underwent alkylation by cuprates with clean S_N2' regioselectivity (eqn. (19) [21]).



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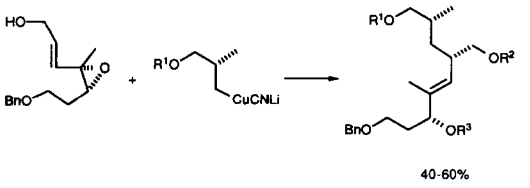

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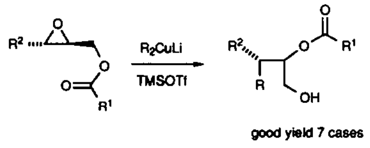

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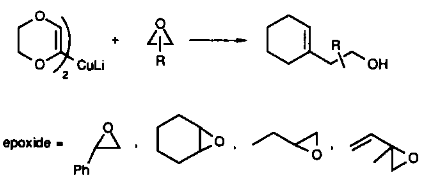

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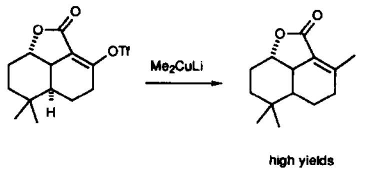

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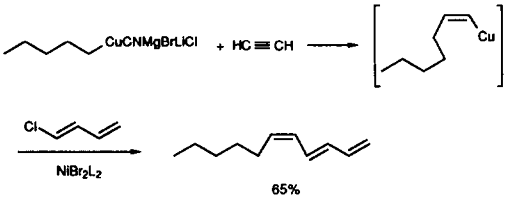

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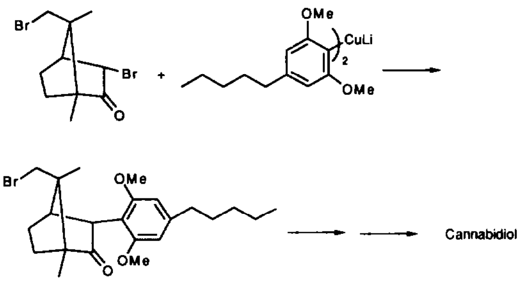

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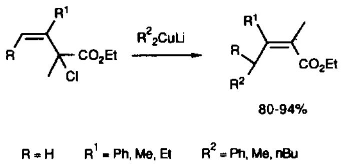
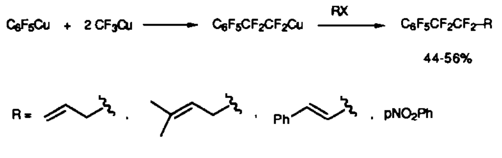


(19)

Pyrrole and imidazole cyanocuprates had typical "higher order cuprate" reactivity [22]. Perfluorophenyl copper combined with perfluoromethyl copper to insert two CF_2 groups, and this homologated fragment transferred to halides (eqn. (20) [23]). Functionalized organocuprates continued to be developed and exploited in synthesis (eqn. (21) [24], eqn. (22) [25], eqn. (23) [26], eqn. (24) [27], and eqn. (25) [28]).



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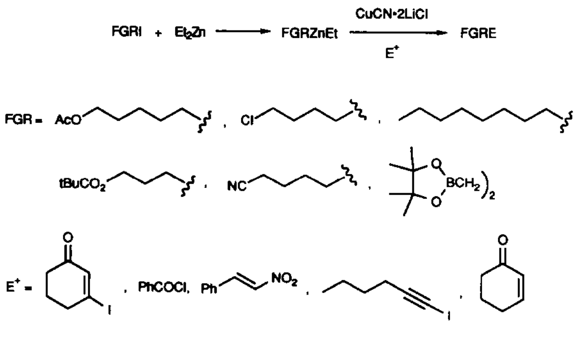

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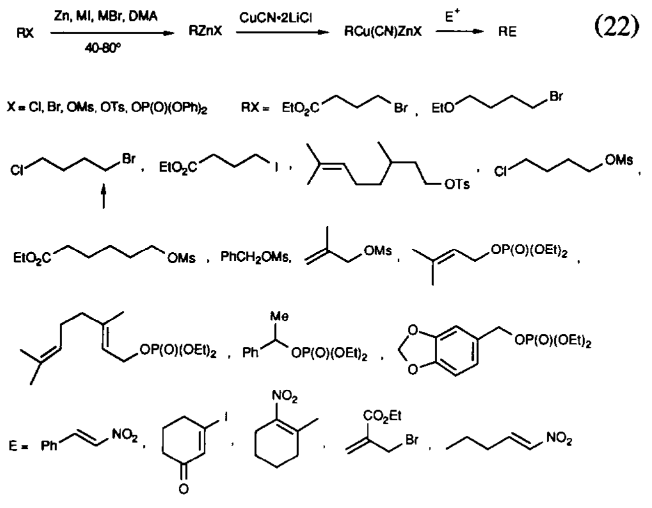

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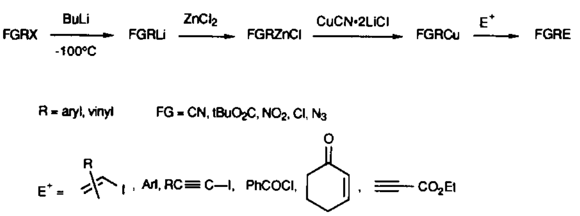

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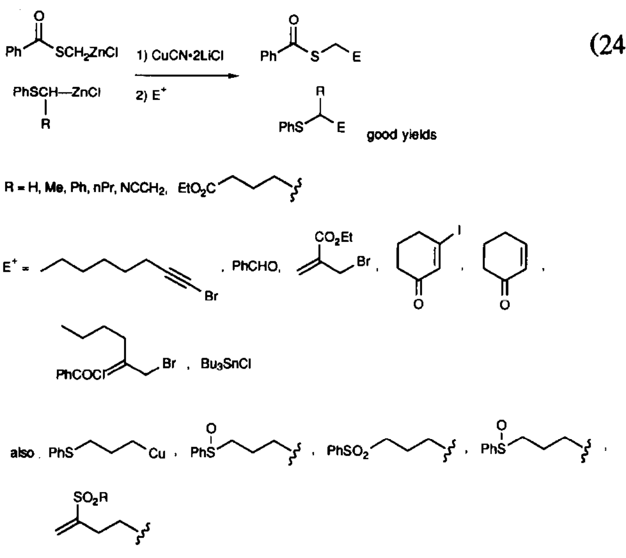

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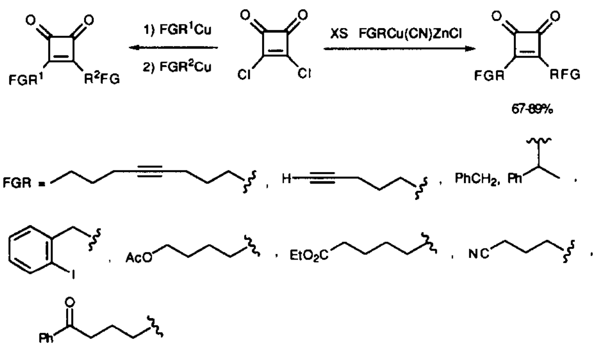
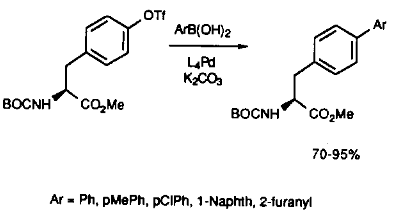


(25)

The reagents Me_4CoLi_2 and Me_4FeLi_2 were claimed to be superior to Me_2CuLi for the methylation of vinyl halides [29]. β-Haloalkenylketones were alkylated by alkyl organomanganese compounds [30]. Allylic manganese compounds alkylated γ-bromo-α,β-unsaturated carboxylic acid esters [31].

Palladium catalyzed coupling of halides and triflates to main group organometallics *via* oxidative addition/transmetallation sequences continues to be a growth industry, an indication that good ideas are easier to recognize than to get. Boron is fast becoming the main group metal of choice. Examples of coupling aryl triflates or halides to arylboronic acids abound (eqn. (26) [32], eqn. (27) [33], eqn. (28) [34], eqn. (29) [35], eqn. (30) [36], eqn. (31) [37], eqn. (32) [38], eqn. (33) [39], eqn. (34) [40], eqn. (35) [41], eqn. (36) [42], eqn. (37) [43], eqn. (38) [44], eqn. (39) [45], and eqn. (40) [46]).



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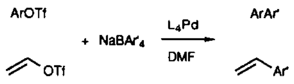

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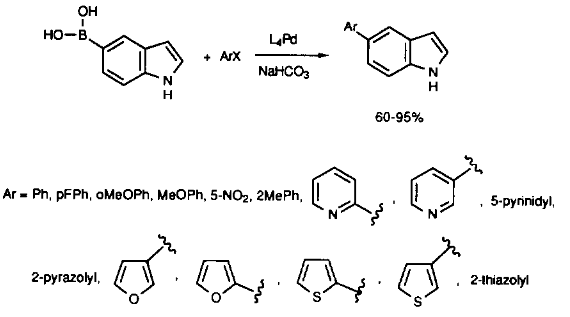

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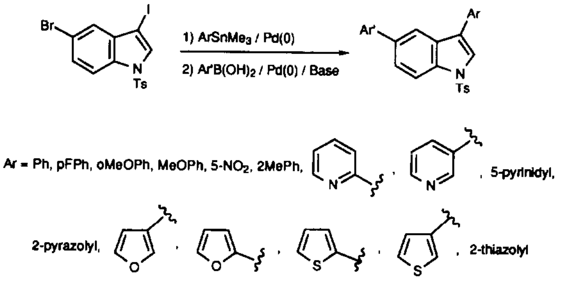

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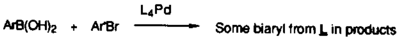

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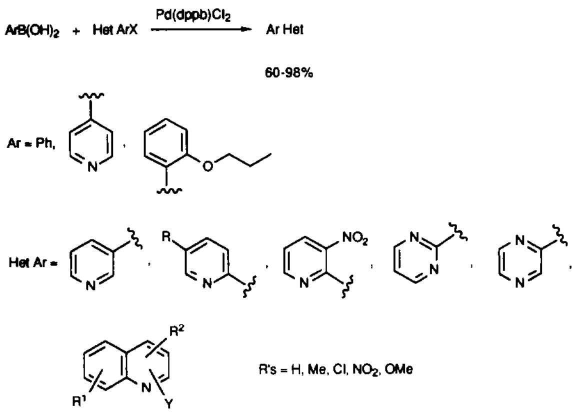

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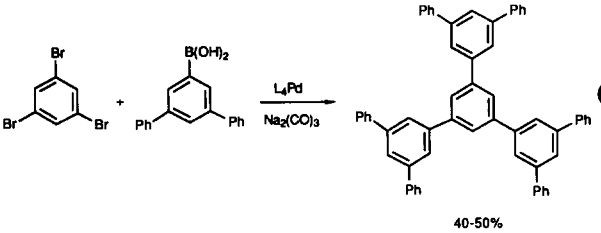

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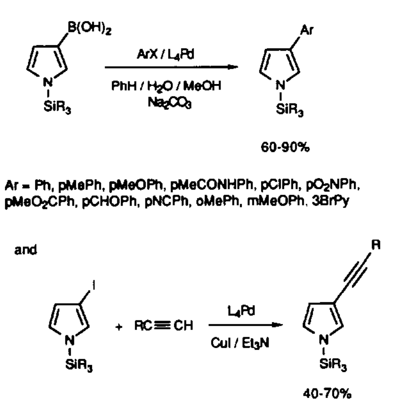

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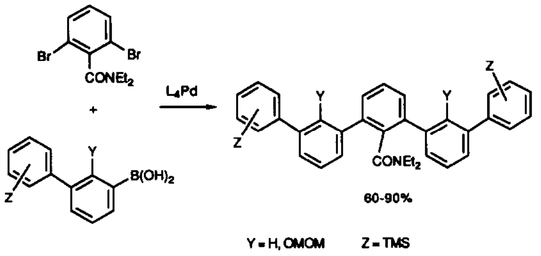

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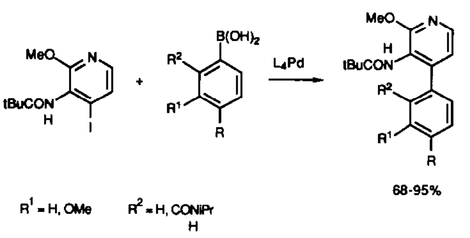

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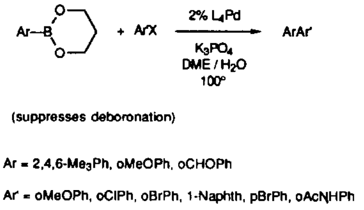

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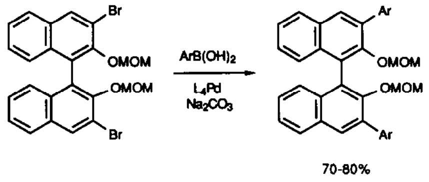

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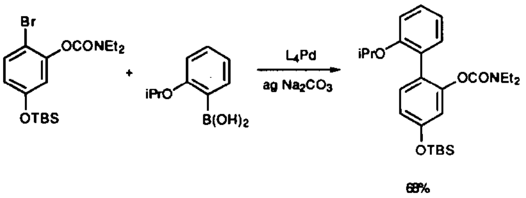

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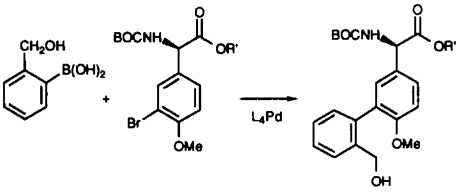

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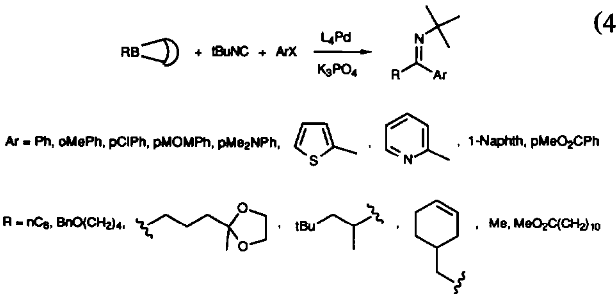
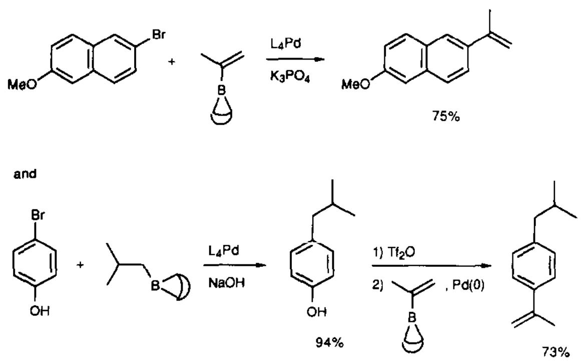


(40)

Vinyl boronates (eqn. (41) [47], eqn. (42) [48], and eqn. (43) [49]) and even alkyl boronates (eqn. (44) [50], eqn. (45) [51], and eqn. (46) [52]) couple. Remarkably, halides having β-hydrogens can also be made to undergo the palladium catalyzed coupling process with only minimal β-elimination (eqn. (47) [53]).



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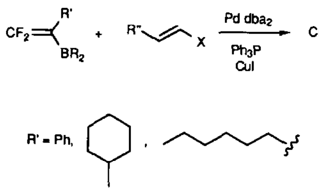

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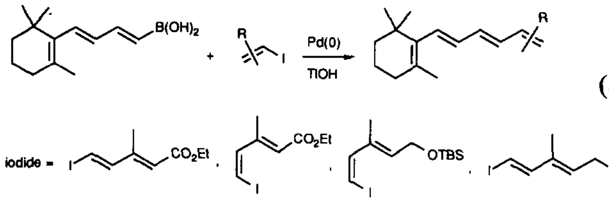

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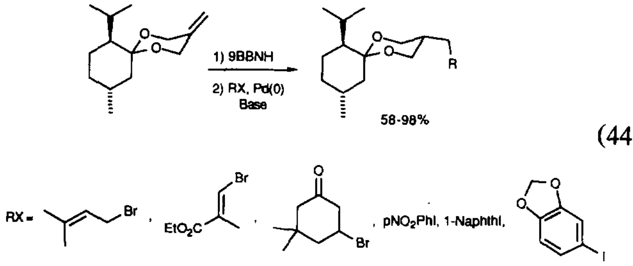

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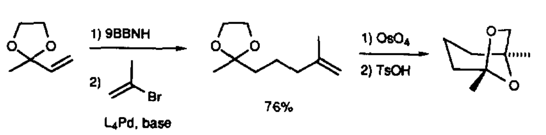

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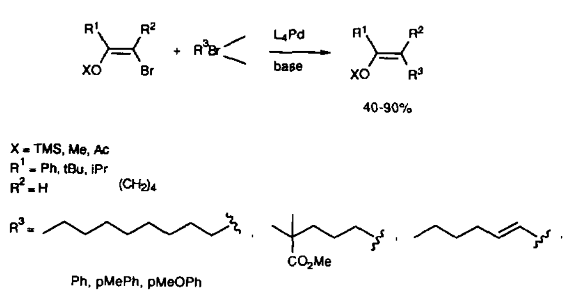

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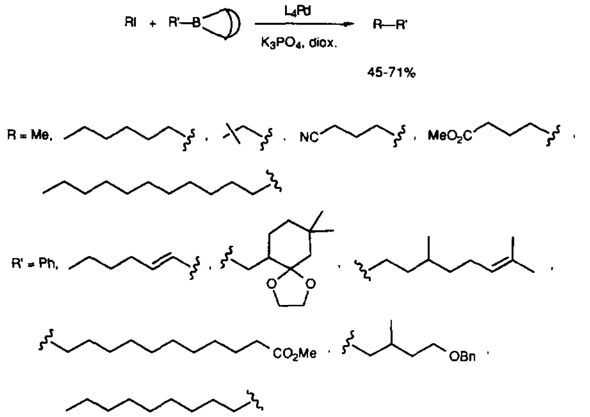
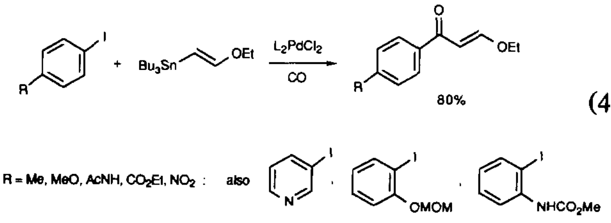


(47)

Palladium catalyzed couplings involving transmetallation from tin remained very popular and were the subject of an in depth review (174 references) [54]. Aryl halides were coupled efficiently to vinyl tin reagents (eqn. (48) [55]), aryl tin reagent (eqn. (49) [56]), acetylene tin reagents (eqn. (50) [57]) and β-stannylenones (eqn. (51) [58]). Aryl triflates (eqn. (52) [59]) and eqn. (53) [60]) and *p*-fluorophenyl sulfonates (eqn. (54) [61]) were also efficiently coupled to stannanes.



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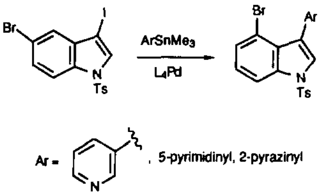

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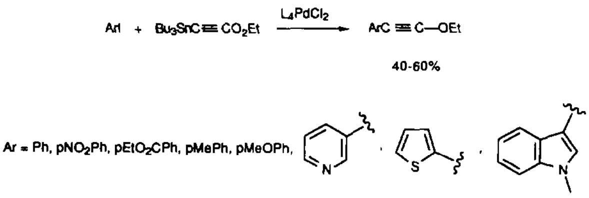

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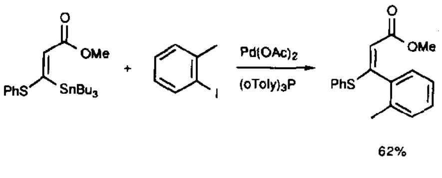

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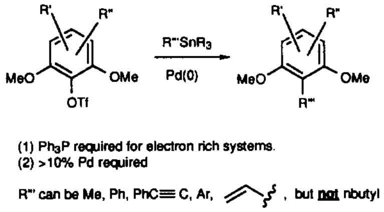
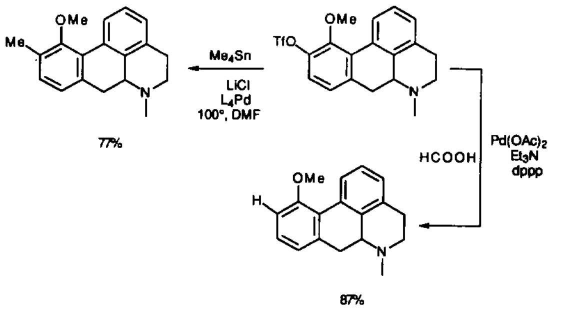


(52)

(1) Ph_3P required for electron rich systems.
(2) >10% Pd required

R''' can be Me, Ph, PhC≡C, Ar, , but not nbutyl



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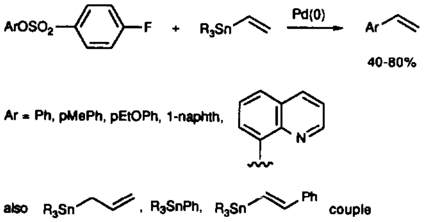
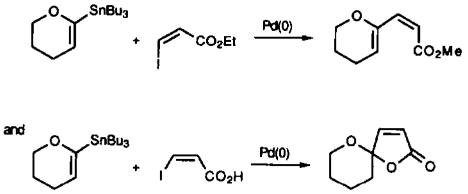


(54)

Palladium also catalyzed a variety of coupling reactions with heterocyclic tin reagents (eqn. (55) [62], eqn. (56) [63], eqn. (57) [64], eqn. (58) [65], and eqn. (59) [66]).



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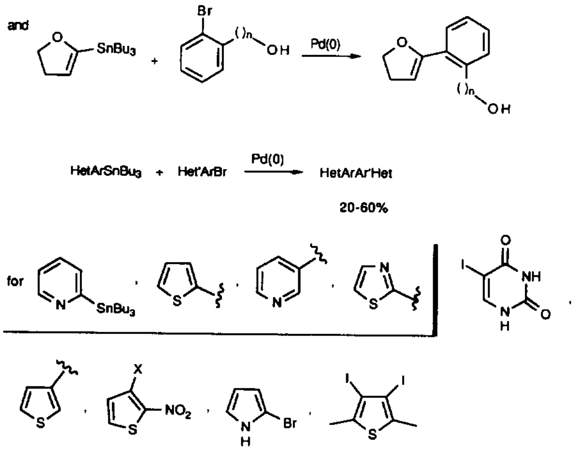

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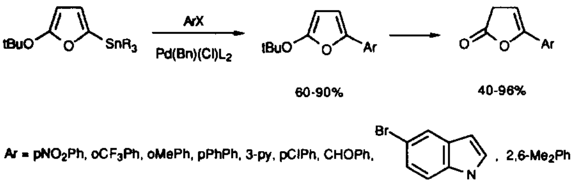

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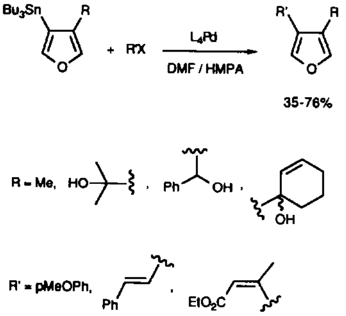

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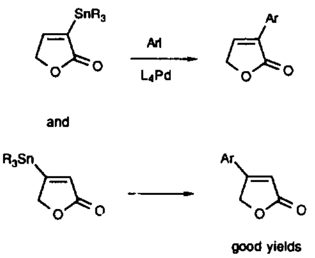
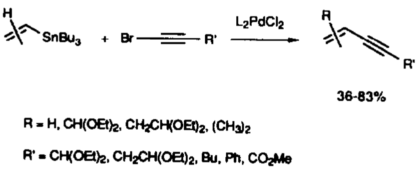


(59)

Vinyl stannanes coupled to bromoalkynes (eqn. (60) [67]), β-iodostyrenes (eqn. (61) [68]) and acetylenic stannanes coupled to vinyl bromide (eqn. (62) [69]). α-Iodoenones were alkylated by vinyl and allyl stannanes in the presence of palladium(0) catalysts (eqn. (63) [70]) as were α-halocyclobutenones (eqn. (64) [71]) and α-halo ethers (eqn. (65) [72]).



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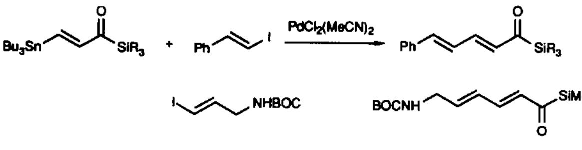

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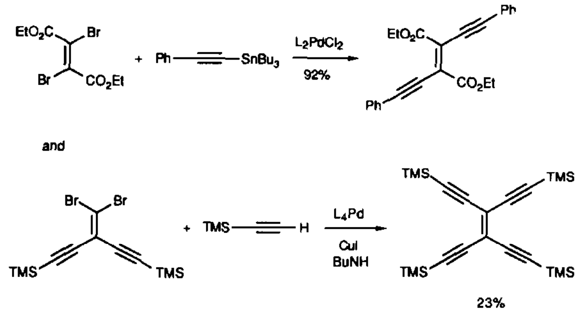

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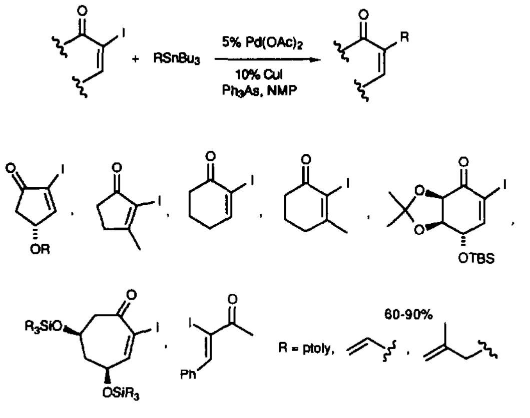

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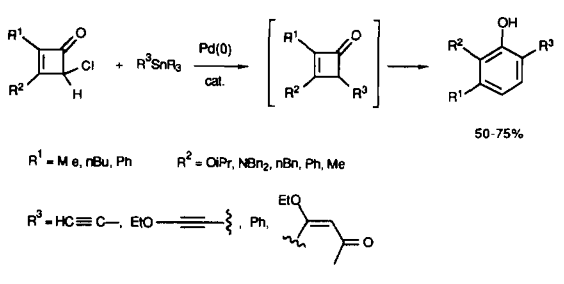

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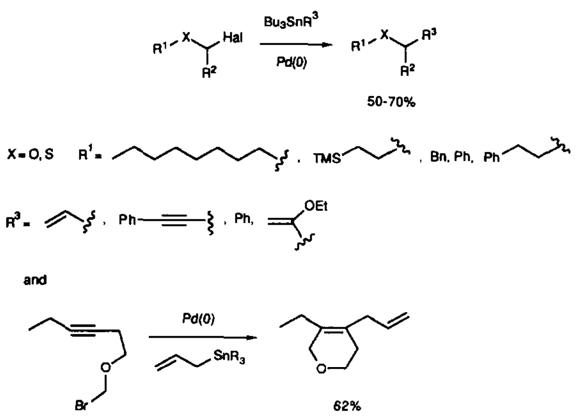
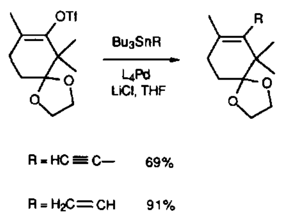


(65)

Palladium catalyzed tin coupling reactions have been used extensively in the synthesis of complex molecules (eqn. (66) [73], eqn. (67) [74], eqn. (68) [75], eqn. (69) [76], and eqn. (70) [77]).



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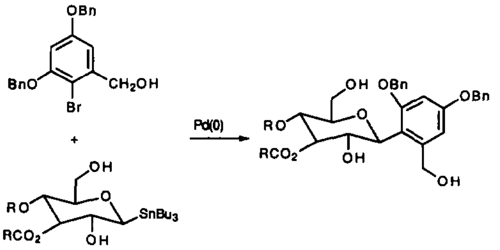

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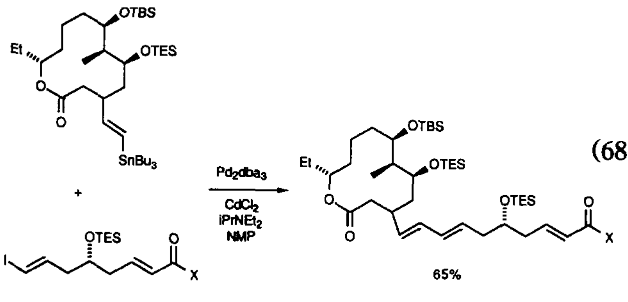

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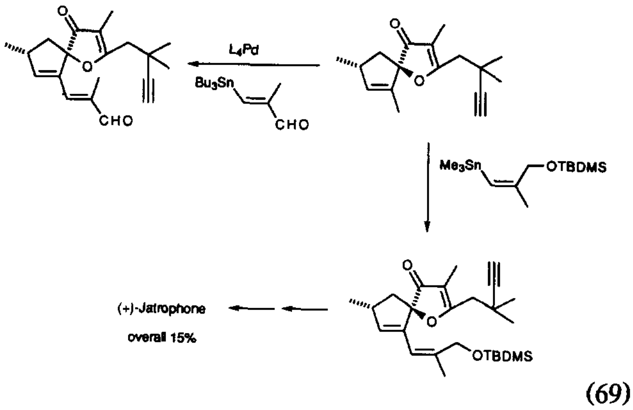
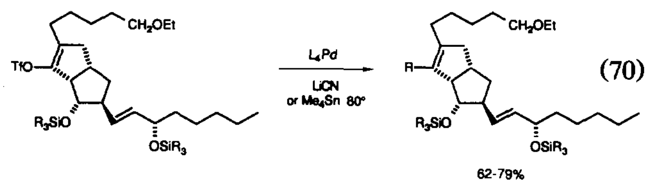


(69)



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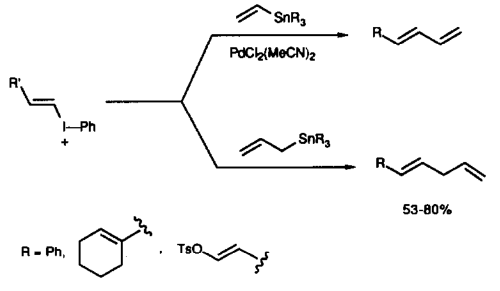
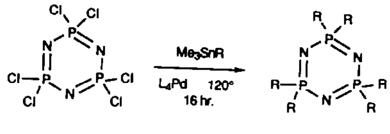


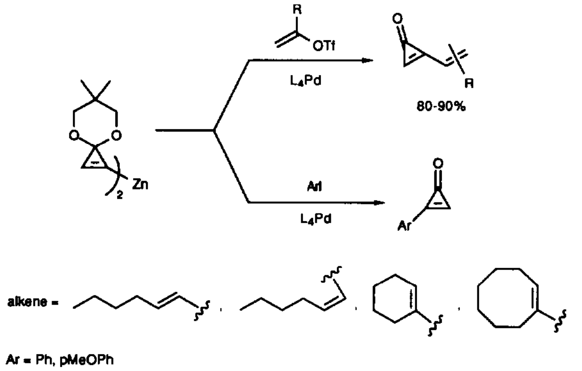
(71)



(72)

Other less conventional halides also underwent palladium catalyzed coupling with organostannanes (eqn. (71) [78] and eqn. (72) [79]).

Zinc also effectively transmetallates to palladium, and many palladium catalyzed couplings of organozinc reagents with triflates and halides have been developed (eqn. (73) [80], eqn. (74) [81], eqn. (75) [82], eqn. (76) [83], eqn. (77) [84], eqn. (78) [85], eqn. (79) [86], eqn. (80) [87], eqn. (81) [88], and eqn. (82) [89]).



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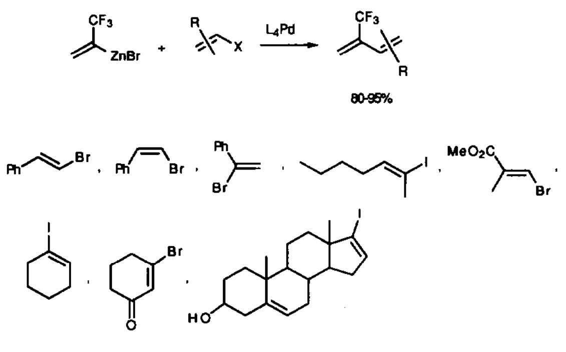

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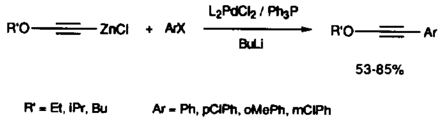

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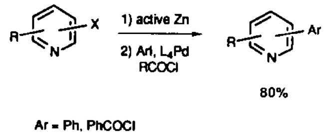

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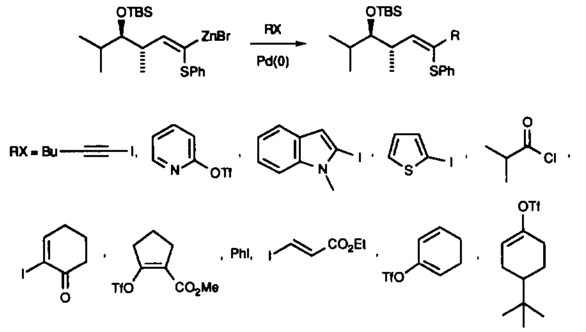

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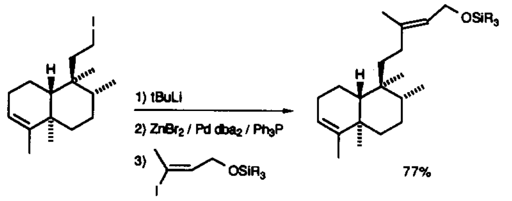

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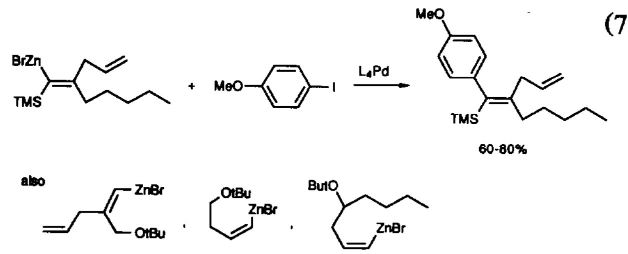

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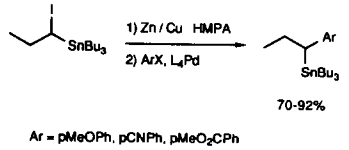

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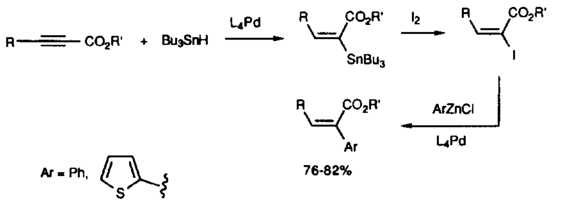

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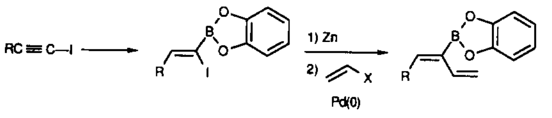
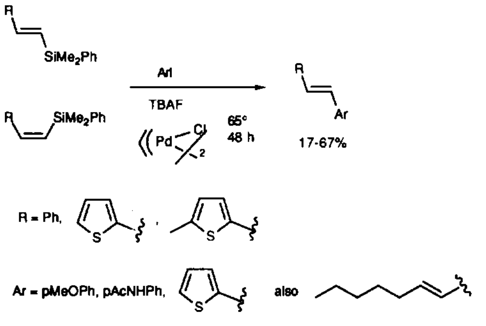


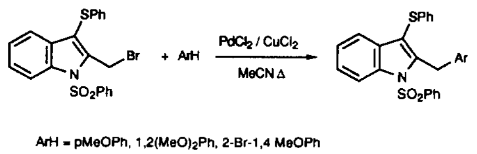
(82)

"Highly selective cross-coupling reactions of organosilicon compounds mediated by fluoride ion and a palladium catalyst" is the title of a recent review (48 references) [90]. Examples of this kind of reaction are shown in eqn. (83) [91].

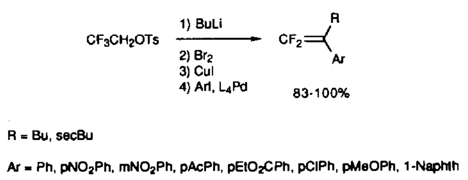


(83)

Palladium also catalyzed the coupling of halides to organocopper species (eqn. (84) [92], eqn. (85) [93], and eqn. (86) [94]), aluminum alkyls (eqn. (87) [95]) and to stabilized carbanions (eqn. (88) [96]).



(84)



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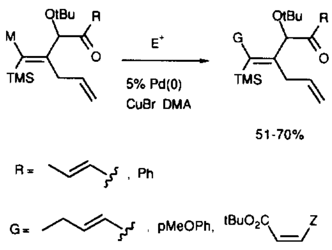

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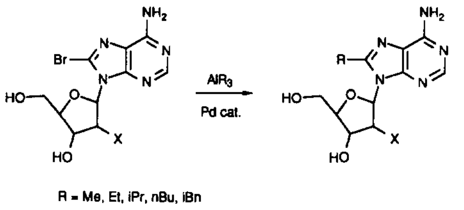

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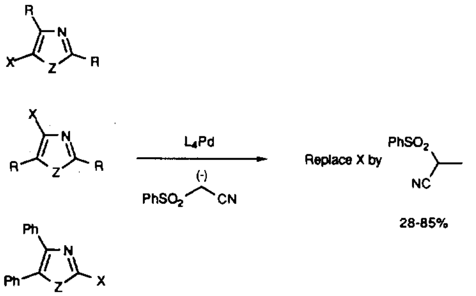
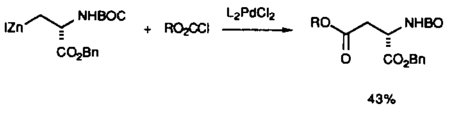


(88)

2.1.2. *Alkylation of acid derivatives*

Palladium efficiently catalyzed the alkylation of acid chlorides by zinc (eqn. (89) [97]) and tin alkyls (eqn. (90) [98]), eqn. (91) [99], eqn. (92) [100], eqn. (93) [101], eqn. (94) [102], and eqn. (95) [103]).



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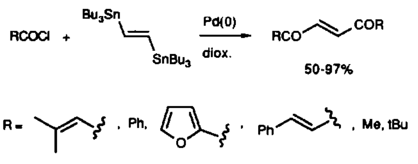
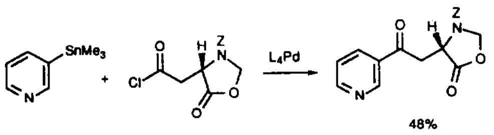


(90)



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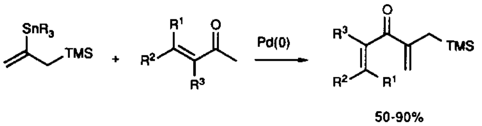
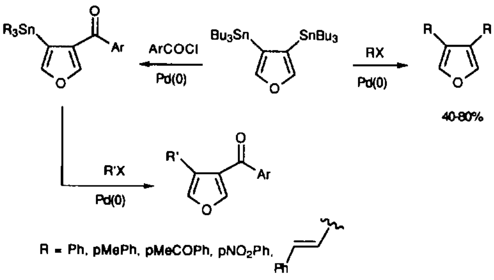
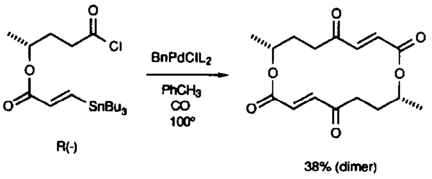


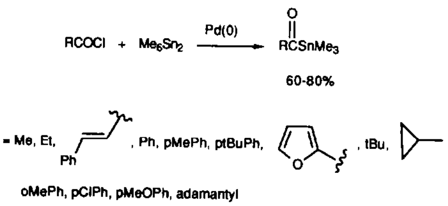
(92)



(93)

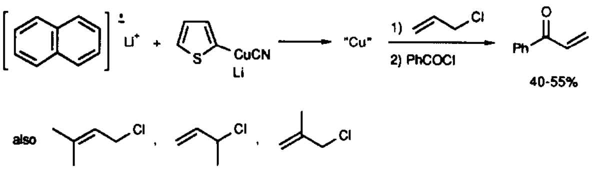


(94)



(95)

Organocopper complexes are waning in popularity for the conversion of acid halides to ketones, but a few cases have been reported (eqn. (96) [104], eqn. (97) [105], and eqn. (98) [106]). Organomanganese complexes also alkylate acid chlorides (eqn. (99) [107] and eqn. (100) [108]).



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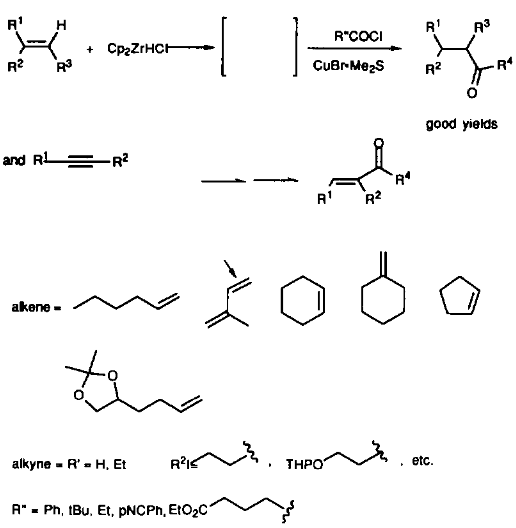
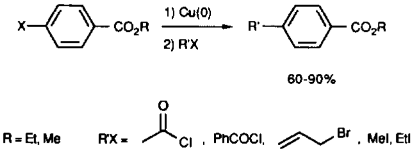


(97)



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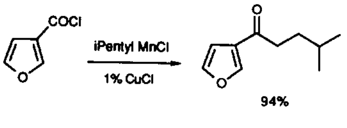

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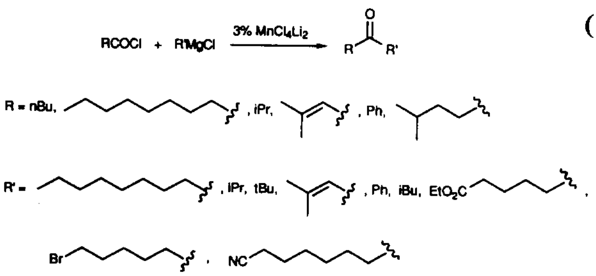
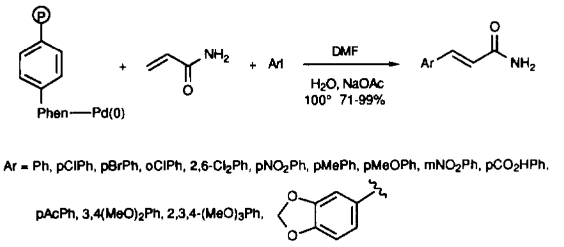


(100)

2.1.3. Alkylation of Olefins

The Heck reaction – palladium catalyzed oxidative addition/olefin insertion/ β-elimination – continued to be the most popular method to alkylate olefins, and many aspects of this reaction have been studied. Heck reactions in aqueous solutions were achieved by using sulfonated phosphines as ligands. The reactions went at mild temperatures in aqueous ethanol or acetonitrile, and gave high yields [109]. Polymer supported phenanthroline ligand/palladium complexes catalyzed the arylation of acrylamide (eqn. (101) [110]). Several other heterogeneous supports were also developed [111,112]. The effects of ligands on the regioselectivity of the arylation of a variety of alkenes by 1-naphthyl iodide or triflate were studied (eqn. (102) [113] and eqn. (103) [114]).



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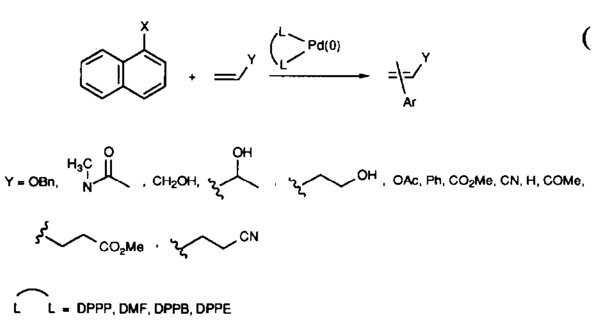
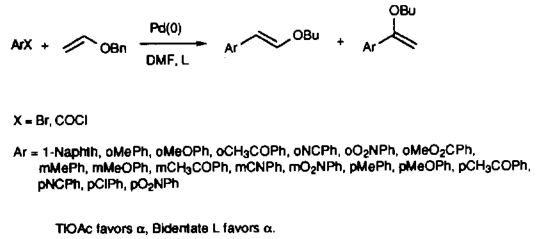


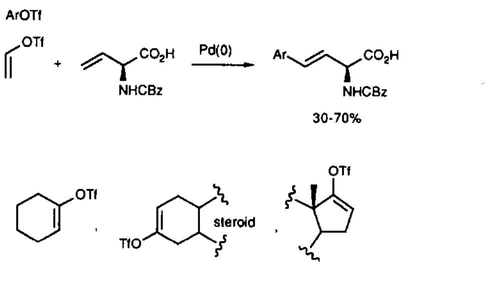
(102)



(103)

Catalyzed asymmetric Heck reactions have been reviewed (15 references) [115] and (24 references) [116].

Palladium(0) catalyzed the arylation and vinylation of vinyl glycine by triflates (eqn. (104) [117]), the vinylation of indole triflates (eqn. (105) [118]) and naphthyl triflates (eqn. (106) [119]), and the arylation of acetamido acrylates (eqn. (107) [120]) and acrylamides (eqn. (108) [121]). Palladium(0) also catalyzed the vinylation of cyclopentene diols (eqn. (109) [122]) and the arylation of styrenes (eqn. (110) [123]).



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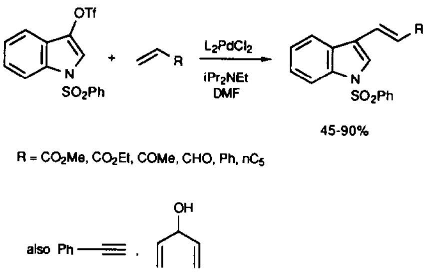

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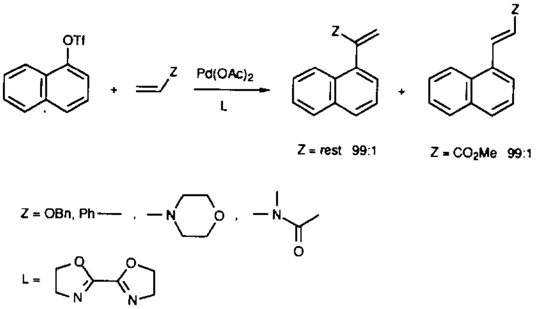

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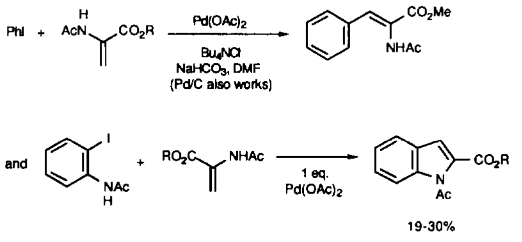
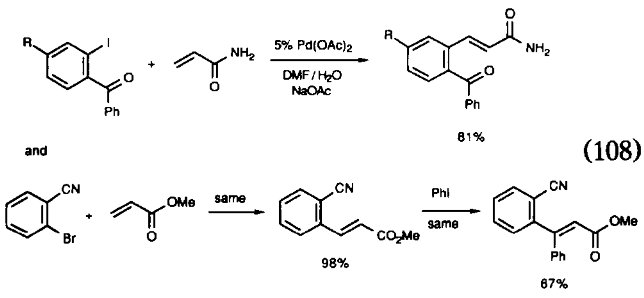
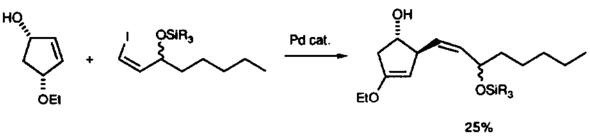


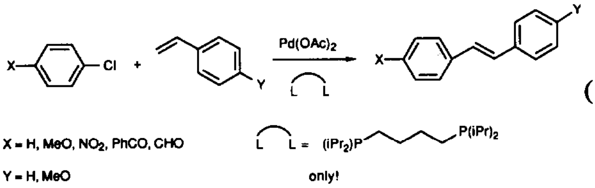
(107)



(108)



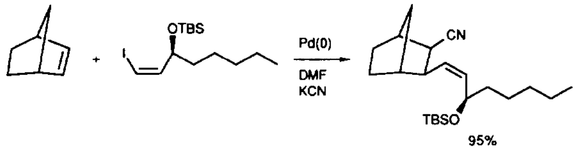
(109)



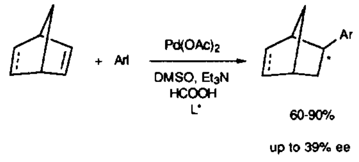
X = H, MeO, NO$_2$, PhCO, CHO
Y = H, MeO

(110)

Norbornene (eqn. (111) [124], eqn. (112) [125], eqn. (113) [126]) and 1,3-dienes (eqn. (114) [127]) were alkylated under Heck reaction conditions.

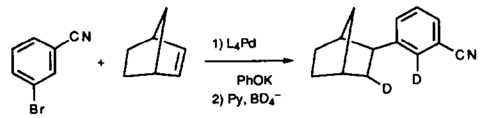


(111)

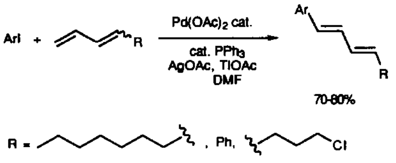


Ar = Ph, pCF$_3$CONHPh, pMeOPh, mMeOPh, oMeOPh

(112)



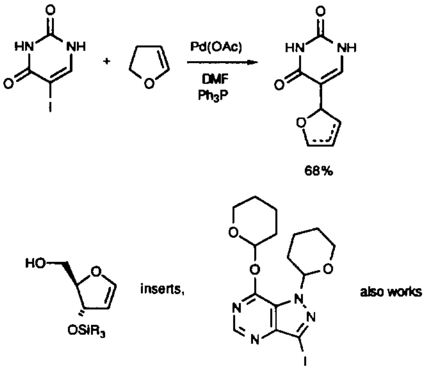
(113)



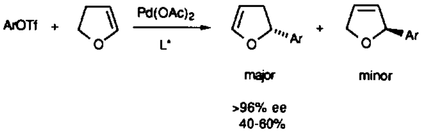
Ar = pCH$_3$COPh, mMePh, pClPh, pMeO$_2$CPh, Ph

(114)

Oxygen (eqn. (115) [128], eqn. (116) [129], eqn. (117) [130], eqn. (118) [131]) and nitrogen (eqn. (119) [132], eqn. (120) [133]) heterocyclic alkenes were alkylated under Heck conditions. Benzyl chlorides also alkylated olefins under Heck conditions (eqn. (121) [134]).

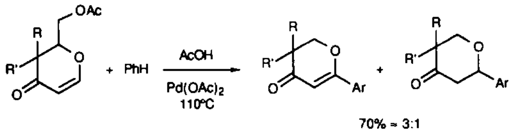


(115)



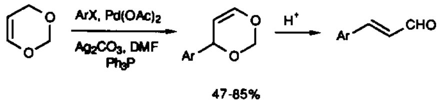
Ar = Ph, pClPh, mClPh, oClPh, pAcPh, pNCPh, pMeOPh, 2-Naphth

(116)



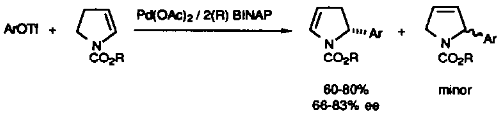
R = H, R' = OAc
R = OAc, R' = OH

(117)



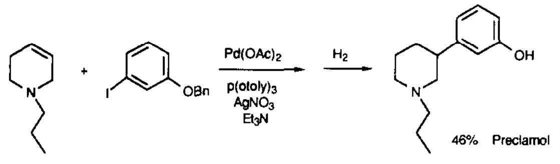
ArX = PhI, PhOTf, pMeOPhI, pEtO$_2$CPhI, pNO$_2$PhI

(118)

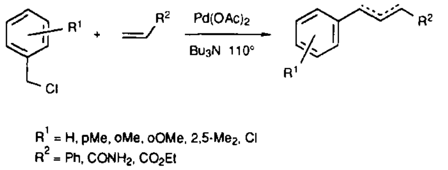


Ar = pClPh, Ph, pAcPh, pNCPh

(119)

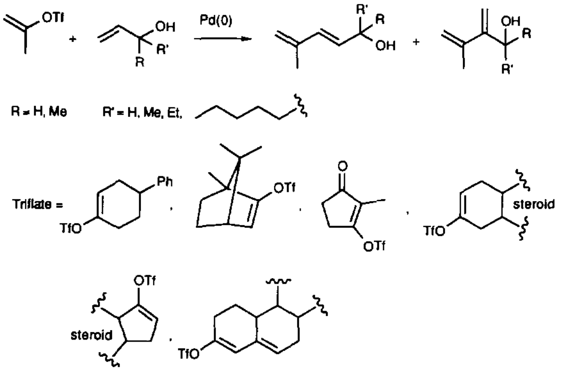


(120)

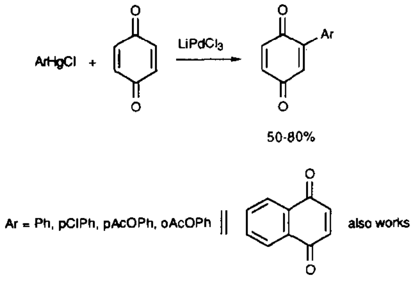


(121)

Tertiary allylic alcohols were alkylated by vinyl triflates under Heck conditions (eqn. (122) [135]). Quinones were arylated by aryl mercuric chlorides in the presence of palladium(II) catalysts (eqn. (123) [136]).

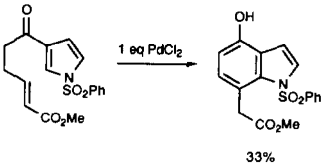


(122)

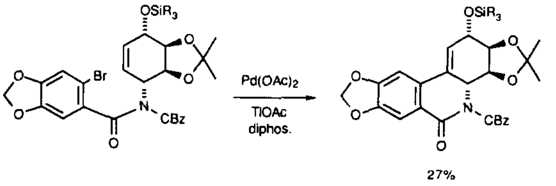


(123)

Intramolecular Heck reactions have been extensively used to form cyclic systems and have been the subject of several reviews [137] (23 references), [138] (25 references) [139]. It has proved very useful for the synthesis of a wide variety of nitrogen heterocycles (eqn. (124) [140], eqn. (125) [141], eqn. (126) [142], eqn. (127) [143], eqn. (128) [144], eqn. (129) [145], and eqn. (130) [146]).



(124)



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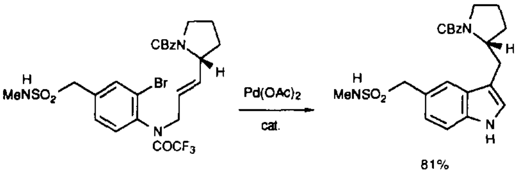

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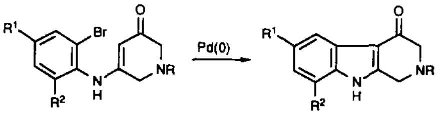

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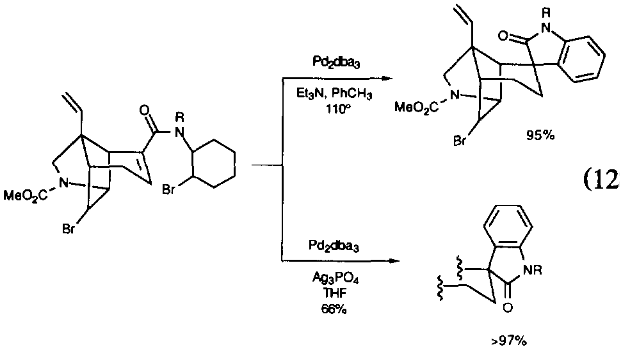
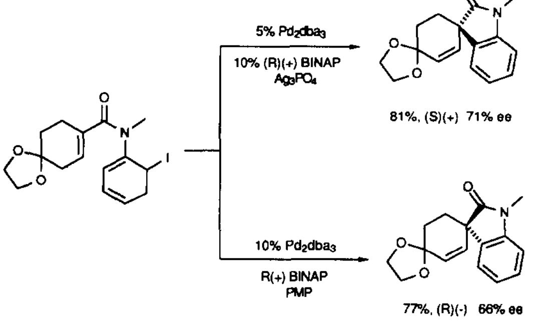
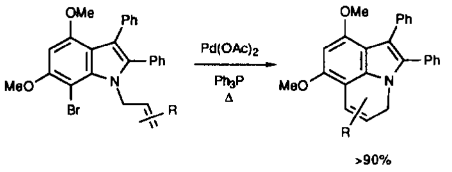


(128)

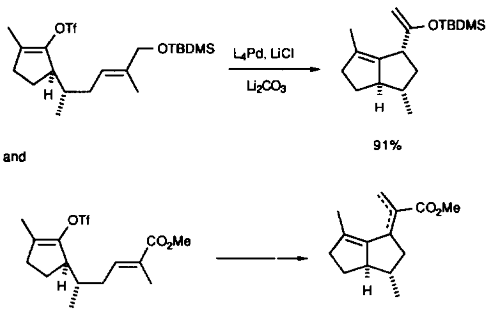


(129)



(130)

Carbocycles were also produced by intramolecular Heck alkylations of alkenes (eqn. (131) [147], eqn. (132) [148], eqn. (133) [149], eqn. (134) [150], and eqn. (135) [151]).



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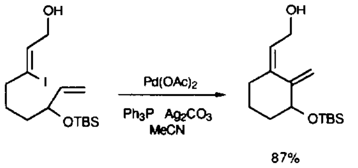
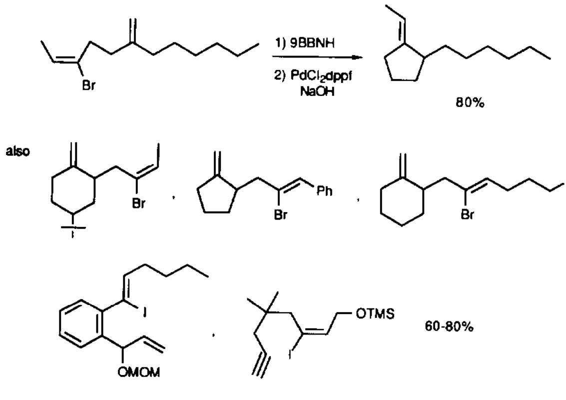
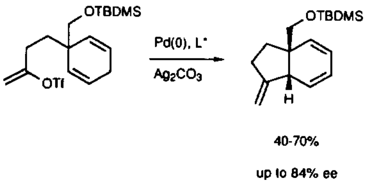


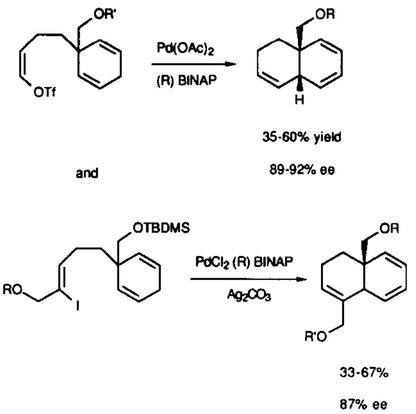
(132)



(133)

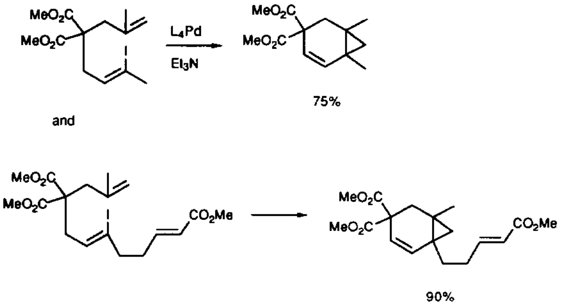


(134)

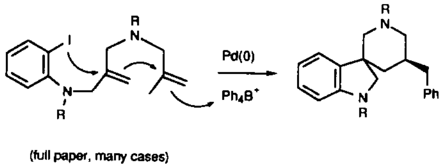


(135)

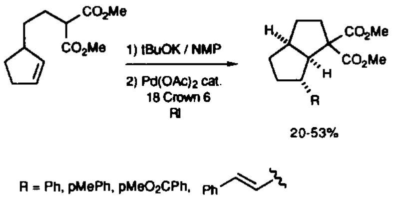
By intercepting the initial σ-alkylpalladium intermediate in the Heck reaction, multiple bonds can be formed, generating cascade cyclizations, a topic of a recent review (15 references) [152]. Examples of this process are seen in eqn. (136) [153], eqn. (137) [154], eqn. (138) [155], and eqn. (139) [156].



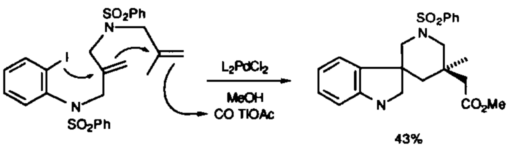
(136)



(137)

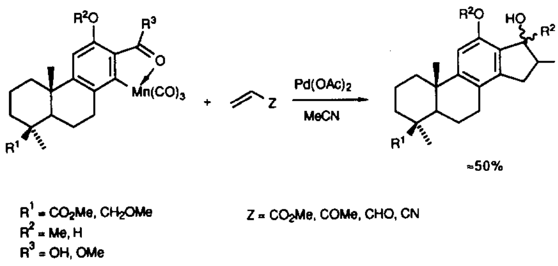


(138)

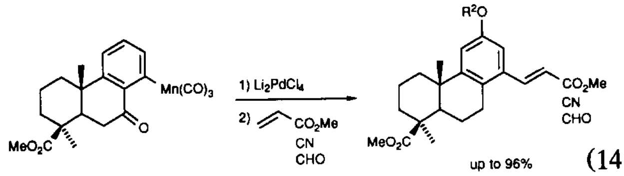


(139)

Ortho-manganated arenes underwent palladium catalyzed olefin insertion (eqn. (140) [157] and eqn. (141) [158]).

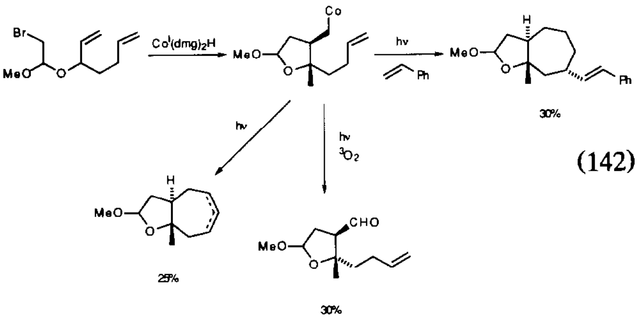


(140)



(141)

Alkenes were alkylated by free radical reactions initiated by cobalt(I) (eqn. (142) [159]), copper(I) (eqn. (143) [160]), ruthenium(II) (eqn. (144) [161]) or chromium(II) (eqn. (145) [162,163]).



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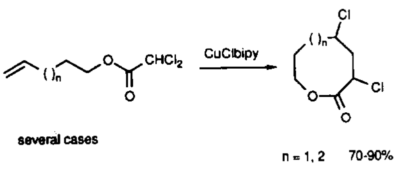

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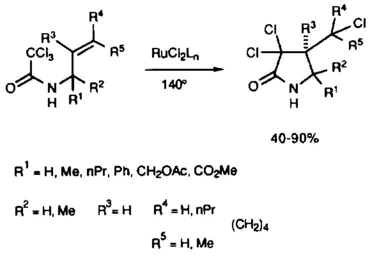

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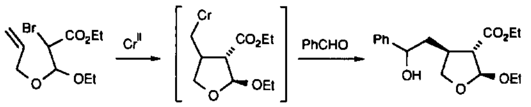
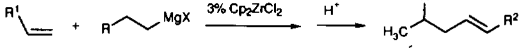
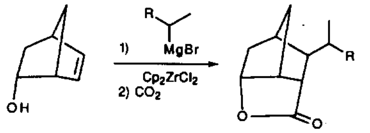


(145)

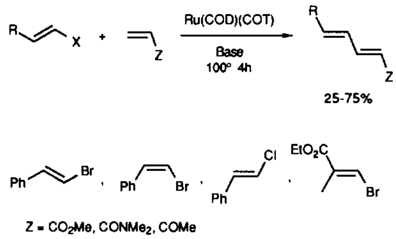
Zirconocene dichloride catalyzed the alkylation of olefins by Grignard reagents (eqn. (146) [164] and eqn. (147) [165]). Ruthenium complexes catalyzed the alkylation of alkenes by vinyl halides (eqn. (148) [166]). Nickel(II) phosphine complexes catalyzed the alkylative ring opening of dihydrofurans (eqn. (149) [167], eqn. (150) [168]) and dihydropyrans (eqn. (151) [169]).



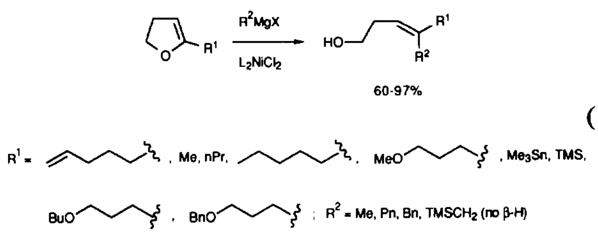
(146)



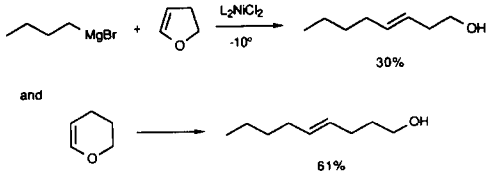
(147)



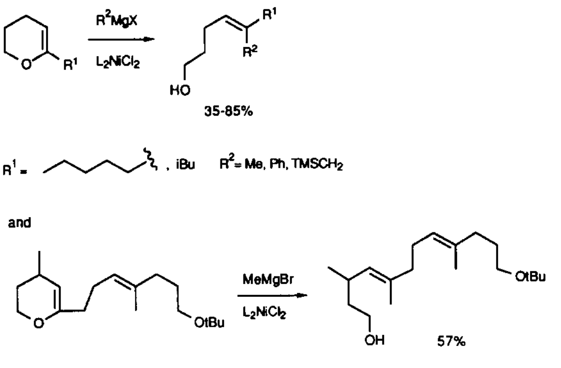
(148)



(149)

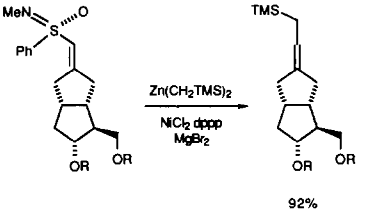


(150)

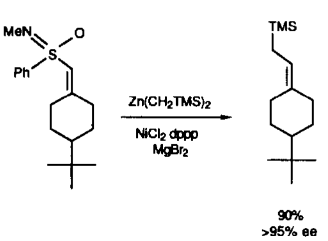


(151)

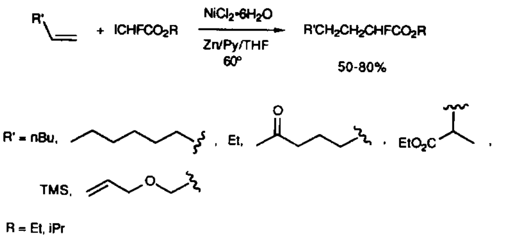
Nickel(II) phosphine complexes catalyzed the alkylation of vinyl sulfinamides by organozinc reagents (eqn. (152) [170] and eqn. (153) [171]). Nickel(0) complexes catalyzed the alkylation of olefins by α-iodoesters (eqn. (154) [172] and eqn. (155) [173]). Copper catalyzed the alkylation of olefins with perfluoroallyl iodides (eqn. (156) [174]) and cyclopropene acetals by halides (eqn. (157) [175]).



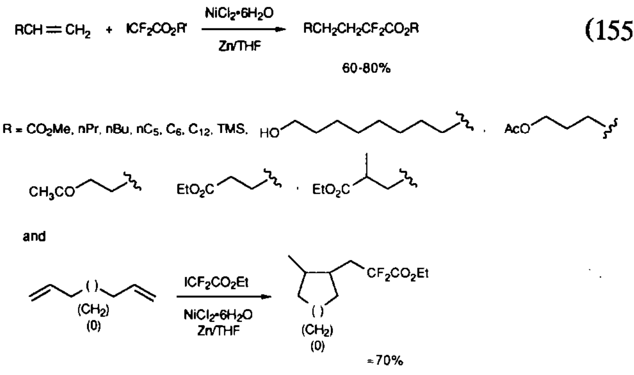
(152)



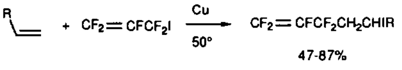
(153)



(154)



(155)



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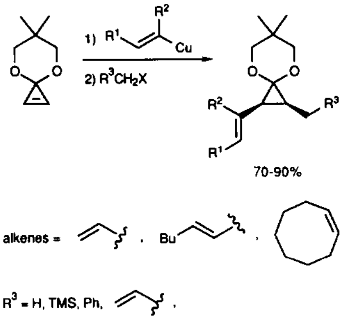
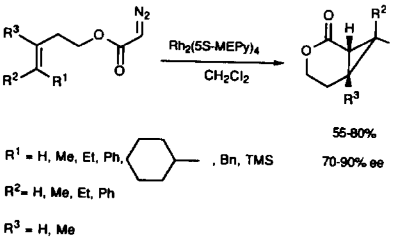


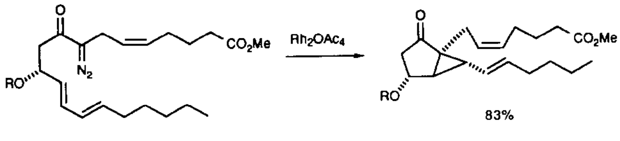
(157)

2.1.4. Decomposition of diazoalkanes and other cyclopropanation reactions

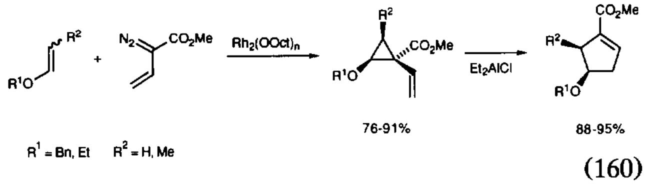
Metal catalyzed decomposition of diazoalkanes is another fairly standard class of organometallic reaction that has been "discovered" by organic chemists and has been explored with a vengeance. Perhaps the best-known process is the Rh(II) catalyzed cyclopropanation of alkanes by α-diazoketones and esters. The chiral rhodium(II) catalysis "MEPyH"$_4$Rh$_2$ has been bound to soluble polyethylene to aid in its recovery from completed cyclopropanation reactions [176]. Rhodium(II) catalyzed intramolecular cyclopropanation was an efficient process (eqn. (158) [177] and eqn. (159) [178]). Cyclopentenes were prepared by rhodium(II) catalyzed cyclopropanations followed by ring expansion (eqn. (160) [179]). Vinyl cyclopropanes were made by rhodium(II) catalyzed decomposition of vinyl diazo compounds (eqn. (161) [180]).



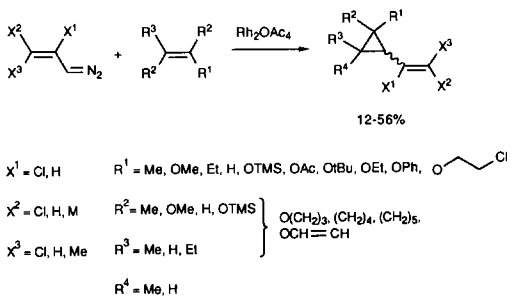
(158)



(159)

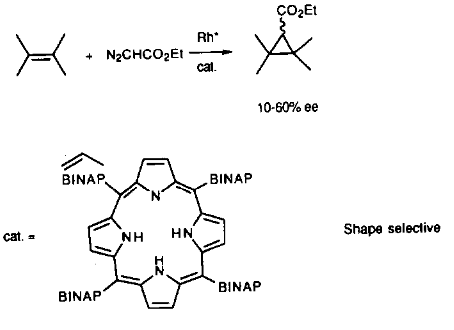


(160)

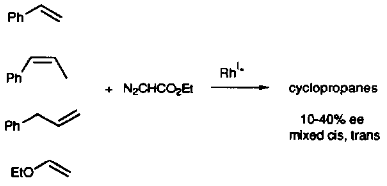


(161)

The mechanism of rhodium–porphyrin catalyzed cyclopropanation of alkenes has been studied [181]. Chiral BINAP–porphyrin rhodium complexes catalyzed olefin cyclopropanation with modest ee (eqn. (162) [182] and eqn. (163) [183]).

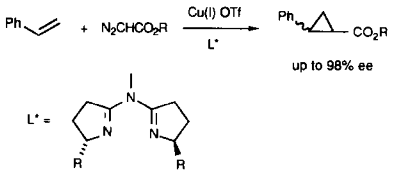


(162)

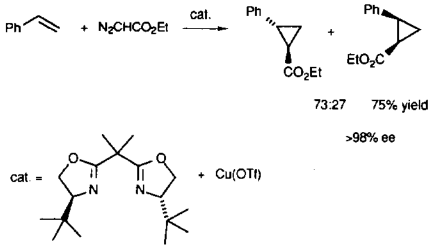


(163)

Chiral copper complexes also catalyzed the asymmetric cyclopropanation of alkenes (eqn. (164) [184] and eqn. (165) [185,186]).

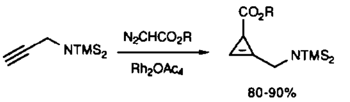


(164)

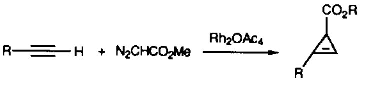


(165)

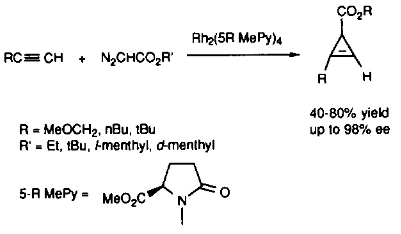
The cyclopropanation of alkenes by diazoesters was also catalyzed by ruthenium carborane clusters [187], copper(II) acetylacetonate [188], palladium(II) acetate [189] and copper salen complexes [190]. Rhodium(II) complexes also catalyzed the cyclopropenation of alkynes by diazoalkanes (eqn. (166) [191], eqn. (167) [192], eqn. (168) [193], and eqn. (169) [194]).



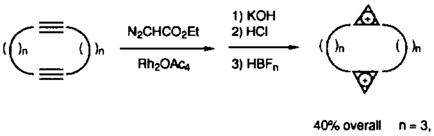
(166)



(167)

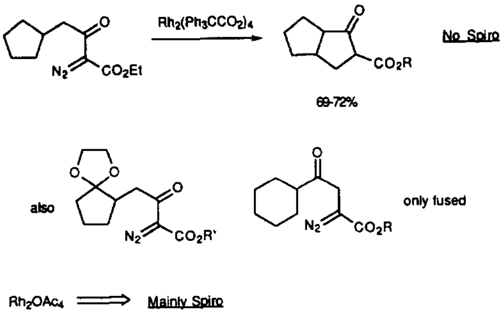


(168)

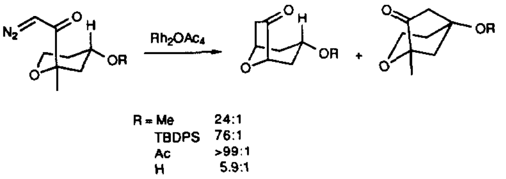


(169)

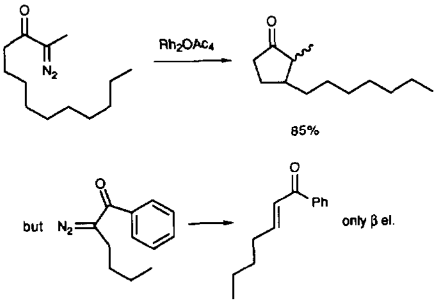
Rhodium(II) complexes also catalyzed C–H insertion reaction of diazoesters, but regiochemical predictions were difficult and strongly dependent on the parameters of the reaction (eqn. (170) [195], eqn. (171) [196], eqn. (172) [197], and eqn. (173) [198]). However, many reactions were straightforward (eqn. (174) [199], eqn. (175) [200], eqn. (176) [201], and eqn. (177) [202]).



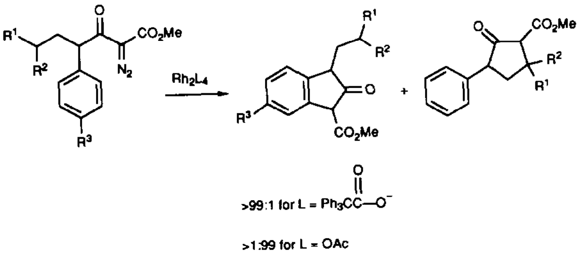
(170)



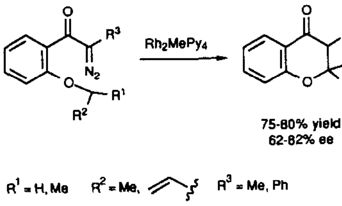
(171)



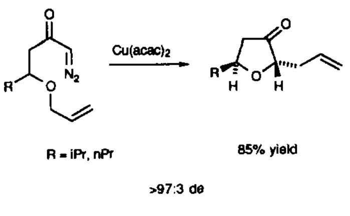
(172)



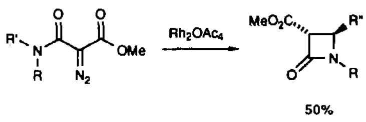
(173)



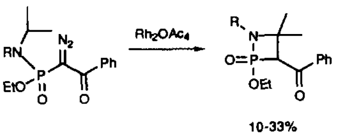
(174)



(175)

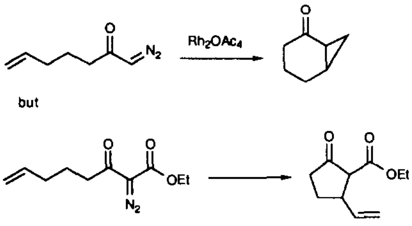


(176)

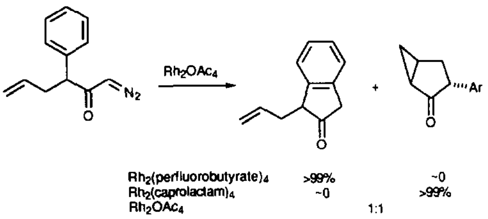


(177)

In substrates that can partition between cyclopropanation and CH insertion, several parameters were observed to effect the outcome of the reaction. In eqn. (178 [203]) diazoketones preferred to cyclopropanate whereas diazoesters underwent CH insertion. This partitioning was also influenced by the nature of the catalyst (eqn. (179) [204] and eqn. (180) [205]).



(178)



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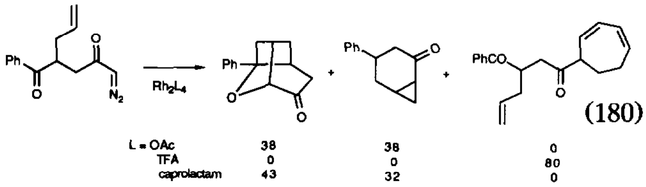
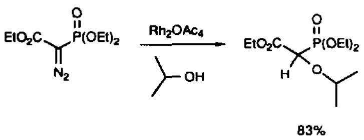


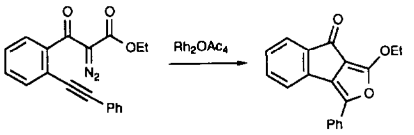
(180)

(Binaphthol phosphate)rhodium(II) complexes were efficient catalysts for CH insertion reactions for decomposition of diazo compounds, but enantioselectivities were low [206]. Rhodium(II) acetate catalyzed O–H insertion reactions of diazoketones, as well (eqn. (181) [207]).



(181)

"Application of intramolecular carbenoid reactions in organic synthesis" was the title of a review (228 references) [208]. Rhodium(II) complexes catalyzed a bewildering array of cycloaddition reactions based on the formation of ylides by addition of heteroatoms to carbenoids generated by diazodecomposition reactions (eqn. (182) [209], eqn. (183) [210], eqn. (184) [211], eqn. (185) [212], and eqn. (186) [213]).



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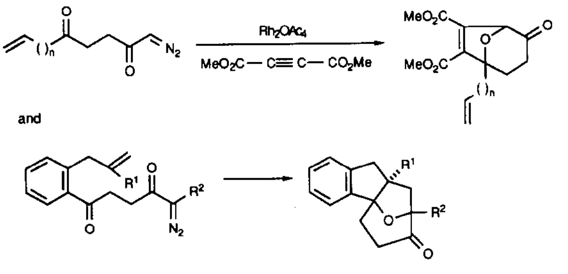
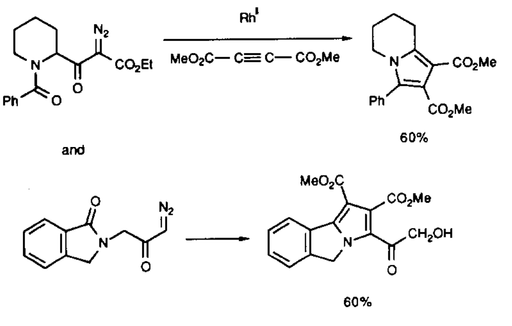
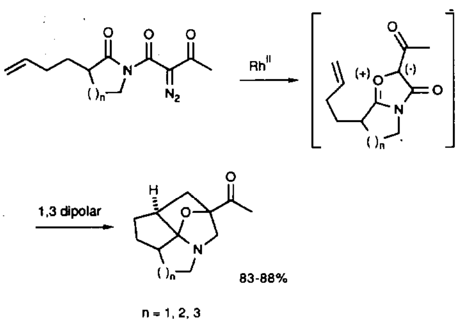


(183)



(184)



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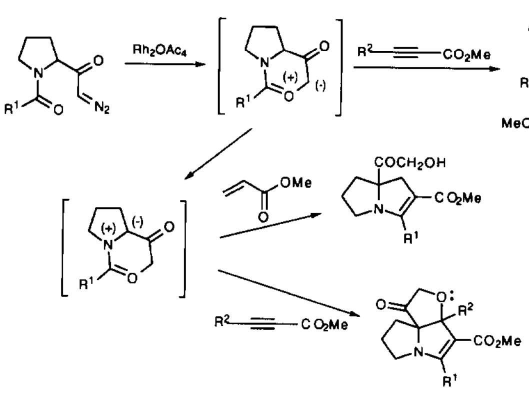
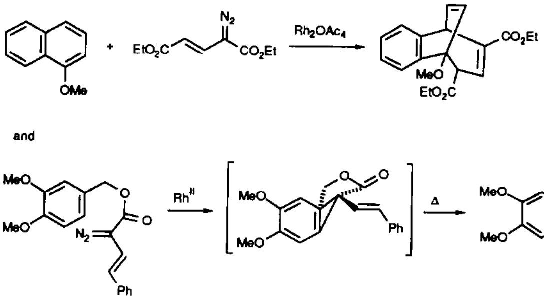


(186)

Rhodium(II) complexes catalyzed a number of unusual cycloaddition reactions of diazoalkanes (eqn. (187) [214], eqn. (188) [215], eqn. (189) [216], and eqn. (190) [217]).



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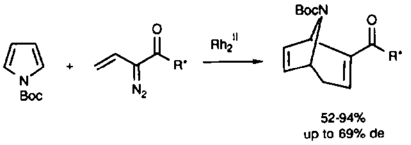
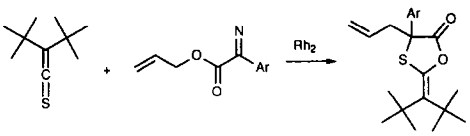
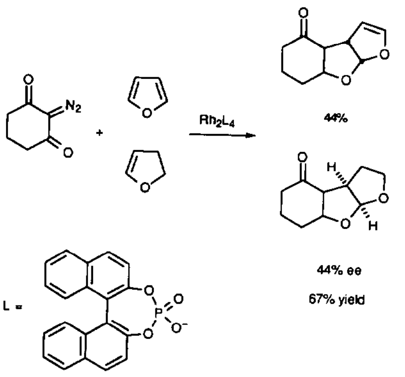


(188)

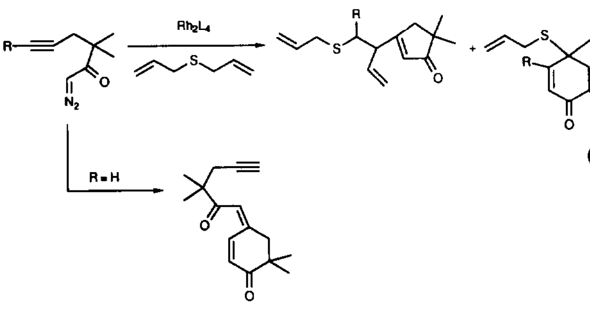


(189)



(190)

Rhodium(II) complexes catalyzed a number of unusual "cascade" processes which involved metal carbenes as intermediates (eqn. (191) [218], eqn. (192) [219], eqn. (193) [220], and eqn. (194) [221]). The same complexes catalyzed the intramolecular dimerization of carbenoids (eqn. (195) [222]).



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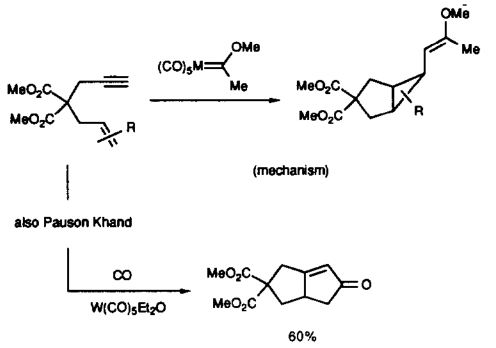
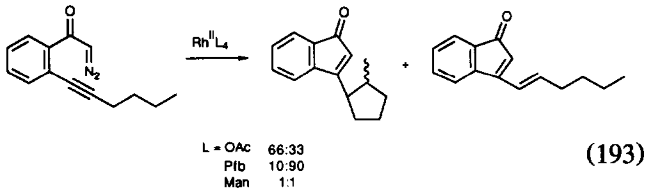
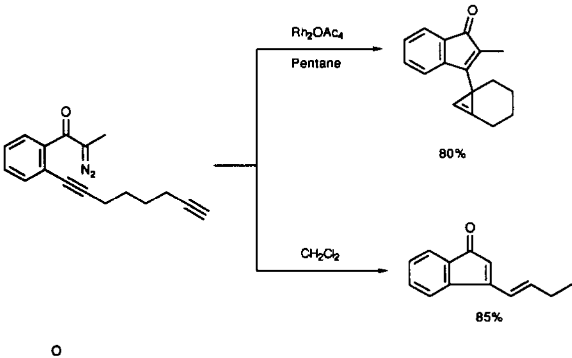


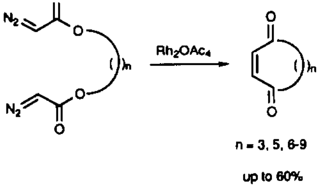
(192)



(193)

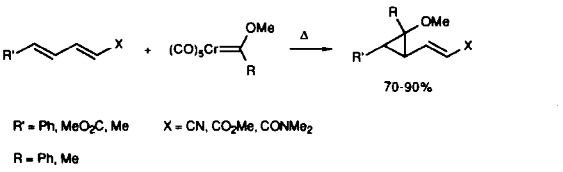


(194)



(195)

Electron poor dienes were cyclopropanated on the *remote* alkene by chromium carbene complexes (eqn. (196) [223]). Cationic iron complexes catalyzed the cyclopropanation of alkenes by diazoesters (eqn. (197) [224]). A route to iron carbene complexes, for use in cyclopropanation, from aldehydes has been developed (eqn. (198) [225]). Dienes were monocyclopropanated by iron carbene complexes, by protecting one alkene as the iron complex (eqn. (199) [226]). Nickel(0) catalyzed the cyclopropanation of electron deficient alkenes by gem-dihalo-alkanes [227].



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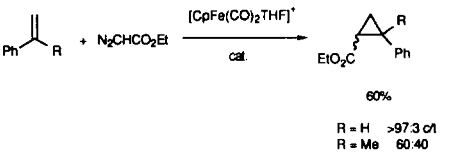
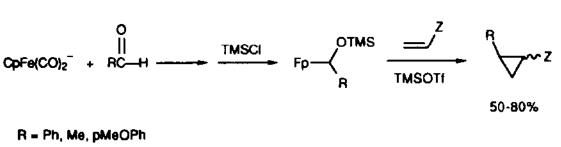
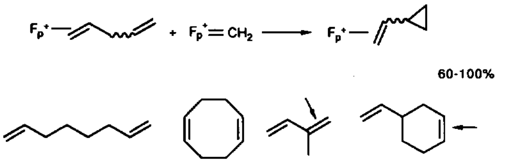


(197)



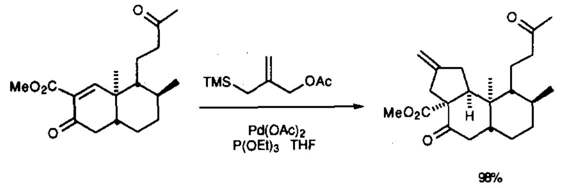
(198)



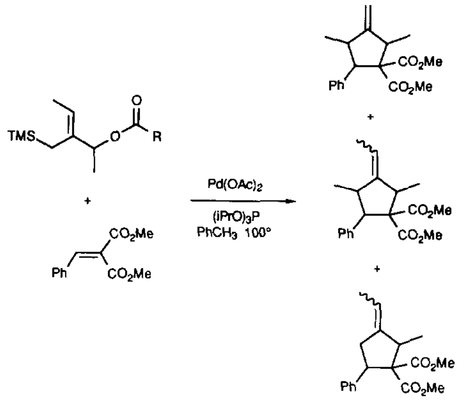
(199)

2.1.5. Cycloaddition reactions

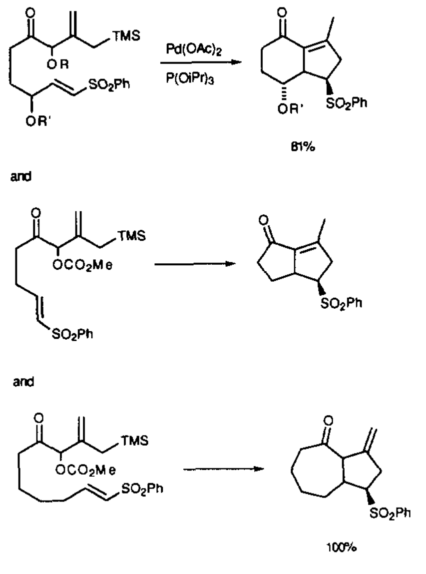
Cycloaddition reactions using transition metal trimethylene methane derivatives have been reviewed (6 references) [228]. A convenient synthesis of the requisite Z-2-trimethylsilylmethyl-2-butene-1-ol starting material for palladium catalyzed 3 + 2 cycloadditions has been reported [229]. This process was useful for the synthesis of a variety of complex products (eqn. (200) [230], eqn. (201) [231], and eqn. (202) [232]). By changing conditions, the cycloaddition to conjugated enones can be diverted from addition to the alkene to addition to the carbonyl group (eqn. (203) [233]). Allylic diacetates added to both α-positions of cyclic keto esters, giving bridged bicyclic intermediates (eqn. (204) [234]).



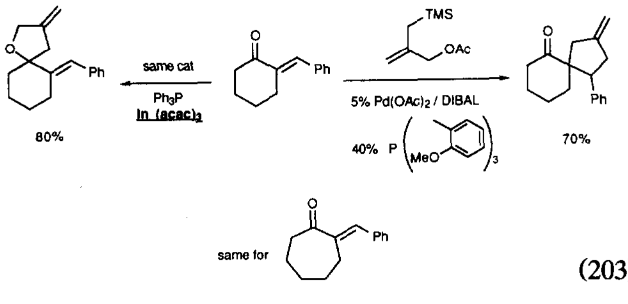
(200)



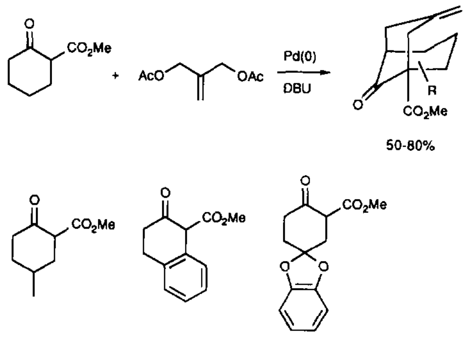
(201)



(202)

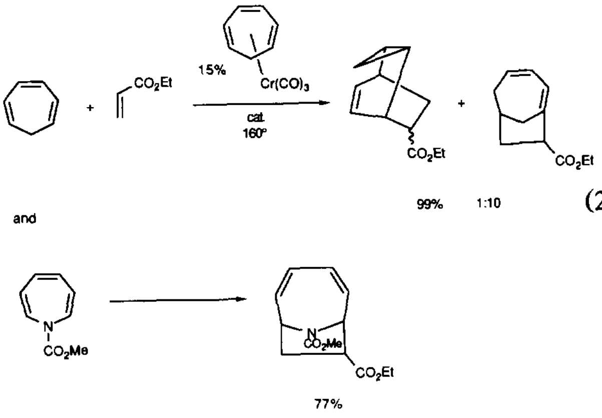


(203)

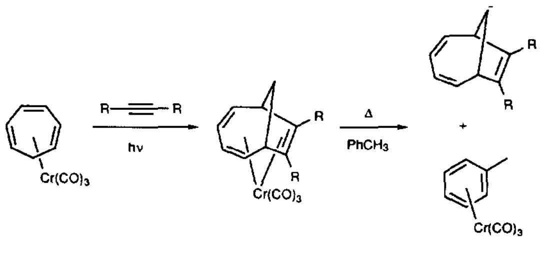


(204)

Chromium cycloheptatriene complexes catalyzed a number of [2 + 6] and [4 + 6] cycloadditions (eqn. (205) [235], eqn. (206) [236], and eqn. (207) [237]). Reduced cobalt complexes catalyzed an intramolecular homo Diels Alder reaction (eqn. (208) [238]). Ruthenium hydrides catalyzed [2 + 2] and other unusual cycloadditions (eqn. (209) [239]). Reduced titanium species catalyzed [4 + 2] and [6 + 2] cycloadditions (eqn. (210) [240]). Oxidation of cyclobutadiene iron complexes in the presence of norbornadiene led to several cycloadducts (eqn. (211) [241]). Polysubstituted phenols were synthesized from cyclobutenones *via* cobalt vinyl ketene intermediates (eqn. (212) [242]).



(205)



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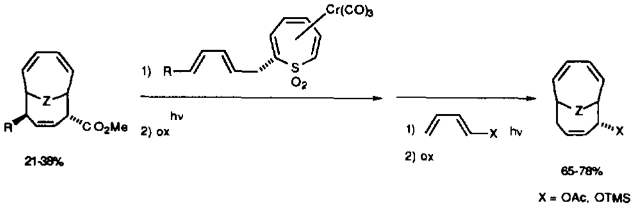

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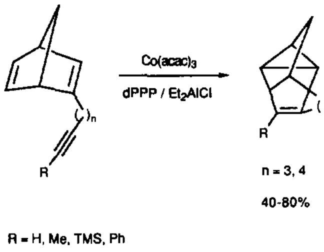

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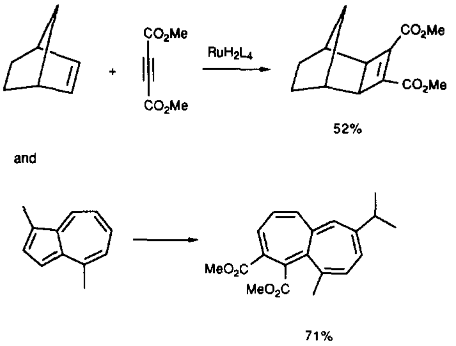
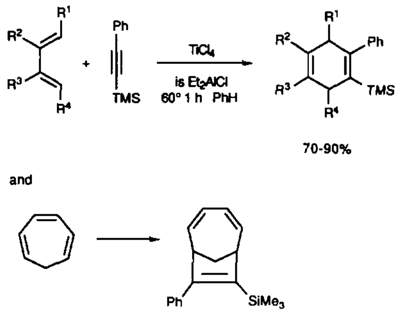
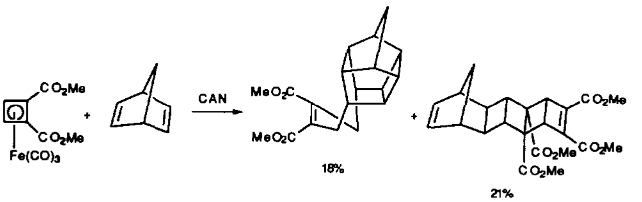


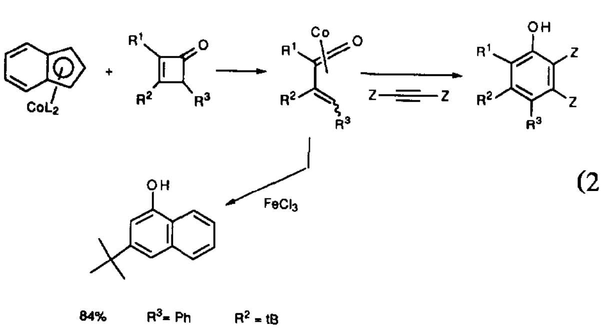
(209)



(210)



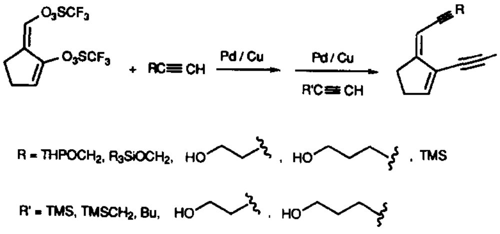
(211)



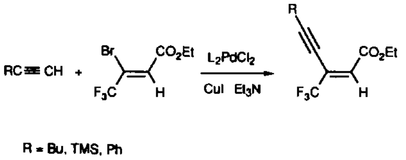
(212)

2.1.6. Alkylation of alkynes

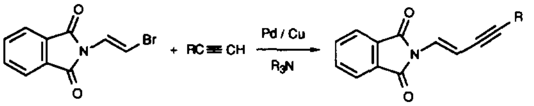
The Castro–Stevens reaction (Pd/Cu/amine) has become the premier way to couple alkynes to aryl and vinyl halides and triflates, and a large number of simple cases have been reported (eqn. (213) [243], eqn. (214) [244], eqn. (215) [245], eqn. (216) [246], eqn. (217) [247], eqn. (218) [248], eqn. (219) [249], eqn. (220) [250], eqn. (221) [251], and eqn. (222) [252]).



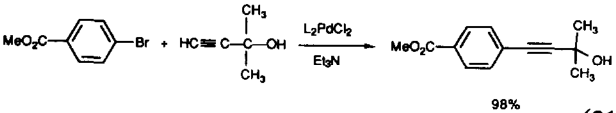
(213)



(214)



(215)



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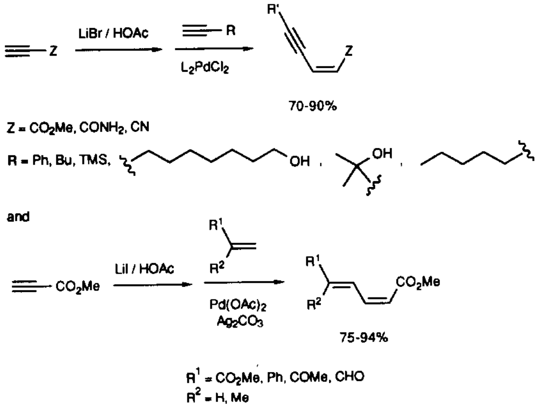
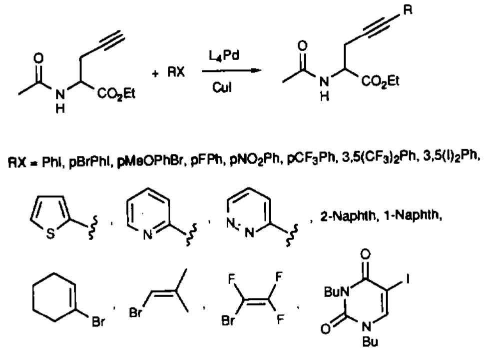
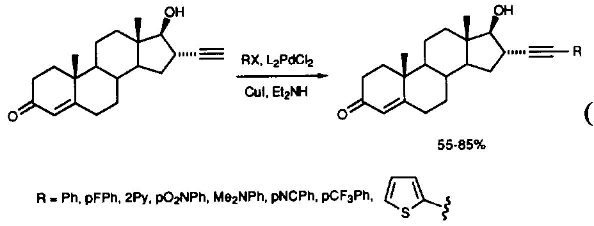


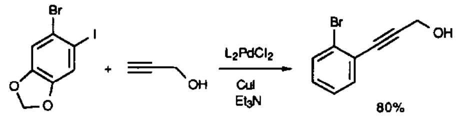
(217)



(218)



(219)



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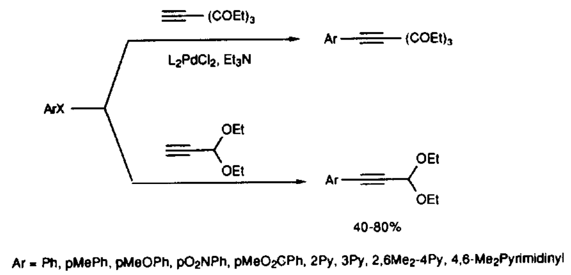

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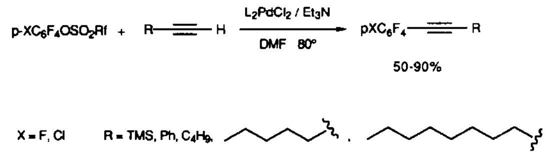
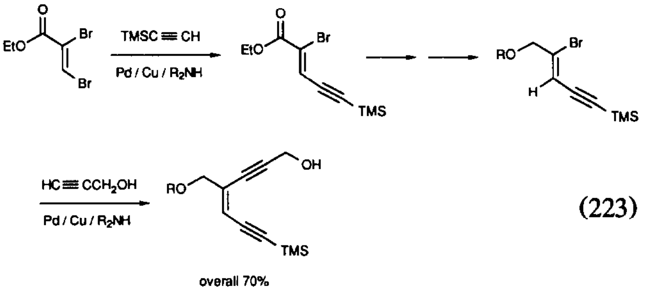


(222)

Additional examples are seen in eqn. (223) [253], eqn. (224) [254], eqn. (225) [255], eqn. (226) [256], eqn. (227) [257], eqn. (228) [258], and eqn. (229) [259].



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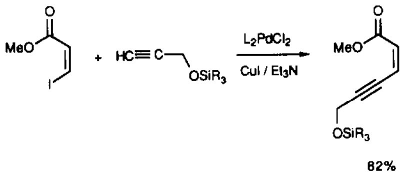
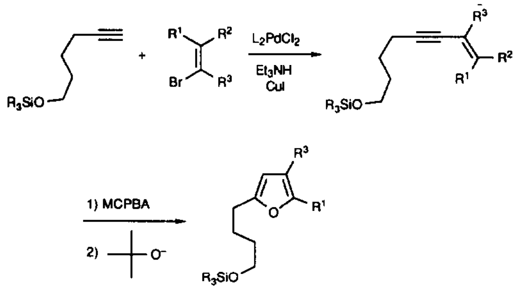


(224)



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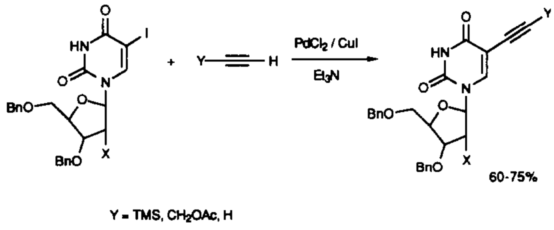

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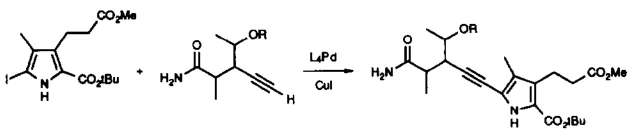

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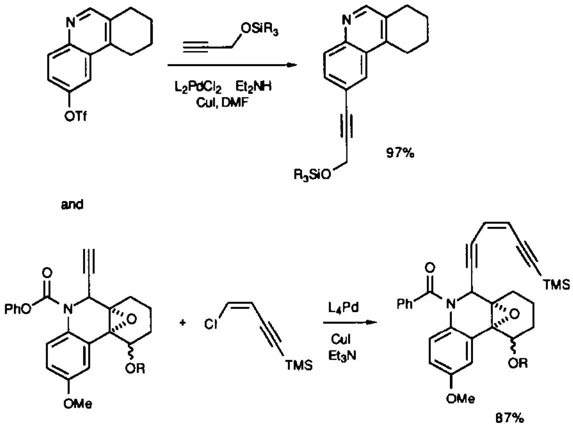

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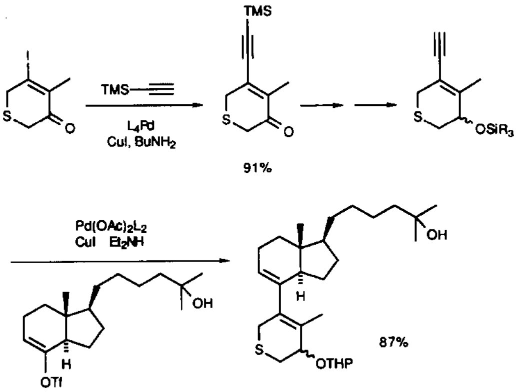
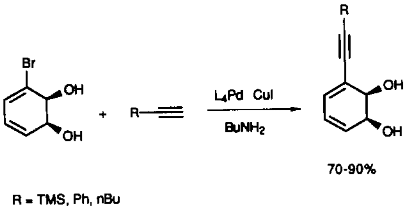


(229)

This process was efficient for alkynylation of functionalized arenes (eqn. (230) [260] and eqn. (231) [261]), and for multiple incorporation of alkynes into arenes (eqn. (232) [262], eqn. (233) [263], eqn. (234) [264], eqn. (235) [265], and eqn. (236) [266]).



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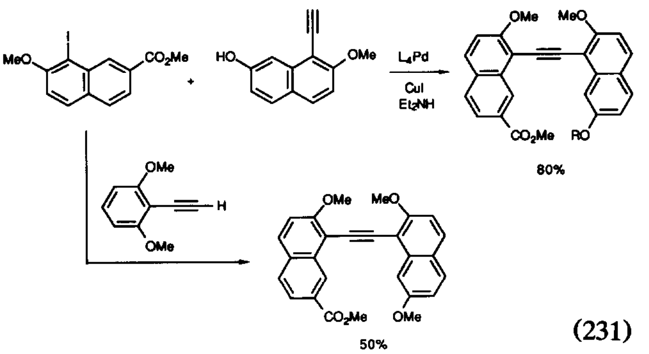

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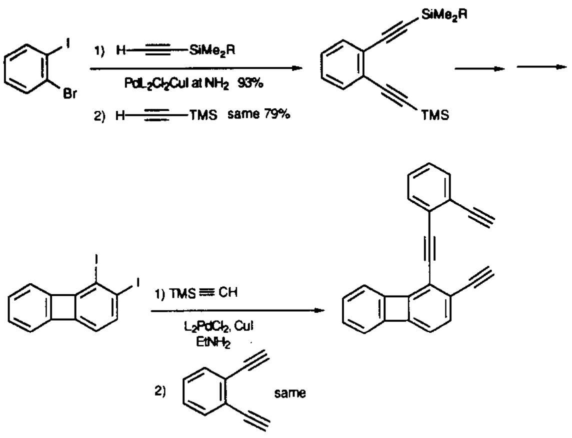
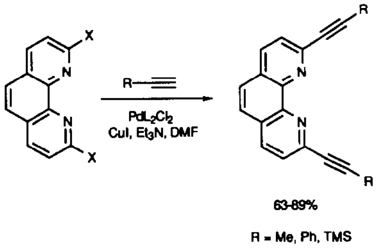
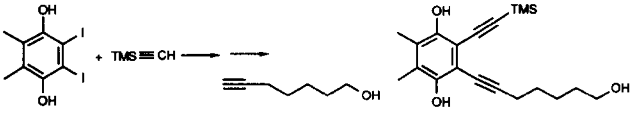


(232)



(233)



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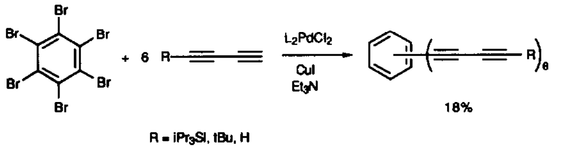

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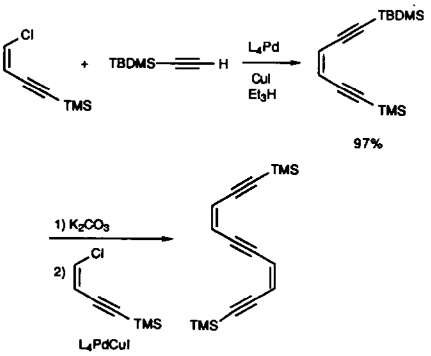
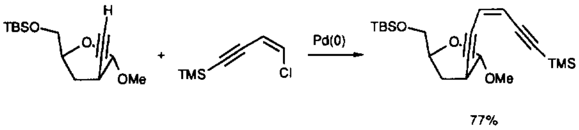


(236)

The Castro-Stevens coupling was extensively used in the synthesis of ene-diyne natural products (eqn. (237) [267], eqn. (238) [268], eqn. (239) [269], eqn. (240) [270], eqn. (241) [271], and eqn. (242) [272]) as well as other natural products (eqn. (243) [273], eqn. (244) [274], and eqn. (245) [275]).



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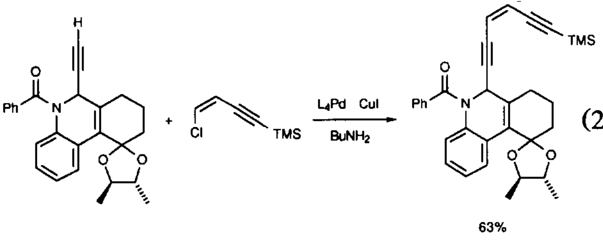
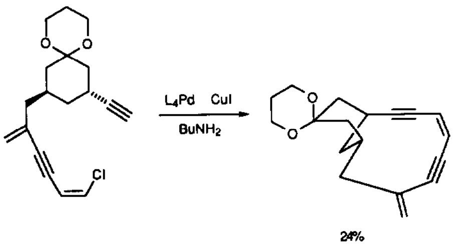


(238)



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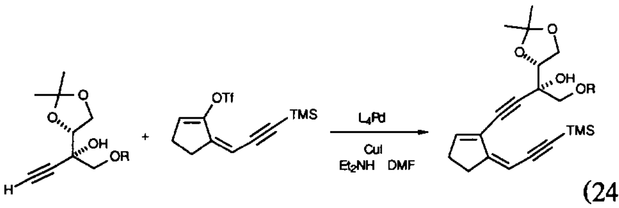

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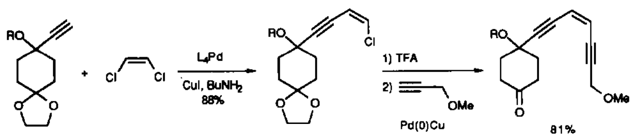

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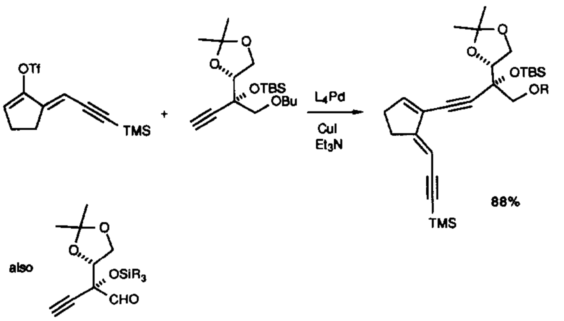

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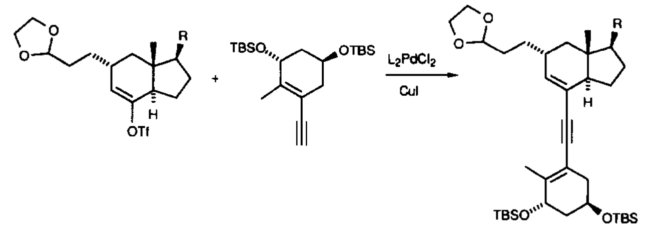

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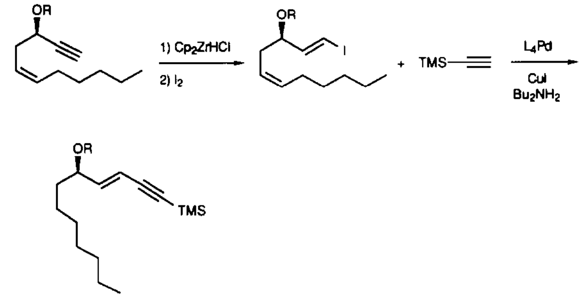

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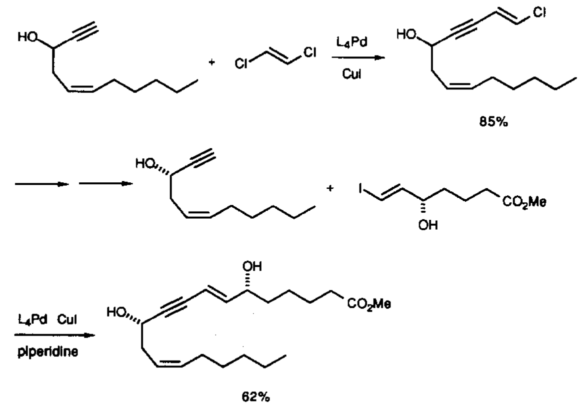
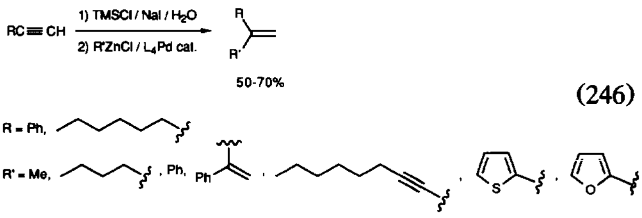


(245)

Alkynes were alkylated to give alkenes by treatment with organozinc reagents in the presence of palladium catalysts (eqn. (246) [276]). Orthopalladated species inserted alkynes to give polycyclic materials (eqn. (247) [273]). Alkynes were alkylated by propargyl halides in the presence of copper(I) salts (eqn. (248) [278]). Allyl halides behaved in a similar manner (eqn. (249) [279]), as did aryl and vinyl halides (eqn. (250) [280]). Alkynes were readily carbocuprated (eqn. (251) [281]), and stannylcuprated (eqn. (252) [282]). Copper(I) catalyzed the intramolecular alkylation of alkynes by stabilized carbanions (eqn. (253) [283]).



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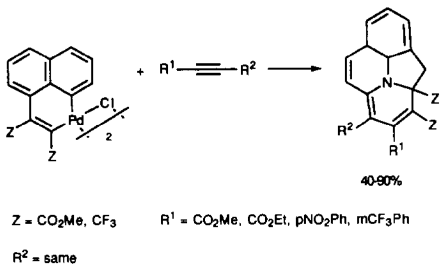

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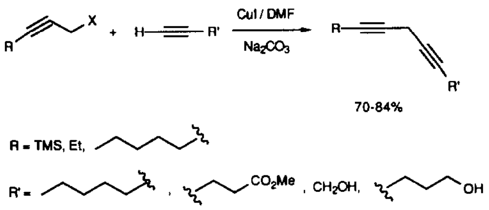

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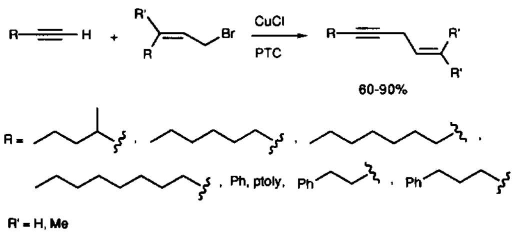

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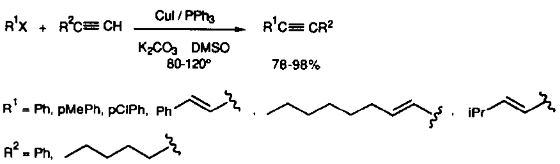

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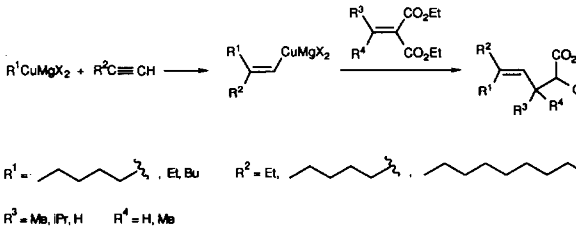

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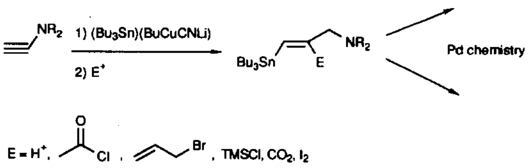

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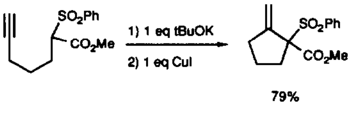
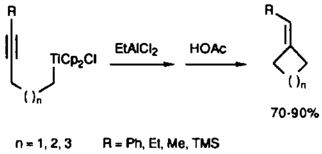


(253)

Titanocene complexes alkylated alkynes (eqn. (254) [284]), eqn. (255) [285]). Zirconium porphyrin complexes catalyzed the alkylation of alkynes by triethyl aluminum (eqn. (256) [286]). η^2-Ketimine complexes of zirconium inserted alkynes (eqn. (257) [287] and eqn. (258) [288]). Ruthenium(I) complexes catalyzed the alkylation of alkynes by allyl alcohols (eqn. (259) [289]). Alkynes inserted into arylmanganese complexes (eqn. (260) [290]), and into orthopalladated arenes (eqn. (261) [291]).



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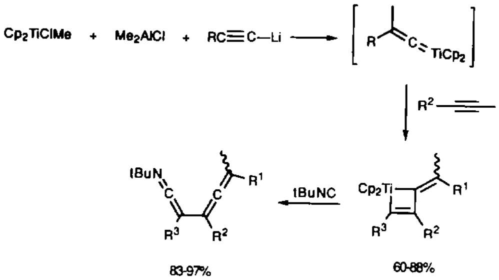

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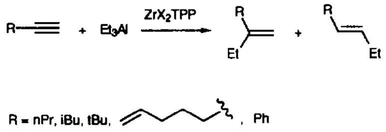

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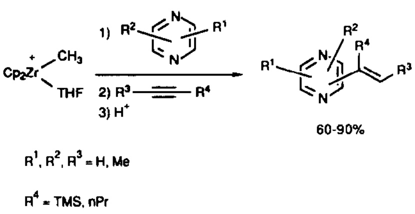

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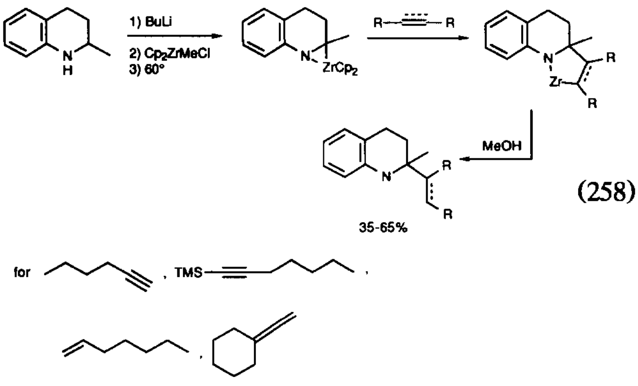

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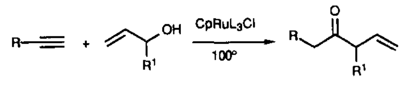

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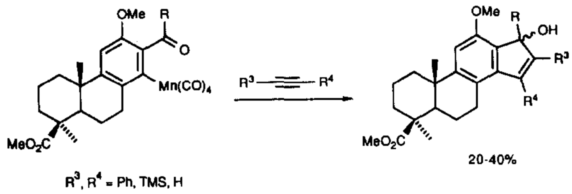

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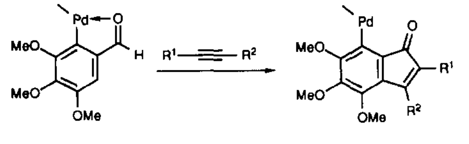
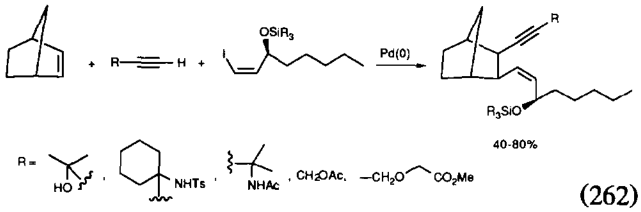


(261)

Alkynes participated in a number of "cascade" cyclization processes, involving palladium catalyzed oxidative addition insertion processes (eqn. (262) [292], eqn. (263) [293], eqn. (264) [294], eqn. (265) [295], eqn. (266) [296], eqn. (267) [297], eqn. (268) [298], eqn. (269) [299], and eqn. (270) [300]).



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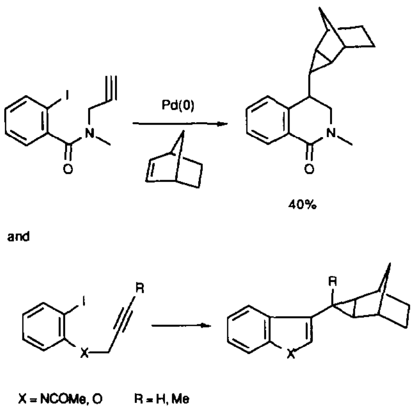

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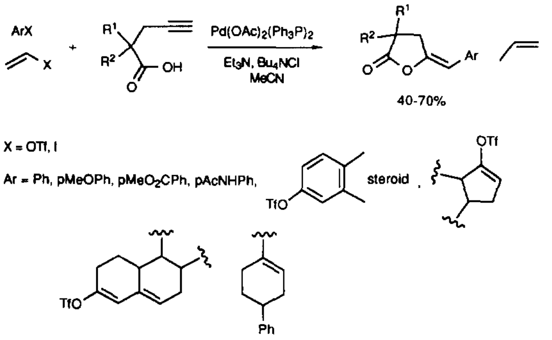

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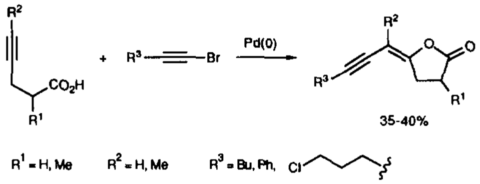

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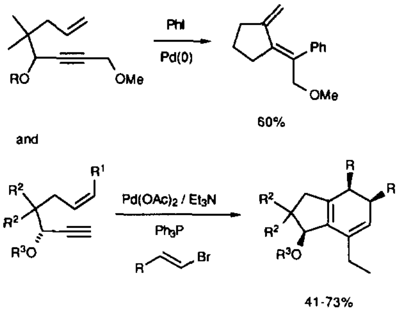

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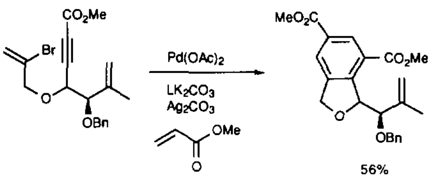

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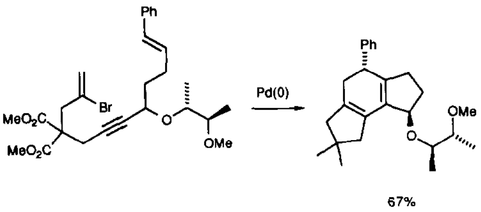

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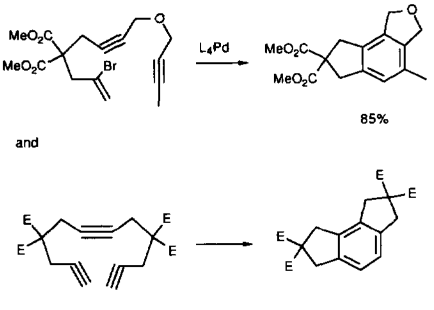
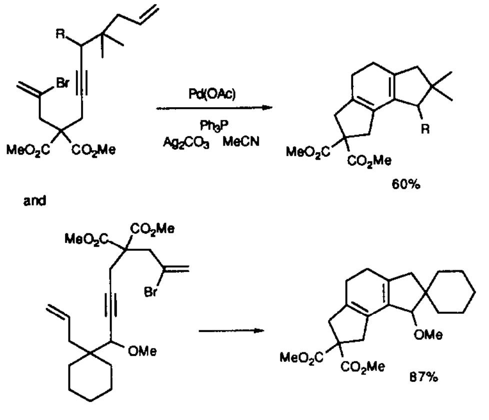


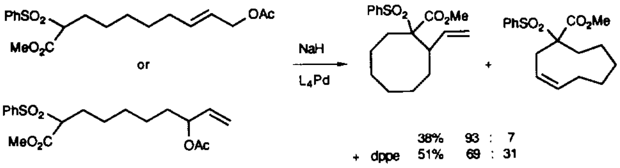
(269)



(270)

2.1.7. Alkylation of allyl, propargyl and allenyl systems

"Selectivity in palladium catalyzed allylic substitutions" was the title of a review (130 references) [301]. Palladium catalyzed alkylation of allyl acetates by stabilized carbanions has been used extensively, both intramolecularly (eqn. (271) [302], eqn. (272) [303]), and intermolecularly (eqn. (273) [304], eqn. (274) [305], eqn. (275) [306], eqn. (276) [307], eqn. (277) [308], and eqn. (278) [309]).



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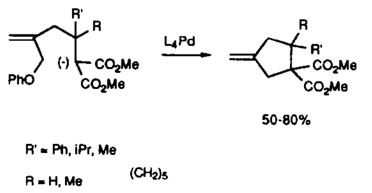

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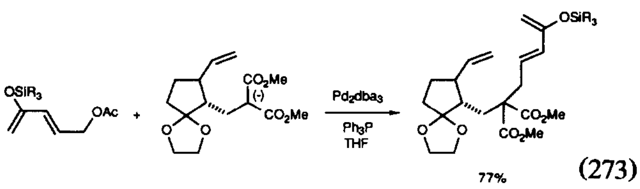

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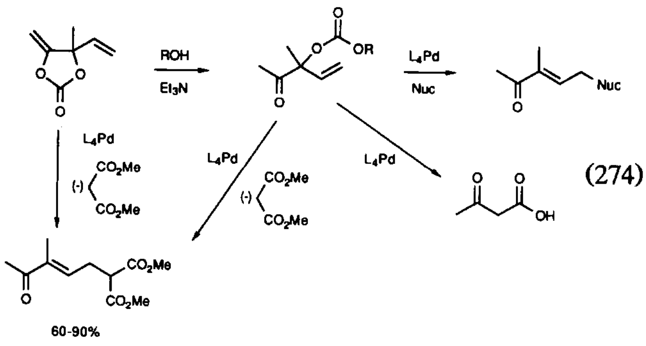
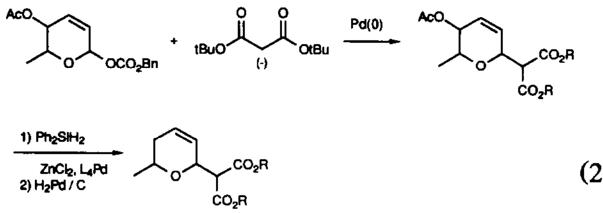
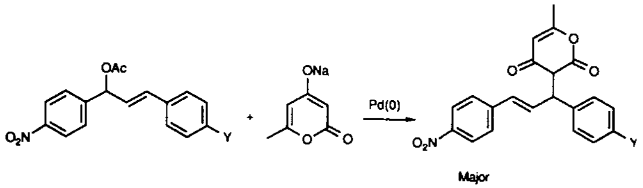


(274)

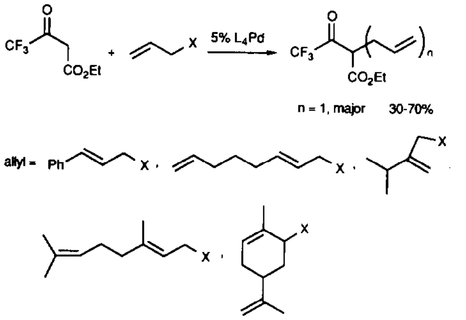


(275)

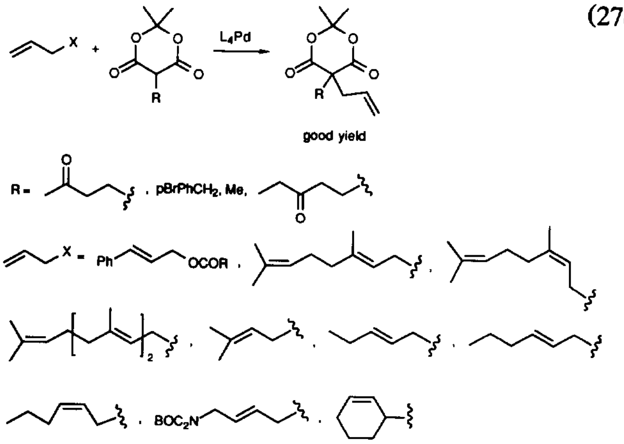


Major
attack remote from electron withdrawing group

(276)

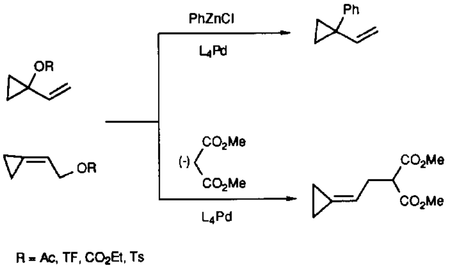


(277)



(278)

Palladium(0) catalyzed the alkylation of allylic systems of vinyl cyclopropanes (eqn. (279) [310], eqn. (280) [311]), the alkylation of allyl acetates by ketene silyl acetals (eqn. (281) [312]), the alkylation of cholestenyl esters by carbon nucleophiles (eqn. (282) [313]), and the alkylation of allyl acetates by α-hydroxy acid derivatives (eqn. (283) [314]). Vinyl mercurials (eqn. (284) [315]) and zinc reagents (eqn. (285) [316]) alkylated allyl acetates under palladium catalysis.



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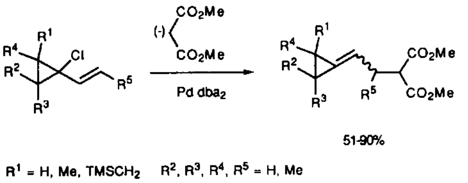

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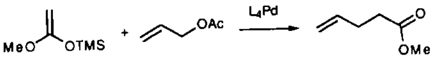

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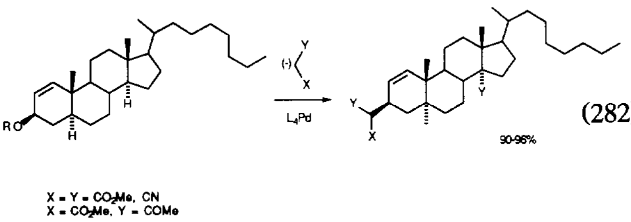

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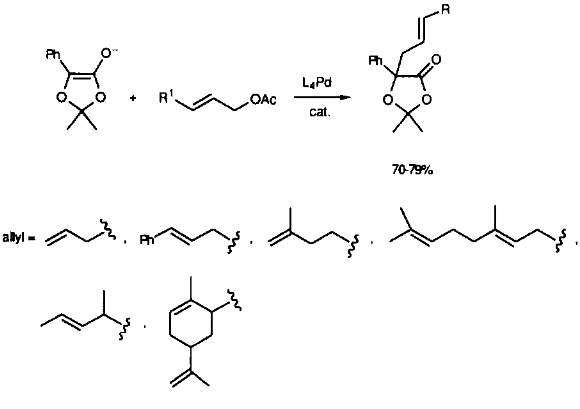

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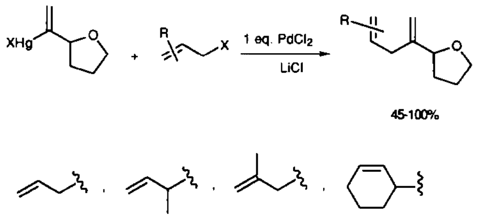

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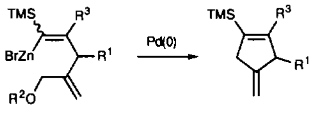
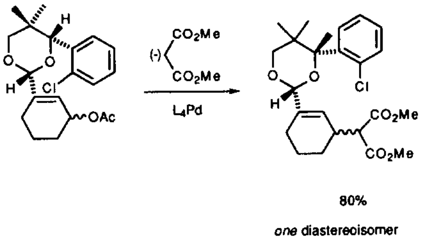
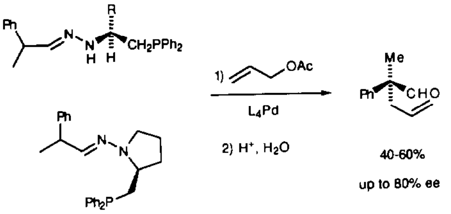


(285)

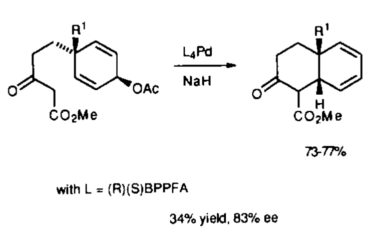
Asymmetric induction in the palladium catalyzed allylic alkylation reaction has been achieved both by using chiral substrates (eqn. (286) [317], eqn. (287) [318]), and chiral ligands (eqn. (288) [319], eqn. (289) [320], eqn. (290) [321], eqn. (291) [322], and eqn. (292) [323]).



(286)



(287)



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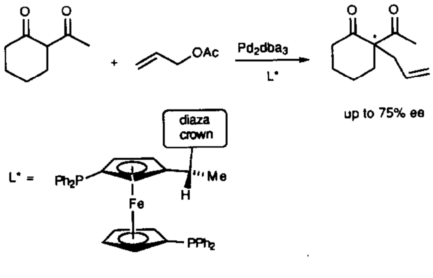

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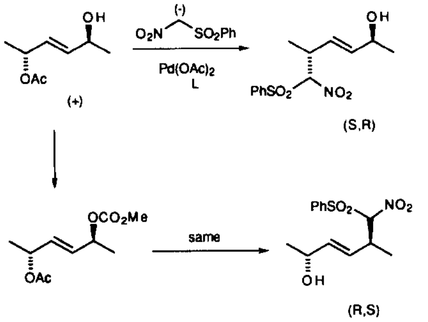

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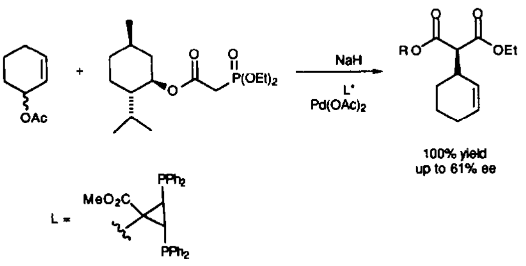

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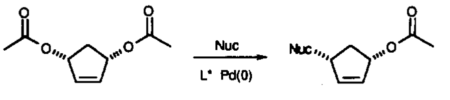
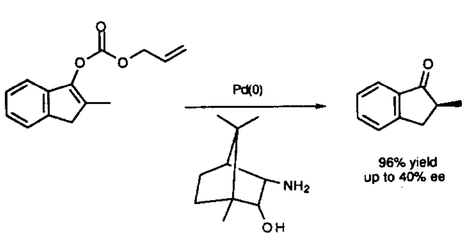


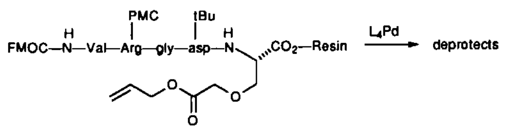
(292)

Full paper on design of efficient ligands for this reaction.

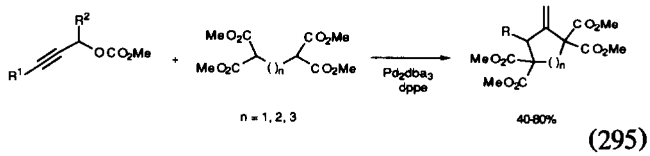
Palladium(0) complexes catalyzed the removal of allyl carbonate protecting groups (eqn. (293) [324] and eqn. (294 [325]). Palladium catalyzed reactions of propargyl carbonates have been reviewed (27 references) [326]. Propargyl carbonates were alkylated by stabilized carbanions in the presence of palladium(0) catalysts (eqn. (295) [327,328]). Benzyl carbonates underwent similar alkylations (eqn. (296) [329]).



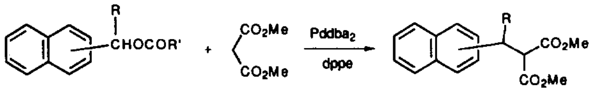
(293)



(294)

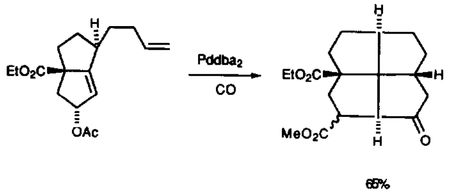


(295)



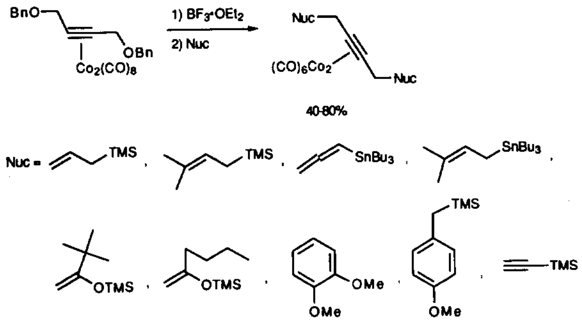
(296)

Palladium(0) complexes catalyzed "cascade" cyclizations which were initiated by oxidative addition to an allyl acetate (eqn. (297) [330,331]).

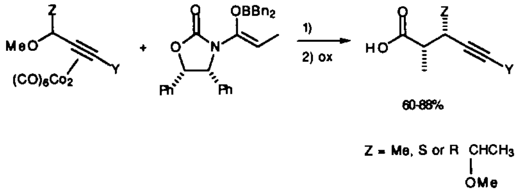


(297)

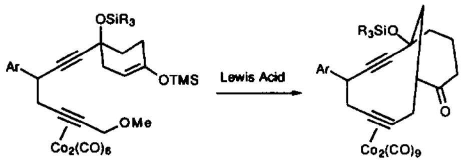
Cobalt-stabilized propargyl cations were alkylated by a variety of carbon nucleophiles (eqn. (298) [332], eqn. (299) [333], and eqn. (300) [334]).



(298)

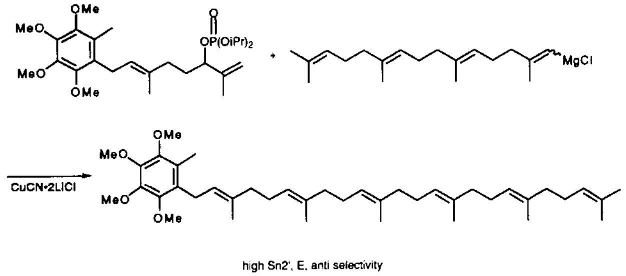


(299)

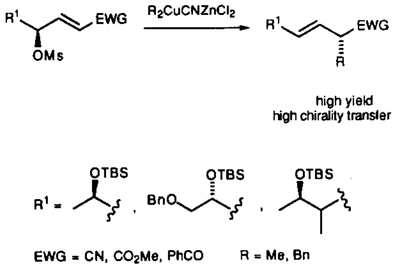


(300)

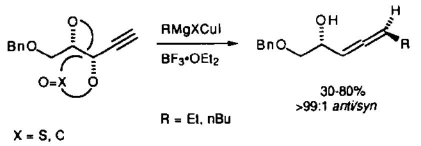
Organocuprates alkylated allylic (eqn. (301) [335] and eqn. (302) [336]) and propargyl systems (eqn. (303) [337] and eqn. (304) [338]). The stereo- and regiochemistry of displacement of allyl benzothiazines by alkyl copper species was the subject of an extensive investigation [339].



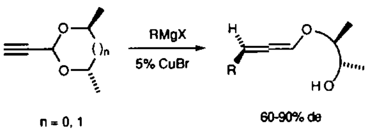
(301)



(302)

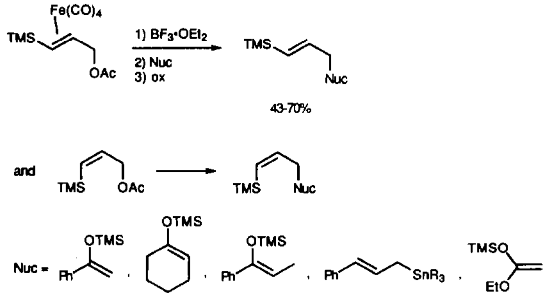


(303)

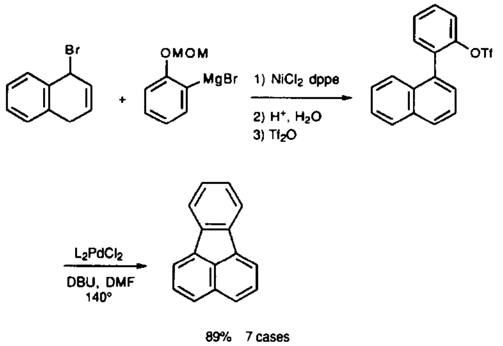


(304)

Silyl enol ethers alkylated allyl acetates complexed to $Fe(CO)_4$ (eqn. (305) [340]). Nickel(0) complexes catalyzed the reaction of aryl Grignards with allylic bromides (eqn. (306)).



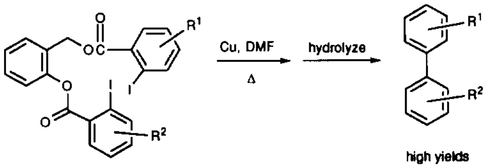
(305)



(306)

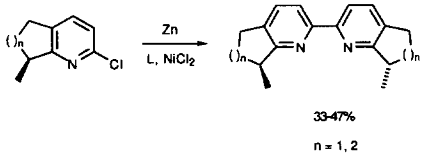
2.1.8. Coupling reactions

"Controlled decomposition of kinetic higher order cyanocuprates – a new route to unsymmetrical biaryls" was the title of a review (20 references) [342]. Unsymmetrical biaryls were synthesized by copper catalyzed coupling of unsymmetrical aryl diesters (eqn. (307) [343]). Reduced nickel species coupled α-halopyridines (eqn. (308) [344]). Aryl triflates were reductively coupled electrochemically in the presence of palladium catalysts (eqn. (309) [345]). Palladium(II) acetate couple o-iodoanisoles (eqn. (310) [346]). Dienes were dimerized by palladium(0) complexes and hexamethylditin (eqn. (311) [347]).



(307)

R^1	3,4-OCH$_2$O–	3NO$_2$	3,5-Cl$_2$	3,4,5-(MeO)$_3$	4,5-(MeO)$_2$
R^2	3,4,5-(MeO)$_3$	3,5-Cl$_2$	3,4,5-(MeO)$_3$	3NO$_2$	3NO$_2$

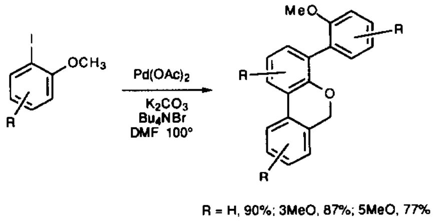


(308)

$$2ArOTf + 2e^- \xrightarrow[\text{DMF}\ 90°]{L_2PdCl_2} ArAr \quad 30\text{-}70\%$$

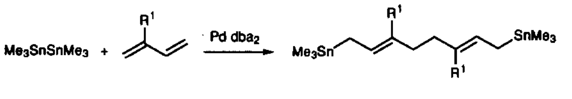
Ar = 1-Naphth, Ph, pCNPh, pCF$_3$Ph, pClPh, oClPh

(309)



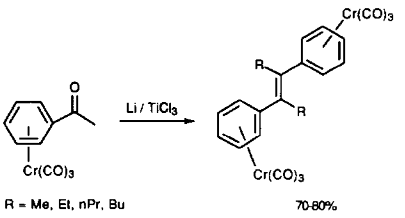
R = H, 90%; 3MeO, 87%; 5MeO, 77%

(310)

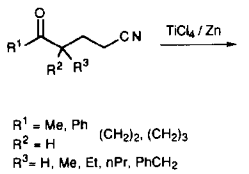


(311)

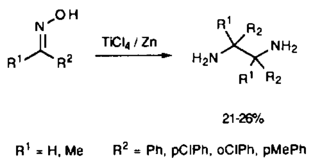
Low valent titanium coupled chromium-complexed aryl ketones (eqn. (312) [348]), α-ketonitriles (eqn. (313) [349]), and oximes (eqn. (314) [350]). Low valent vanadium species coupled α-amino aldehydes (eqn. (315) [351]), and cross coupled ketones with formaldehyde (eqn. (316) [352]). Niobium(III) coupled aldehydes (eqn. (317) [353]).



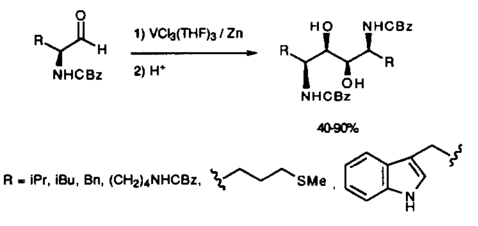
(312)



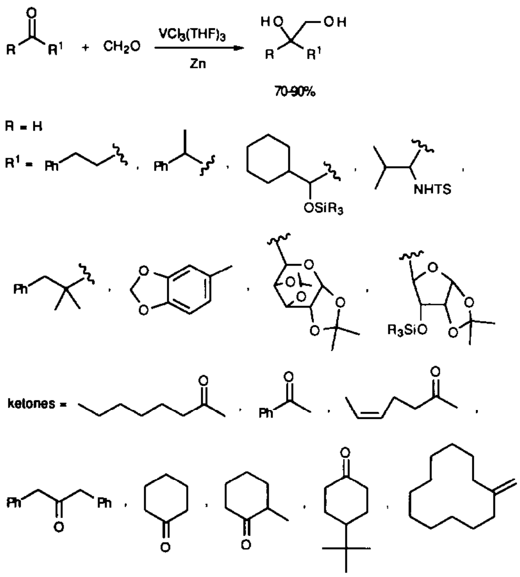
(313)



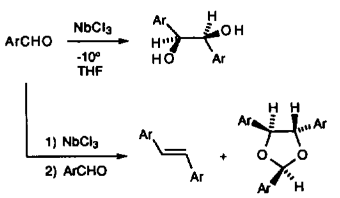
(314)



(315)

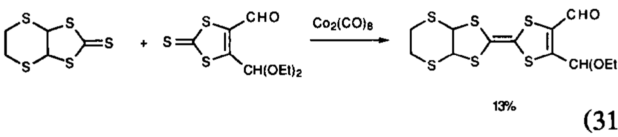


(316)

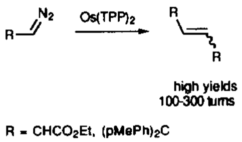


(317)

Dicobalt octacarbonyl coupled thiocarbonates (eqn. (318) [354]). Osmium porphyrin complexes catalyzed the coupling of diazocompounds (eqn. (319) [355]). Silylenol ethers were coupled by vanadium oxychlorides (eqn. (320) [356]). Ruthenium oxide catalyzed oxidative biaryl coupling (eqn. (321) [357]).



(318)



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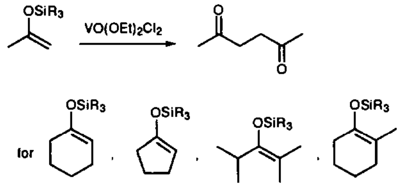
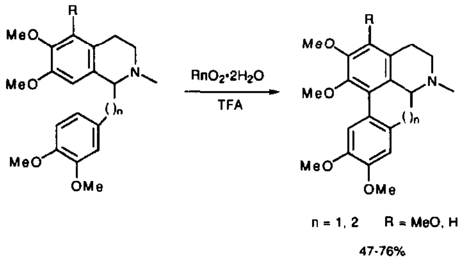


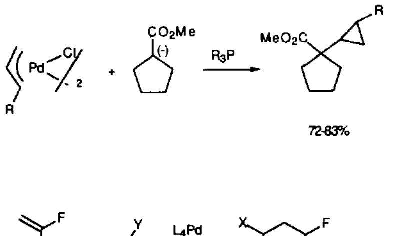
(320)



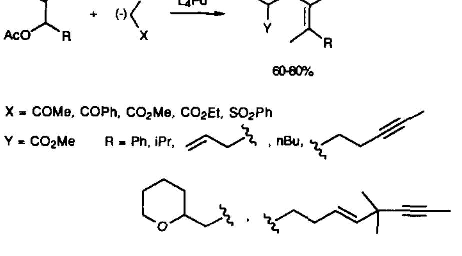
(321)

2.1.9. Alkylation of π-allyl complexes

A number of unusual facets of reactivity of π-allylpalladium complexes have been reported this year. The fact that α-branched ester enolates attacked the *central* carbon of π-allylpalladium complexes, giving cyclopropanes, a reaction originally reported over ten years ago, was again reported (eqn. (322) [358]). Complexes from fluorinated allyl acetates were alkylated at the less substituted position (eqn. (323) [359]). The stereochemistry of oxidative addition of palladium(0) complexes to allyl acetates depended strongly on the solvent (eqn. (324) [360]), and on the steric bias of the starting material (eqn. (325) [361]). Evidence for the intermediacy of cationic allyl palladium phosphine complexes in palladium-catalyzed allylic alkylations was obtained by isolating and studying just such intermediates (eqn. (326) [362]). π-Allylpalladium complexes from methlenecyclopropanes were alkylated by carbanions (eqn. (327) [363]). Palladium(0) complexes *isomerized* optically active π-allyl complexes, accounting for loss of stereoselectivity in some reactions (eqn. (328) [364]). π-Allyliron complexes were alkylated by organocuprates (eqn. (329) [365]) and organolithium (eqn. (330) [366]).



(322)



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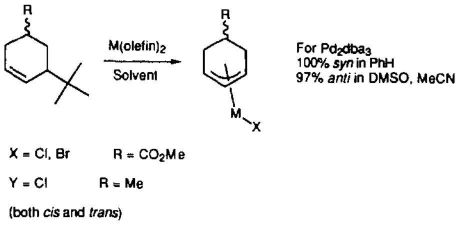
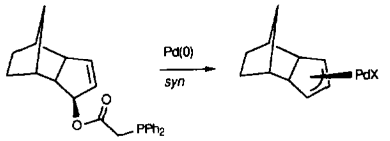
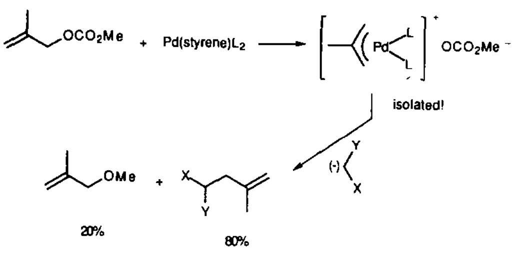


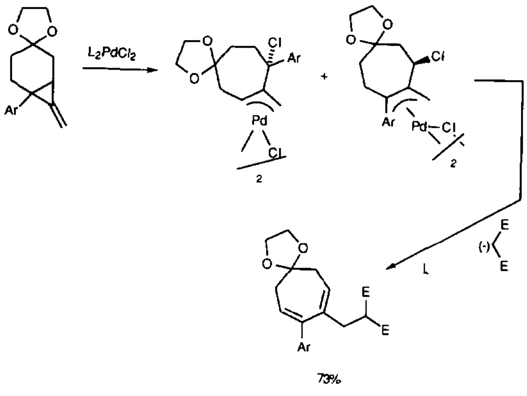
(324)



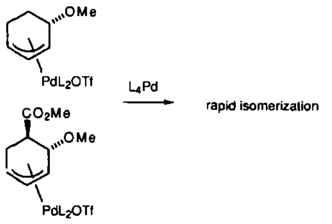
(325)



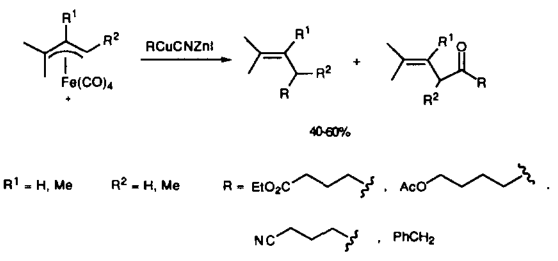
(326)



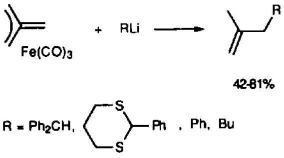
(327)



(328)



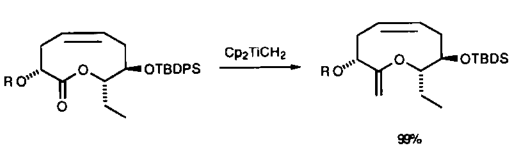
(329)



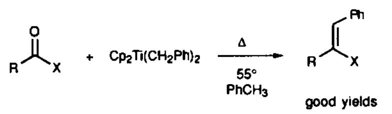
(330)

2.1.10. Alkylation of carbonyl compounds

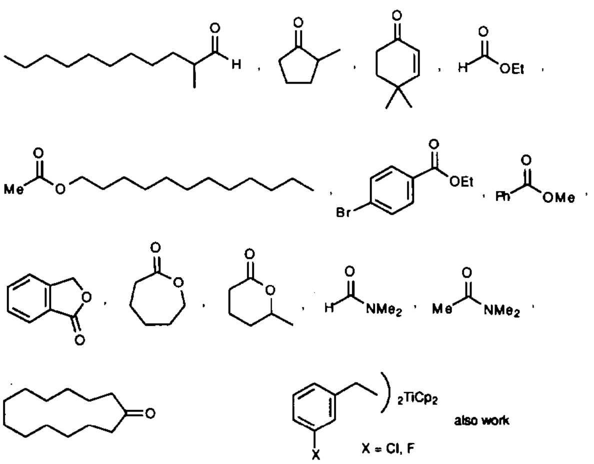
Tebbe's reagent effectively methylenated a complex lactone (eqn. (331) [367]). Several new carbonyl olefination reagents have been developed (eqn. (332) [368], eqn. (333) [369], and eqn. (334) [370]). Ruthenium salen complexes catalyzed the alkylation of ketones by silyl enol ethers (eqn. (335) [371]). Tungsten(II) complexes promoted the alkylation of ketones by alkenes (eqn. (336) [372]).

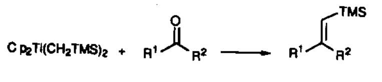


(331)

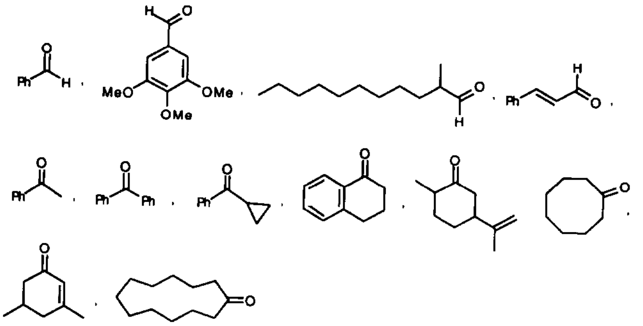


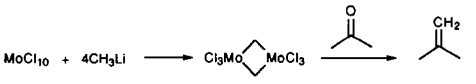
(332)





(333)





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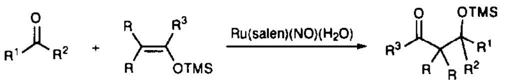
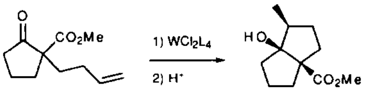
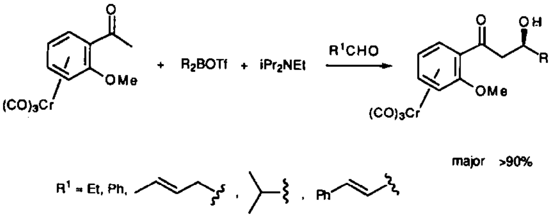


(335)

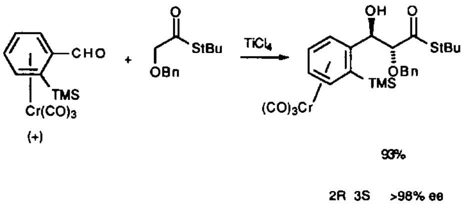


(336)

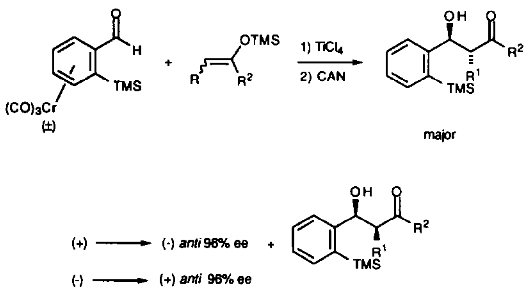
Chromium complexes of aryl ketones (eqn. (337) [373]) and aryl aldehydes (eqn. (338) [374] and eqn. (339) [375,376]) were alkylated with high stereoselectivity. Cobalt complexed propargyl aldehydes were alkylated by silyl ketene acetals (eqn. (340) [377]).



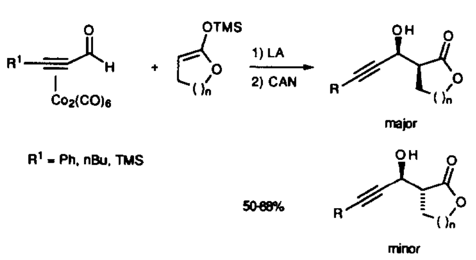
(337)



(338)

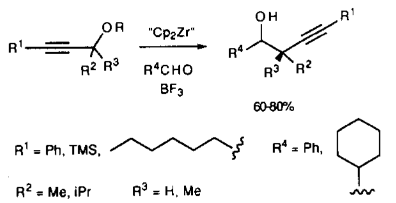


(339)



(340)

Aldehydes were alkylated by propargyl ethers (eqn. (341) [378]) and allyl ethers (eqn. (342) [379] and eqn. (343) [380]) in the presence of zirconocene. η^2-zirconium complexes alkylated aldehydes (eqn. (344) [381]). Hydrozirconation of alkynes and alkenes gave zirconium alkyls which alkylated aldehydes (eqn. (345) [382], eqn. (346) [383], and eqn. (347) [384]).



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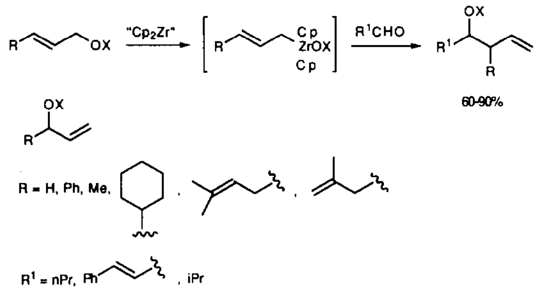

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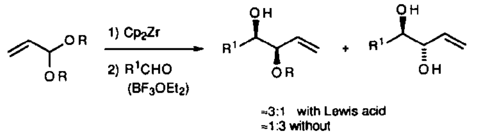

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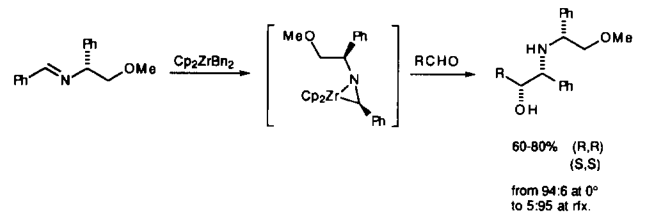

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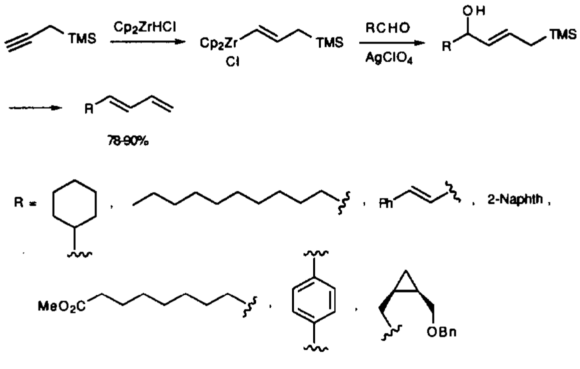
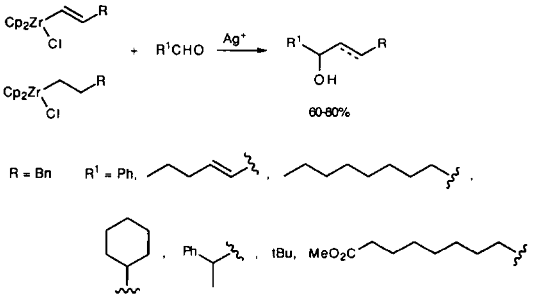


(345)



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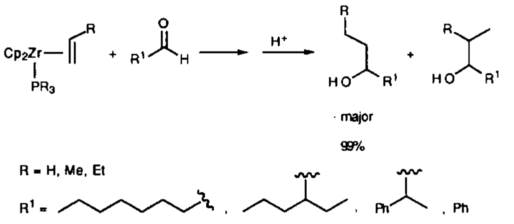
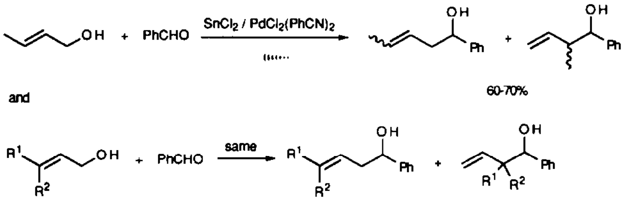


(347)

Palladium catalyzed the alkylation of aldehydes by allyl alcohols (eqn. (348) [385] and eqn. (349) [386]) and by α-bromoamides (eqn. (350) [387]). Nickel enolates alkylated aldehydes (eqn. (351) [388]).



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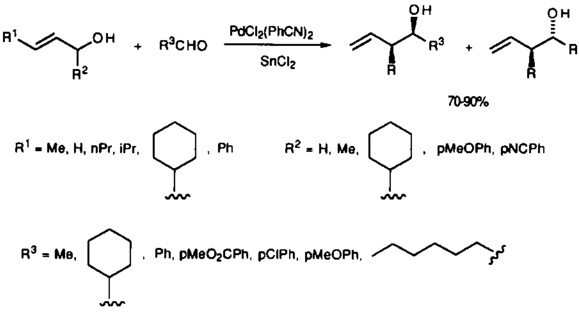

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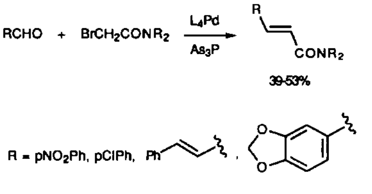

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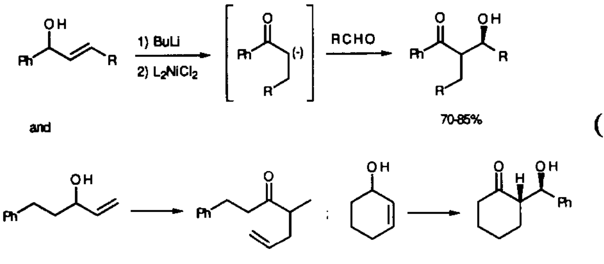
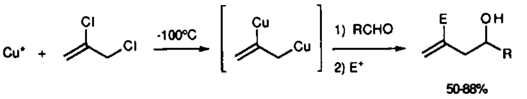
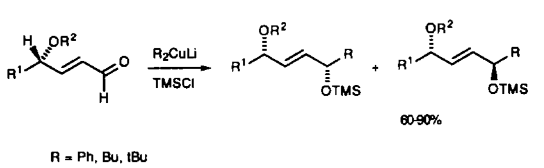


(351)

Aldehydes were alkylated by allyl cuprates (eqn. (352) [389]) and alkyl cuprates (eqn. (353) [390]). Reduced tantalum species alkylated aldehydes and ketones with alkynes (eqn. (354) [391,392]). Imines were alkylated in a similar manner (eqn. (355) [393]).

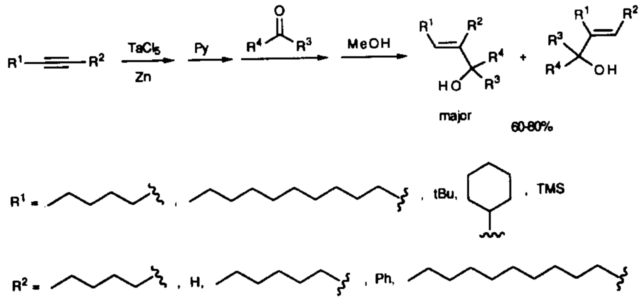


(352)



(353)

(354)



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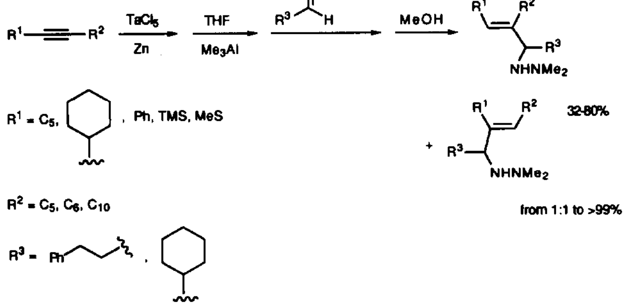
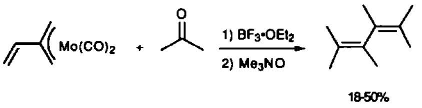


Allylmolybdenum complexes alkylated aldehydes (eqn. (356) [394], and eqn. (357) [395]). The addition of organochromium compounds to aldehydes – the Nozaki–Hiyama reaction – was the subject of a review (43 references) [396]. Allylic halides alkylated aldehydes when treated with chromium(II) salts (eqn. (358) [397] and eqn. (359) [398]). Optically active arene chromium complexes induced asymmetry in the alkylation of aldehydes by diethyl zinc (eqn. (360) [399]).



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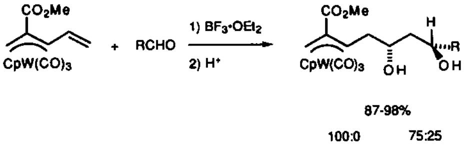
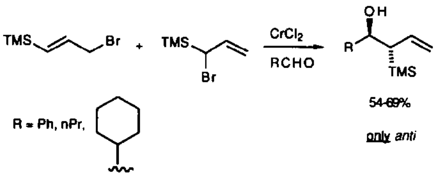


(357)



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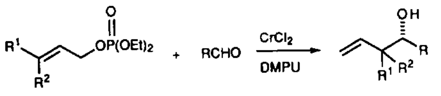

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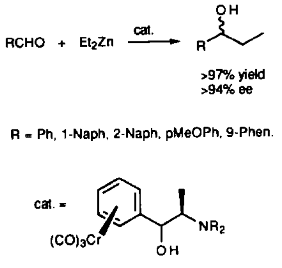
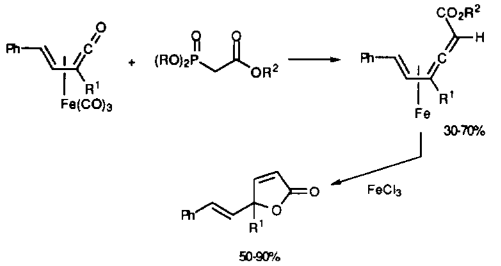


(360)

Iron complexes of vinyl ketenes were alkylated by stabilized ylides (eqn. (361) [400]) and by alkyllithium (eqn. (362) [401]). Cationic iron cyclopentadienyl complexes catalyzed the alkylation of aldehydes by ketene silyl acetals (eqn. (363) [402]). Iron(II) complexes of acetonitrile anion alkylated ketones [403] and aldehydes (eqn. (364) [404]). Titanocene alkylated ketones with α-bromoesters (eqn. (365) [405]). Iron carbene precursors were made by the reaction of ketals with anionic cyclopentadienyl iron complexes (eqn. (366) [406]).



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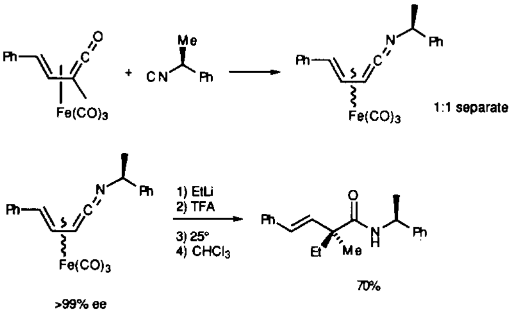

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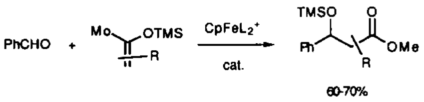

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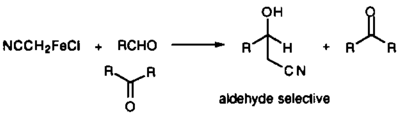

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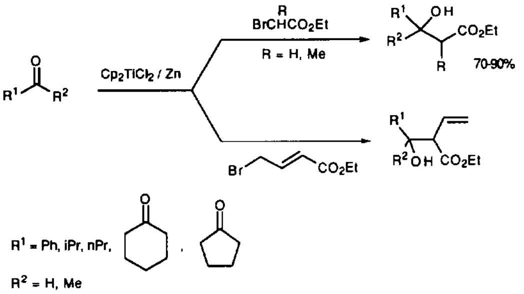

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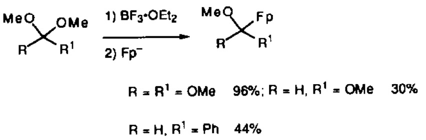
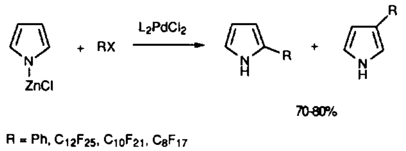


(366)

2.1.11. Alkylation of aromatic compounds

Palladium(II) complexes catalyzed the alkylation of pyrroles by organic halides (eqn. (367) [307] and eqn. (368) [408]), as well as intramolecular alkylation of arenes by aryl bromides (eqn. (369) [409]). Aryl cuprates added to the 4-position of N-acylpyridinium salts (eqn. (370) [410]). Nickel(II) acetyolacetonate catalyzed the reaction of Grignard reagents with aryl triflates (eqn. (371) [411]).



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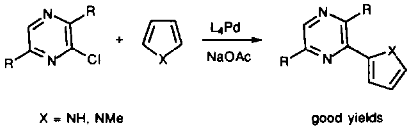

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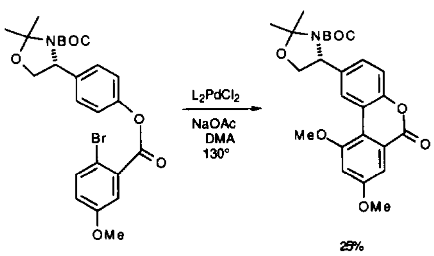

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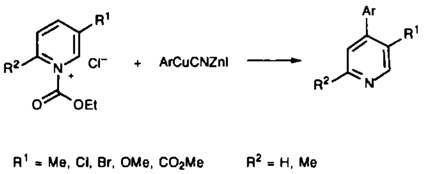


(370)

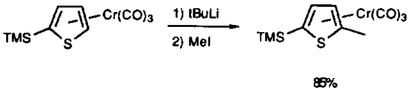
$$\mathrm{ArOZ} + \mathrm{RMgX} \xrightarrow{\mathrm{Ni(acac)_2}} \mathrm{ArR} \qquad (371)$$

Z = Tf, CONMe$_2$ 30-65%

R = TMSCH$_2$, Ph, Bu

Ar = 33 cases!

Chromium-complexed thiophene was lithiated, then α-alkylated (eqn. (372) [412]). Chromium-complexed polyaromatic hydrocarbons were similarly alkylated (eqn. (373) [413]). Chromium-complexed tetraline (eqn. (374) [414]), benzaldehyde SAMP derivatives (eqn. (375) [415]), oxazolines (eqn. (376) [416]) and acetophenone ketals (eqn. (377) [417]) were lithiated, then alkylated.



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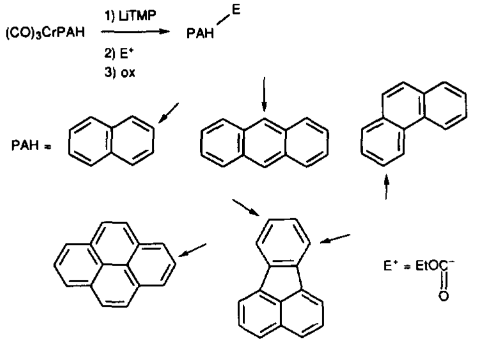

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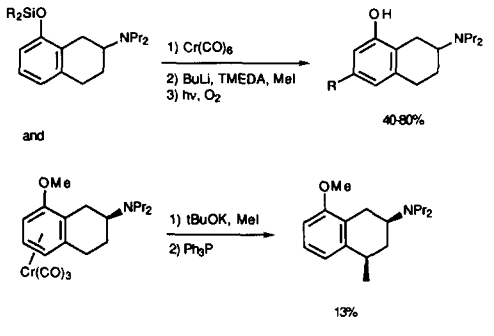

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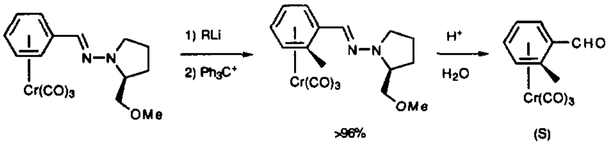

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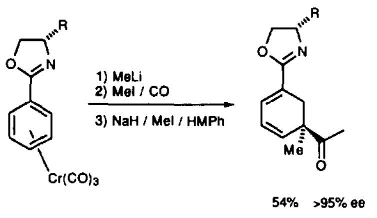

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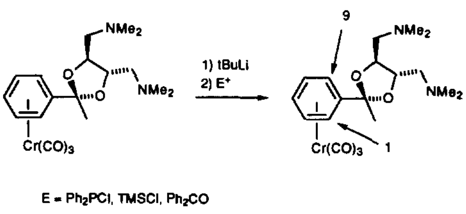
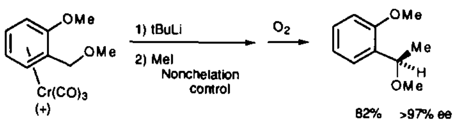


(377)

"α-Benchrotrenic carbanions. Formation, stabilization and synthetic applications" was the title of a review (69 references) [418]. Optically active arene-chromium tricarbonyl complexes were benzylically alkylated with high ee (eqn. (378) [419]). Optically active chromium arene complexes were prepared by the procedures shown in eqn. (379) [420] and eqn. (380) [421].

Stereoselective manipulation of acetals derived from o-substituted benzaldehyde chromium tricarbonyl complexes was the topic of a lecture [422].



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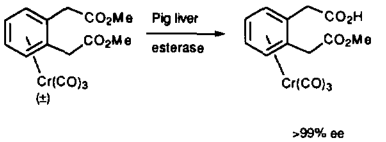

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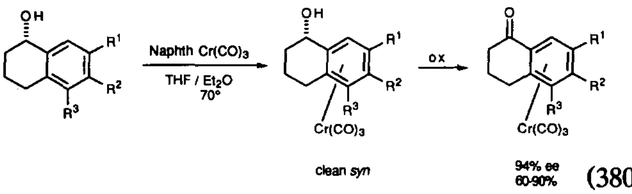
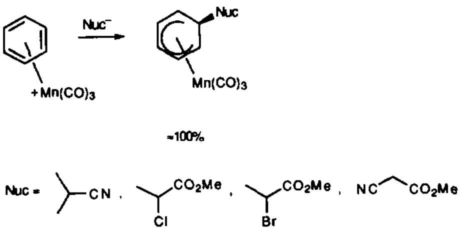


(380)

Arene complexes of manganese (eqn. (380) [423], eqn. (382) [424], eqn. (383) [425]), iron (eqn. (384) [426]) and ruthenium (eqn. (385) [427]) were alkylated.



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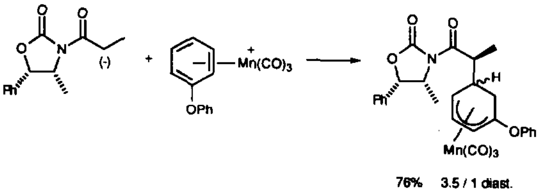

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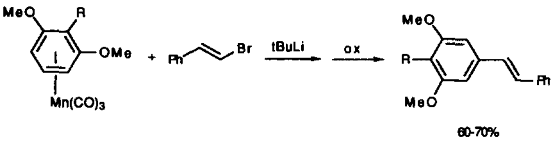

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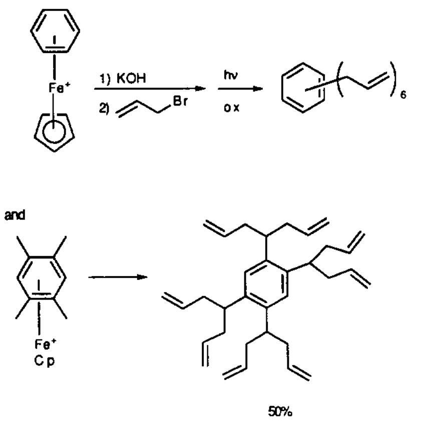

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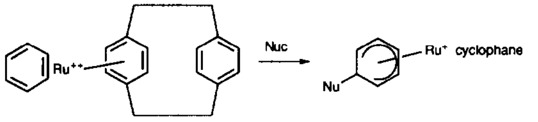
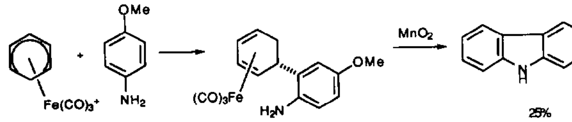


(385)

2.1.12. *Alkylation of diene and dienyl complexes*

"Aryl substituted cyclohexadienyl iron complexes in alkaloid synthesis" was the title of a dissertation [428]. Indole alkaloids were synthesized in low yields by oxidative cleavage of an iron-diene complex (eqn. (386) [429]). The role of substituent patterns in selectivity of preparation of cationic iron cyclohexadienyl complexes by acid catalyzed demethoxylation of iron complexes alkoxycyclohexadienes was examined [430]. Iron dienyl complexes found numerous applications in organic synthesis (eqn. (387) [431], eqn. (388) [432], eqn. (389) [433], eqn. (390) [434], eqn. (391) [431], and eqn. (392) [436]).



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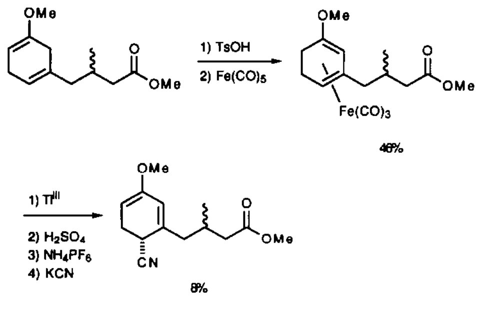

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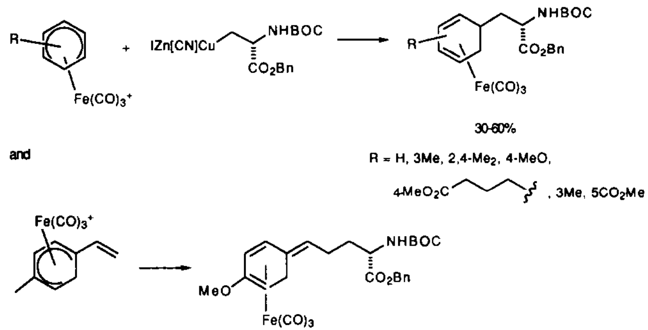

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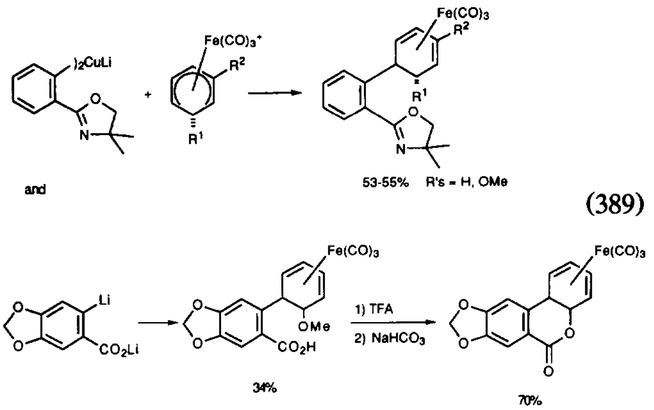

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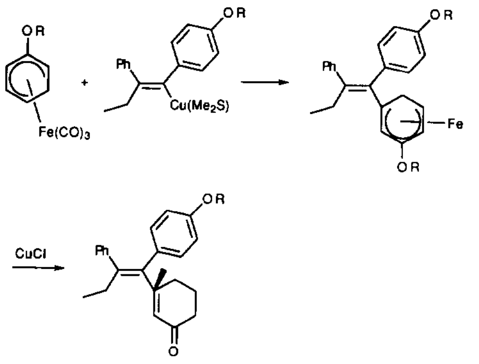

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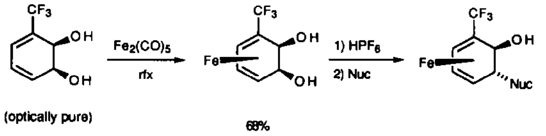

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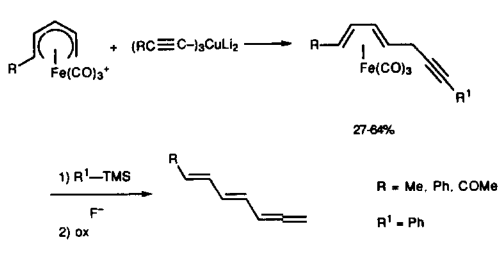
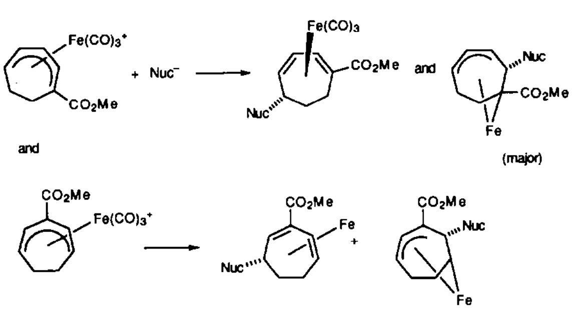


(392)

Cycloheptadienyl complexes (eqn. (393) [437], eqn. (394) [438] and cyclooctadienyl complexes eqn. (395) [439] were similarly useful.



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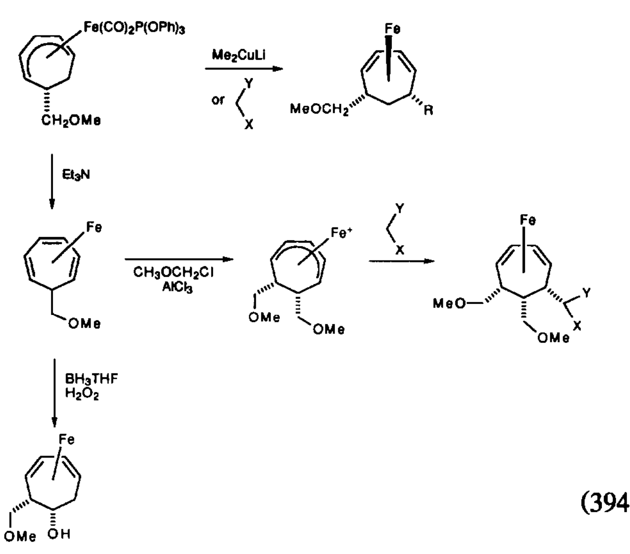

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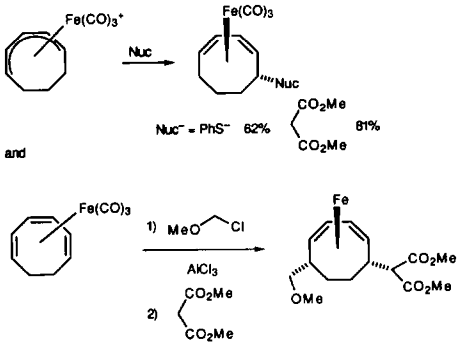
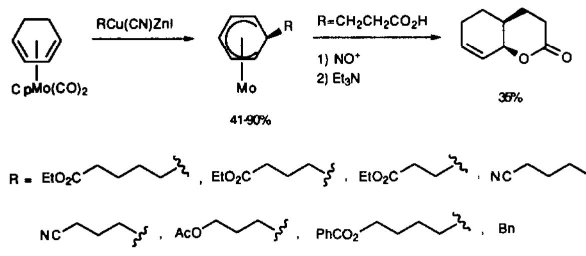


(395)

Diene complexes were also reactive toward nucleophiles (eqn. (396) [440], eqn. (397) [441], and eqn. (398) [442]). Dienes were complexed to iron to protect them from reagents used for carrying out reactions at remote sites (eqn. (399) [443], eqn. (400) [444], eqn. (401) [445]).



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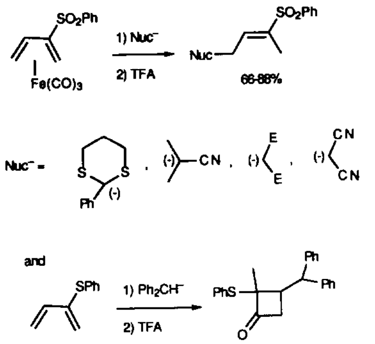

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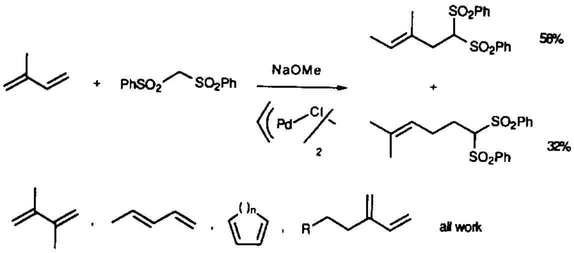

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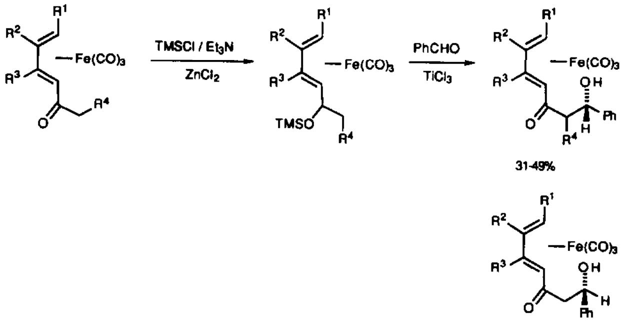

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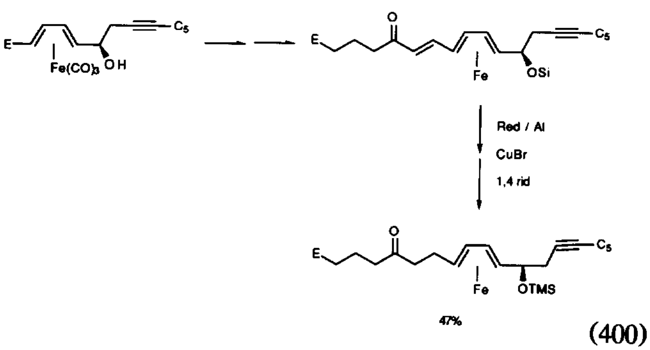

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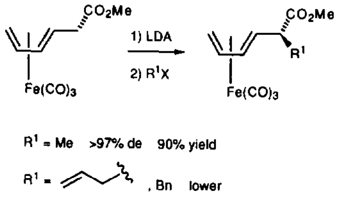
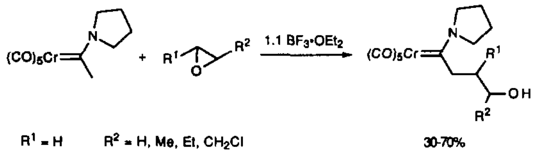


(401)

2.1.13. Metal carbene reactions

Metal carbene complexes continued to be developed for use in organic synthesis, and a number of procedures to elaborate carbene complexes themselves have been developed (eqn. (402) [446], eqn. (403) [447], eqn. (404) [448], eqn. (405) [449], and eqn. (406) [450]).



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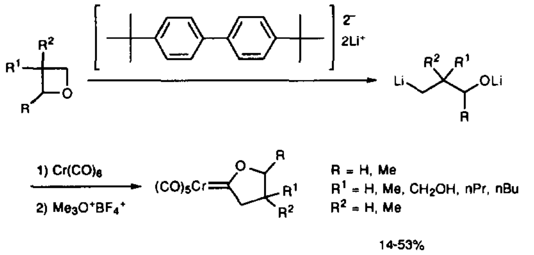
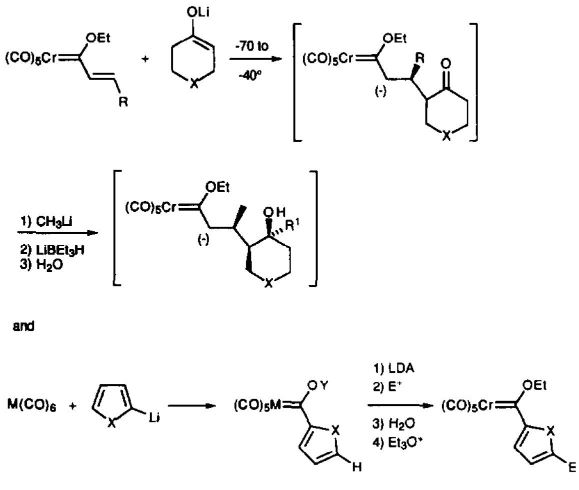


(403)



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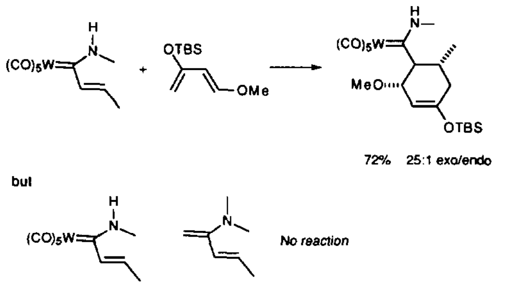

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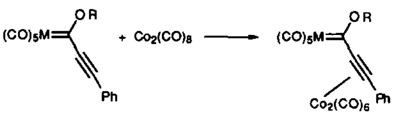
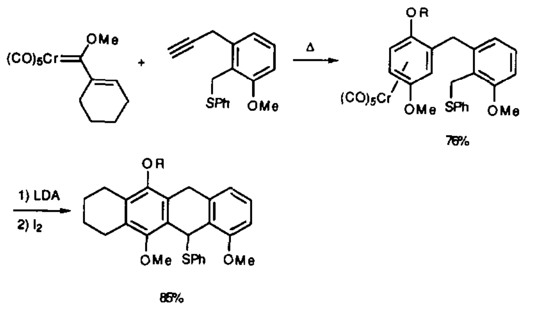


(406)

The classic reaction between chromium carbene complexes and alkynes (the Dötz reaction) continued its development. A theoretical paper addressed the role of metallacyclobutenes *via* $\eta\{2\}$-vinylcarbene complexes in this process [451]. It was used to make polycyclic aromatic compounds (eqn. (407) [452], eqn. (408) [453]), cyclopentenones (eqn. (409) [454]) and cyclobutenones (eqn. (410) [455]). Manganese carbene complexes underwent similar reactions (eqn. (411) [456] and eqn. (412) [457]).



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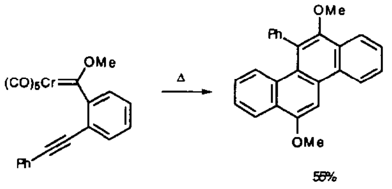

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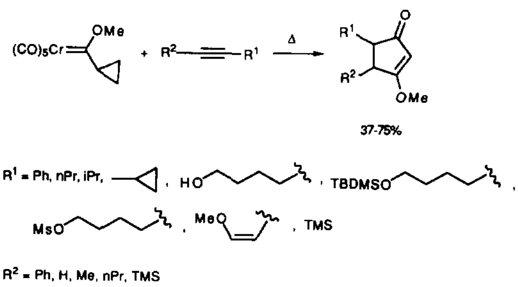

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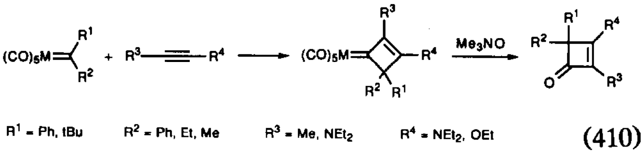

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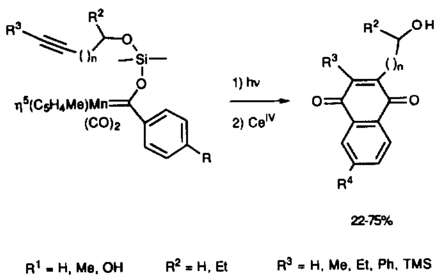

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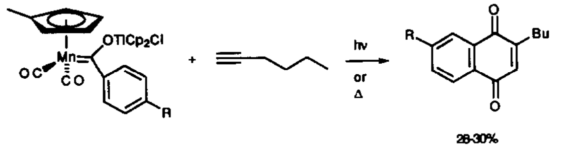
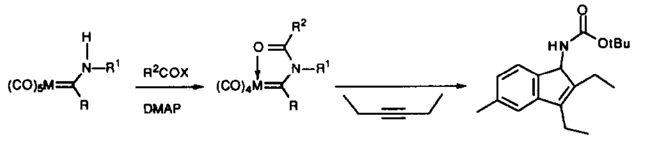
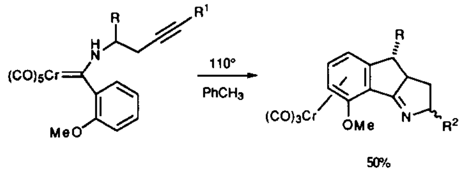


(412)

Aminocarbene complexes underwent reactions with alkynes without undergoing CO insertion (eqn. (413) [458], eqn. (414) [459], and eqn. (415) [460]). Polyunsaturated carbene complexes cyclized with isonitriles to give aminophenols (eqn. (416) [461]).



(413)



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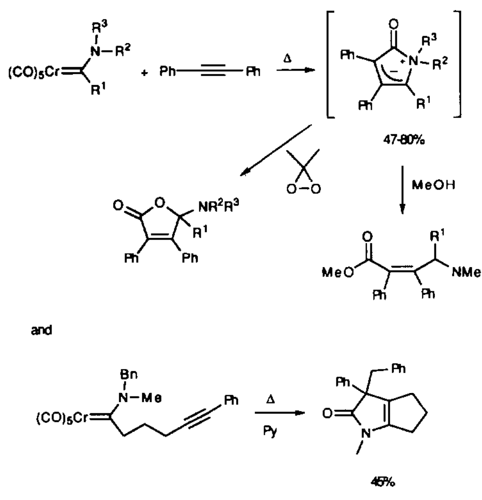

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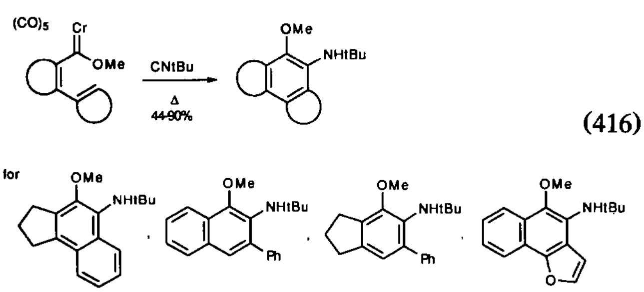
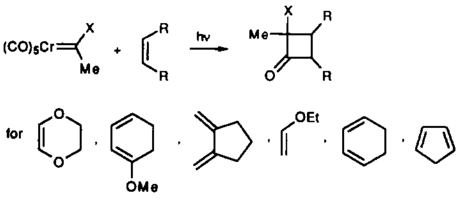
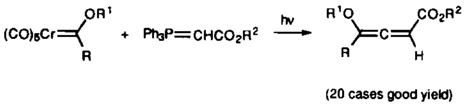


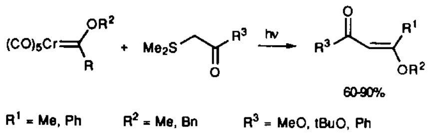
Chromium carbene complexes underwent photochemical cycloaddition with alkenes to give cyclobutanones (eqn. (417) [462]), with stabilized ylides to give push-pull allenes (eqn. (418) [463]) and with sulfur ylides to give conjugated enones (eqn. (419) [464]).



(417)

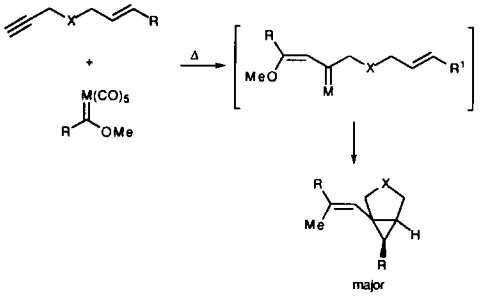


(418)



(419)

Carbene complexes underwent a series of "metathesis cascade" reactions with polyunsaturated substrates (eqn. (420) [465], eqn. (421) [466], and eqn. (422) [467]).



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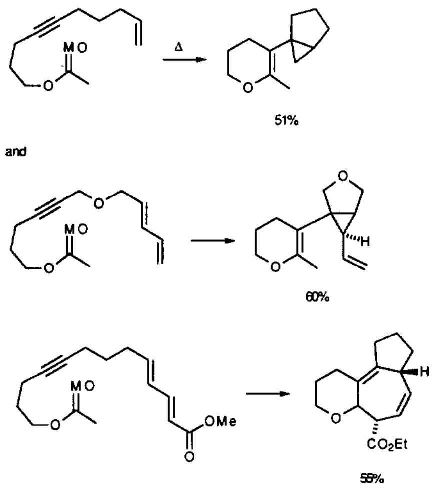

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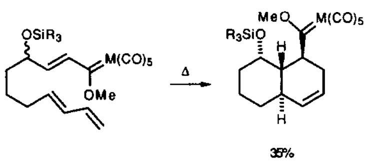
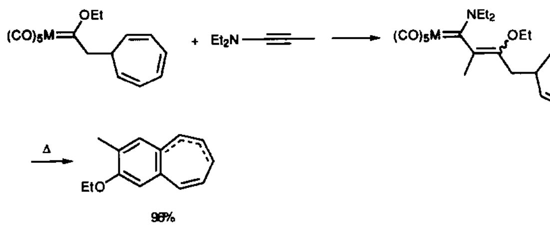


(422)

Other unusual reactions of carbene complexes are shown in eqn. (423) [468] and eqn. (424) [469].



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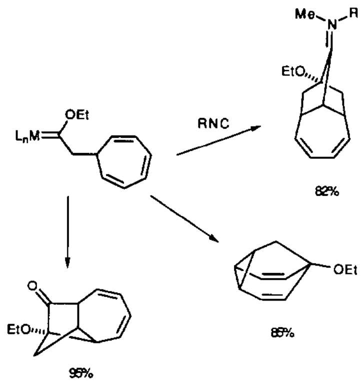
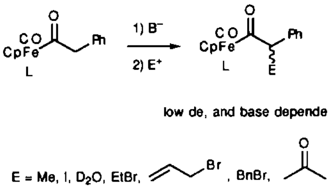


(424)

2.1.14. Alkylation of metal acyl enolates

Only two examples were reported this year (eqn. (425) [470] and eqn. (426) [471]).



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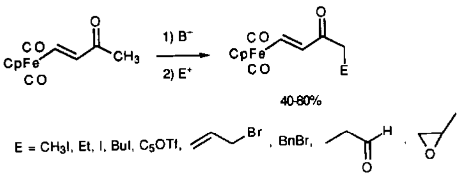
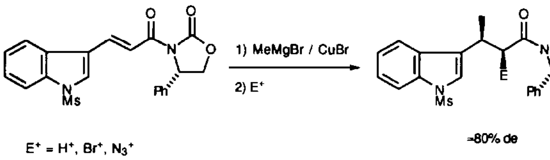


(426)

2.2. Conjugate addition

Organocuprates continued to be the reagents of choice for conjugate additions, and a review of this important class of reagents has appeared (1695 references) [472]. Asymmetric conjugate addition has been reviewed (124 references) [473] and has been achieved using chiral conjugated amides (eqn. (427) [474], eqn. (428) [475]), asymmetric γ-alkoxy substrates (eqn. (429) [476], eqn. (430) [477,478]), and asymmetric γ-alkyl substrates (eqn. (431) [479]).



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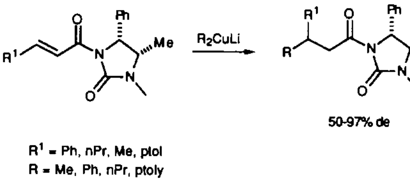

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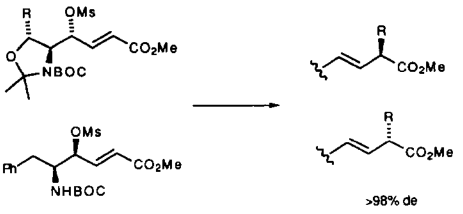

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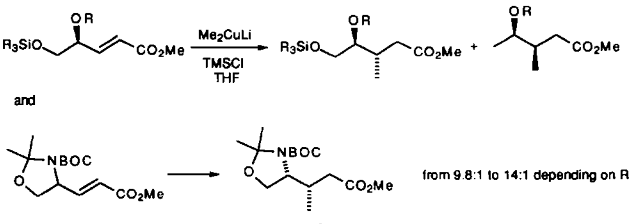

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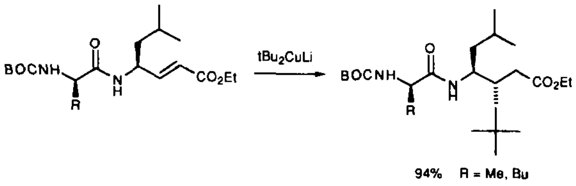
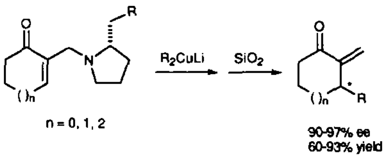


(431)

Asymmetric induction from more remote centers was also observed (eqn. (432) [480], eqn. (433) [481], and eqn. (434) [482]). Chiral ligands were also used to induce asymmetry (eqn. (435) [483] and eqn. (436) [484]).



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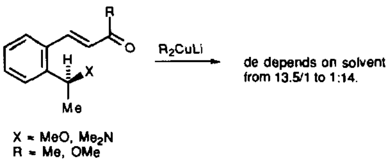

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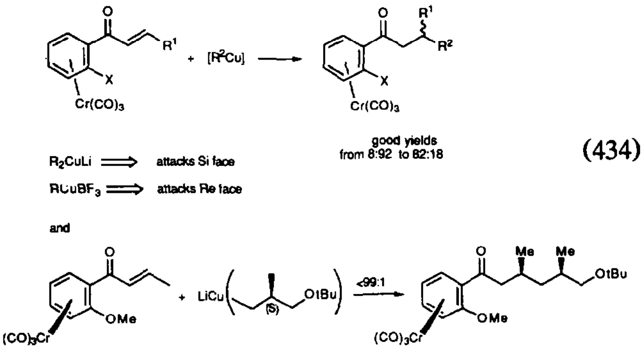

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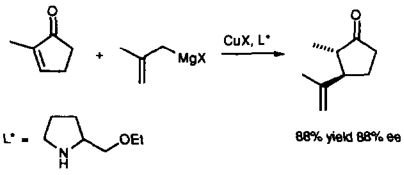

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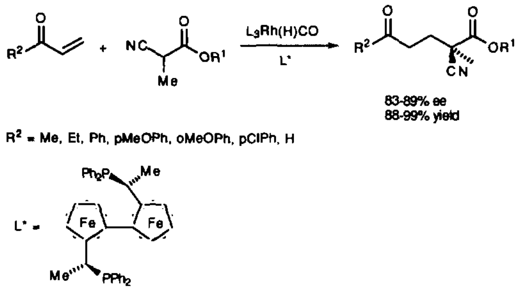
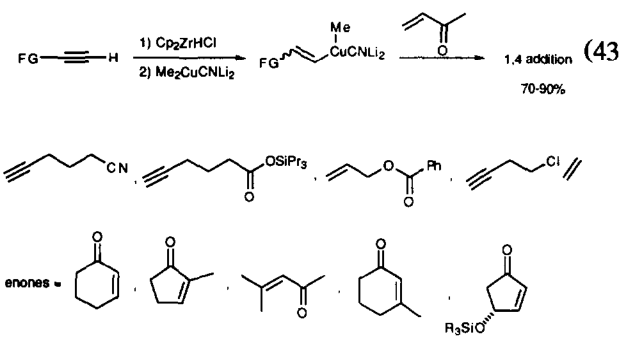


(436)

Vinyl cuprates, generated from hydrozirconation of alkynes (eqn. (437) [485], eqn. (438) [486], eqn. (439) [487]) and stannylcupration of alkynes (eqn. (440) [488]), underwent conjugate addition reactions. Cuprates added 1,4 to propargyl iminium ions (eqn. (441) [489]).



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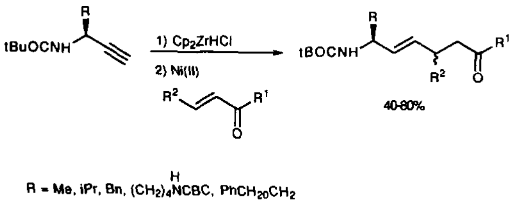

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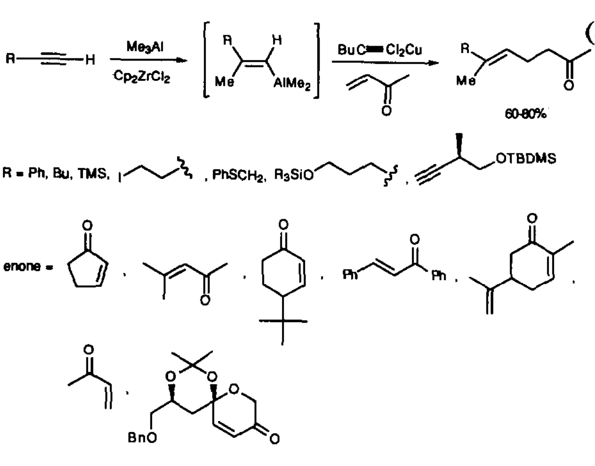

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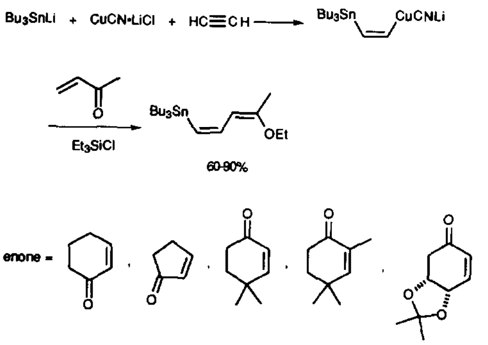

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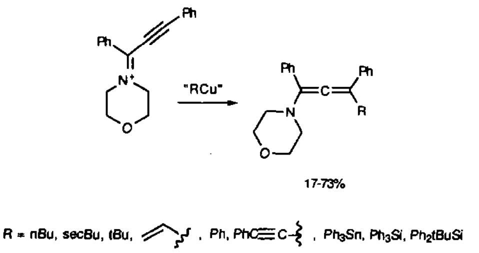
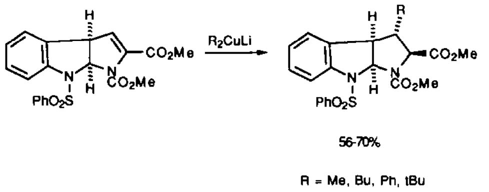
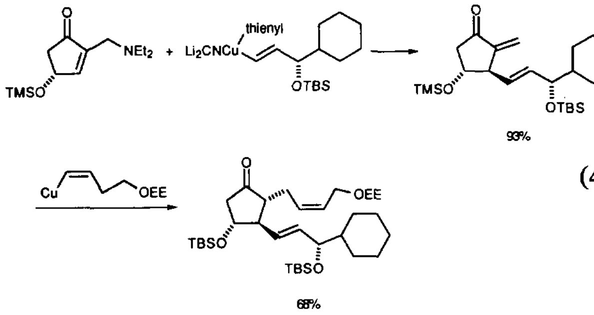


(441)

Cuprates added in a 1,4 manner to a number of complex systems (eqn. (442) [490], eqn. (443) [491], eqn. (444) [492], and eqn. (445) [493]).



(442)



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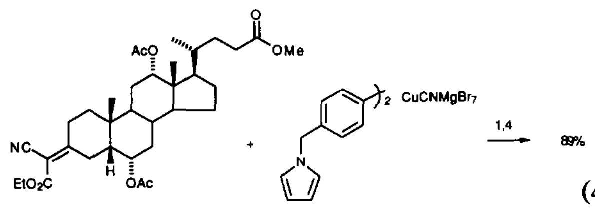

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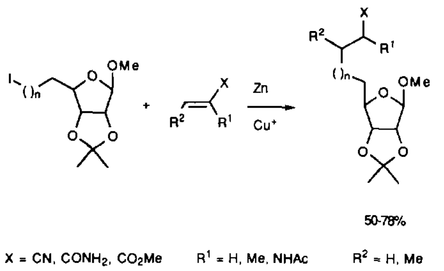
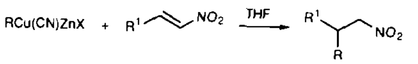


(445)

Cuprates alkylated the β-position of nitroalkenes (eqn. (446) [494]). Cuprates catalyzed the conjugate addition of amidines to enones (eqn. (447) [495]). Both *cis* and *trans* enones underwent conjugate addition to give the same product (eqn. (448) [496]).



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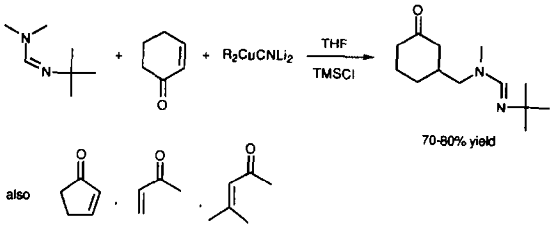

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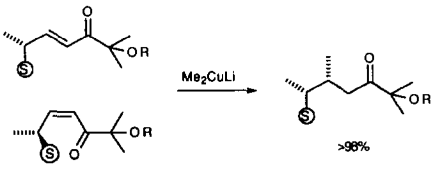
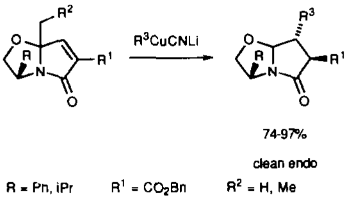


(448)

Other useful conjugate additions are reported in eqn. (449) [497], eqn. (450) [498], eqn. (451) [499], eqn. (452) [500], eqn. (453) [501], and eqn. (454) [502].



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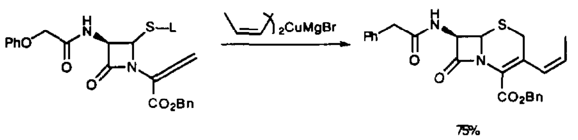

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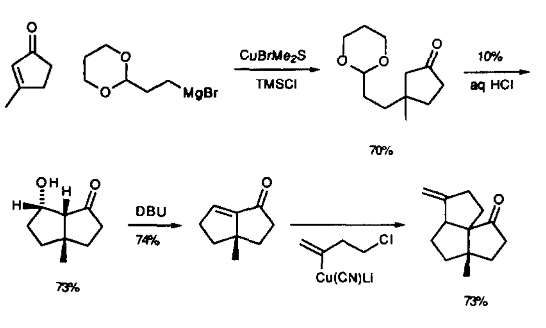

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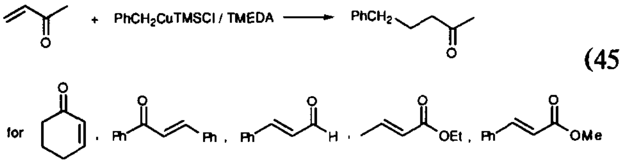

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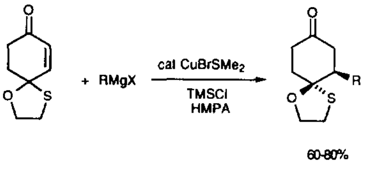

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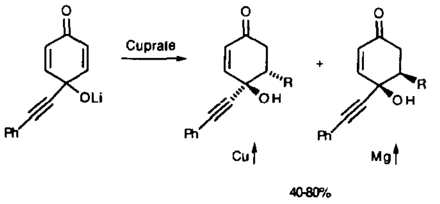
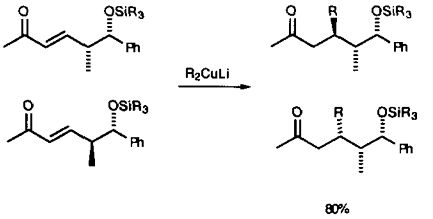


(454)

Cuprates added mainly *anti* to γ-alkyl enones (eqn. (455) [503], eqn. (456) [504] and eqn. (457) [505]). Cuprates added to β-silylenones (eqn. (458) [506]). Organic halides added 1,4 to enones in the presence of samarium iodide and copper iodide (eqn. (459) [507]). Iron complexes of α-acetamidoacrylates were alkylated in a 1,4-manner (eqn. (460) [508]). Cobalt alkyls β-alkylated enones (eqn. (461) [509]).



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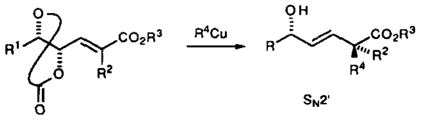

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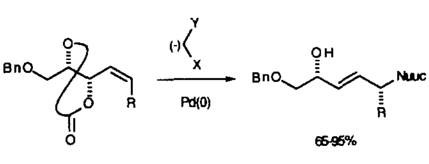

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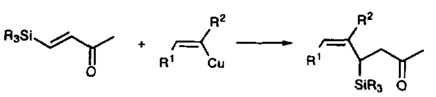

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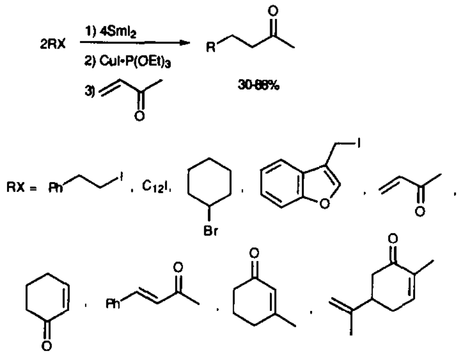

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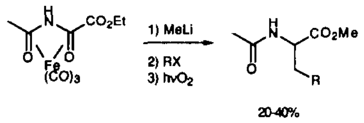

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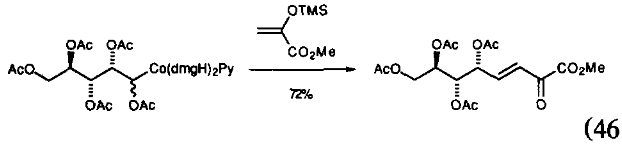
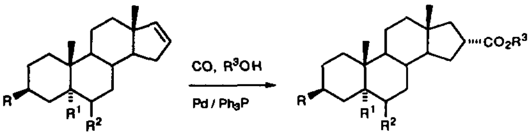


(461)

2.3. *Acylation reactions (excluding hydroformylation)*

2.3.1. *Carbonylation of alkenes and arenes*

Androstene was hydroalkoxycarbonylated in the presence of palladium phosphine catalysts (eqn. (462) [510]). Vinyl silanes were carbonylated to α or β-silyl esters, depending on the catalyst (eqn. (463) [511]). Allylic alcohols were stereospecifically carbonylated using rhodium(I) catalysts (eqn. (464) [512]). Nickel carbonyl cyclocarbonylated ω-olefinic vinyl halides (eqn. (465) [513]). Allyl amines were cycloaminoacylated using rhodium catalyst (eqn. (466) [514]) (for a review with 36 references see [515]). Palladium (eqn. (467) [516]) and rhodium (eqn. (468) [517]) catalyzed the intramolecular acylation of alkenes by aldehydes.



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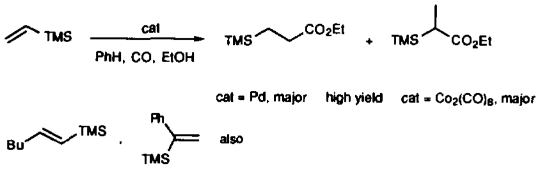

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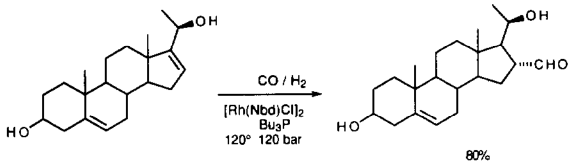
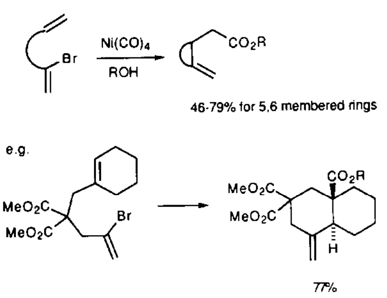


(464)



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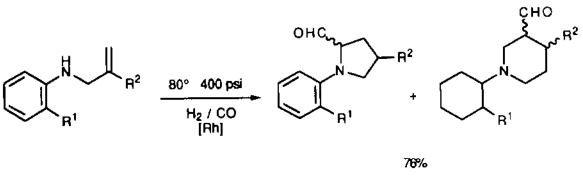

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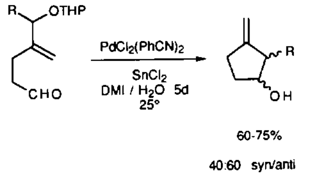

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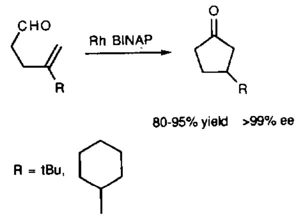
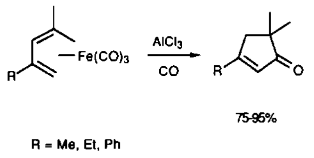


(468)

Treatment of iron diene complexes with aluminum halides produced cyclopentenones (eqn. (469) [518] and eqn. (470) [519]). Chromium complexes of polycyclic aromatic hydrocarbons were carboethoxylated with ethyl chloroformate [520]. Aryl mercuric halides were carbonylatively vinylated using palladium catalysts (eqn. (471) [521]). Pyridine (eqn. (472) [522]) and other arenes (eqn. (473) [523]) were also carbonylated using transition metal catalysts.



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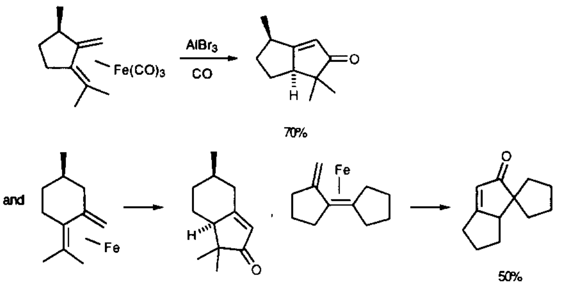

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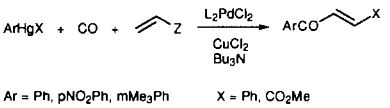

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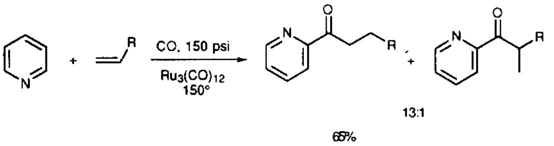

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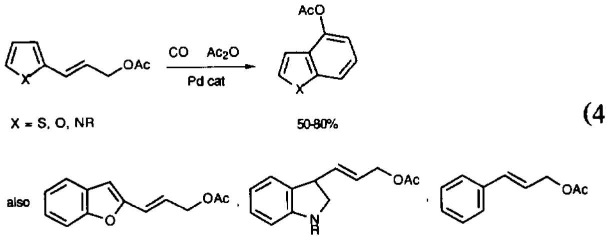
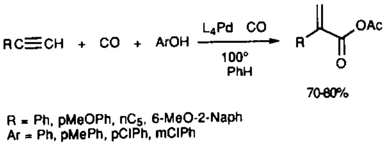


(473)

2.3.2. *Carbonylation of alkynes (including the Pauson–Khand reaction)*

Palladium (eqn. (474) [524], eqn. (475) [525], and eqn. (476) [526]), rhodium (eqn. (477) [527]) and nickel complexes (eqn. (478) [528]) all catalyzed the carbonylation of alkynes.



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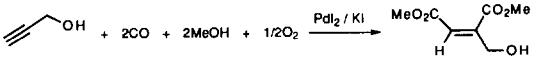

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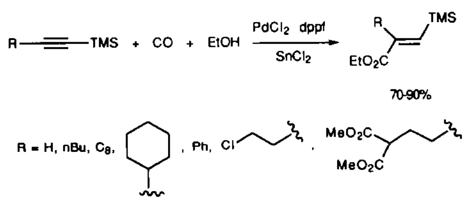

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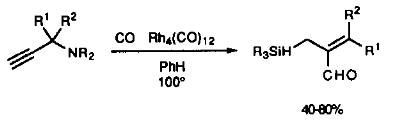

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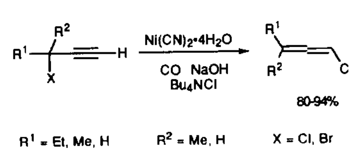
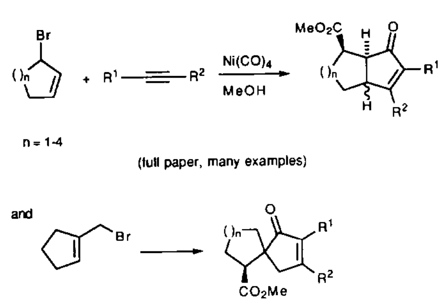
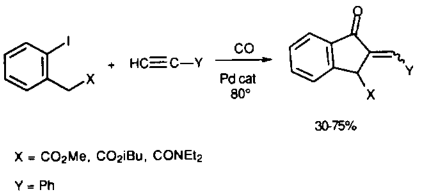


(478)

Nickel carbonyl catalyzed the cyclocarbonylation of alkynes with allylic halides (eqn. (479) [529,530]). Palladium complexes catalyzed a similar reaction (eqn. (480) [531]). Iron carbonyl converted alkynes into cyclopentadienones (eqn. (481) [532]).



(479)



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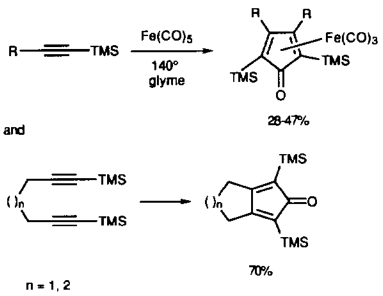
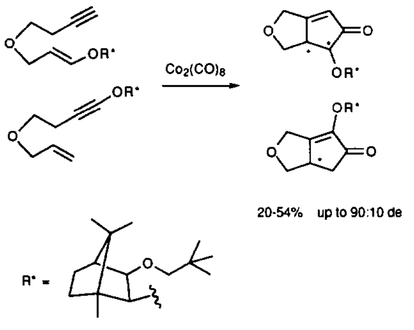


(481)

The Pauson–Khand reaction was the subject of a review (23 references) [533] and a dissertation [534]. Chiral auxilliaries in the substrate resulted in high diastereoselectivity in the Pauson–Khand process (eqn. (482) [535]). The regioselectivity of the Pauson–Khand was controlled to a degree by the use of remote ligands (eqn. (483) [536], eqn. (484) [537] and eqn. (485) [538]). Electron deficient alkynes were used in Pauson–Khand reactions (eqn. 486) [539]).



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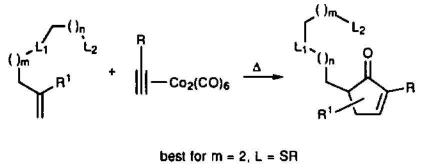

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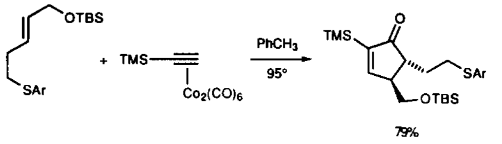

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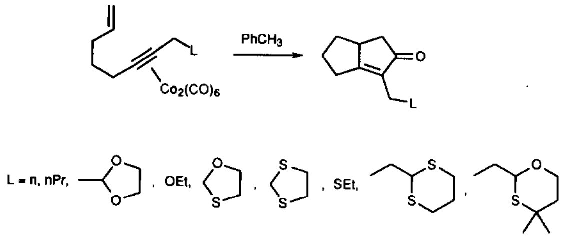

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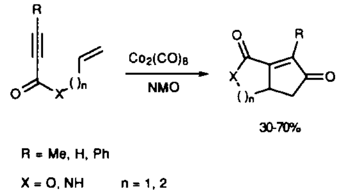
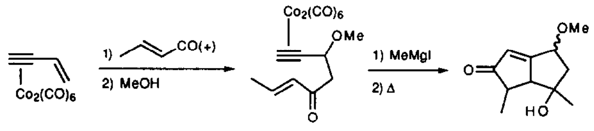


(486)

The general sequence shown in eqn. (487) was used to synthesize [5.5.5], [6.5.5], [6.5.5.5] and [5.5.5.5] angularly and linearly fused systems [540]. Nickel carbonyl promoted a Pauson–Khand like process (eqn. (488) [491]). Other related reactions are seen in eqn. (489) [542], eqn. (490) [543], eqn. (491) [544], and eqn. (492) [545]. The Pauson–Khand reaction was used to synthesize dendroline (eqn. (493) [546]) and kainic acid (eqn. (494) [547]).



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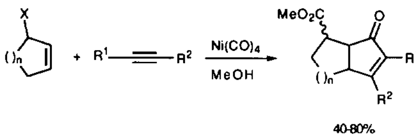
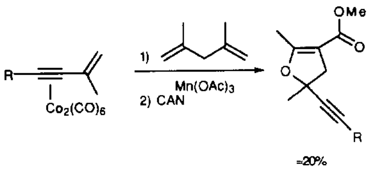


(488)

n = 1-4 R^1 = Me, Et, H R^2 = CO$_2$Me, COMe, TMS



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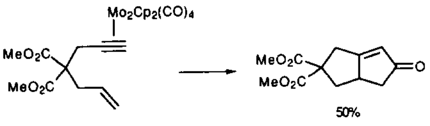

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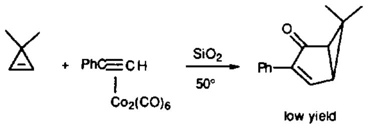

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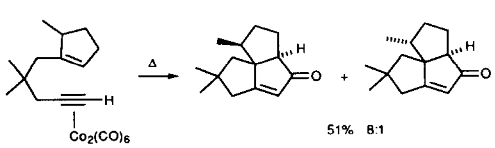

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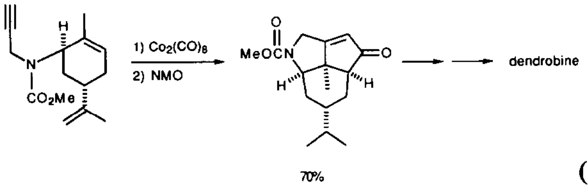

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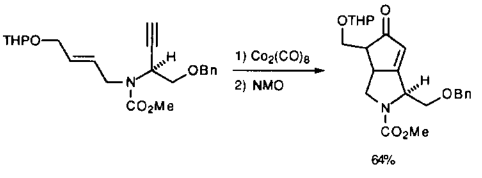
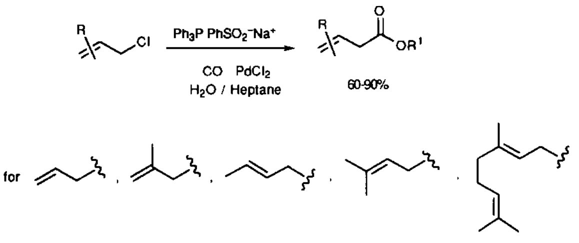


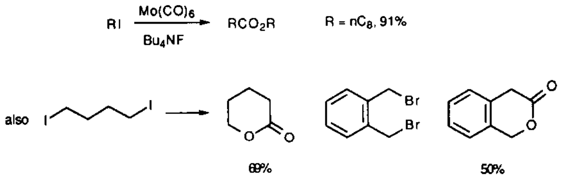
(494)

2.3.3. *Carbonylation of halides and triflates*

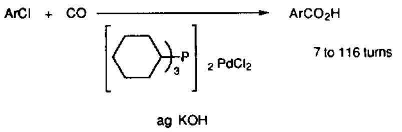
Palladium complexes catalyzed the carbonylation of allylic chlorides (eqn. (495) [548]). Polyvinylpyrrolidinone-supported palladium catalysts were more efficient for this process [549]. Aliphatic iodides were carbonylated by molybdenum hexacarbonyl (eqn. (496) [550]). Aryl chlorides (eqn. (497) [551]) and iodides [552] were carbonylated using palladium catalysts. Dicobalt octacarbonyl carbonylated 1,4-bis(chloromethyl) benzene and allyl chloride [553]. Palladium(0) catalyzed the carbonylation of iodides and fluorosilanes to ketones (eqn. (498) [554]), and the carbonylation of iminoyl chlorides (eqn. (499) [555]). Collmans reagent coupled halides to give diketones (eqn. (500) [556]). Ruthenium complexes oxidized iodides to acids (eqn. (501) [557]).



(495)

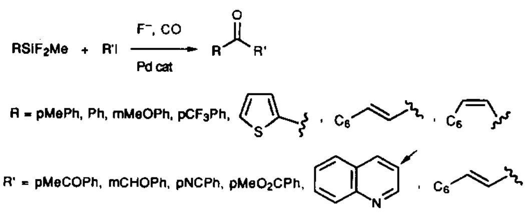


(496)

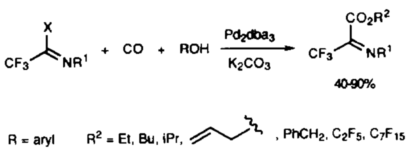


(497)

Ar = Ph, 1-Naphth, pMePh, mMePh, oMePh, pMeOPh, mPhCOPh, nCF$_3$Ph /// pNO$_2$Ph fails

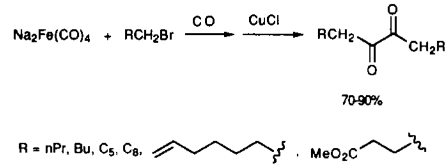


(498)

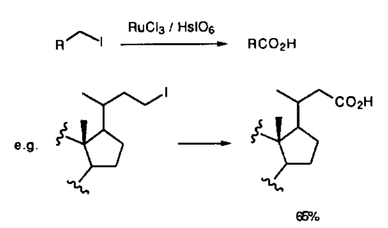


(499)

R = aryl R^2 = Et, Bu, iPr, , PhCH$_2$, C$_2$F$_5$, C$_7$F$_{15}$

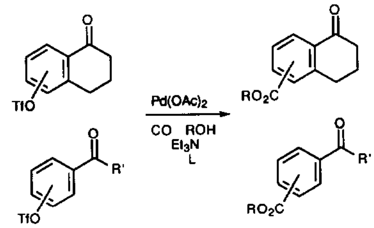


(500)



(501)

Palladium(0) complexes catalyzed the carbonylation of aryl (eqn. (502) [558]) and vinyl (eqn. (503) [599], eqn. (504) [560]), triflates and fluorosulfonates (eqn. (505) [561]).



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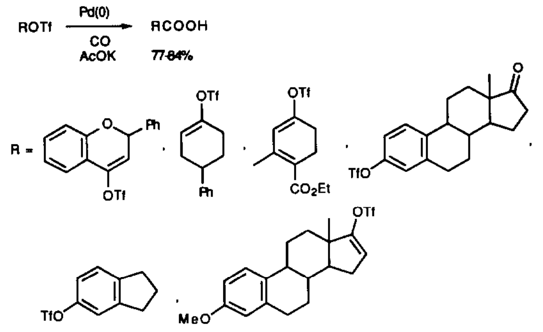
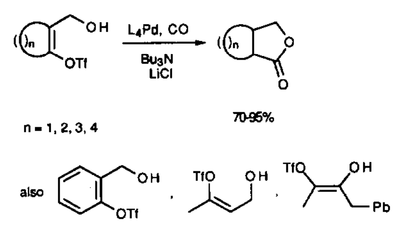
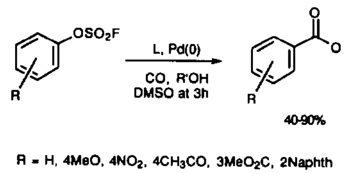


(503)



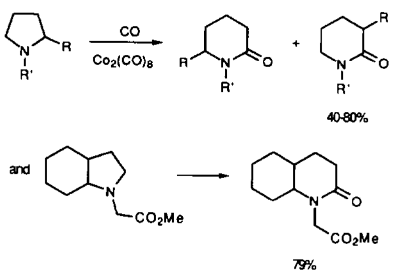
(504)



(505)

2.3.4. Carbonylation of nitrogen compounds

Catalytic carbonylation of nitrogen-containing organic compounds has been reviewed (41 references) [562]. Palladium catalyzed the synthesis of diphenyl urea from nitrobenzene, aniline and carbon monoxide [563] the carbonylation of N-chloroamines to carbamoyl chlorides [504] and the acylation of anilines by aryl halides [565]. Cobalt carbonyl catalyzed the unusual conversion of pyrrolidines to piperidones (eqn. (506) [566]). Cobalt porphyrins catalyzed the N-carbonylation of amines (eqn. (507) [567]). An unusual carbonylation is seen in eqn. (508) [568].



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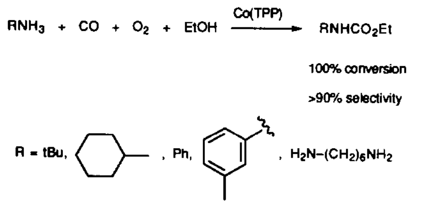
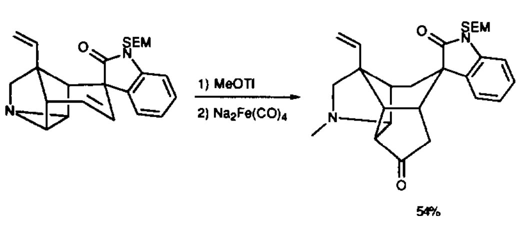


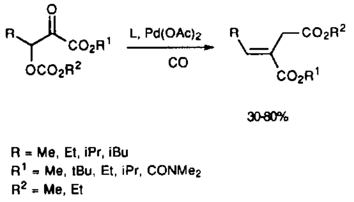
(507)



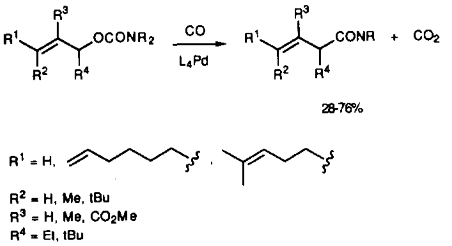
(508)

2.3.5. Carbonylation of oxygen compounds

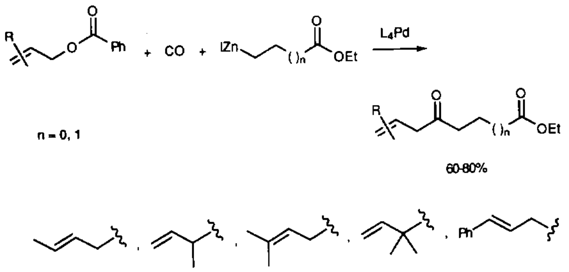
Palladium catalyzed the carbonylation of allylic alcohols in the presence of lithium chloride and titanium isopropoxide [569], the carbonylation of allyl carbonates (eqn. (509) [570]), allyl carbamates (eqn. (510) [571]) and allyl carboxylates (eqn. (511) [572] and eqn. (512) [573]). Benzyl alcohols were carbonylated by rhodium(I) catalysts [574]. "Transition metal complex catalyzed new carbonylation of oxiranes, acetals, and allylic acetates using N-silyl amines" was the title of a review (12 references) [575]. An example is seen in eqn. (513) [576].



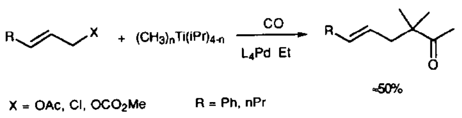
(509)



(510)



(511)



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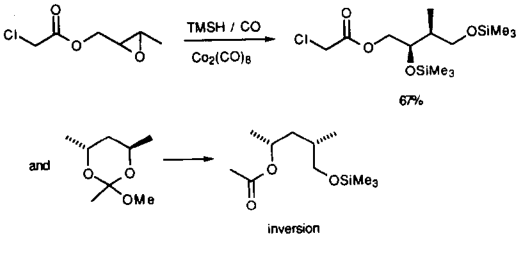
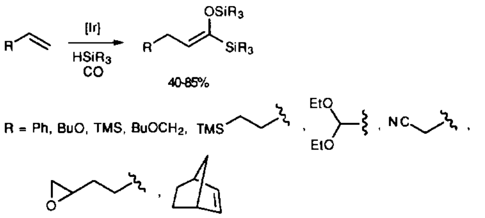


(513)

2.3.6. Miscellaneous carbonylations

The synthesis of carbonyl compounds utilizing organomanganese pentacarbonyl complexes was the topic of a disertation [577]. A review dealing with the synthesis of C-2 compounds directly from synthesis gas *via* organometallic catalysts has appeared (118 references) [578]. Alkenes (eqn. (514) [579]) and amines (eqn. (515) [580] and eqn. (516) [581]) underwent catalyzed silylcarbonylation. ω-Stannyl acid chlorides were cyclocarbonylated by palladium catalysts (eqn. (517) [582]).



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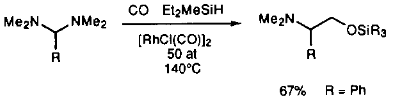

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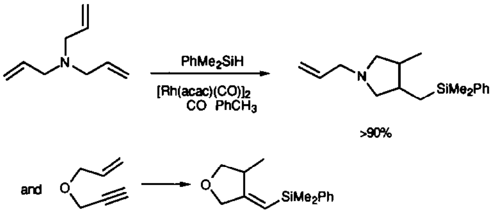

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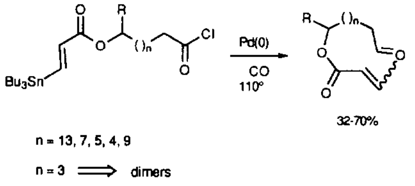
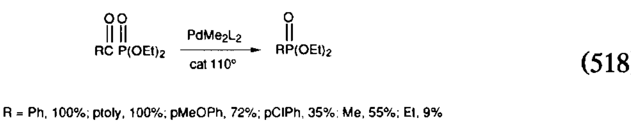


(517)

2.3.7. Decarbonylation reactions

Acylphosphates (eqn. (518) [583]), allyl carbamates (eqn. (519) [584]), and allyl carbonates (eqn. (520) [585]) were deacylated by palladium(0) catalysts. Rhodium on alumina deformylated aldehydes (eqn. (521) [586]).



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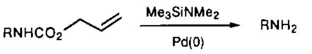

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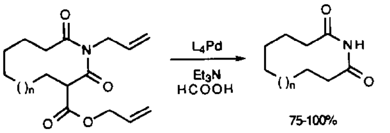

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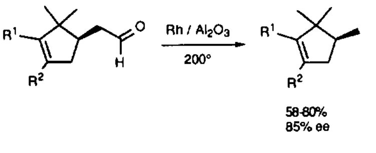
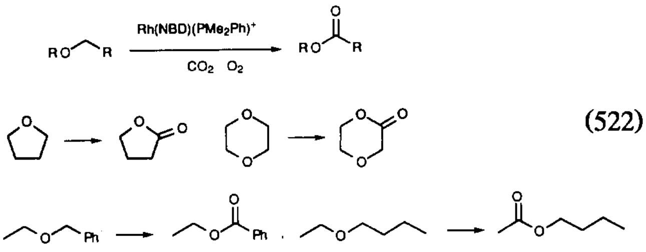


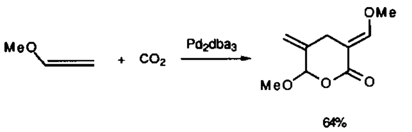
(521)

2.3.8. Reactions of carbon dioxide

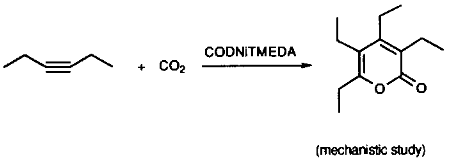
A review dealing with carbon dioxide in organic synthesis and polymer synthesis by means of transition metal complex catalysts has appeared (20 references) [587]. η^6-Arene chromium tricarbonyl complexes were lithiated, then carboxylated with carbon dioxide [588]. Unsaturated carbamates, carbonates, and ureas were synthesized by ruthenium(II) catalyzed reactions of propargyl alcohols [589]. Ethers were converted to esters by CO_2 in the presence of a rhodium(I) catalyst (eqn. (522) [590]). Methoxy allene was cocyclotrimerized with CO_2 in the presence of palladium catalysts (eqn. (523) [591]). A review dealing with the synthesis of unsaturated lactones using carbon monoxide with transition metals (22 references) has appeared [592]. An example is seen in eqn. (524) [593]. Enynes were carboxylated by CO_2 in the presence of nickel catalysts (eqn. (525) [594]).



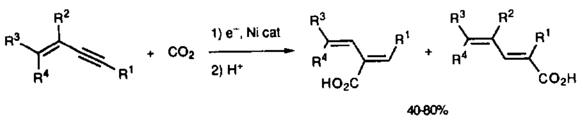
(522)



(523)



(524)

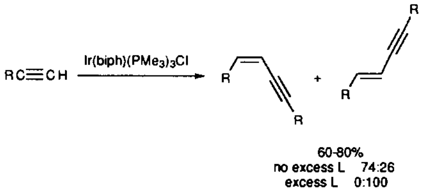


(525)

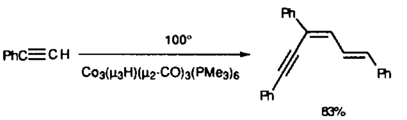
R^1 = H, Me, nPr, nBu, nC_5, nC_6
R^2 = $(CH_2)_4$, Me, H
R^3 =
R^4 = H, C_5

2.4. Oligomerization (including cyclotrimerization of alkynes and metathesis polymerization)

A review dealing with ethylene dimerization and oligomerization to α-olefins (194 references) has appeared [595] as has one dealing with dimerization of ethene to 2-butene and subsequent metathesis [596]. Nickel(0) complexes in the presence of phosphines dimerized acrylonitrile to 2,4-dicyanobutene [597,598]. Vinyl ketones were head-to-tail dimerized using modified rhodium catalysts [599]. Conjugated dienes were linearly dimerized by nickel(0) aminophosphonite systems [600]. Iridium complexes dimerized terminal alkynes (eqn. (526) [601]) while cobalt complexes trimerized phenylacetylene (eqn. (527) [602]).

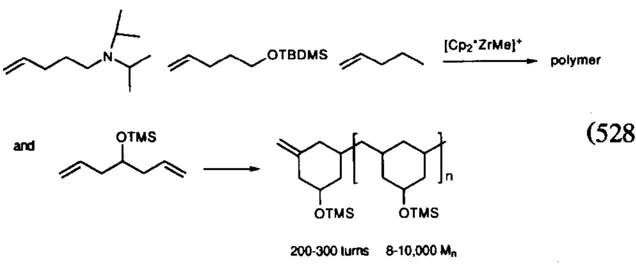


(526)



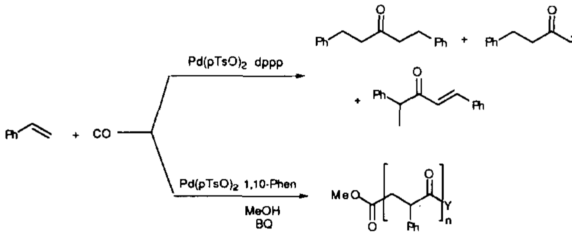
(527)

Developing new, specific catalysts for Ziegler–Natta polymerization continued to be a very active area. The catalyst $[(indenyl)_2TiMe]^+$ catalyzed ethylene polymerization and its activity decreased with decreasing solvent polarity [603]. The related catalysts $[Cp'_2M{-}Me]^+$ when M = Ti < < HF < Zr and $Cp' = C_5H_4TMS$ also polymerized ethylene [604]. Silicon bridged indenylzirconium and silylated cyclopentadienylzirconium complexes catalyzed isotactic polymerization of propylene, butene, pentene and hexene [605,606]. The cationic complex $[Cp'_2ZrH_2]^+B(C_6H_5)_3^-$ was an active olefin polymerization catalyst [607]. Stereoselective propene polymerization was achieved using cholestanylindene-derived non-bridged group 4 bent metallocene catalysts [608]. *trans*-1,2-Bis-indenylcyclohexane zirconium dichloride catalyzed propene polymerization with high stereoselectivity even at 50°C [609]. Functionalized alkenes could also be Ziegler–Natta polymerized (eqn. (528) [610]).

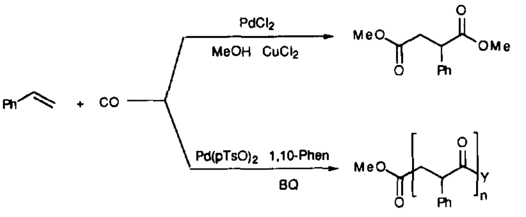


(528)

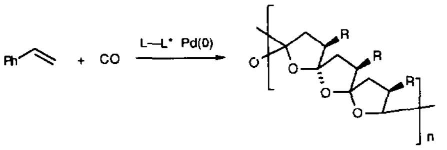
The mechanism of rhodium(I) catalyzed alternating cooligomerization of carbon monoxide with alkenes has been studied [611], and ways to control the regioselectivity of palladium catalyzed copolymerization of propene and carbon monoxide have been developed [612]. The complex $[(\text{bipy})\text{Pd}(\text{CH}_3)(\text{MeCN})]^+$ is a living catalyst for the copolymerization of carbon monoxide with 4-t-butylstyrene [613]. Unusual palladium catalyzed cooligomerizations of alkenes with carbon monoxide are seen in eqn. (529) [614], eqn. (530) [615], eqn. (531) [616], and eqn. (532) [617]. Iron carbonyl cyclocarbonylated bis allenes (eqn. (533) [618]).



(529)

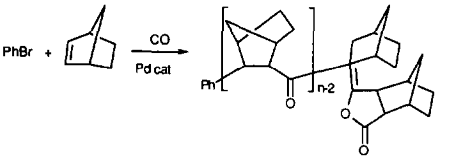


(530)

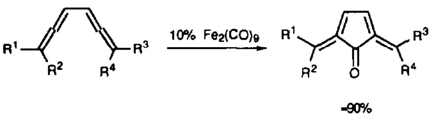


(531)

LL* = (S)-(6,6'-dimethylbiphenyl-2,2'-diyl)bis(dicyclohexylphosphine)

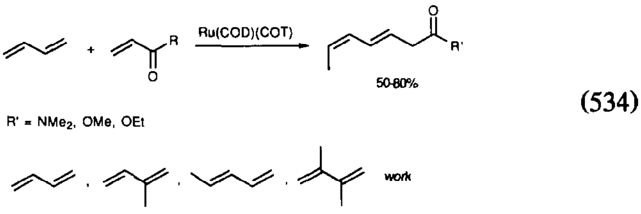


(532)



(533)

Palladium complexes catalyzed the telomerization of isoprene with primary amines [619] and N-substituted tosamides [620]. Ruthenium codimerized butadiene with conjugated enones (eqn. (534) [621]). Palladium was used extensively in the synthesis shown in eqn. (535) [622]).



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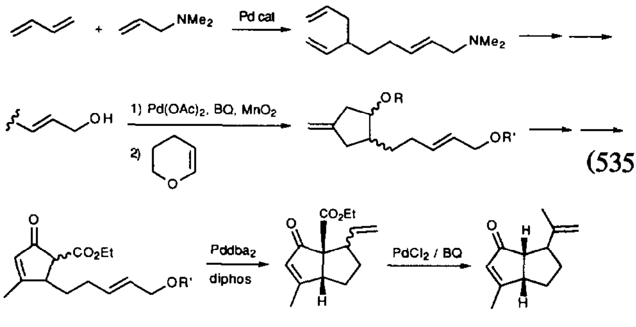
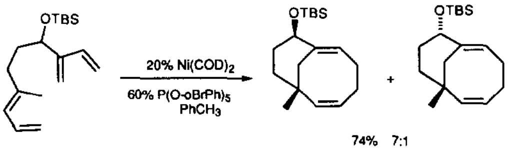


(535)

Butadiene was cyclotrimerized by $\text{TiCl}_4/\text{Et}_x\text{AlCl}_{3-x}$ systems [623]. Nickel(0) complexes cyclodimerized butadienes (eqn. (536) [624]) as did iron azadiene complexes (eqn. (537) [625]). Palladium acetate cyclodimerized tetraenes (eqn. (538) [626]) while iron complexes cyclodimerized alkenes with dienes (eqn. (539) [627]). Palladium complexes in acetic acid cyclodimerized enynes (eqn. (540) [628], eqn. (541) [629], and eqn. (542) [630]).



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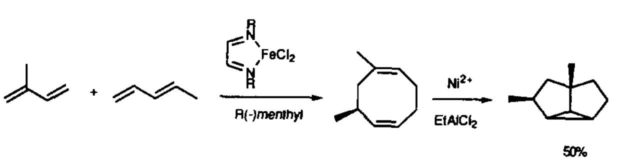

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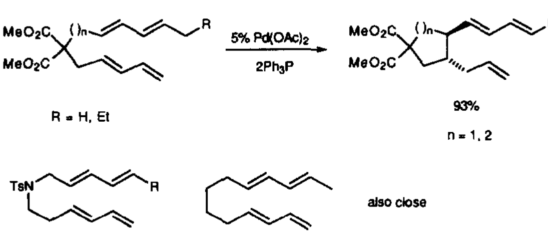

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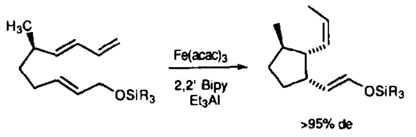

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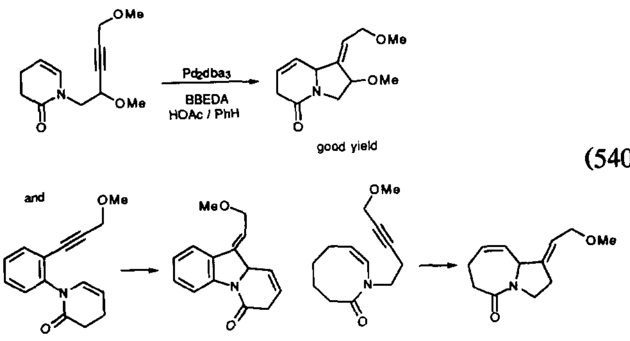

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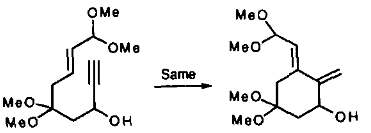
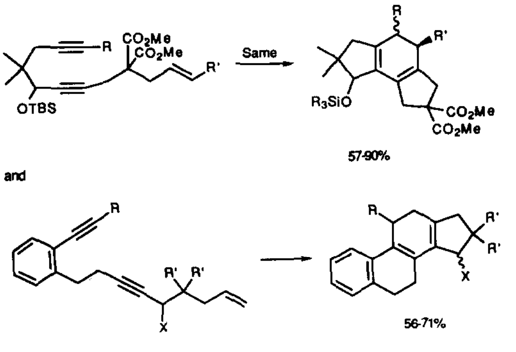


(541)

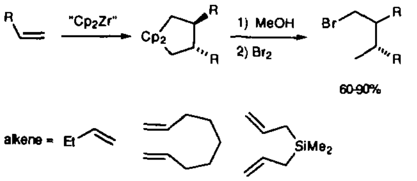


(542)

R = X = R' = H

R = CO_2Me, R' = Me, X = OTBS

"Zirconocene" cyclodimerized alkenes (eqn. (543) [631], eqn. (544) [632] and eqn. (545) [633]) while both "titanocene" (eqn. (546) [634]) and "zirconocene" (eqn. (547) [635] and eqn. (548) [636]) cocyclized alkenes and alkynes.



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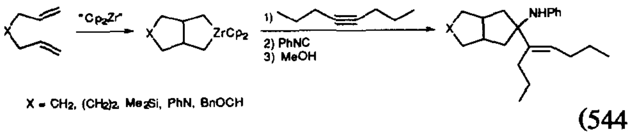

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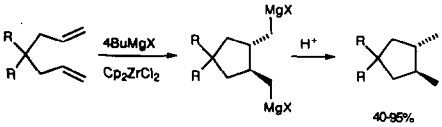

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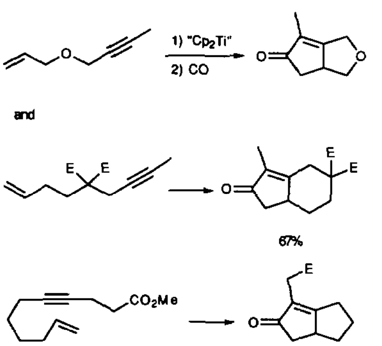
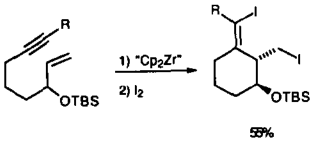


(546)



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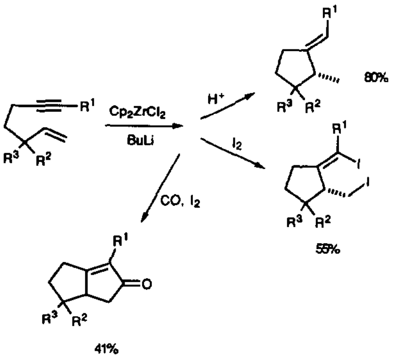
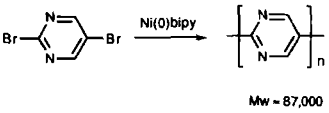
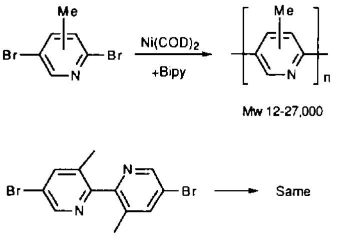


(548)

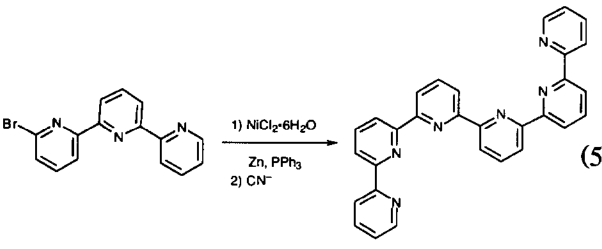
Nickel(0) complexes catalyzed the oligomerization of dibromoheterocycles (eqn. (549) [637], eqn. (550) [638], eqn. (551) [639], and eqn. (552) [640]). Head-to-tail and regiorandom polythiophenes were produced using Pd and Ni catalysis, respectively (eqn. (553) [641]). Palladium catalyzed the coupling of dibromothiophene with tin thiofulvalenes (eqn. (554) [642]).



(549)



(550)



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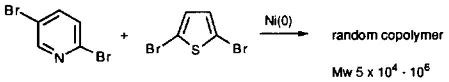
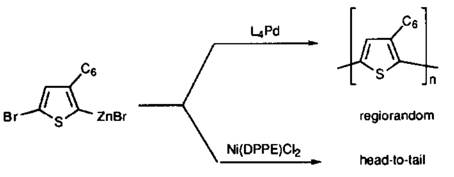


(552)



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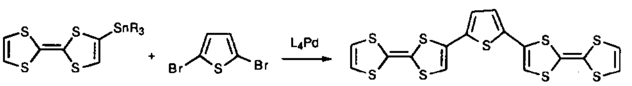
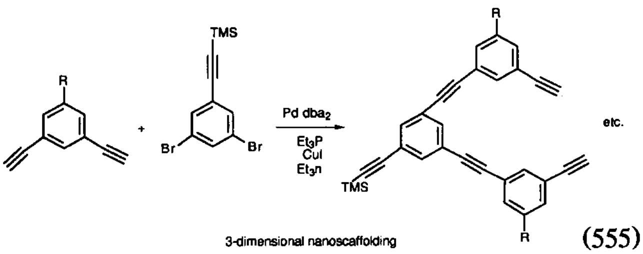
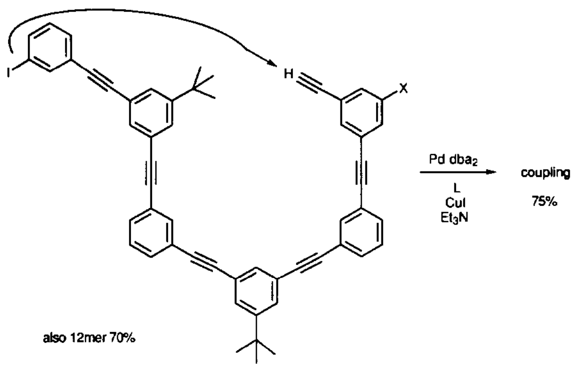


(554)

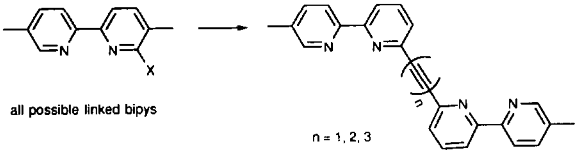
Palladium catalyzed the coupling of arenes with alkynes (eqn. (555) [643]), (eqn. (556) [644]), and (eqn. (557) [645]). Nickel(0) complexes catalyzed the cocyclotrimerization of enynes and isonitriles (eqn. (558) [646]).



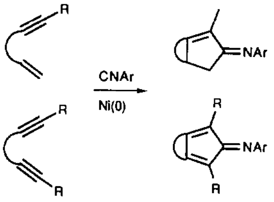
(555)



(556)

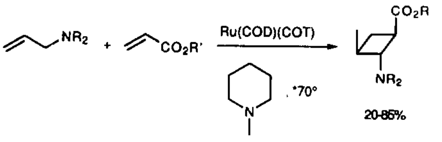


(557)



(558)

Ruthenium catalyzed the codimerization of acrylates with allyl amines (eqn. (559) [647]). Cobalt catalyzed the codimerization of diynes with alkenes (eqn. (560) [648]), as did nickel (eqn. (561) [649]). Palladium cyclodimerized alkynes (eqn. (562) [650]). Rhodium complexes cooligomerized cyclopropenes with alkynes (eqn. (563) [651]).



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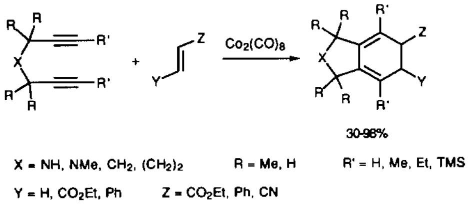

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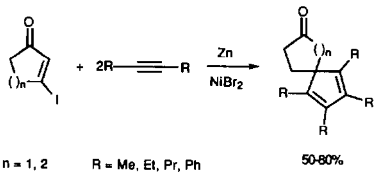

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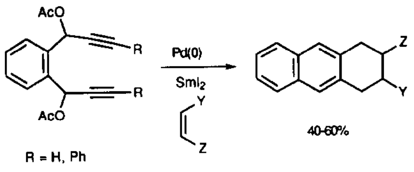
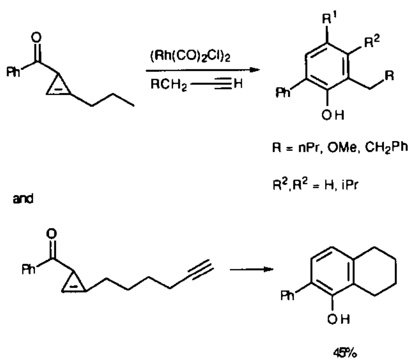
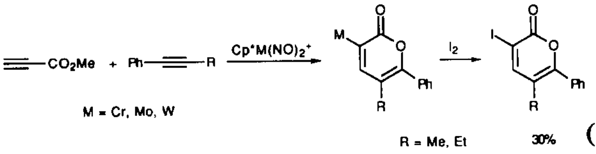


(562)

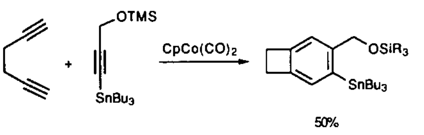


(563)

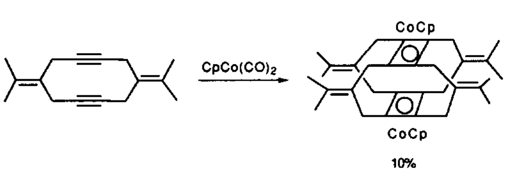
Group 6 complexes cocyclotrimerized alkynes (eqn. (564) [652]) as did cobalt (eqn. (565) [653]). Cycloaddition reactions of alkynes in organic synthesis was the topic of a review (12 references) [654], as was "Cycloalkadiynes – from bent triple bonds to strained Cage compounds" (109 references) [655]. Cobalt cyclodimerized diynes (eqn. (566) [656]). Nickel(0) complexes cocyclooligomerized carbon dioxide and diynes (eqn. (567a) [657]). "3 + 2 Cycloaddition reactions of transition metal 2-alkynyl and η^1-allyl complexes and their utilization in five membered ring compound synthesis" was the title of a review (63 references) [658].



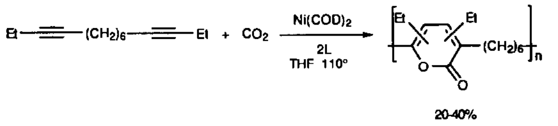
(564)



(565)

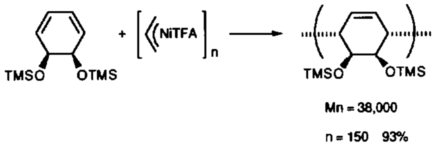


(566)



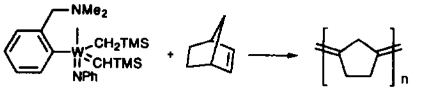
(567a)

Cationic nickel allyl complexes catalyzed the clean 1,4-*cis* polymerization of butadiene [659] while cationic ruthenium diene complexes catalyzed trimerization of butadienes to C_{12} linear oligomers [660]. π-Allylnickel trifluoroacetate polymerized *cis*-dihydroxycyclohexadiene (eqn. (567b) [661]), while reduced nickel species catalyzed the cooligomerization of sorbic acid esters with butadiene [662]. Palladium complexes catalyzed the cyclocodimerization of quadracyclane with norbornene [663].

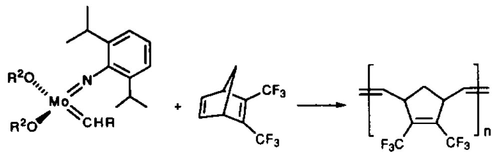


(567b)

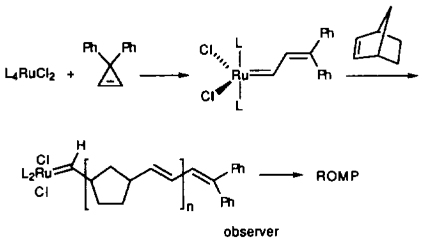
A number of new ROMP catalyst systems have been developed, and many will tolerate functionality (eqn. (568) [664], eqn. (569) [665], eqn. (570) [666], eqn. (571) [667], and eqn. (572) [668]).



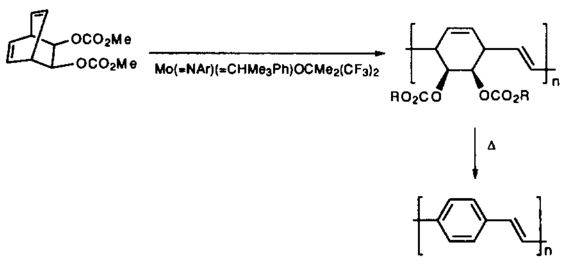
(568)



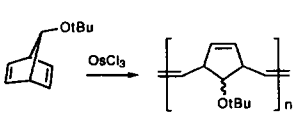
(569)



(570)



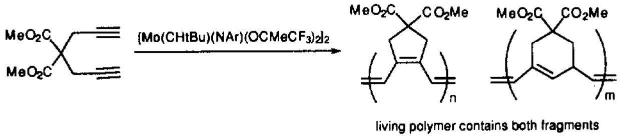
(571)



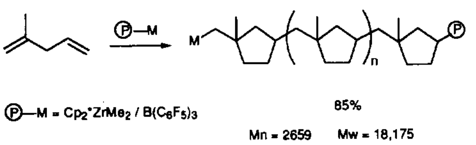
(572)

Alkynes were polymerized by tungsten (eqn. (573) [669]) and molybdenum catalysts (eqn. (574) [670]). Cationic zirconium complexes cyclooligomerized 1,4-dienes (eqn. (575) [671]).

$RC\equiv CH + WCl_6/Et_3Al \longrightarrow$ polymer Mn / 10³ = 77,000 50-94% (573)

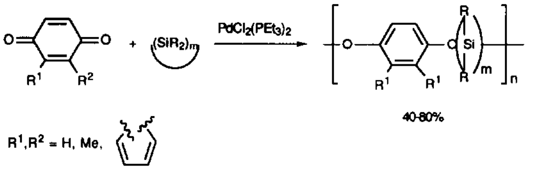


(574)

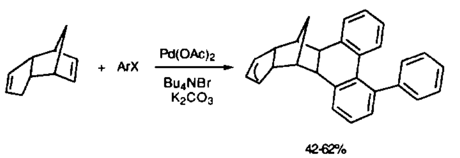


(575)

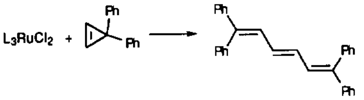
Group 6 metal carbonyls polymerized terminal alkynes but metathesized internal ones [672]. Nickel(0) complexes catalyzed the oligomerization of methylene cyclopropane [673]. Substituent effects in nickel catalyzed olefin oligomerization have been studied [674]. Palladium catalysts cooligomerized quinones with polysilanes (eqn. (576) [675]) and polyarylated norbornenes (eqn. (577) [676]). Ruthenium complexes dimerized diphenylcyclopropene (eqn. (578) [677]).



(576)

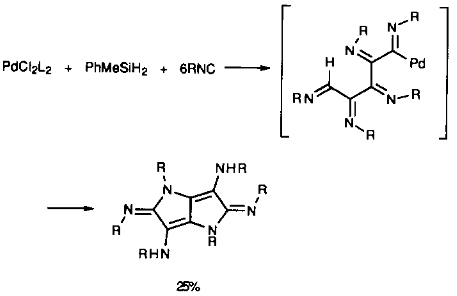


(577)

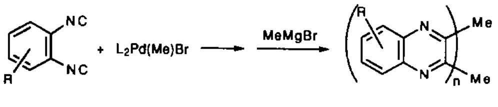


(578)

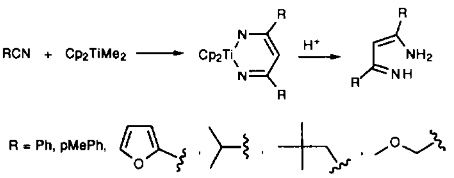
Stereoselection in nickel-catalyzed polymerization of chiral isocyanides was studied [678]. Palladium catalysts cooligomerized isonitriles and silanes (eqn. (579) [679]) and converted bis isonitriles into helical oligomers (eqn. (580) [680]). Dimethyl titanocene dimerized nitriles (eqn. (581) [681]).



(579)



(580)

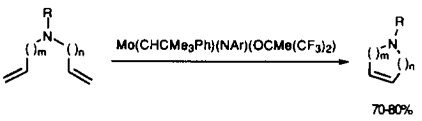


(581)

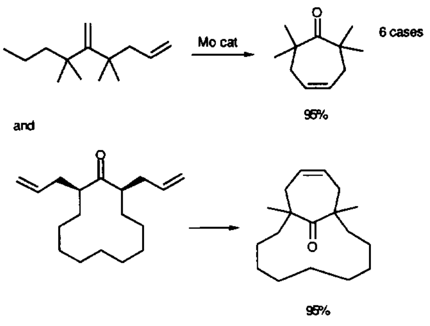
2.5. Rearrangements

2.5.1. Metathesis

A symposium article on the olefin metathesis reaction has been published [682]. Metathesis of 2-pentene by tungsten carbonyl has been studied [683]. Dinitrosomolybdenum catalysts metathesized functionalized alkenes [684]. Metathesis was used to synthesize heterocycles (eqn. (582) [685]) and carbocycles (eqn. (583) [686]).



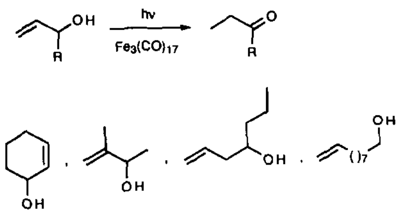
(582)



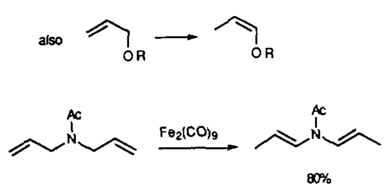
(583)

2.5.2. Olefin isomerization

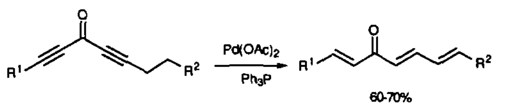
Styrene/divinylbenzene copolymers containing $RuCl_2L_3$ isomerized 1-hexene [687], as did hexaaquoruthenium (2 +) [688]. Iron carbonyls were used to isomerize alkenes (eqn. (584) [689] and eqn. (585) [690]). Palladium acetate isomerized acylenic ketones (eqn. (586) [691] and eqn. (587) [692]). Chiral titanocenes isomerized alkenes with reasonable asymmetric induction (eqn. (588) [693]).



(584)



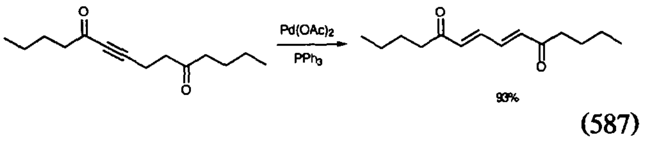
(585)



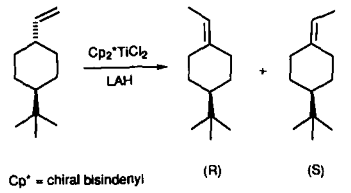
R^1 = nPr, nBu, C_5, C_6, Ph

R^2 = Me, Et, nPr, nBu

(586)



(587)



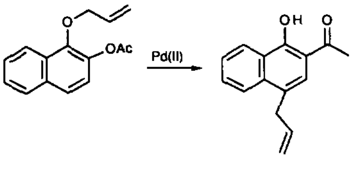
Cp* = chiral bisindenyl

100% yield up to 76% ee

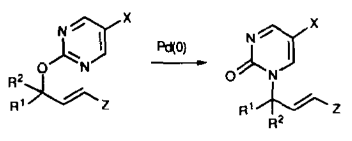
(588)

2.5.3. Rearrangement of allylic and propargylic compounds

Palladium(II) complexes catalyzed a large number of allylic transposition rearrangements (eqn. (589) [694], eqn. (590) [695], eqn. (591) [696], eqn. (592) [697], eqn. (593) [698], eqn. (594) [699], and (eqn. (595) [700]).



(589)



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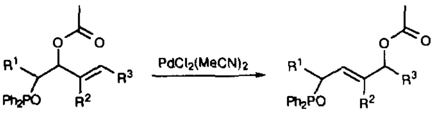

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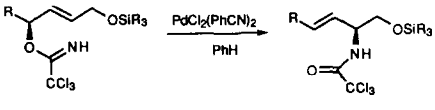
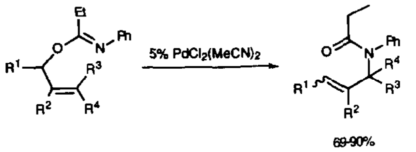


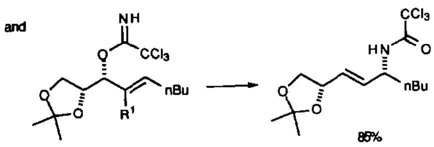
complete chirality transfer

(592)

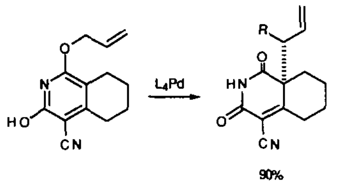


R^1 = H, Me R^2 = H, Me R^3 = H, nPr, Me

R^4 = Me, nPr, H



(593)



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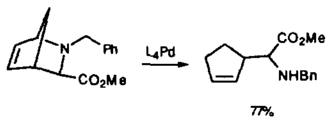
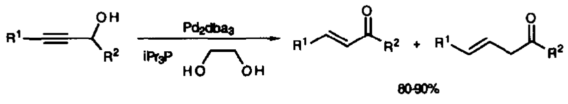


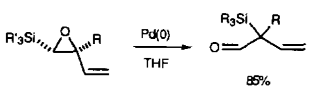
(595)

Palladium(0) complexes rearranged propargyl alcohols to conjugated enones (eqn. (596) [701]) and allyl epoxides to unconjugated enones (eqn. (597) [702]). Cobalt carbonyl ring expanded cyclopropyl-propargyl alcohols (eqn. (598) [703]).

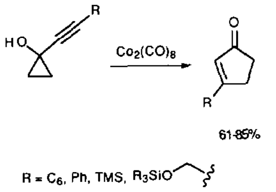


R^1 = nBu, C_5, C_6, Ph R^2 = Et, Me, H, ptolyl

(596)



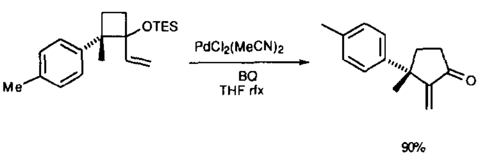
(597)



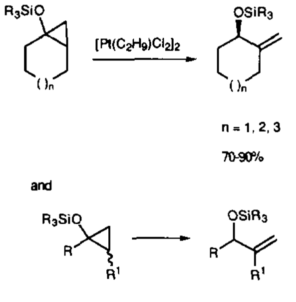
(598)

2.5.4. Skeletal rearrangements

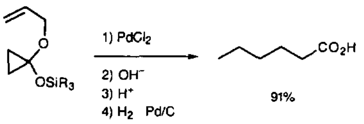
Palladium and platinum catalyzed a number of skeletal rearrangements in small ring compounds (eqn. (599) [704], eqn. (600) [705], and eqn. (601) [706]).



(599)



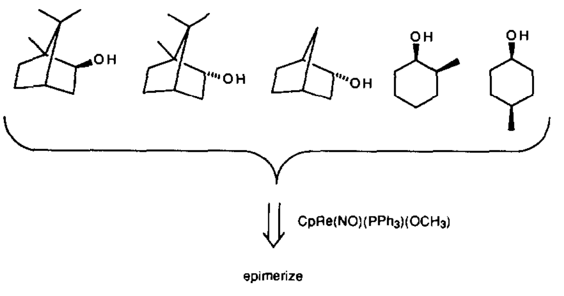
(600)



(601)

2.5.5. Miscellaneous rearrangements

Rhenium complexes epimerized secondary alcohols (eqn. (602) [707]). Rhodium(II) complexes catalyzed the vinylogous Wolff rearrangement [708].

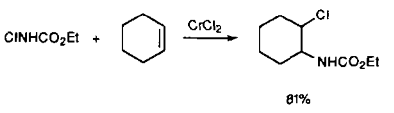


(602)

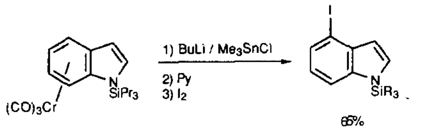
3. Functional group preparations

3.1. Halides

Chromium(II) halides promoted the addition of N-chlorocarbamates to alkenes (eqn. (603) [709]). Wilkinsons complex ($Rh(PPh_3)_3Cl$) catalyzed the chlorination of adamantane to 1-chloroadamantane in 80% yield, by CH_2Cl_2 [710]. Chromium complexed indole was iodinated (eqn. (604) [711]).



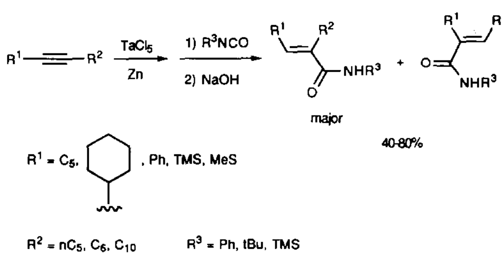
(603)



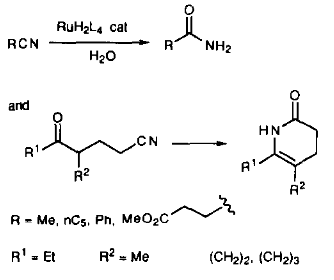
(604)

3.2. Amides, nitriles

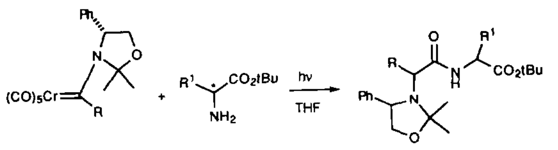
Reduced tantalum species combined alkynes with isocyanates to produce unsaturated amides (eqn. (605) [712]). Nitriles were converted to amides by ruthenium hydrides (eqn. (606) [713]). E-Alkene isosteric dipeptides were synthesized using copper chemistry (review, 19 references) [714]. Dipeptides were synthesized by photolysis of chromium aminocarbene complexes in the presence of α-amino acid esters (eqn. (607) [715]). Chiral nickel complexes catalyzed the asymmetric hydrocyanation of styrenes (eqn. (608) [716]).



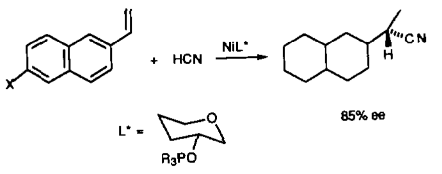
(605)



(606)



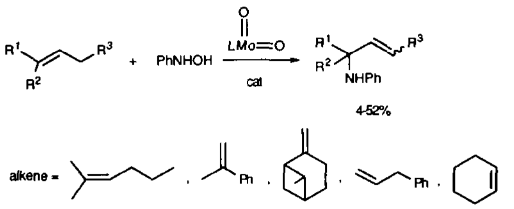
(607)



(608)

3.3. Amines, alcohols

Stereoselective syntheses of acyclic chiral amines by α-amidoalkylation was the topic of a dissertation [717]. Molybdenum oxo species catalyzed the allyl amination of alkenes by hydroxylamines (eqn. (609) [718]). Palladium catalyzed the amination of alkenes (eqn. (610) [719]), allyl epoxides (eqn. (611) [720]), and allyl acetals (eqn. (612) [721]). Fluorobenzene complexes of chromium were aminated by trifluoroacetic acid (eqn. (613) [722]). Zirconium amine complexes aminated alkynes (eqn. (614) [723]).



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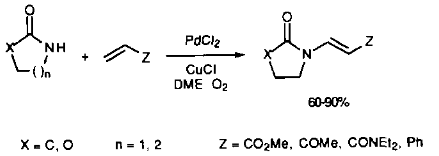
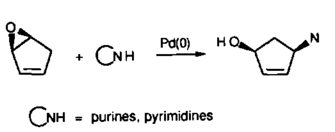
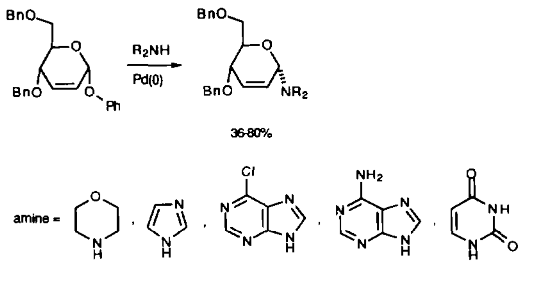


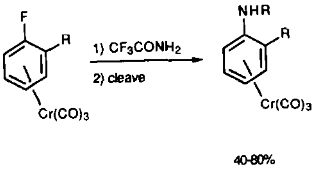
(610)



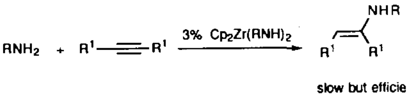
(611)



(612)

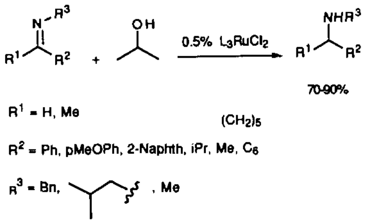


(613)



(614)

Ruthenium carbonyl complexes reduced nitroarenes to amines [724]. Ruthenium complexes catalyzed the reduction of imines by i-propanol (eqn. (615) [725]). Chiral zirconium complexes catalyzed the asymmetric reduction of imines (eqn. (616) [726]). Aryl glycines were synthesized using chromium carbene photochemistry (eqn. (617) [727]), as was deuteroglycine (eqn. (618) [728]).



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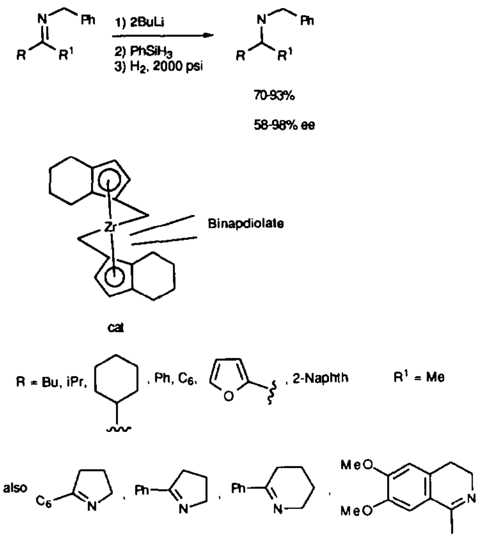
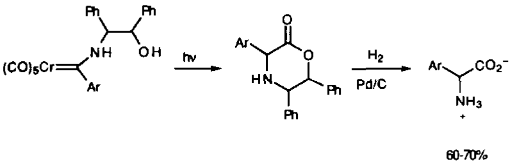
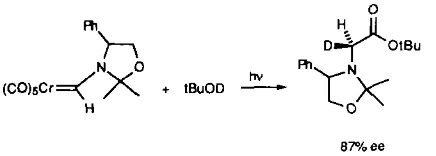


(616)



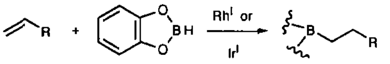
(617)

Ar = Ph, pMeOPh, pClPh, pFPh, pCF₃Ph, oMeOPh, 2,6-F₂Ph, 1-Naphth



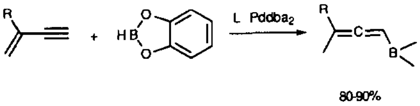
(618)

Stereocontrol in catalyzed and uncatalyzed hydroborations has been reviewed (43 references) [729] and was the subject of two mechanistic studies [730,731]. Some key features of the process are given in eqn. (619) [732]. Styrenes underwent catalyzed hydroborations to place the boron α to the aryl group, exclusively [733,734]. Palladium catalyzed the hydroboration of enynes to give allene boranes (eqn. (620) [735]).



(619)

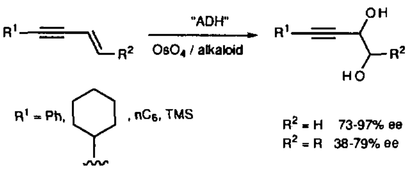
(1) L_3RhCl, $[Ir(COD)(PCy_3)(Py)]^{+1}$ best cat.
(2) Stereoselective for least hindered alkene
(3) *syn* diastereoselectivity
(4) ligand directed



(620)

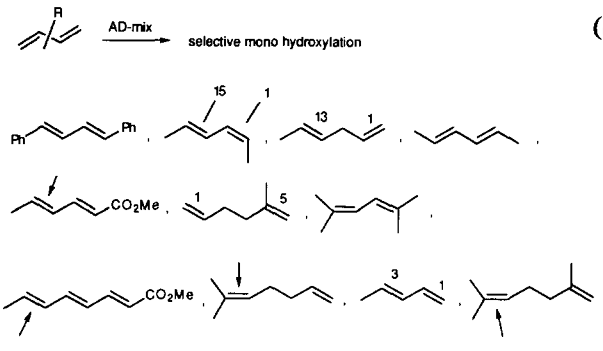
R = Me, C₅, tBu, TMS

Enantioselective *cis*-hydroxylation was the topic of two reviews (17 references) [736], (39 references) [737]. Systems to efficiently carry out this process continue to evolve. The current "best" system is described in ref. 738. Enynes (eqn. (621) [739]) dienes (eqn. (622) [740], eqn. (623) [741]) and enones (eqn. (624) [742]) all were efficiently *cis* hydroxylated. Other *cis* hydroxylating systems are shown in eqn. (625) [743], eqn. (626) [744], eqn. (627) [745], eqn. (628) [746] and eqn. (629) [747].

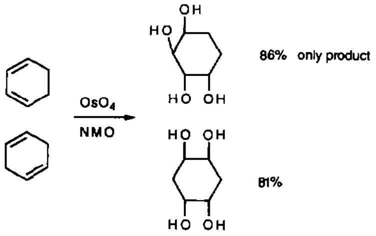


(621)

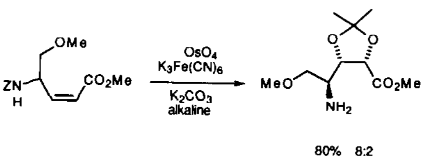
R² = H, Me, Et, Ph, nBu



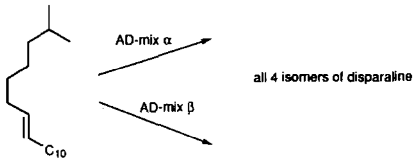
(622)



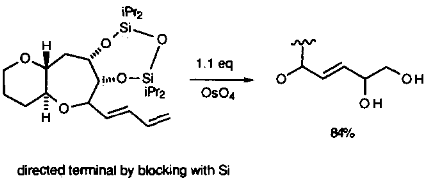
(623)



(624)

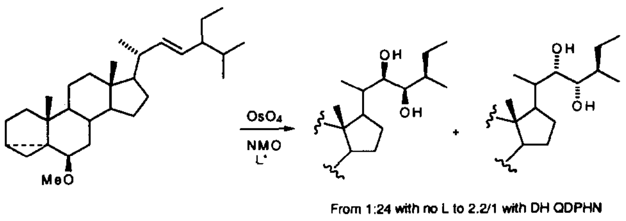


(625)



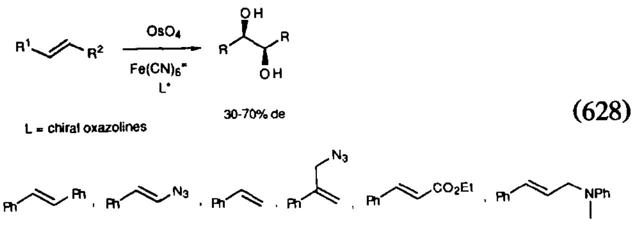
(626)

directed terminal by blocking with Si

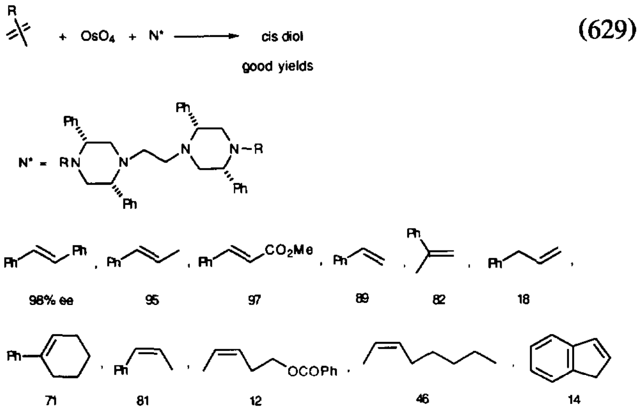


From 1:24 with no L to 2.2/1 with DH QDPHN

(627)

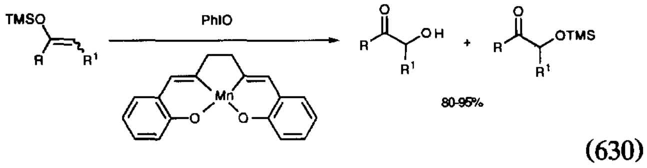


(628)

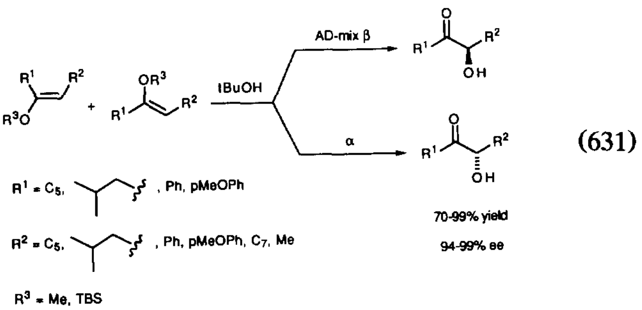


(629)

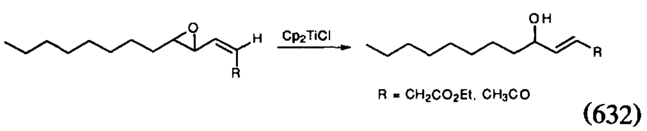
Enol ethers were converted to α-hydroxyketones by iodosyl benzene (eqn. (630) [748] and osmium (eqn. (631) [749]). Reduced titanocenes reduced allyl epoxides to allyl alcohols (eqn. (632) [750]), while nickel complexes catalyzed the air oxidation of epoxides to diols (eqn. (633) [751]). Alkylated naphthols were oxidized to α-hydroxyketones by t-butyl hydroperoxide in the presence of zirconium(II) [752].



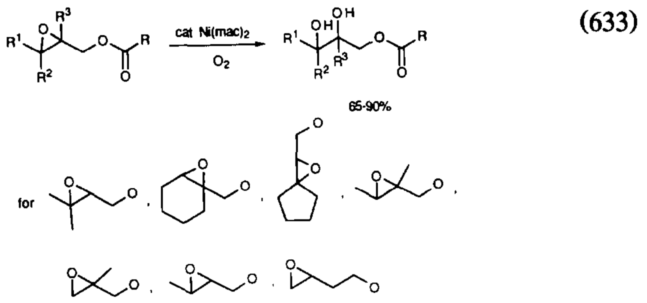
(630)



(631)

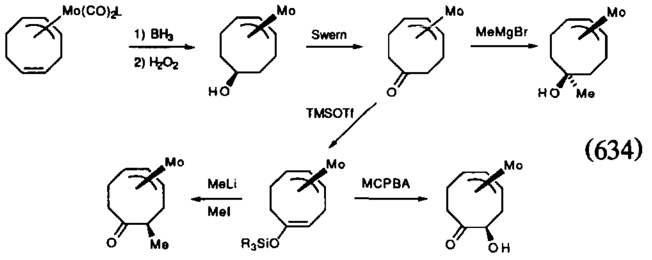


(632)

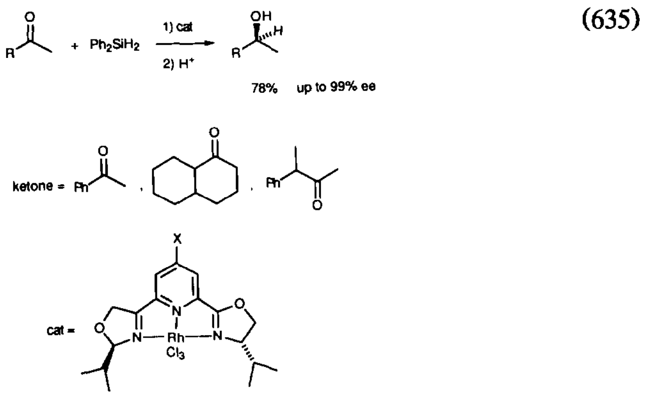


(633)

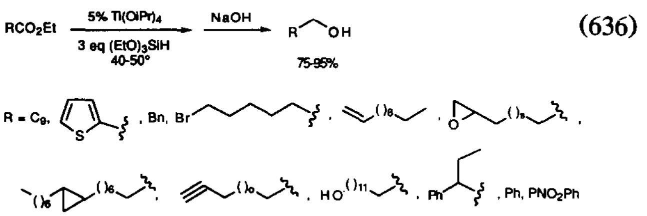
π-Allylmolybdenum compounds were hydroborated and converted to a variety of oxygenated compounds (eqn. (634) [753]). Ketones were asymmetrically reduced by silanes in the presence of rhodium(I) catalysts (eqn. (635) [754]). Esters were reduced to alcohols by silanes in the presence of titanium salts (eqn. (636) [745]). Allyl and benzyl ether protecting groups were removed by low valent titanium species (eqn. (637) [756]).



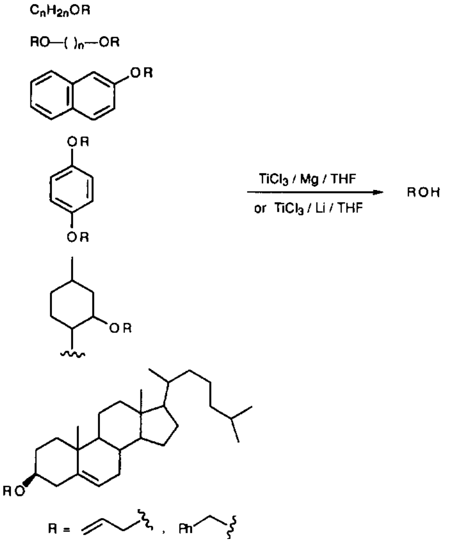
(634)



(635)



(636)

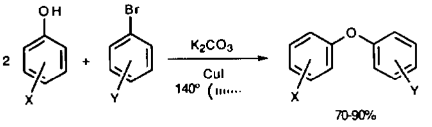


(637)

3.4. Ethers, esters, acids

Aryl ethers were prepared by the copper catalyzed reactions of aryl halides with alkoxides (eqn. (638) [757], eqn. (639) [758] and eqn. (640) [759]), as were enol ethers (eqn. (641) [760]). Aryl ethers were also made by reaction of alkoxides with iron (eqn. (642) [761], eqn. (643) [762], eqn. (644) [763]), ruthenium (eqn. (645) [764]), manganese (eqn. (646) [765]), and chromium (eqn. (647) [766]) complexes of chloroarenes.

$$\mathrm{ArBr} + \mathrm{NaOR'} \xrightarrow{\mathrm{CuBr}} \mathrm{ArOR'} \qquad (638)$$

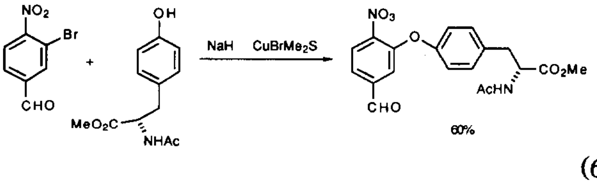


(639)

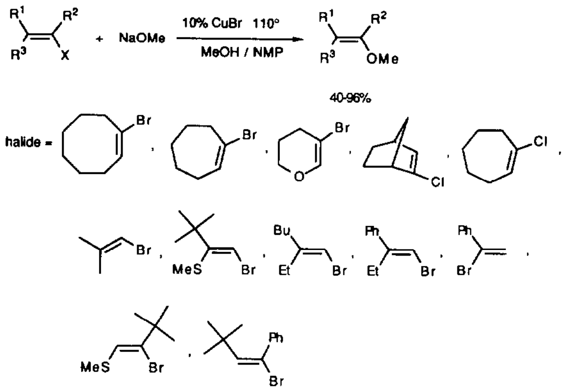
X = H, 2Me, 3Me, 4Me, 2MeO, 3,5-Me₂

Y = 2MeO, 4MeO, 2Me, 3Me, 4Me, H, 1Naphth

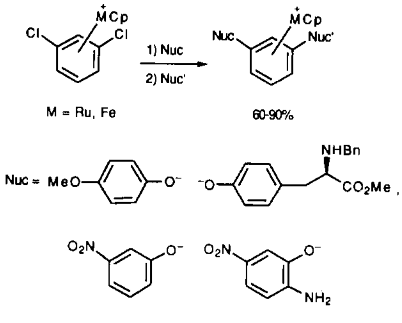
(Equation 640)



(640)

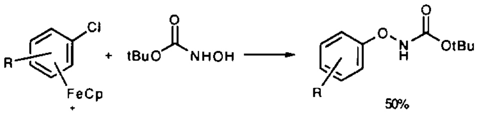


(641)



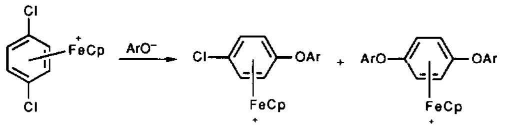
Nuc' = same

(642)

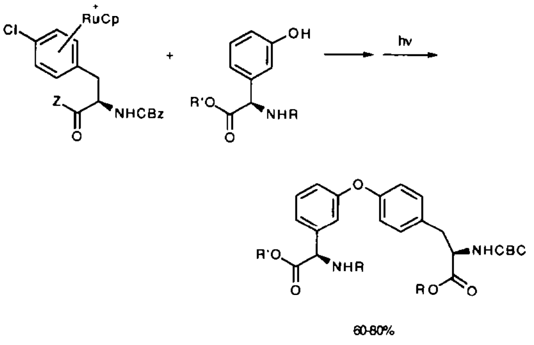


(643)

R = H, OMe, pMe, pMeO, pCl



(644)



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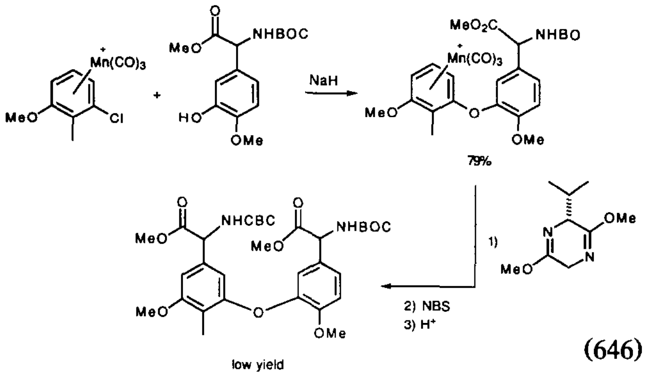

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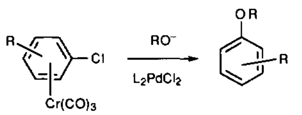
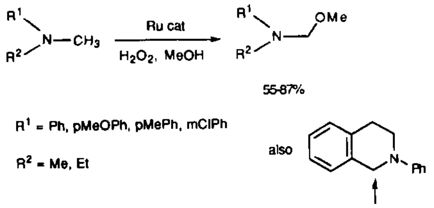


(647)

N-Methylamines were oxidized to methoxymethyl amines by ruthenium catalysts and hydrogen peroxide (eqn. (648) [767]). Palladium catalyzed the alkoxylation (eqn. (649) [768]) and the acetoxylation (eqn. (650) [769], eqn. (651) [770], eqn. (652) [771], eqn. (653) [772]) of alkenes, the allylation of protected ribonucleosides (eqn. (654) [773]), and the conversion of allyl carbonates to allyl aryl ethers (eqn. (655) [774]).



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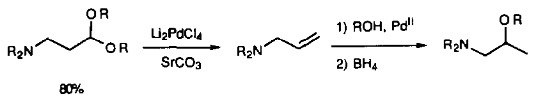

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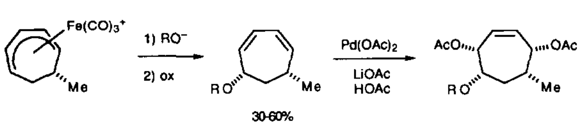

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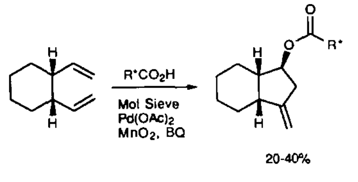

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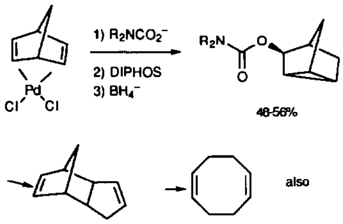

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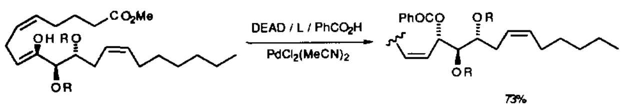

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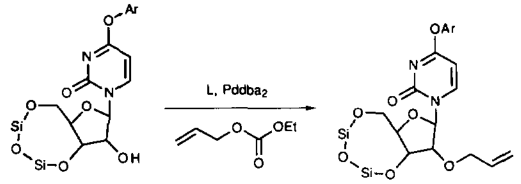

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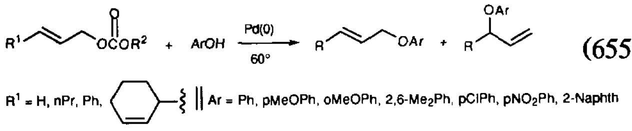
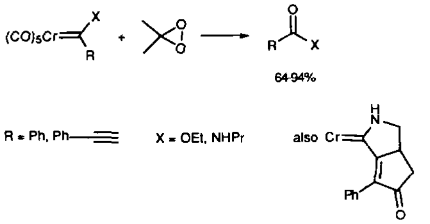


(655)

Oxidation of chromium carbene complexes gave esters (eqn. (656) [775] and eqn. (657) [776]). Chiral esters were made from chromium carbene derived β-lactams (eqn. (658) [777]). Ruthenium oxidized ketals to hydroxy esters (eqn. (659) [778]). Cobalt salen complexes converted αketoaldehydes to α-hydroxyesters (eqn. (660) [779]).



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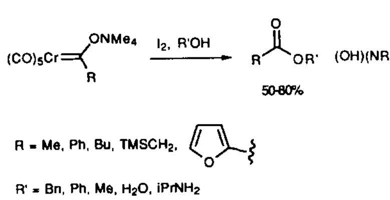

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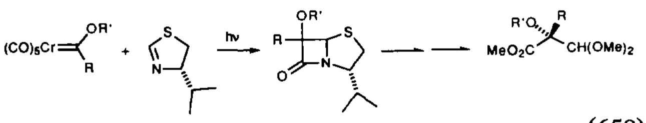

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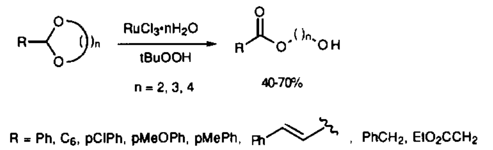

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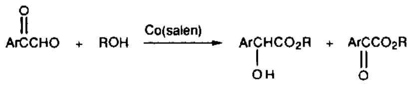


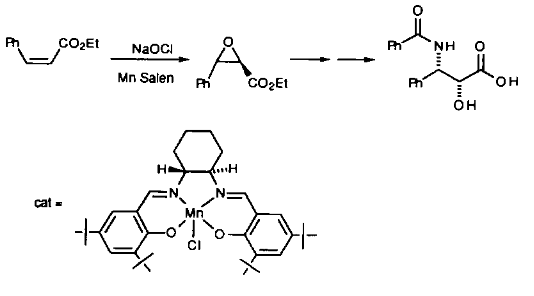
(660)

3.5. Heterocycles

The following reviews on heterocyclic syntheses have appeared: "Synthesis of heterocyclic systems by activation of isocyanide, carbonyl, trifluoromethyl and nitrile ligands in platinum(ii) complexes" (more than 62 references) [780]; "Asymmetric synthesis of nitrogen-containing biologically active compounds utilizing intramolecular aminocyclization to olefin of secondary allylic alcohols" (more than 35 references) [781]; "Synthesis of oxygen-containing heterocycles using palladium(II) catalysts" (more than 50 references) [782]; "Titanium metallacycles as intermediates in the synthesis of acyclic and heterocyclic compounds" (37 references) [783]; "Iron-mediated synthesis of heterocyclic ring systems and applications in alkaloid chemistry" (87 references) [784].

Epoxidation has been extensively studied. Hydroxy chalcones were epoxidized by t-butylhydroperoxide in the presence of V_2O_5 [785]. C-2 symmetrical binaphthyl bridged indenyl titaniumocene complexes catalyzed the asymmetric epoxidation of unifunctionlaized alkenes, but with low (≈ 20%) ee [786]. A conference report on shape selectivity in the epoxidation of olefins over supported titanium catalysts has appeared [787]. Titanium tetraphenyl porphyrin catalyst epoxidized alkenes [788], as did ruthenium(III)/EDTA complexes [789], and dimeric molybdenum(VI) catalyses [790].

Asymmetric epoxidation using salen metal complexes was the topic of a review (9 references) [791]. Examples are seen in eqn. (661) [792], eqn. (662) [793], and eqn. (663) [794]. Cobalt Schiffs base complexes also catalyzed the epoxidation of olefins (eqn. (664) [795]).



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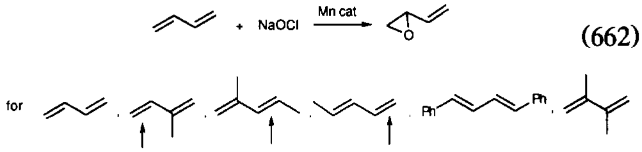

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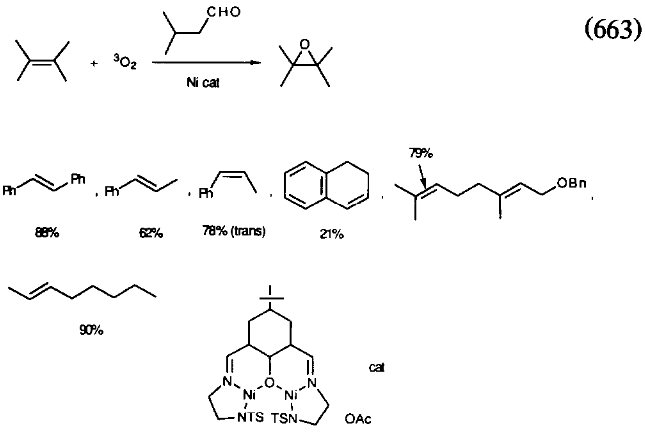

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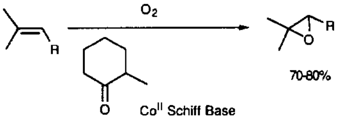
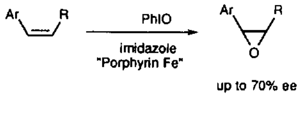


(664)

Iron and manganese "twin coronet" porphyrin complexes (eqn. (665) [796]) and iron binaph capped porphyrins (eqn. (666) [797]) catalyzed the asymmetric epoxidation of alkenes. Steroidal olefins were epoxidized by manganese compounds and air in the presence of isobutyraldehyde (eqn. (667) [798]). A full paper on the nature of the Katsuki–Sharpless Asymmetric Epoxidation catalyst has appeared [799]. Examples of its use are seen in eqn. (668) [800] and eqn. (669) [801]. Tungstate catalyzed the epoxidation of alkenes by peroxides (eqn. (670) [802]).



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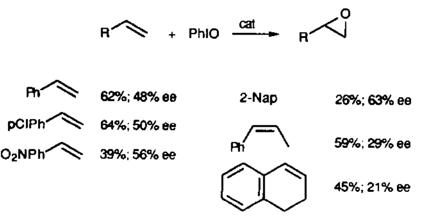

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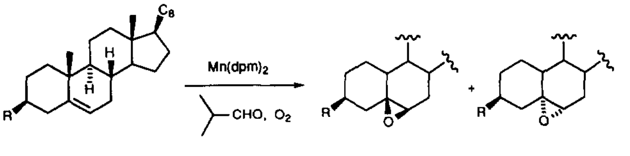

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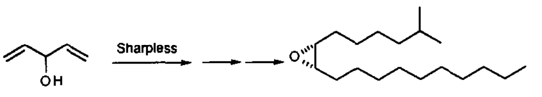

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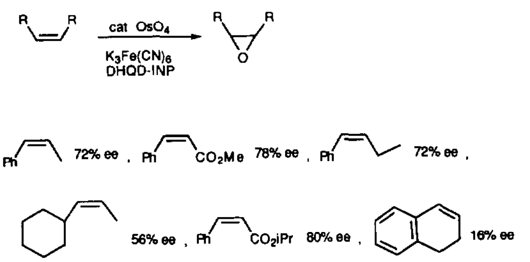

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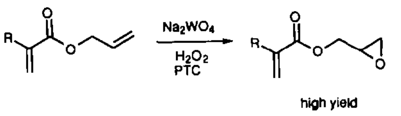
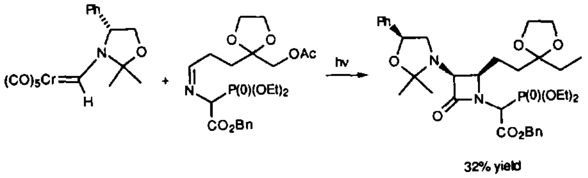


(670)

Chiral β-lactones were made from optically active iron acylenolates [803]. Chromium carbene mediated β-lactam syntheses was the topic of a dissertation [804]. Photolysis of chromium carbene complexes in the presence of imines gave β-lactams (eqn. (671) [805], eqn. (672) [806], and eqn. (673) [807]). Rhodium-catalyzed diazodecomposition also produced β-lactams (eqn. (674) [808]).



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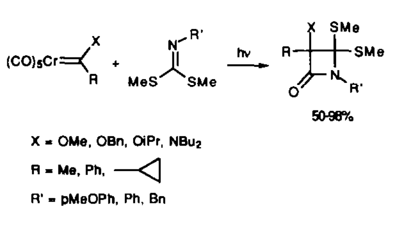

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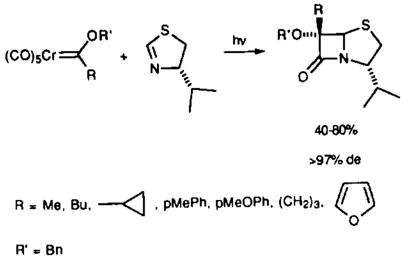

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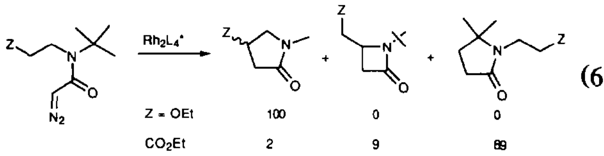
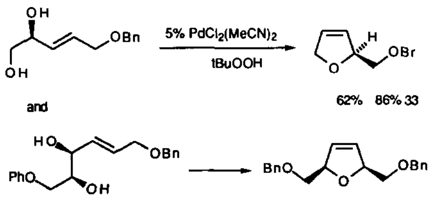


(674)

Five-membered oxygen heterocycles were synthesized by a variety of palladium catalyzed cyclization reactions (eqn. (675) [809], eqn. (676) [810], eqn. (677) [811], eqn. (678) [812], eqn. (679) [813], eqn. (680) [814], and eqn. (681) [815]).



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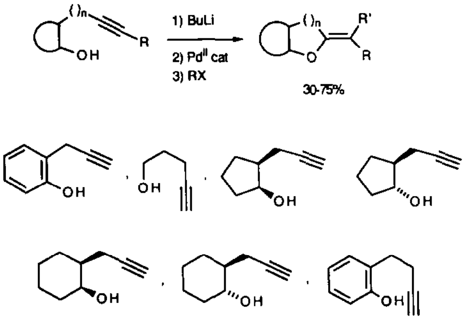

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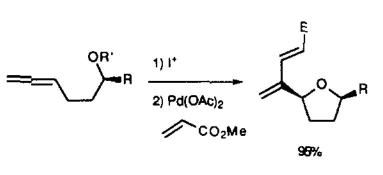

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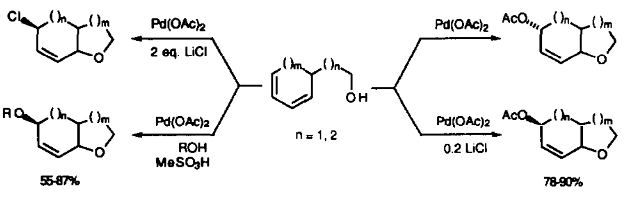

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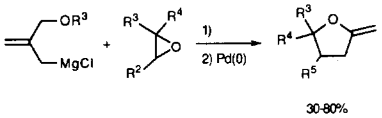

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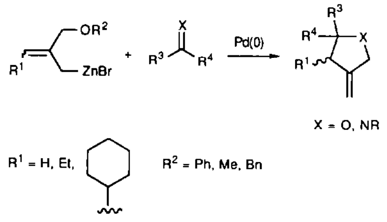

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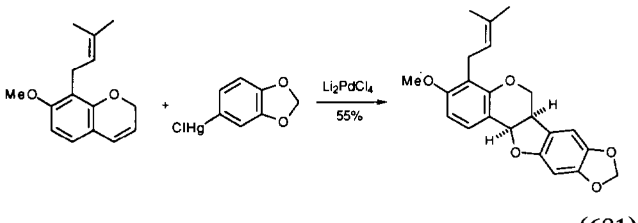
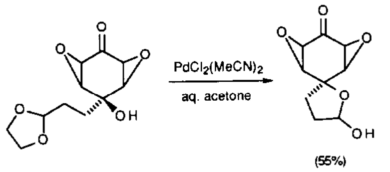


(681)

Five membered oxygen heterocycles were made by hydrolytic (eqn. (682) [816], eqn. (683) [817]), oxidative (eqn. (684) [818], eqn. (819) [820]), and reductive (eqn. (685) [821]) procedures. Rhodium(I) catalyzed the cyclization of olefinic ketones (eqn. (686) [822]). Propargyl tungsten complexes reacted with aldehydes to give five membered oxygen heterocycles (eqn. (687) [823]).



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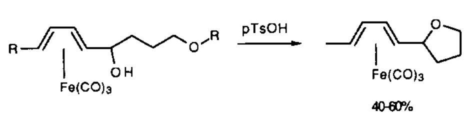

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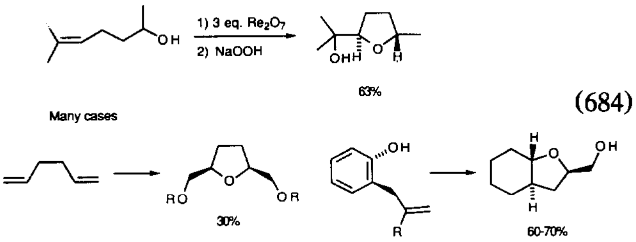

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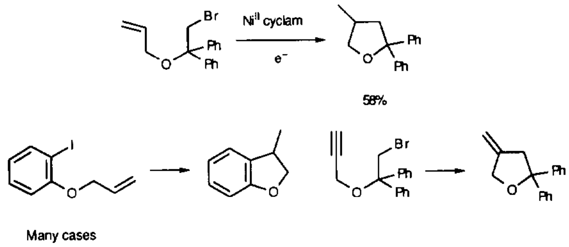

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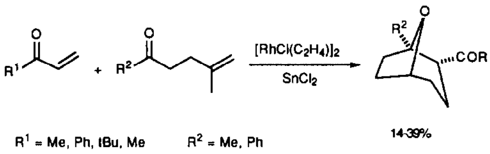

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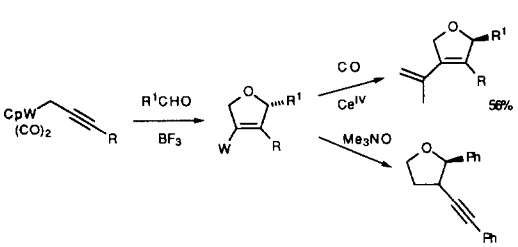
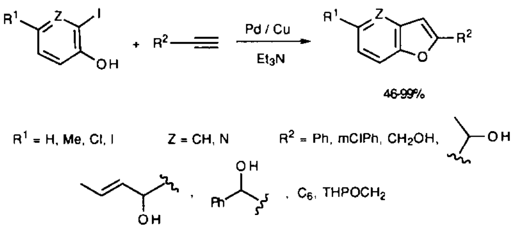


(687)

Palladium catalyzed the reaction between *o*-iodophenol and alkynes to give benzofurans (eqn. (688) [824,825]). Tantalum combined alkynes with isonitriles to produce furans (eqn. (689) [826]). Ruthenate oxidatively produced furans (eqn. (690) [827]). Palladium catalyzed the reaction between acetylenic ketones and aryl halides to produce furans (eqn. (691) [828]).



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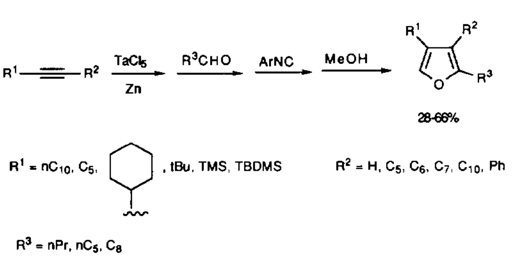

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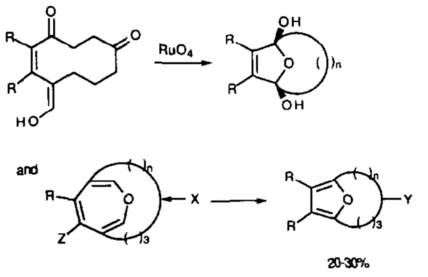

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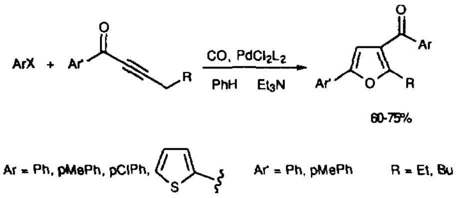
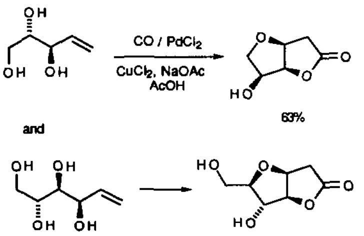


(691)

Furanones were synthesized by palladium catalyzed cyclizations (eqn. (692) [829,830], eqn. (693) [831]), by copper (eqn. (694) [832]), nickel (eqn. (695) [833]), and oxidative chemistry (eqn. (696) [834]). Chromium carbene complexes reacted with ketene acetals to give furanones (eqn. (697) [835]).



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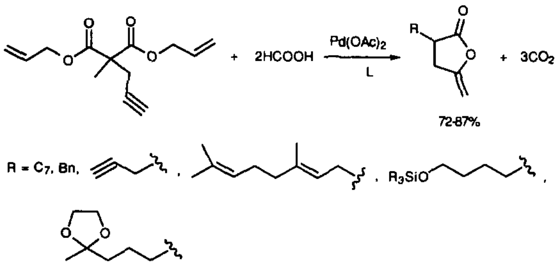

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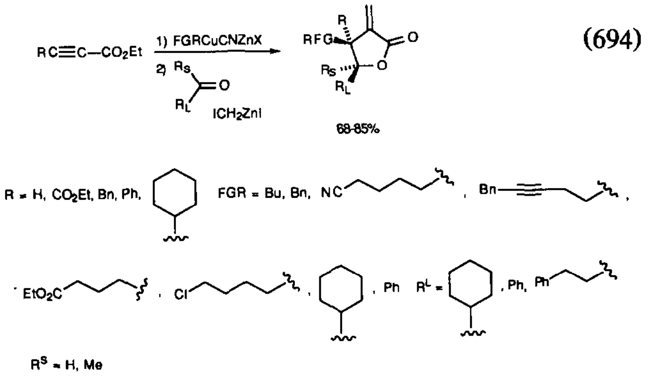

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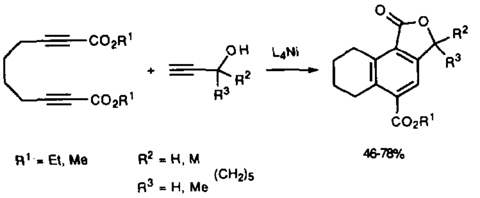

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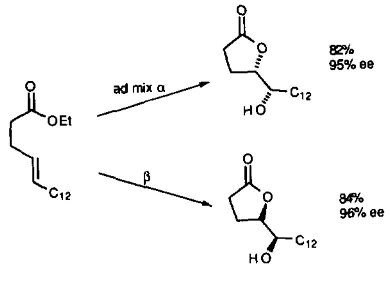

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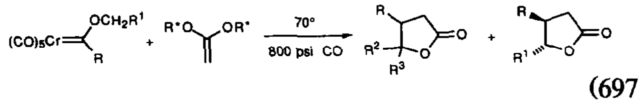
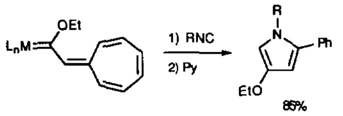


(697)

Pyrroles were made *via* chromium (eqn. (698) [836]) and rhodium (eqn. (699) [837]) carbene chemistry. Indoles were synthesized from alkynes and *o*-iodoanilines *via* palladium chemistry (eqn. (700) [838], eqn. (701) [839]), and by reductive carbonylation of nitrostyrenes (eqn. (702) [840]).



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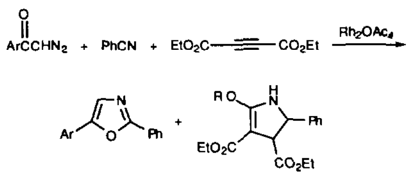

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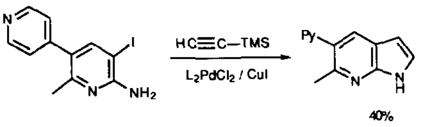

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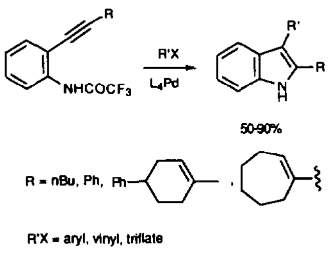

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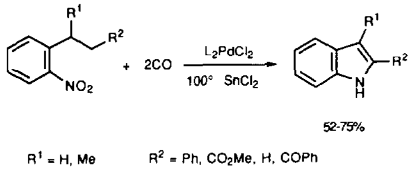
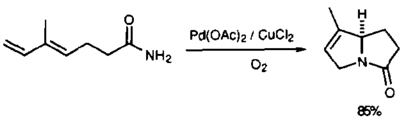


(702)

Five membered nitrogen heterocycles were made by palladium catalyzed olefin amination (eqn. (703) [841], eqn. (704) [842], eqn. (705) [843]), from chromium carbene chemistry (eqn. (706) [844], eqn. (707) [845]), and by iron acyl anion chemistry (eqn. (708) [846]). Rhodium catalyzed the cyclization of amino olefins (eqn. (709) [847]).



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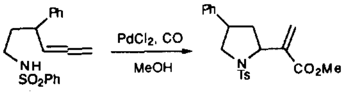

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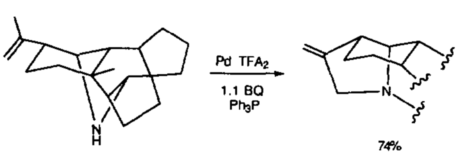

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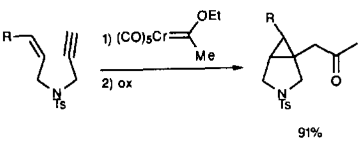

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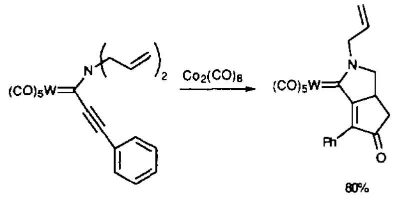

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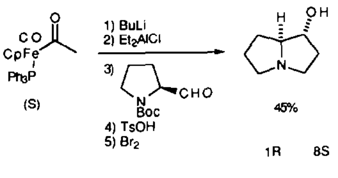

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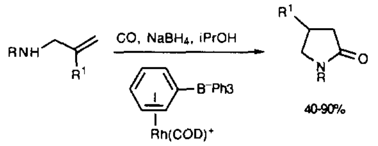
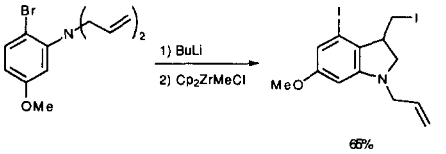


(709)

Five membered nitrogen heterocycles were also made by zirconium (eqn. (710) [848], eqn. (711) [849]) and titanium insertion chemistry (eqn. (712) [850]).



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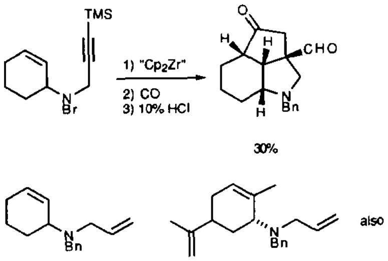

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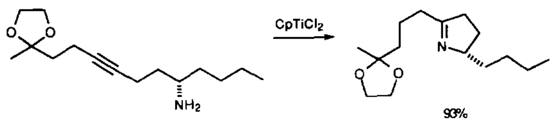
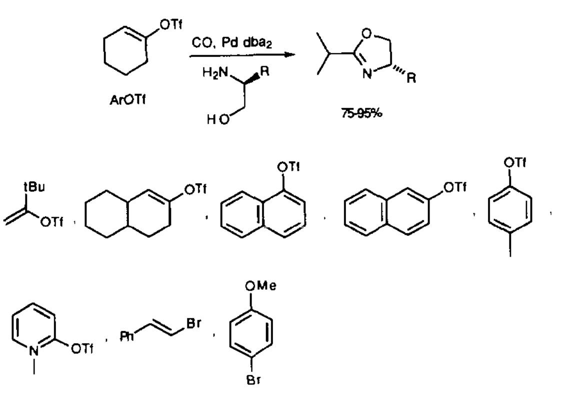
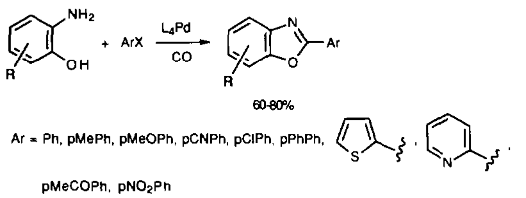


(712)

Oxazolines were synthesized by the palladium catalyzed aminocarbonylation of triflates (eqn. (713) [851]) and aryl halides (eqn. (714) [852]) and the gold-catalyzed condensation of aldehydes with α-isocyanoesters (eqn. (715) [853]). Oxazolidinones were prepared by palladium catalyzed olefin amidation (eqn. (716) [854], eqn. (717) [855]), palladium catalyzed isocyanate exchange into cyclic carbonates (eqn. (718) [856]), and the ruthenium catalyzed reaction of ureas with diols (eqn. (719) [852]).



(713)



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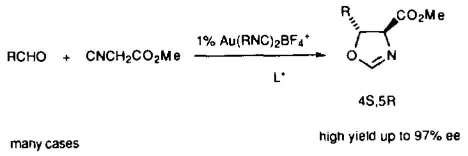

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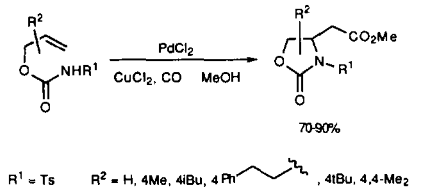

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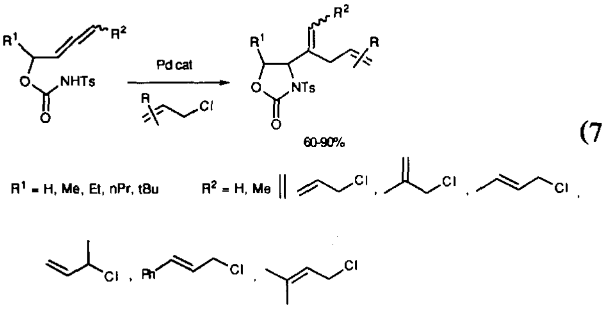

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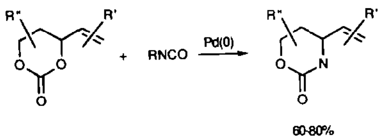

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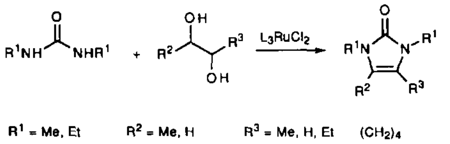
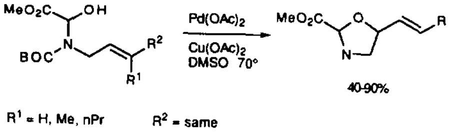


(719)

Other N, O-heterocycles were synthesized as in eqn. (720) [858], eqn. (721) [859], eqn. (722) [860], eqn. (723) [861], and eqn. (724) [862].



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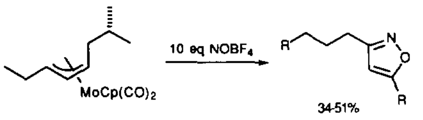

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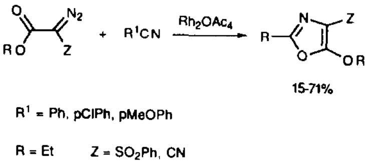
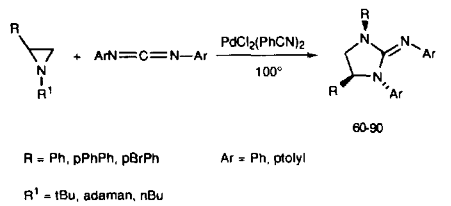


(722)



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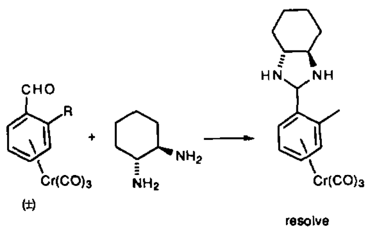
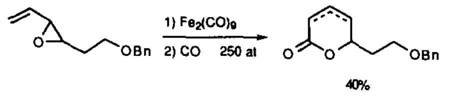
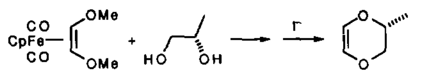


(724)

Six membered oxygen heterocycles were synthesized from allyl epoxides *via* iron chemistry (eqn. (725) [863]), iron alkene chemistry (eqn. (726) [864]), palladium catalyzed alkoxylation of olefins (eqn. (727) [865]), chromium carbene chemistry (eqn. (728) [866]) and osmium oxidation chemistry (eqn. (729) [867]).



(725)



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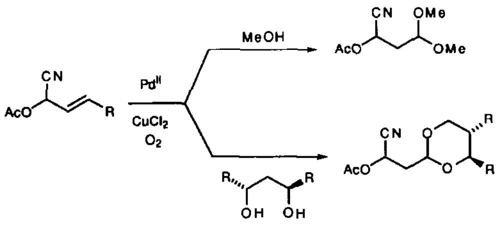

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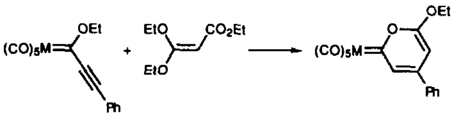
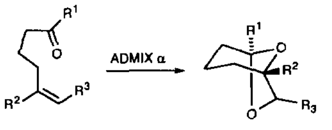
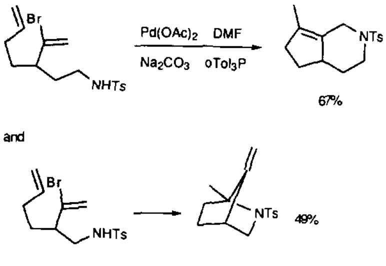


(728)



(729)

Six membered nitrogen heterocycles were prepared by palladium catalyzed olefin amination (eqn. (730) [868]), allylic amination (eqn. (731) [869], eqn. (732) [870]), palladium catalyzed alkyne amination (eqn. (733) [871], eqn. (734) [872], eqn. (735) [873], eqn. (736) [874]), rhodium catalyzed N-H insertion (eqn. (737) [875]), chromium carbene chemistry (eqn. (738) [876]), and ruthenium catalyzed oxidation chemistry (eqn. (739) [877]).



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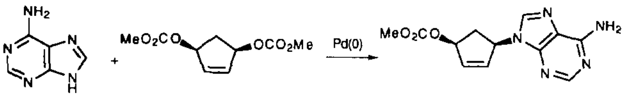

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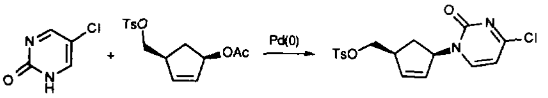

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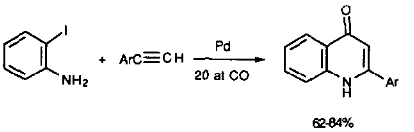

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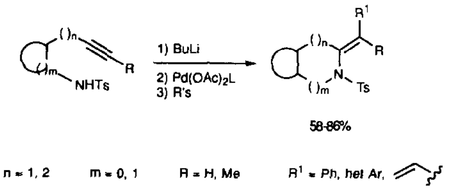

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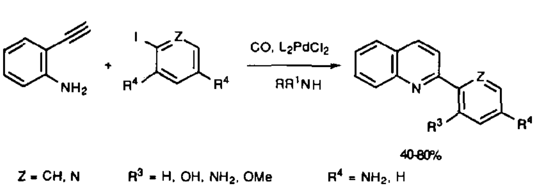

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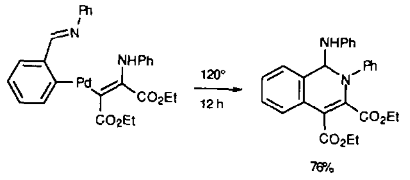

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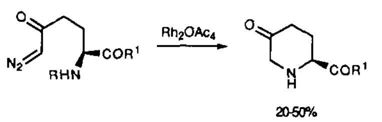

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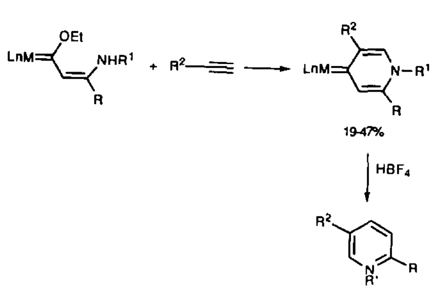

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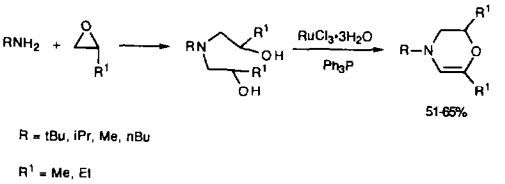
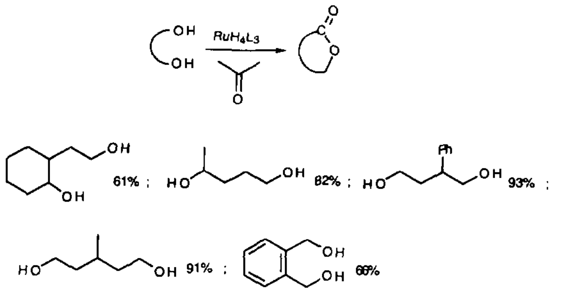


(739)

Other miscellaneous approaches to heterocycles are seen in eqn. (740) [878], eqn. (741) [879], eqn. (742) [880], eqn. (743) [881], eqn. (744) [882], eqn. (745) [883], and eqn. (746) [884].



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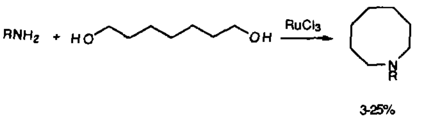

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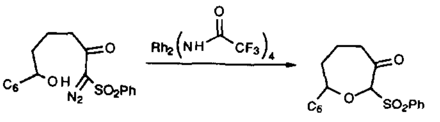

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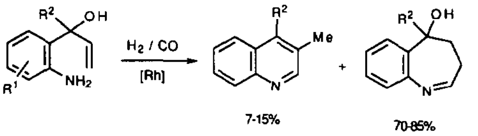

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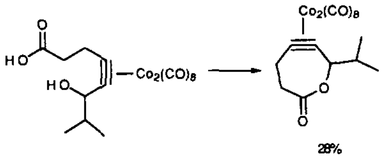
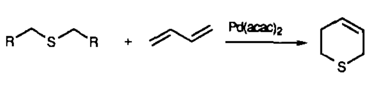


(will not close without complexation)

(744)



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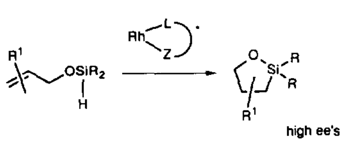


full paper, many substrates

(746)

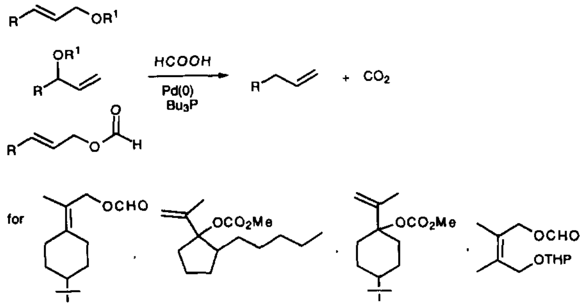
3.6. Alkanes, alkenes

Palladium (or nickel) catalyzed the reduction of aryl sulfonates (review, 11 references) [885], (eqn. (747) [886]), allyl sulfonates (eqn. (748) [887]), allyl ethers (eqn. (749) [888]), and allyl esters (eqn. (750) [889] and eqn. (751) [890]).

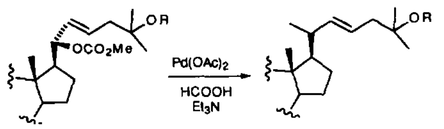
$$\mathrm{ArOTs} \xrightarrow{\mathrm{NaBH_4\,/\,NiCl_2}} \mathrm{ArH} \quad 90\%$$ (747)

Ar = L-naphth, pPhPh, pPhOPh, steroidal, etc.

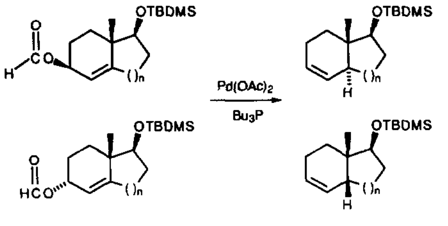
(748)



(749)



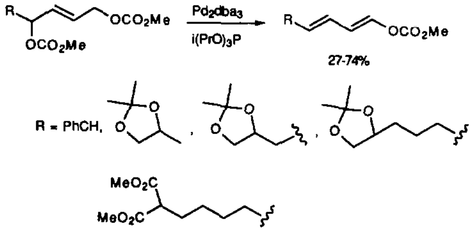
(750)



n = 1, 2 high yield, stereochemically clean

(751)

Palladium catalyzed the elimination of allyl esters to give dienes (eqn. (752) [891], eqn. (753) [892], eqn. (754) [893] and eqn. (755) [894]). Molybdenum isonitriles catalyzed a similar process (eqn. (756) [895]).



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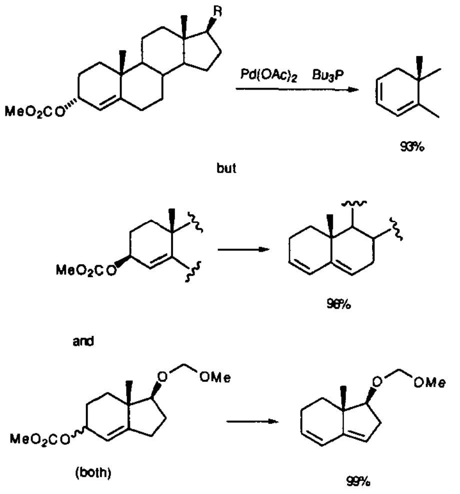
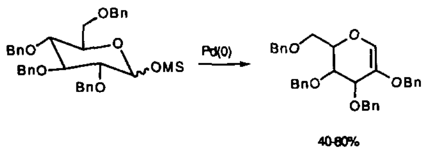
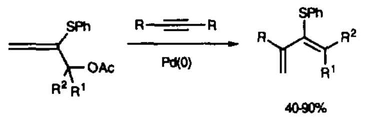


(753)



(754)



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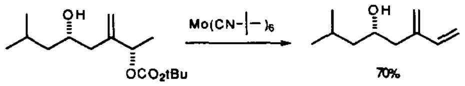
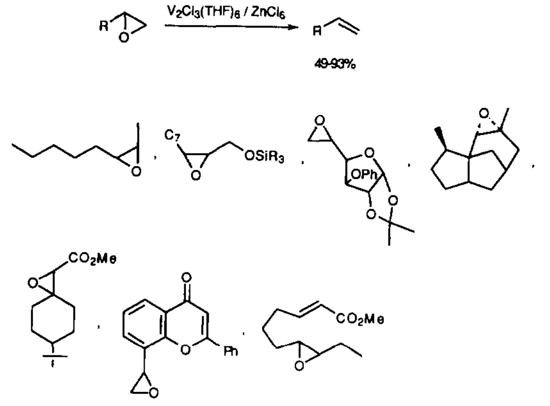


(756)

Reduced vanadium species deoxygenated epoxides (eqn. (757) [896]) while reduced titanium species deoxygenated diols (eqn. (758) [897]). Tungsten (eqn. (759) [898] and zirconium species (eqn. (760) [899]) deoxygenated organic compounds.



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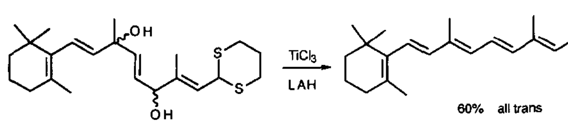
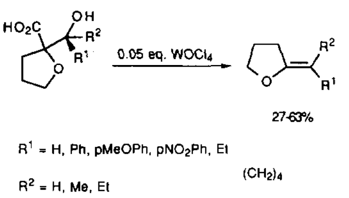


(758)



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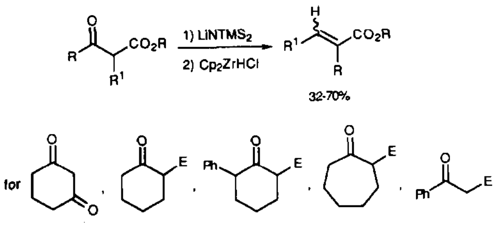
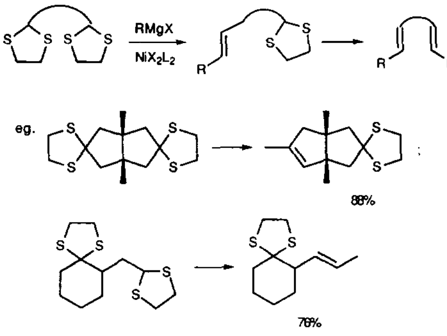


(760)

Grignard reagents converted thiols to alkenes in the presence of nickel catalysts (eqn. (761) [900] and eqn. (762) [901]). Hydrozirconation of long chain olefin sulfur compounds resulted in loss of the functional group (eqn. (763) [902]). Alkynes were reduced to alkenes by reduced tantalum or niobium species (eqn. (764) [903]). Functionalized alkenes were prepared by coupling alkyl zirconium to allylic halides (eqn. (765) [904]). Ruthenium complexes catalyzed phenolic coupling (eqn. (766) [905]). A catalyst system for decarbonylation of aldehydes was devised (eqn. (767) [906]).



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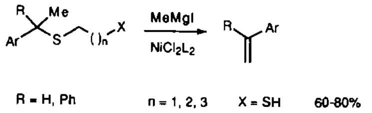

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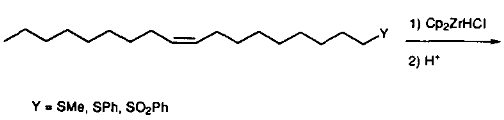

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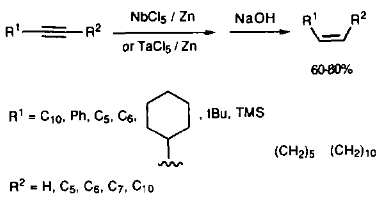

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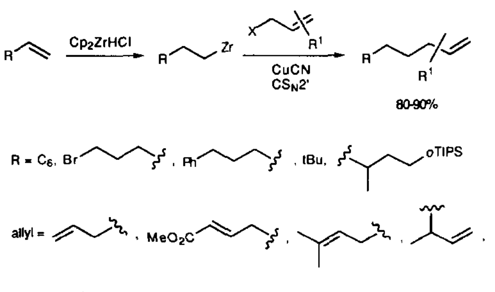

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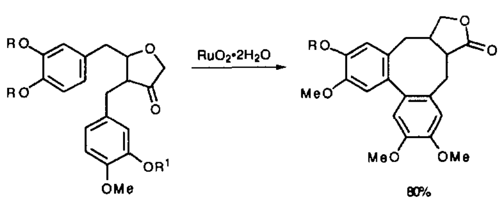
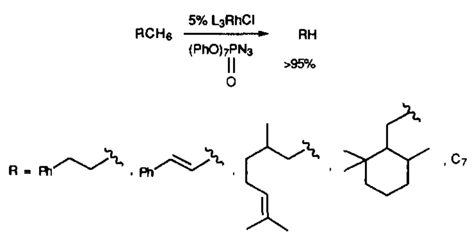


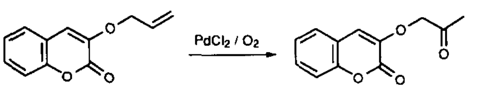
(766)



(767)

3.7. Ketones, aldehydes

Electrode mediated Wacker oxidation of cyclic olefins has been developed [907]. Palladium catalyzed the oxidation of alkenes to carbonyl compounds efficiently (eqn. (768) [908]), eqn. (769) [909], eqn. (770) [910], and eqn. (771) [911]). It catalyzed the amination of dihydropyrane (eqn. (772) [912]), the acetoxylation of propargyl acetates (eqn. (773) [913]), and the funny reaction in eqn. (774 [914]). Peroxy ditungstate oxidized alkenes to hydroxyketones (eqn. (775) [915]). Ruthenium catalyzed the cleavage of electron rich olefins to aldehydes [916].



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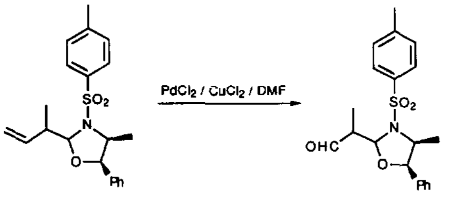

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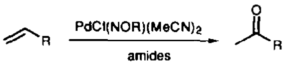

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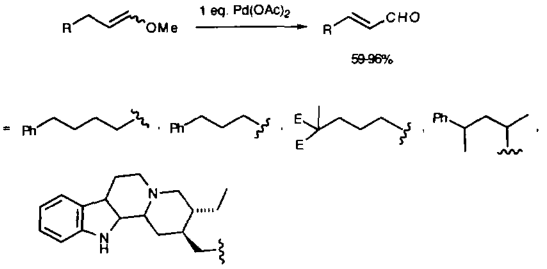

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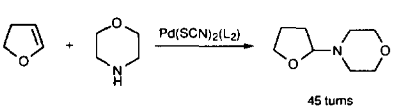

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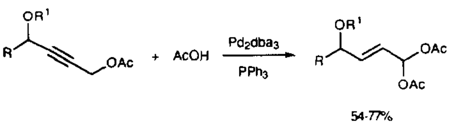

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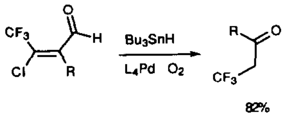

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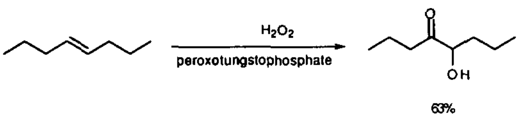
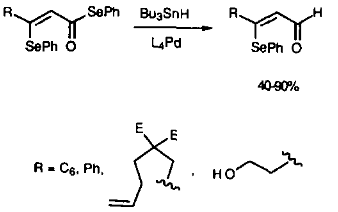


(775)

Palladium catalyzed the conversion of selenoesters to aldehydes (eqn. (776) [917]), the coupling of allyl alcohols to diketones (eqn. (777) [918]), and the cleavage of β-lactams to formamides (eqn. (778) [919]). Tungsten oxychloride converted α-hydroxyacids to ketones (eqn. (779) [920]). Iron acetylene complexes reacted with diphenyl ketene to give cyclopentenones (eqn. (780) [921]). Ruthenium complexes catalyzed the oxidation of alcohols to ketones (eqn. (781) [922]). Carbene complexes were converted to ketones thermally (eqn. (782) [923]).



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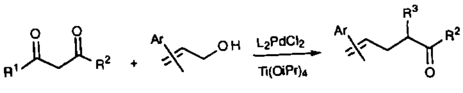

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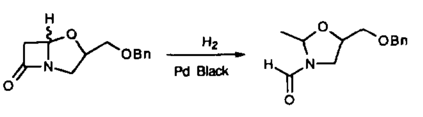

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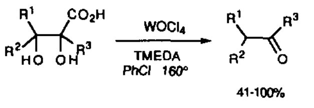

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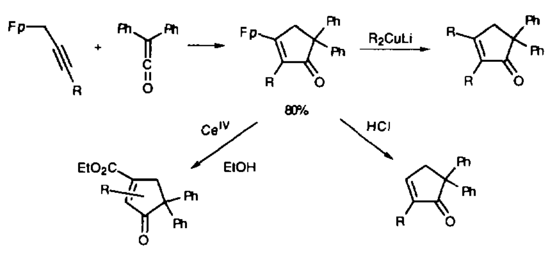

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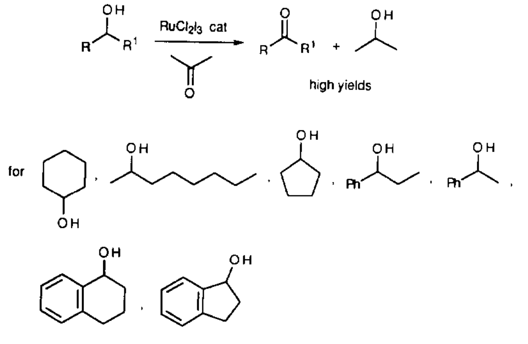

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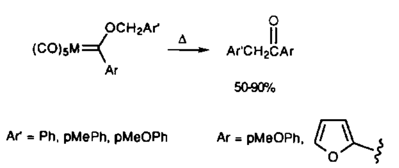


(782)

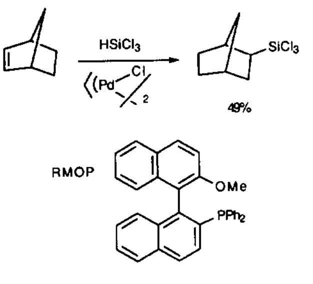
3.8. Organosilanes

Rhodium(II) catalyzed hydrosilylation was discussed in a current review (375 references) [924]. Rhodium (eqn. (783) [925]), palladium (eqn. (784) [926]) and zirconium (eqn. (785) [927]) catalyzed hydrosilylation of alkenes. Platinum catalyzed the disilylation of dienes (eqn. (786) [928]). Intramolecular hydrosilylation was developed in several systems (eqn. (787) [929], eqn. (788) [930], and eqn. (789) [931]).

$$\mathrm{RCH_2CH{=}CH_2} + \mathrm{R'_3SiH} \xrightarrow{\mathrm{Rh_2pfb_4}} \mathrm{RCH_2CH_2CH_2SiR'_3} \qquad (783)$$

good yield

R = nBu, C$_6$, C$_8$, Ph, pBuPh



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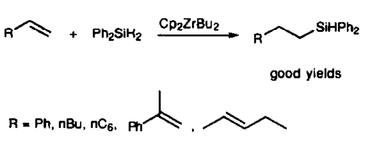

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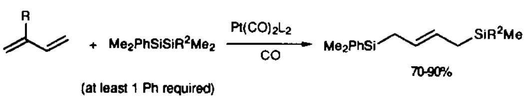

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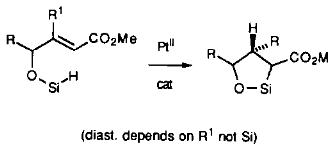

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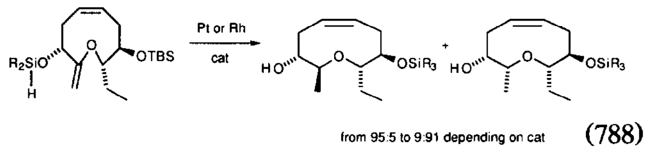

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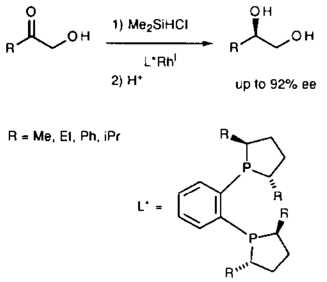
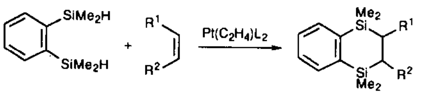


(789)

Cyclic disilanes were synthesized by metal catalyzed addition of disilanes to alkenes (eqn. (790) [932], eqn. (791) [933], eqn. (792) [934], eqn. (793) [935], and eqn. (794) [936]).



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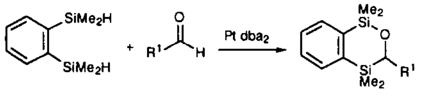

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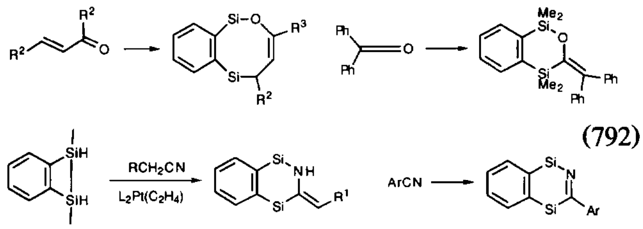

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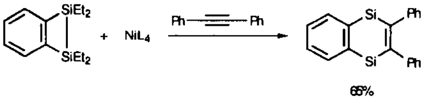

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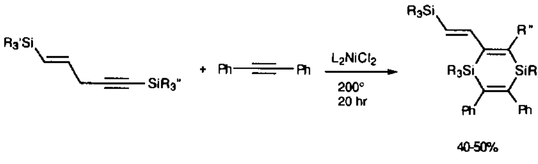
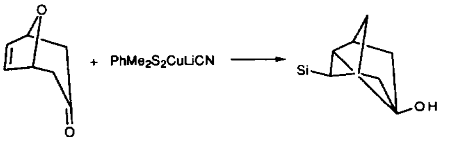


(794)

Other silylations are seen in eqn. (795) [937] and eqn. (796) [938].



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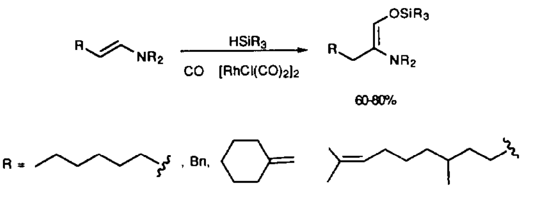
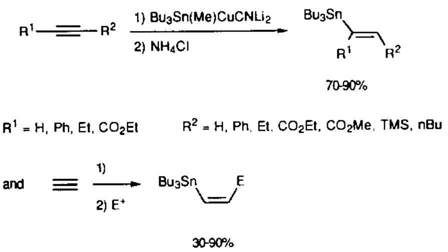


(796)

3.9. Miscellaneous

Herein are found all reactions which fit no other classification. Organotin compounds were made *via* organocopper chemistry (eqn. (797) [939], eqn. (798) [940], eqn. (799) [941], eqn. (800) [942]), organopalladium chemistry (eqn. (801) [943], eqn. (802) [944], eqn. (803) [945]), organozirconium chemistry (eqn. (804) [946]) and organochromium chemistry (eqn. (805) [947]).



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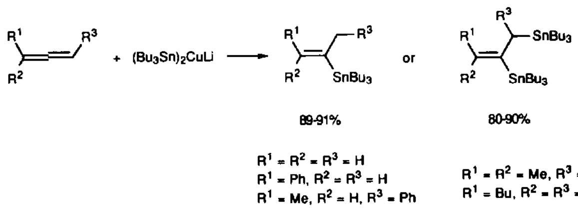

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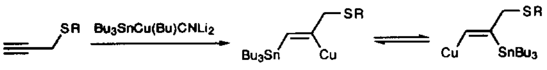

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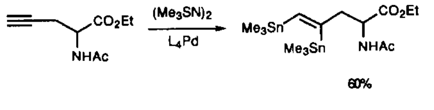

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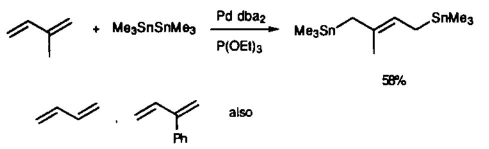

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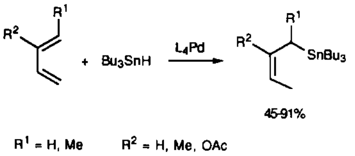

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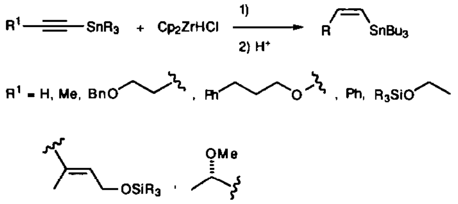

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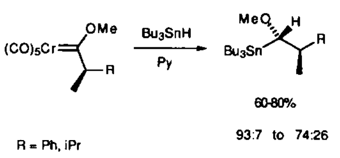
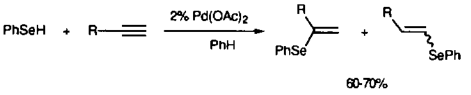


(805)

Palladium catalyzed the selenation of alkynes (eqn. (806) [948]). Zirconacycles underwent reaction with PhClBr (eqn. (807) [949]). Transition metals were used to introduce germanium (eqn. (808) [950]), boron (eqn. (809) [951]), phosphorous (eqn. (810) [952]), eqn. (811) [953]), and iron (eqn. (812) [954]) into organic substrates.



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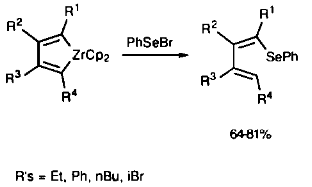

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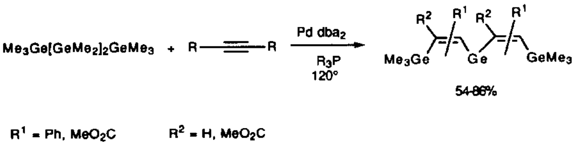

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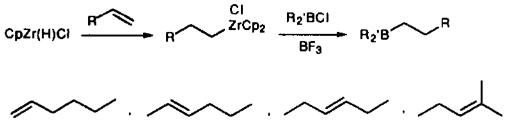

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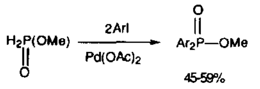

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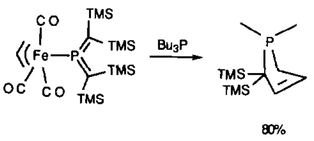

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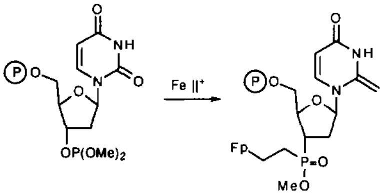
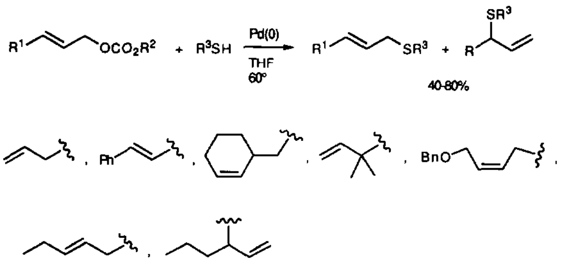


(812)

Palladium catalyzed the thiation of allyl carbonates (eqn. (813) [955]), aryl halides (eqn. (814) [956]), and alkynes (eqn. (815) [957]). Nucleosides were synthesized *via* zirconium (eqn. (816) [958]) and palladium chemistry (eqn. (817) [959] and eqn. (818) [960]). Hexaalkoxycyclohexanes were made by osmate oxidation (eqn. (819) [961]).



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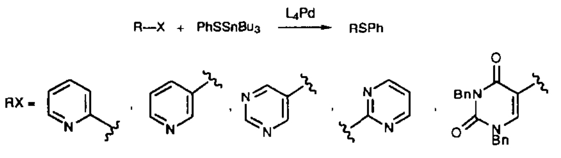
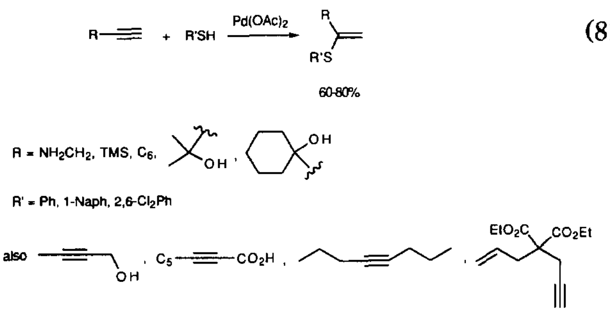


(814)



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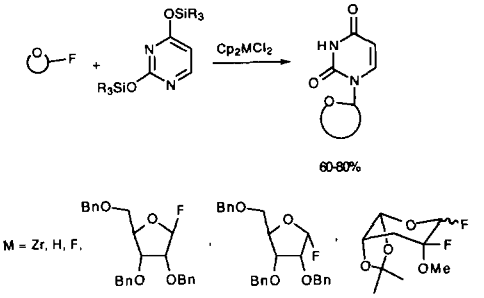

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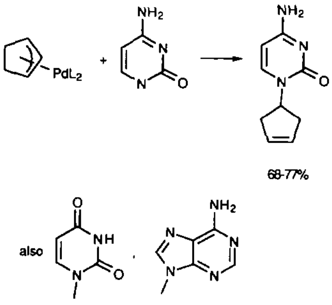

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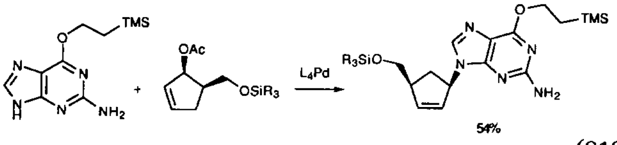

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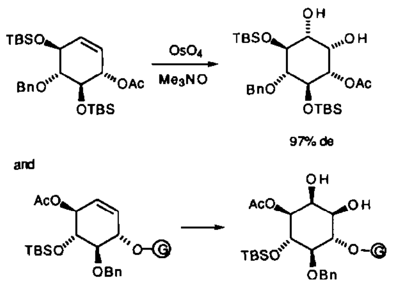

(819)

4. Reviews

The following reviews have appeared.

Dicobalt hexacarbonyl complexes as chirality relay for the differentiation of acetylenic diasteeomers [962];

Selected applications to organic synthesis of intramolecular C–H activation reactions by transition metals (12 references) [963];

Stereoselective synthesis with zirconium complexes (14 references) [964];

Biomimetic oxidation in organic synthesis using transition metal catalysts (31 references) [965];

Enzyme models and organometallic chemistry (15 references) [966];

The chemistry of polyfunctional organozinc and copper reagents (15 references) [967];
Applications of nickel(II)/chromium(II)-mediated coupling reactions to natural products syntheses (24 references) [968];
Synthesis and reactivity of iron tricarbonyl complexes of vinylketenes, vinylketenimines and vinylallenes (12 references) [969];
Asymmetric hydrogen transfer reactions promoted by homogeneous transition metal catalysts (more than 79 references) [970];
Enantioselective rhodium(II) catalysts (18 references) [971];
Organotitanium reagents in organic synthesis (21 papers) [972];
Synthesis of enantiomerically pure 2°α halo allylic alcohols and their use in the synthesis of leukotrienes (41 references) [973];
New aspects of organocopper reagents: 1,3- and 1,2-chiral induction and reaction mechanism (59 references) [974];
Remote substituent effects on regioselectivity of Rh(I) cat. hydroboration of norbornene [975];
Ruthenium oxo complexes as organic oxidants [976];
Transition metals in organic synthesis – hydroformylation, reduction, and oxidation (897 references) [977];
Catalytic asymmetric synthesis by means of secondary interaction between chiral ligands and substrates (129 references) [978];
Synthesis and application of chiral Cp metal complexes (122 references) [979];
Asymmetric hydrogen transfer reactions promoted by homogeneous transition metal catalysts (79 references) [980];
Transition metals in organic synthesis annual survey 1990 (1048 references) [981];
Fluorinated organometallics, perfluoroalkyl, and functionalized organometallic reagents in synthesis (297 references) [982];
Transition metal catalyzed reactions involving reactions with ammonia and amines (278 references) [983];
Recent developments in the synthesis of optically active α-arylpropanoic acids: an important class of non-steroidal anti-inflammatory agents (48 references) [984];
Synthesis of organophosphorous compounds via coordination spheres of transition metals (63 references) [985];
Synthesis and applications of binaphthylic C_2-symmetry derivatives as chiral auxilliaries in enantioselective reactions (86 references) [986];
Catalytic synthesis of optically active alcohols via hydrosilylation of olefins with a chiral monophosphine-palladium catalyst (19 references) [987];
Development of organopalladium(IV) chemistry: fundamental aspects and systems for studies of mechanism in organometallic chemistry and catalysis (many references) [988];
Transition metal catalyzed reactions of organozinc reagents (144 references) [989];
Recent advances in the asymmetric dihydroxylation of alkenes (101 references) [990];
Organic derivatives of manganese(II) in organic synthesis (99 references) [991];
Selectivity control in cobalt(0) catalyzed cycloaddition reactions (29 references) [992];
Organotitanium reagents in reduction reactions (41 references) [993];
Organometallic chemistry. Part 1. The transition elements (226 references) [994];
Organometallic chemistry. Part 2. Main-group elements (211 references) [995];
Synthesis of optically active natural products based on palladium-catalyzed stereoselective reduction of alkenyloxiranes (9 references) [996];
Organic synthesis via organometallics. Proceedings of the 3rd symposium in Marburg, July 11–14, 1990 [997];
Aminocarbene complexes of chromium and molybdenum: initiators for cascade reactions with alkynes leading to new heterocyclic compounds via nitrogen ylides (60 references) [998];
Palladium and BINAP, a strong pair (3 references) [999];
Regio-, stereo-, and enantioselectivity in palladium- and platinum-catalyzed organic reactions (more than 77 references) [1000];
Metals as selective coupling agents (4 references) [1001];
Titanium metallacycles as intermediates in the synthesis of acyclic and heterocyclic compounds (37 references) [1002];
Synthesis of optically active alcohols using ferrocene catalysts (29 references) [1003];
Ligand-controlled catalysis: chemo- to stereoselective syntheses from olefins and dienes over nickel catalysts (more than 40 references) [1004];
Basic principles in carbene chemistry and applications to organic synthesis (more than 42 references) [1005];
Chemical synthesis of optically pure compounds. 3. Asymmetric catalysis (42 references) [1006];
Carbonylchromium(0) complexes in organic synthesis (37 references) [1007];
Homogeneous catalysis by transition metal complexes (370 references) [1008];
Organo-iron complexes in aromatic synthesis (more than 14 references) [1009];
Regio- and stereocontrol in allylation (11 references) [1010];

Chemistry of organochromium(III) complexes (more than 85 referencees) [1011];
Organometallics in synthesis. The transition elements (89 references) [1012];
Transition metals which changed organic synthesis: fundamentals and applications [1013];
The allyl ether as a protecting group in carbohydrate chemistry (23 references) [1014];
Studies in organo-transition metal chemistry [1015];
Synthesis and reactivity patterns of (arene)manganese carbonyl and (cyclohexadienyl)manganese carbonyl derivatives [1016];
Application of organic copper compounds (87 references) [1017];
The chemistry of iron imido clusters and synergistic bimetallic iron/ruthenium catalysts for the carbonylation of nitroaromatics [1018];
Homogeneous catalytic oxidations using metalloporphyrin complexes with emphasis on ruthenium systems (67 references) [1019];
Allyl based side-chain protection for SPPS [1020];
Transition metals in organic synthesis: hydroformylation, reduction, and oxidation. Annual survey covering the year 1990 (897 references) [1021];
Palladium(II)-catayzed oxidation, isomerization and exchange of olefins, allylic alcohols and allylic ethers in water and methanol solvents [1022];
Palladium cluster catalysts supported on chelate resin-metal complexes (13 references) [1023];
Organic derivatives of manganese(II) in organic synthesis (99 references) [1024];
A new development of ruthenium complex catalysts. Carbon–carbon bond forming reactions (25 references) [1025];
Homogeneous metal-catalyzed oxidations by molecular oxygen (71 references) [1026];
Photocatalysis by transition-metal complexes (164 references) [1027];
Iron- and cobalt-induced activation of hydrogen peroxide and dioxygen for the selective oxidation-dehydrogenation and oxygenation of organic molecules (209 references) [1028];
Transition metal-promoted reactions of main group species and main group-promoted reactions of transition metal species (more than 76 references) [1029];
New routes to biologically active heterocyclic natural products (12 references) [1030];
New development in catalytic asymmetric hydrogenation (50 references) [1031];
Cyclizations made easy by transition metal catalysts (20 references) [1032];
High-velocity palladium catalysis (10 references) [1033];

References

1 V.N. Kalinin, *Synthesis*, (1992) 413.
2 R. van Asselt and C.J. Elsevier, *Organometallics*, *11* (1992) 1999.
3 M. Kuroda, J. Nakayama, M. Hoshino and N. Furasho, *Tetrahedron Lett.*, *33* (1992) 7553.
4 M. Uemura, R. Miyake, H. Nishimura, Y. Matsumoto and T. Hayashi, *Tetrahedron: Asymmetry*, *3* (1992) 213.
5 T.-M. Yuan and T.-Y. Luh, *J. Org. Chem.*, *57* (1992) 4550.
6 K.-T. Wong and T.-Y. Luh, *J. Chem. Soc., Chem. Commun.*, (1992) 564.
7 W.-L. Cheng and T.-Y. Luh, *J. Org. Chem.*, *57* (1992) 3516.
8 W.L. Cheng and T.-Y. Luh, *J. Chem. Soc., Chem. Commun.*, (1992) 1394.
9 C. Malanga, R. Menicagli and L. Lardicci, *Gazz. Chim. Ital.*, *122* (1992) 45.
10 R. Fischer, D. Walther, G. Brannlich, B. Undentsch, W. Ludwig and H. Bandmann, *J. Organomet. Chem.*, *427* (1992) 395.
11 B. Heckmann, C. Yu, J. Mioskowski and J.R. Falck, *Tetrahedron Lett.*, *33* (1992) 5201.
12 K. Mori and J.-L. Brevet, *Synthesis*, (1991) 1125.
13 Y. Zhang, C. Fu and W. Fan, *Youji Huaxue*, *12* (1992) 71.
14 J.M. Chong and E.K. Mar, *J. Org. Chem.*, *57* (1992) 46.
15 J.A. Marshall, T.D. Crute III and J.D. Hsi, *J. Org. Chem.*, *57* (1992) 115.
16 G. Molander and K.L. Bobbitt, *J. Org. Chem.*, *57* (1992) 5031.
17 V. Blancot-Courtas and I. Hanna, *Tetrahedron Lett.*, *33* (1992) 8087.
18 J.A. Bacigaluppo, M.I. Columbo, J. Zincuik and E.A. Ruveda, *Synth. Commun.*, *22* (1992) 1973.
19 A. Alexakis, M.-M. Barthel, J.F. Normant, C. Fugier and M. Leroux, *Synth. Commun.*, *22* (1992) 1839.
20 V. Vaillancourt and K.F. Albizati, *J. Org. Chem.*, *57* (1992) 3627.
21 J. Mathew, *J. Org. Chem.*, *57* (1992) 2753.
22 B.H. Lipshutz, P. Fatheree, W. Hagen and K.L. Stevens, *Tetrahedron Lett.*, *33* (1992) 1041.
23 Z.-Y. Yang, D.M. Wiemers and P.J. Burton, *J. Am. Chem. Soc.*, *114* (1992) 4402.
24 M.J. Rozema, A.R. Sidduri and P. Knochel, *J. Org. Chem.*, *57* (1992) 1956.
25 C. Jukert and P. Knochel, *J. Org. Chem.*, *57* (1992) 5425.
26 C.E. Tucker, T.N. Majid and P. Knochel, *J. Am. Chem. Soc.*, *114* (1992) 3983.
27 S.A. Rao, T.-S. Chou, I. Snipor and P. Knochel, *Tetrahedron*, *48* (1992) 2025.
28 A. Sidduri, N. Budries, R.M. Laine and P. Knochel, *Tetrahedron Lett.*, *33* (1992) 7515.
29 T. Kauffmann and D. Stack, *Chem. Ber.*, *125* (1992) 913.
30 A.N. Kasatkin, O.Yu. Tsypysheva, T.Yu. Romanova and G.A. Tolstikov, *Metalloorg. Khim.*, *5* (1992) 443.
31 A.N. Kasatkin, O. Yu. Tsypysheva, T.Yu. Romanova and G.A. Tolstikov, *Izv. Akad. Nauk SSSR, Ser. Khim.*, *3* (1991) 656.
32 W.-C. Shieh and J.A. Carlson, *J. Org. Chem.*, *57* (1992) 379.
33 P. Ciattini, E. Morera and G. Ortar, *Tetrahedron Lett.*, *33* (1992) 4815.
34 Y. Yang and A.R. Martin, *Heterocycles*, *34* (1992) 1395.
35 Y. Yang and A.R. Martin, *Synth. Commun.*, *22* (1992) 1757.
36 D.F. O'Keefe, M.C. Dannock and S.M. Marcuccio, *Tetrahedron Lett.*, *33* (1992) 6679.
37 N.M. Ali, A. McKillop, M.B. Mitchell, R.A. Rebelo and P.T. Wallbank, *Tetrahedron*, *48* (1992) 8117.

38 T.M. Miller, T.X. Neenan, R. Zayas and H.E. Bair, *J. Am. Chem. Soc.*, *114* (1992) 1018.

39 A. Alvarez, A. Guzman, A. Ruiz, E. Verlarde and J.M. Muchowski, *J. Org. Chem.*, *57* (1992) 1653.

40 C.M. Unrau, M.G. Campbell and V. Snieckus, *Tetrahedron Lett.*, *33* (1992) 2773.

41 A. Godard, J.-C. Rovera, F. Marsais, N. Plé and G. Quequiner, *Tetrahedron*, *48* (1992) 4123.

42 T. Watanabe, N. Miyaura and A. Suzuki, *Synth. Lett.*, (1992) 207.

43 P.J. Cox, W. Wang and V. Snieckus, *Tetrahedron Lett.*, *33* (1992) 2253.

44 W. Wang and V. Snieckus, *J. Org. Chem.*, *57* (1992) 424.

45 A.G. Brown, M.J. Crimmin and P.D. Edwards, *J. Chem. Soc., Perkin Trans. 1*, *1* (1992) 123.

46 T. Ishiyama, T. Oh-e, N. Miyaura and A. Suzuki, *Tetrahedron Lett.*, *33* (1992) 4465.

47 I. Rivera, J.C. Colberg and J.A. Soderquist, *Tetrahedron Lett.*, *33* (1992) 6919.

48 J. Ichikawa, C. Ikeura and T. Minami, *Synth. Lett.*, (1992) 739.

49 A.R. de Lera, A. Corrado, B. Iglesias and S. Lopez, *Tetrahedron Lett.*, *33* (1992) 6205.

50 Y. Nomoto, N. Miyaura and A. Suzuki, *Synth. Lett.*, (1992) 727.

51 B. Santiago and J.A. Soderquist, *J. Org. Chem.*, *57* (1992) 5844.

52 S. Abe, N. Miyaura and A. Suzuki, *Bull. Chem. Soc. Jpn.*, *65* (1992) 2863.

53 T. Ishiyama, S. Abe, N. Miyaura and A. Suzuki, *Chem. Lett.*, (1992) 691.

54 T.N. Mitchell, *Synthesis*, (1992) 803.

55 T. Sakamoto, A. Yasuhara, Y. Kondo and H. Yamanaka, *Chem. Pharm. Bull.*, *40* (1992) 1137.

56 Y. Yang and A.R. Martin, *Synth. Commun.*, *22* (1992) 1757.

57 T. Sakamoto, A. Yasuhara, Y. Kondo and H. Yamanaka, *Synlett.*, (1992) 502.

58 C. Booth, H. Imanich, P. Quayle and L.S. Yu, *Tetrahedron Lett.*, *33* (1992) 413.

59 J.M. Saa, G. Martorell and A. Garcia-Raso, *J. Org. Chem.*, *57* (1992) 678.

60 M. Hedberg, A.M. Johansson and U. Hacksell, *J. Chem. Soc., Chem. Commun.*, (1992) 845.

61 D. Badone, R. Cecchi and U. Guzzi, *J. Org. Chem.*, *57* (1992) 6321.

62 D.A. Elsley, D. MacLeod, J.A. Miller and P. Quayle, *Tetrahedron Lett.*, *33* (1992) 409.

63 J. Malin, P. Björk, S. Gronowitz and A.-B. Hörnfelt, *Tetrahedron Lett.*, *33* (1992) 2199.

64 B.C. Pearce, *Synth. Commun.*, *22* (1992) 1627.

65 Y. Yang and H.N.C. Wong, *J. Chem. Soc., Chem. Commun.*, (1992) 1723.

66 G.J. Hollingworth and J.B. Sweeney, *Tetrahedron Lett.*, *33* (1992) 7049.

67 I. Beaudet, J.-L. Parrain and J.-P. Quintard, *Tetrahedron Lett.*, *33* (1992) 3647.

68 A. Degl'Innocenti, E. Stucchi, A. Capperucci, A. Mordini, G. Reginato and A. Ricci, *Synlett*, (1992) 332.

69 A.M. Boldi, J. Anthony, C.B. Knobler and F. Diederich, *Angew. Chem., Int. Ed. Engl.*, *31* (1992) 1240.

70 C.R. Johnson, J.P. Adams, M.P. Braun and C.B.W. Senayake, *Tetrahedron Lett.*, *33* (1992) 919.

71 D.J. Krysan, A. Gurski and L.S. Liebeskind, *J. Am. Chem. Soc.*, *114* (1992) 1412.

72 R.K. Bhatt, D.-S. Shin, J.R. Falck and C. Mioskowski, *Tetrahedron Lett.*, *33* (1992) 4885.

73 Y. Quenean, W.J. Krol, W.G. Bormann and S.J. Danishefsky, *J. Org. Chem.*, *57* (1992) 4043.

74 E. Dubois and J.M. Beau, *Carbohydr. Res.*, *223* (1992) 157.

75 D.A. Evans and W.C. Black, *J. Am. Chem. Soc.*, *114* (1992) 2261.

76 Q. Han and D.F. Wiemer, *J. Am. Chem. Soc.*, *114* (1992) 7692.

77 S.-I. Hashimoto, A. Suzuki, T. Shinoda, Y. Miyazaki and S.I. Kegami, *Chem. Lett.*, (1992) 1835.

78 R.M. Moriarty and W.R. Epa, *Tetrahedron Lett.*, *33* (1992) 4095.

79 H. Rolland, P. Potin, J.-P. Majoral and G. Bertrand, *Tetrahedron Lett.*, *33* (1992) 8095.

80 M. Isaka, S. Ejiri and E. Nakamura, *Tetrahedron*, *48* (1992) 2405.

81 B. Jiang and Y. Xu, *Tetrahedron Lett.*, *33* (1992) 511.

82 A. Löffler and G. Himbert, *Synthesis*, (1992) 495.

83 T. Sakamoto, Y. Kondo, N. Murata and H. Yamanaka, *Tetrahedron Lett.*, *33* (1992) 5373.

84 A. Pimm, P. Kocienski and S.D.A. Street, *Synlett*, (1992) 886.

85 E. Piers and J.Y. Roberge, *Tetrahedron Lett.*, *33* (1992) 6923.

86 L. Labandiniere and J.-F. Normant, *Tetrahedron Lett.*, *33* (1992) 6139.

87 T. Sato, A. Kawase and T. Hirose, *Synlett*, (1992) 891.

88 R. Rossi, A. Carpita and P. Cossi, *Tetrahedron Lett.*, *33* (1992) 4495.

89 J.R. Waas, A. Sidduri and P. Knochel, *Tetrahedron Lett.*, *33* (1992) 3717.

90 Y. Hatanaka and T. Hiyama, *Synlett*, *12* (1991) 845.

91 R. Rossi, A. Carpita and T. Messeri, *Gazz. Chim. Ital.*, *122* (1992) 65.

92 W.G. Rajeswaran and P.C. Srinivasan, *Synthesis*, (1992) 835.

93 J. Ichikawa, T. Minami, T. Sonoda and H. Kobayashi, *Tetrahedron Lett.*, *33* (1992) 3779.

94 L. Labaudiniere, J. Hanaizi and J.-F. Normant, *J. Org. Chem.*, *57* (1992) 6903.

95 K. Hiroata, Y. Kitade, Y. Kanbe and Y. Maki, *J. Org. Chem.*, *57* (1992) 5269.

96 T. Sakamoto, Y. Kondo, T. Sugimone, S. Ohba and H. Yamancha, *Synthesis*, (1992) 552.

97 R.F.W. Jackson, N. Wishart and M.J. Wythes, *J. Chem. Soc., Chem. Commun.*, (1992) 1587.

98 M. Perez, A.M. Castaño and A.M. Echavarren, *J. Org. Chem.*, *57* (1992) 5047.

99 R. Pelliciari, M.A. Gallo-Mezo, B. Natalini and A.M. Amer, *Tetrahedron Lett.*, *33* (1992) 3003.

100 K.-T. Kang, S.S. Kim, J.C. Lee and J.S. U, *Tetrahedron Lett.*, *33* (1992) 3495.

101 Y. Yang and N.C. Wong, *J. Chem. Soc., Chem. Commun.*, (1992) 656.

102 J.E. Baldwin, R.M. Adlington and S.H. Ramcharitar, *Synlett*, (1992) 875.

103 T.N. Mitchell and K. Kwetkat, *J. Organomet. Chem.*, *439* (1992) 127.

104 W.R. Klein and R.D. Rieke, *Synth. Commun.*, *22* (1992) 2635.

105 P. Wipf and W. Xu, *Synlett*, (1992) 718.

106 G.W. Ebert, J.W. Cheasty, S.S. Tehrani and E. Aouad, *Organometallics*, *11* (1992) 1561.

107 G. Cahiez, P.-Y. Chavant and E. Metais, *Tetrahedron Lett.*, *33* (1992) 5245.

108 G. Cahiez and B. Labone, *Tetrahedron Lett.*, *33* (1992) 4439.

109 J.P. Genet, E. Blart and M. Savignar, *Synlett*, (1992) 715.

110 Z. Zhuangyu, P. Yi, H. Honwen and K. Tsi-yu, *Synthesis*, (1992) 539.

111 R.L. Augustine and S.T. L'Leary, *J. Mol. Catal.*, *72* (1992) 229.

112 L. Hong and E. Ruckenstein, *React. Polym.*, *16* (1992) 181.

113 W. Cabri, I. Candiani, A. Bedeschi and R. Santi, *J. Org. Chem.*, *57* (1992) 3558.

114 W. Cabri, I. Candiani, A. Bedeschi and S. Penco, *J. Org. Chem.*, *57* (1992) 1481.
115 T. Hayashi, A. Kubo and F. Ozawa, *Pure Appl. Chem.*, *64* (1992) 421.
116 M. Shibasaki, Y. Sato and K. Kagechika, *Yuki Gosei Kagaku Kyokaishi*, *50* (1992) 826.
117 G.T. Crisp and P.T. Glink, *Tetrahedron*, *48* (1992) 3541.
118 G.W. Gribble and S.C. Conway, *Synth. Commun.*, *22* (1992) 2129.
119 W. Cabri, I. Candiani, A. Bedeschi and R. Santi, *Synlett*, (1992) 871.
120 A.S. Carlstrom and T. Frejd, *Acta Chem. Scand.*, *46* (1992) 163.
121 C.A. Busacca and R.E. Johnson, *Tetrahedron Lett.*, *33* (1992) 165.
122 S. Torii, H. Okumoto and T. Kotani, *Synlett*, (1992) 349.
123 Y. Ben-David, M. Portnoy, M. Gozin and D. Milstein, *Organometallics*, *11* (1992) 1995.
124 S. Torii, H. Okamoto, H. Ozaki, S. Nakayasu, T. Tadokovo and T. Kotani, *Tetrahedron Lett.*, *33* (1992) 3499.
125 H. Brunner and K. Kransler, *Synthesis*, (1991) 1121.
126 M. Catellani and G.P. Chiusoli, *J. Organomet. Chem.*, *437* (1992) 369.
127 T. Jeffery, *Tetrahedron Lett.*, *33* (1992) 1989.
128 H.-C. Zhang and G.D. Daves Jr., *J. Org. Chem.*, *57* (1992) 4690.
129 F. Ozawa, A. Kubo and T. Hayashi, *Tetrahedron Lett.*, *33* (1992) 1485.
130 R. Benhaddon, S. Czernecki and G. Ville, *J. Org. Chem.*, *57* (1992) 4612.
131 T. Sakamoto, Y. Kondo and H. Yamanaka, *Tetrahedron Lett.*, *33* (1992) 6845.
132 F. Ozawa and T. Hayashi, *J. Organomet. Chem.*, *428* (1992) 267.
133 K. Nilsson and A. Hallberg, *J. Org. Chem.*, *57* (1992) 4015.
134 P. Yi, Z. Zhanangyu and H. Hongwen, *Synth. Commun.*, *22* (1992) 2019.
135 E. Bernocchi, S. Cacchi, P.G. Ciattini, E. Merera and E. Ortar, *Tetrahedron Lett.*, *33* (1992) 3073.
136 P.K. Singh, B.K. Rohtagi and R.N. Khanna, *Synth. Commun.*, *22* (1992) 987.
137 L.E. Overman, M.M. Abelman, D.J. Kuera, V.D. Tran and D.J. Ricca, *Pure Appl. Chem.*, *64* (1992) 1813.
138 S. Ma, *Youji Huaxue*, *11* (1991) 561.
139 L. Cao, M. Bei and L. Hua, *Fenzi Cuihua*, *5* (1991) 296.
140 Y. Yokoyama, H. Suzuki, S. Matsumoto, Y. Sunaga, M. Tani and Y. Murakami, *Chem. Pharm. Bull.*, *39* (1991) 2830.
141 T. Hudlicky and H.F. Olivo, *J. Am. Chem. Soc.*, *114* (1992) 9694.
142 J.E. Macor, D.H. Blank, R.J. Post and K. Ryan, *Tetrahedron Lett.*, *33* (1992) 8011.
143 S.C. Yang, H.M. Wang, C.S. Kuo and L.C. Chen, *J. Chin. Chem. Soc.*, *39* (1992) 169.
144 A. Madin and L.E. Overman, *Tetrahedron Lett.*, *33* (1992) 4859.
145 A. Ashimori and L.E. Overman, *J. Org. Chem.*, *57* (1992) 4571.
146 D.St.C. Black, P.A. Keller and N. Kumar, *Tetrahedron*, *48* (1992) 7601.
147 S. Liang and L.A. Paquette, *Acta Chem. Scand.*, *46* (1992) 597.
148 J. Mascureñas, A.M. Garcia, L. Castedo and A. Mouriño, *Tetrahedron Lett.*, *33* (1992) 4365.
149 N. Miyaura, M. Ishikawa and A. Suzuki, *Tetrahedron Lett.*, *33* (1992) 2571.
150 Y. Sato, T. Honda and M. Shibasaki, *Tetrahedron Lett.*, *33* (1992) 2593.
151 Y. Sato, S. Watanabe and M. Shibasaki, *Tetrahedron Lett.*, *33* (1992) 2589.
152 H.M.R. Hoffmann, *Angew. Chem.*, *104* (1992) 1361.
153 Z. Owczarczyk, F. Lamaty, E.J. Vawter and E.-I. Negishi, *J. Am. Chem. Soc.*, *114* (1992) 1009.
154 B. Burns, R. Grigg, V. Santhakumar, V. Sridharan, P. Stevenson and T. Worskan, *Tetrahedron*, *48* (1992) 7297.
155 G. Balme, D. Bonyssi, R. Faure, J. Gore and B. van Hemelryck, *Tetrahedron*, *19* (1992) 3891.
156 R. Grigg, P. Kennewell and A.J. Teasdale, *Tetrahedron Lett.*, *33* (1992) 7789.
157 R.C. Cambie, M.R. Metzler, C.E.F. Rickard, P.S. Rutledge and P.D. Woodgate, *J. Organomet. Chem.*, *426* (1992) 213.
158 R.C. Cambie, M.R. Metzler, P.S. Rutledge and P.D. Woodgate, *J. Organomet. Chem.*, *429* (1992) 59.
159 A. Ali, D.C. Harrowven and G. Pattenden, *Tetrahedron Lett.*, *33* (1992) 2851.
160 F.O.H. Pirrung, W.J.M. Steeman, H. Hiemstra, W.N. Speckamp, B. Kaptein, W.H.J. Boesten, H.E. Schoemaker and J. Kamphius, *Tetrahedron Lett.*, *33* (1992) 5141.
161 H. Nagashima, H. Wakamatsu, N. Ózaki, T. Ishii, M. Watanabe, T. Tajima and K. Itoh, *J. Org. Chem.*, *57* (1992) 1682.
162 T. Luebbers and H.J. Schaefer, *Synlett*, *9* (1992) 743.
163 H.I. Tashtoush and R. Sustmann, *Chem. Ber.*, *125* (1992) 287.
164 C.J. Rousset, E.-I. Negishi, N. Suzuki and T. Takahashi, *Tetrahedron Lett.*, *33* (1992) 1965.
165 A. Hoveyda, J.P. Morken, A.F. Houre and Z. Xu, *J. Am. Chem. Soc.*, *114* (1992) 6692.
166 T.-E. Mitsudo, M. Takagi, S.-W. Zhang and Y. Watanabe, *J. Organomet. Chem.*, *423* (1992) 405.
167 P.J. Kocienski, M. Prichard, S.N. Wadman, R.J. Whitby and C.L. Xeates, *J. Chem. Soc., Perkin Trans. 1*, (1992) 3419.
168 J.-P. Ducoux, P.Le Menez, N. Kunesuch, G. Kunesch and E. Wenkert, *Tetrahedron Lett.*, *48* (1992) 6403.
169 P.A. Ashworth, N.J. Dixon, P.J. Kocienski and S.N. Wadman, *J. Chem. Soc., Perkin Trans. 1*, (1992) 3431.
170 H.-J. Gais and G. Bülow, *Tetrahedron Lett.*, *33* (1992) 465.
171 H.-J. Gais and G. Bülow, *Tetrahedron Lett.*, *33* (1992) 461.
172 Y. Wang, Z.-Y. Yang and D.J. Burton, *Tetrahedron Lett.*, *33* (1992) 2137.
173 Z.-Y. Yang and D.J. Burton, *J. Org. Chem.*, *57* (1992) 5144.
174 Z.-Y. Yang, B.V. Nguyen and D.J. Burton, *Synlett*, (1992) 141.
175 E. Nakamura, K. Kubota and M. Isaka, *J. Org. Chem.*, *57* (1992) 5809.
176 M.P. Doyle, M.Y. Eismont, D.E. Bergbreiter and H.N. Gray, *J. Org. Chem.*, *57* (1992) 6103.
177 S.F. Martin, C.J. Oalmann and S. Liras, *Tetrahedron Lett.*, *33* (1992) 6727.
178 D.F. Taker and R.S. Hoerner, *J. Org. Chem.*, *57* (1992) 441.
179 H.M.L. Davies and B. Hu, *Tetrahedron Lett.*, *33* (1992) 453.
180 A. de Meijere, T.J. Schulz, R. Kostikov, F. Graupner, T. Murr and T. Bielfelt, *Synthesis*, (1992) 547.
181 J.L. Maxwell, K.C. Brown, D.W. Bartley and T. Kodadek, *Science*, *256* (1992) 1544.
182 J.L. Maxwell, S. O'Malley, K.C. Brown and T. Kodadek, *Organometallics*, *11* (1992) 645.
183 S. O'Malley and T. Kodadek, *Organometallics*, *11* (1992) 2299.
184 U. Leutenegger, G. Umbricht, C. Fahrni, P. von Matt and A. Pfaltz, *Tetrahedron*, *48* (1992) 2143.
185 D.A. Evans, K.H. Woerpel and M.J. Scott, *Angew. Chem., Int. Ed. Engl.*, *31* (1992) 430.
186 H. Brunner and K. Wutz, *New. J. Chem.*, *16* (1992) 57.
187 A. Demonceau, E. Saive, Y. de Froidmont, A.F. Noels and A.J. Hubert, *Tetrahedron Lett.*, *33* (1992) 2009.
188 K. Gunaydin and O. Anac, *Rev. Roum. Chim.*, *36* (1991) 1325.

189 I. Basnak, K. Jurkovic and G. Basnakova, *Synth. Commun.*, *22* (1992) 773.

190 Z. Li, H. Chen, Z. Yu and H. Guo, *Yingyong Huaxue*, *9* (1992) 102.

191 K. Paulini and H.-U. Reissig, *Synlett*, (1992) 505.

192 E.A. Shapiro, A.V. Kalinin and O.M. Nefedov, *Org. Prep. Proced. Int.*, *24* (1992) 517.

193 M.N. Protopopova, M.P. Doyle, P. Müller and D. Ene, *J. Am. Chem. Soc.*, *114* (1992) 2755.

194 R. Gleiter and M. Meiger, *Tetrahedron Lett.*, *33* (1992) 3473.

195 S.-I. Hashimoto, N. Watanabe and S. Ikegami, *Tetrahedron Lett.*, *33* (1992) 2709.

196 D.M. Spero and J. Adams, *Tetrahedron Lett.*, *33* (1992) 1143.

197 D.F. Taber, M.J. hennessy and J.P. Louey, *J. Org. Chem.*, *57* (1992) 536.

198 S.-I. Hashimoto, N. Watanabe and S. Ikegami, *J. Chem. Soc., Chem. Commun.*, (1992) 1508.

199 M.A. McKervey and T. Ye, *J. Chem. Soc., Chem. Commun.*, (1992) 823.

200 J.S. Clark, *Tetrahedron Lett.*, *33* (1992) 6193.

201 A.G.H. Wee, B. Lin and L. Zhang, *J. Org. Chem.*, *57* (1992) 4404.

202 K. Afarinkia, J.I.G. Cadogan and C.W. Rees, *J. Chem. Soc., Chem. Commun.*, (1992) 285.

203 P. Ceccherelli, M. Curini, M.C. Marcolullio and O. Rosati, *Tetrahedron*, *48* (1992) 9767.

204 A. Padwa, D.J. Austin, S.F. Hornbuckle, M.A. Semones, M.P. Doyle and M.N. Protopopova, *J. Am. Chem. Soc.*, *114* (1992) 1875.

205 A. Padwa, D.J. Austin, S.F. Hornbuckle and A.T. Price, *Tetrahedron Lett.*, *33* (1992) 6427.

206 N. McCarthy, M.A. McKervey, T. Ye, M. McCann, E. Murphy and M.P. Doyle, *Tetrahedron Lett.*, *33* (1992) 5983.

207 C.J. Moody, E.-R.H.B. Sie and J.J. Kulagowski, *Tetrahedron*, *48* (1992) 3991.

208 A. Padwa and K.E. Krumpe, *Tetrahedron*, *48* (1992) 5385.

209 D.J. Fairfax, D.J. Austin, S.L. Xu and A. Padwa, *J. Chem. Soc., Perkin Trans. 1*, (1992) 2837.

210 A. Padwa, S.F. Hornbuckle, G.E. Fryxell and Z.J. Zhang, *J. Org. Chem.*, *57* (1992) 5747.

211 A. Padwa, D.C. Dean, D.L. Hertzog, W.R. Nadler and L. Zhi, *Tetrahedron*, *48* (1992) 7585.

212 D.L. Hertzog, D.J. Austin, W.R. Nadler and A. Padwa, *Tetrahedron Lett.*, *33* (1992) 4731.

213 A. Padwa, D.C. Dean and L. Zhi, *J. Am. Chem. Soc.*, *114* (1992) 593.

214 H.M. Davies, H.D. Smith, B. Hu, S.M. Klenzak and F.J. Hegner, *J. Org. Chem.*, *57* (1992) 6900.

215 H.M.L. Davies and N.J.S. Huby, *Tetrahedron Lett.*, *33* (1992) 6935.

216 H. Nakano and T. Ibata, *Chem. Express*, *7* (1992) 789.

217 M.C. Pirrung and J. Zhang, *Tetrahedron Lett.*, *33* (1992) 5987.

218 T.R. Hoye and C.J. Dinsmore, *Tetrahedron Lett.*, *33* (1992) 169.

219 T.R. Hoye and J.A. Suriano, *Organometallics*, *11* (1992) 2044.

220 A. Padwa, K.E. Krumpe and J.M. Kassir, *J. Org. Chem.*, *57* (1992) 4940.

221 A. Padwa, D.J. Austin and S.L. Xu, *J. Org. Chem.*, *57* (1992) 1330.

222 E. Lee, D.S. Lee, K.H.J. Lee and I.S. Choi, *Bull. Korean Chem. Soc.*, *13* (1992) 470.

223 M. Buchert and H.-U. Ressig, *Chem. Ber.*, *125* (1992) 2723.

224 W.J. Seitz, A.K. Saha, D. Casper and M.M. Hossain, *Tetrahedron Lett.*, *33* (1992) 7755.

225 R.M. Vargas, R.D. Theys and M.M. Hossain, *J. Am. Chem. Soc.*, *114* (1992) 777.

226 V. Guerchais, S. Leveque, A. Hornbeck, C. Lapinte and S. Sinbankit, *Organometallics*, *11* (1992) 3926.

227 H. Kanai and S. Iida, *J. Mol. Catal.*, *71* (1992) 7.

228 S. Yamago and E. Nakamura, *Kagaku (Kyoto)*, *47* (1992) 63.

229 B.M. Trost and M.C. Matelich, *Synthesis*, (1992) 151.

230 L.A. Paquette, D.R. Sauer, D.G. Cleary, M.A. Kinsella, C.M. Blackwell and L.G. Anderson, *J. Am. Chem. Soc.*, *114* (1992) 7375.

231 B.M. Trost and M.C. Matelich, *Synthesis*, (1992) 151.

232 B.M. Trost and T.A. Grese, *J. Org. Chem.*, *57* (1992) 686.

233 B.M. Trost, S. Sharma and T. Schmidt, *J. Am. Chem. Soc.*, *114* (1992) 7903.

234 D. Gravel, S. Benoit, S. Kumanovic and H. Sivaramakahnan, *Tetrahedron Lett.*, *33*, (1992) 1403, 1407.

235 J.H. Rigby, K.M. Short, H.S.A. Teeq and J.A. Henshilwood, *J. Org. Chem.*, *57* (1992) 5290.

236 K. Chaffee, J.B. Sheridan and A. Aistars, *Organometallics*, *11* (1992) 18.

237 J.H. Rigby, H.S. Ateeq and A.C. Krueger, *Tetrahedron Lett.*, *33* (1992) 5873.

238 M. Lautens, W. Tam and L.G. Edwards, *J. Org. Chem.*, *57* (1992) 8.

239 A.J. Rippert and H.-J. Hansen, *Helv. Chim. Acta*, *75* (1992) 2219.

240 R. Klein, P. Sedmera, J. Cejka and K. Mack, *J. Organomet. Chem.*, *436* (1992) 143.

241 G. Mehta, M.B. Viswanath, M. Nethaji and K. Venkatesan, *J. Chem. Soc., Chem. Commun.*, (1992) 83.

242 M.A. Huffman and L.S. Liebeskind, *Organometallics*, *11* (1992) 255.

243 S.W. Schueplein, K. Harms, R. Brueckner and J. Suffert, *Chem. Ber.*, *125* (1992) 271.

244 W.Y. Huang and L. Lu, *Chin. Chem. Lett.*, *2* (1991) 769.

245 J. Reisch, I. Kaiserling-Buddemeier and A. Baader, *Acta Pharm. Turc.*, *33* (1991) 99.

246 A.P. Melissaris and M.H. Litt, *J. Org. Chem.*, *57* (1992) 6998.

247 X. Lu, X. Huang and S. Ma, *Tetrahedron Lett.*, *33* (1992) 2535.

248 G.T. Crisp and T.A. Robertson, *Tetrahedron*, *48* (1992) 3239.

249 V. Kumar and A.B. Todaro, *Synthesis*, (1992) 523.

250 J.S. Swenton, A. Callinan and S. Wang, *J. Org. Chem.*, *57* (1992) 78.

251 T. Sakamoto, F. Shiga, A. Yasuhara, D. Uehiyama, Y. Kondo and H. Yamanaka, *Synthesis*, (1992) 746.

252 Q.-Y. Chen and Z.-T. Li, *J. Chem. Soc., Perkin Trans. 1*, (1992) 2931.

253 A.G. Meyers, P.S. Dragovich and E.Y. Kno, *J. Am. Chem. Soc.*, *114* (1992) 9369.

254 K. Toshima, K. Ohta, A. Ohashi, A. Ohtsuka, M. Nakata and K. Tatsuta, *J. Chem. Soc., Chem. Commun.*, (1992) 1307.

255 J.A. Marshall and W.J. DuBay, *J. Am. Chem. Soc.*, *114* (1992) 1450.

256 Y. Yamamoto, T. Seko, H. Nakamura, H. Nemoto, H. Hojo, M. Mukai and Y. Hashimoto, *J. Chem. Soc., Chem. Commun.*, (1992) 157.

257 P.A. Jacobi and S. Raseswari, *Tetrahedron Lett.*, *33* (1992) 6235.

258 K.C. Nicolaou, P. Maligres, T. Suzuki, S.V. Wendborn, W.-M. Dai and R.K. Chadha, *J. Am. Chem. Soc.*, *114* (1992) 8890.

259 A.S. Lee, A.W. Norman and W.H. Okamura, *J. Org. Chem.*, *57* (1992) 3846.

260 T. Hudlicky and E.E. Boros, *Tetrahedron: Asymmetry*, *3* (1992) 217.

261 P. Prince, K.L. Evans, V.M. Rosas-Garcia, R.D. Gandour and F.R. Fronczek, *Tetrahedron Lett.*, *33* (1992) 6431.

262 R.H. Schmidt-Radde and K.P.C. Vollhardt, *J. Am. Chem. Soc.*, *114* (1992) 9713.

263 M. Sjogren, S. Hansson, P.O. Norrby, B. Åkermark, M.E. Cweciolitto and A. Vitagliano, *Organometallics*, *11* (1992) 3954.

264 K.C. Nicolaou, A. Liu, Z. Zeng and S. McComb, *J. Am. Chem. Soc.*, *114* (1992) 9279.

265 R. Boese, J.R. Green, J. Mittendorf, D.L. Mohler and K.P.C. Vollhardt, *Angew. Chem., Int. Ed. Engl.*, *31* (1992) 1643.

266 K.N. Bharacha, R.M. Marsh, R.E. Minto and R.G. Bergman, *J. Am. Chem. Soc.*, *114* (1992) 3120.

267 M.E. Maier and T. Brandstetter, *Tetrahedron Lett.*, *33* (1992) 7511.

268 K.C. Nicolaou, Y.P. Hong, W.-M. Dai, Z.J. Zeng and W. Wrasidlo, *J. Chem. Soc., Chem. Commun.*, (1992) 1543.

269 D. Schnitzer and J. Kabbara, *Synlett*, (1992) 766.

270 K. Nakatani, K. Arai and S. Terashima, *J. Chem. Soc., Chem. Commun.*, (1992) 289.

271 P. Magnus, P. Carter, J. Elliot, R. Lewis, J. Harling, T. Pittena, W.E. Banta and S. Fort, *J. Am. Chem. Soc.*, *114* (1992) 2545.

272 K. Nakatani, K. Arai, N. Hirayama, F. Matsuda and S. Terashima, *Tetrahedron Lett.*, *48* (1992) 633.

273 M. Torneiro, Y. Fall, L. Castedo and A. Mouriño, *Tetrahedron Lett.*, *33* (1992) 105.

274 M. Treilhon, A. Fauve, J.-R. Pougny, J.-C. Promé and H. Veschambre, *J. Org. Chem.*, *57* (1992) 3203.

275 D. Chemin, M. Alami and G. Linstrumelle, *Tetrahedron Lett.*, *19* (1992) 2681.

276 F.T. Luo, S.-L. Fwu and W.S. Huang, *Tetrahedron Lett.*, *33* (1992) 6839.

277 M. Pfeffer, M.A. Rotteveel, G. LeBorgne and J. Fischer, *J. Org. Chem.*, *57* (1992) 2147.

278 T. Jeffery, S. Gueugnot and G. Lindstrumelle, *Tetrahedron Lett.*, *33* (1992) 5757.

279 V.V. Grushin and H. Alper, *J. Org. Chem.*, *57* (1992) 2188.

280 K. Okuro, M. Furuune, M. Miura and M. Nomura, *Tetrahedron Lett.*, *33* (1992) 5363.

281 G. Cahiez, P. Venegas, C.E. Tucker, T.M. Majid and P. Knochel, *J. Chem. Soc., Chem. Commun.*, (1992) 1407.

282 L. Capell, A. Degl'Innocenti, A. Mordini, G. Reginato, A. Ricci and G. Seconi, *Synthesis*, (1992) 1201.

283 N. Monteiro, G. Balme and J. Gore, *Synlett*, (1992) 227.

284 A.E. Harms and J.R. Stille, *Tetrahedron Lett.*, *33* (1992) 6565.

285 R.J. Dennehy and R.J. Whitby, *J. Chem. Soc., Chem. Commun.*, (1992) 35.

286 K. Shibata, T. Aida and S. Inoue, *Tetrahedron Lett.*, *33* (1991) 1077.

287 A.S. Guram and R.F. Jordan, *J. Org. Chem.*, *57* (1992) 5994.

288 N. Coles, R.J. Whitby and J. Blagg, *Synlett*, (1992) 143.

289 B.M. Trost and R.J. Kulawiec, *J. Am. Chem. Soc.*, *114* (1992) 5579.

290 R.C. Cambie, M.R. Metzler, P.S. Rutledge and P.D. Woodgate, *J. Organomet. Chem.*, *429* (1992) 41.

291 J. Vicente, J.A. Abad and J. Gil-Rubio, *J. Organomet. Chem.*, *436* (1992) C9.

292 S. Torii, K. Okumoto, T. Kotani, S. Nakayasu and H. Ozaki, *Tetrahedron Lett.*, *33* (1992) 3503.

293 R. Grigg and V. Sridharam, *Tetrahedron Lett.*, *33* (1992) 7965.

294 A. Arcadi, A. Burini, S. Cacchi, M. Delmastro, F. Marinelli and B.R. Pietroni, *J. Org. Chem.*, *57* (1992) 976.

295 D. Bouyssi, J. Gore and G. Balme, *Tetrahedron Lett.*, *33* (1992) 2811.

296 B.M. Trost, W.P. Frengle, H. Urake and J. Dumas, *J. Am. Chem. Soc.*, *114* (1992) 1923.

297 P.J. Parsons, M. Stefinovic, P. Willis and F. Meyer, *Synlett*, (1992) 864.

298 F.E. Meyer, H. Hennings and A. de Meijere, *Tetrahedron Lett.*, *33* (1992) 8039.

299 E.-I. Negishi, L.S. Harring, Z. Owczarczyk, M.M. Mohammad and M. Ay, *Tetrahedron Lett.*, *33* (1992) 3253.

300 F.E. Mayer, J. Brandenburg, P.J. Parsons and A. de Meijere, *J. Chem. Soc., Chem. Commun.*, (1992) 390.

301 C.G. Frost, J. Howarth and J.M.J. Williams, *Tetrahedron Asymmetry*, *3* (1992) 1089.

302 B.M. Trost, B.A. Vos, C.M. Brzezowski and D.P. Martina, *Tetrahedron Lett.*, *33* (1992) 717.

303 T.A. van der Heide, J.L. van der Baan, F. Bickelhaupt and G.W. Klumpp, *Tetrahedron Lett.*, *33* (1992) 475.

304 P.C. Bulman Page and D.C. Jennens, *J. Chem. Soc., Perkin Trans. 1*, (1992) 2587.

305 J.M. Joumier, C. Bruneau and P.H. Dixneuf, *Synlett*, (1992) 453.

306 M.W. Bredenkamp, C.W. Holzapfel and F. Toevian, *Synth. Commun.*, *22* (1992) 2447.

307 M. Prat, J. Ribas and M. Moreño-Mañas, *Tetrahedron*, *48* (1992) 1695.

308 I. Shimizu, M. Toyodo, T. Terashima, M. Oshima and H. Hasegawa, *Synlett*, (1992) 301.

309 E. Bernocchi, S. Cacchi, E. Morera and G. Ortar, *Synlett*, (1992) 161.

310 A. Stolle, J. Ollivier, P.P. Piras, J. Salaun and A. de Meijere, *J. Am. Chem. Soc.*, *114* (1992) 4051.

311 G. McGaffin, S. Michalski, A. Stolle, S. Bräse, J. Salaün and A. de Meijere, *Synlett*, (1992) 558.

312 C. Carfagna, R. Galarini, A. Musco and R. Santi, *J. Mol. Catal.*, *72* (1992) 19.

313 V.K. Datcheva and B.A. Marples, *J. Chem. Res., Synop.*, *7* (1992) 238.

314 H. Moorlag, J.G. deVries, B. Kaptein, H.E. Schoemaker, J. Kamphius and R.M. Kellog, *Rec. Trav. Chim.*, *111* (1992) 129.

315 R.D. Walkup and L. Guan, *Synth. Commun.*, *22* (1992) 1007.

316 J. van der Louw, J.L. van der Baan, F.J.J. deKanter, F. Bickelhaupt and G. Klumpp, *Tetrahedron*, *48* (1992) 6087.

317 R. Sjouken, R. Ebens and R.M. Kellog, *Recl. Trav. Chim. Pays. Bas*, *111* (1992) 57.

318 K. Hiroi, M. Haraguchi, Y. Masuda and J. Abe, *Chem. Lett.*, (1992) 2409.

319 T. Takemoto, Y. Nishikimi, M. Sodeoka and M. Shibasaki, *Tetrahedron Lett.*, *33* (1992) 3527.

320 M. Sawamura, H. Nagata, H. Sakamoto and Y. Ito, *J. Am. Chem. Soc.*, *114* (1992) 2587.

321 H.E. Schink and J.-E. Backvall, *J. Org. Chem.*, *57* (1992) 1588.

322 Y. Okada, T. Minami, T. Yamamoto and J. Ichikawa, *Chem. Lett.*, (1992) 547.

323 B.M. Trost, D.L. van Vranken and C. Bingel, *J. Am. Chem. Soc.*, *114* (1992) 9329.

324 F. Henin and J. Muzart, *Tetrahedron Asymmetry*, *3* (1992) 1161.

325 M.S. Stanley, *J. Org. Chem.*, *57* (1992) 6421.

326 T. Mandai and J. Tsuji, *Yuki Gosei Kagaku Kyokaishi*, *50* (1992) 908.

327 L. Geng and X. Lu, *J. Chem. Soc., Perkin Trans. 1*, (1992) 17.

328 L. Geng and X. Lu, *Chin. Chem. Lett.*, *2* (1991) 595.

329 J.-Y. Legros and J.-C. Fiaud, *Tetrahedron Lett.*, *33* (1992) 2509.

330 R. Keese, R. Guidetti-Grept and B. Herzog, *Tetrahedron Lett.*, *33* (1992) 1207.

331 W. Oppolzer and A. Ando, *Chimia*, *46* (1992) 122.

332 S. Takano, T. Sugihara and K. Ogusawara, *Synlett*, (1992) 70.

333 P.A. Jacobi and S. Rajeswari, *Tetrahedron Lett.*, *33* (1992) 6231.

334 M.E. Maier and B. Greiner, *Liebigs Ann. Chem.*, (1992) 855.

335 A. Yanagisawa, N. Nomura, Y. Noritake and H. Yamamoto, *Synthesis*, (1992) 1130.

336 Y. Yamamoto, Y. Chounan, M. Tanaka and T. Ibuka, *J. Org. Chem.*, *57* (1992) 1024.
337 S.-K. Kang, S.-G. Kim and D.-G. Cho, *Tetrahedron Asymmetry*, *3* (1992) 1509.
338 I. Marek, A. Alexakis, P. Mangeney and J.F. Normant, *Bull. Soc. Chim. Fr.*, *129* (1992) 171.
339 S. Valverde, M. Bernabe, A.M. Gomez and P. Puebla, *J. Org. Chem.*, *57* (1992) 4546.
340 C. Gajda and J.R. Green, *Synlett*, (1992) 973.
341 J.E. Rice and Z.-W. Cai, *Tetrahedron Lett.*, *33* (1992) 1675.
342 B.H. Lipshutz, K. Siegmann and E. Garcia, *Tetrahedron*, *48* (1992) 2579.
343 M. Takahashi, Y. Moritani, T. Ogiku, H. Ohmizu, K. Kondo and T. Iwasaki, *Tetrahedron Lett.*, *33* (1992) 5103.
344 K. Ito, S. Tabuchi and T. Katsuki, *Synlett*, (1992) 575.
345 A. Jutland, S. Negri and A. Mosleh, *J. Chem. Soc., Chem. Commun.*, (1992) 1729.
346 G. Dyber, *Angew. Chem., Int. Ed. Engl.*, *31* (1992) 1023.
347 Y. Tsuji and T. Kabehi, *J. Chem. Soc., Chem. Commun.*, (1992) 1000.
348 J. Besancon, J. Szymoniak and C. Moise, *J. Organomet. Chem.*, *426* (1992) 325.
349 J. Chen, W. Chen, J. Zhang and J. Gao, *Youji Huaxue*, *12* (1992) 26.
350 M. Hu, S. Xi, W. Sheng, X. Gu and W. Chen, *Nanjing Daxue Xuebao, Ziran Kexue*, *28* (1992) 88.
351 A.W. Konradi and S.F. Pedersen, *J. Org. Chem.*, *57* (1992) 28.
352 J. Park and S.F. Pedersen, *Tetrahedron*, *48* (1992) 2069.
353 J. Szymoniak, J. Besancon and C. Moïse, *Tetrahedron*, *48* (1992) 3867.
354 Ph. Blanchard, M. Salle, G. Duguay, M. Jubault and A. Gorgues, *Tetrahedron Lett.*, *33* (1992) 2685.
355 L.K. Woo and D.A. Smith, *Organometallics*, *11* (1992) 2344.
356 T. Fukii, T. Hirao and Y. Ohshiro, *Tetrahedron Lett.*, *33* (1992) 5823.
357 Y. Landais and J.-P. Rolan, *Tetrahedron*, *48* (1992) 7185.
358 H.M.R. Hoffmann, A.R. Otte and A. Wilde, *Angew. Chem.*, *104* (1992) 224.
359 P.V. Fish, S.P. Reddy, C.H. Lee and W.S. Johnson, *Tetrahedron Lett.*, *33* (1992) 8001.
360 H. Kurosawa, H. Kajimaru, S. Ogoshi, H. Yoneda, K. Miki, N. Kasai, S. Murai and I. Ikeda, *J. Am. Chem. Soc.*, *114* (1992) 8417.
361 I. Stary, J. Zajicek and P. Kocovsky, *Tetrahedron*, *48* (1992) 7229.
362 F. Ozawa, T.-I. Son, S. Ebina, K. Osakada and A. Yamamoto, *Organometallics*, *11* (1992) 171.
363 W.A. Donaldson and D.J. Stepuszek, *J. Org. Chem.*, *57* (1992) 1309.
364 K.L. Granberg and J.E. Backvall, *J. Am. Chem. Soc.*, *114* (1992) 6858.
365 M.-C.P. Yeh and S.-I. Tan, *J. Chem. Soc., Chem. Commun.*, (1992) 13.
366 W.H. Donaldson and M.A. Hossain, *Tetrahedron Lett.*, *33* (1992) 4107.
367 N.R. Curtis, A.B. Holmes and M.G. Looney, *Tetrahedron Lett.*, *33* (1992) 671.
368 N.A. Petasis and E.I. Bzowej, *J. Org. Chem.*, *57* (1992) 1326.
369 N.A. Petasis and I. Akritopoulou, *Synlett*, (1992) 665.
370 T. Kauffmann, P. Fiegenbaum, M. Papenberg, R. Wiesschollek and J. Sander, *Chem. Ber.*, *125* (1992) 143.
371 W. Odenkirk, J. Whelan and B. Bosnich, *Tetrahedron Lett.*, *33* (1992) 5729.
372 J.-C. Bryan, J.B. Arterburn, G.K. Cook and J.M. Mayer, *Organometallics*, *11* (1992) 3965.
373 M. Uemura, T. Minami, M. Shiro and Y. Hayashi, *J. Org. Chem.*, *57* (1992) 5590.
374 C. Mukai, C.J. Kim and M. Hanaoka, *Tetrahedron Asymmetry*, *3* (1992) 1007.
375 C. Mukai, M. Miyakawa, A. Mihira and M. Hanaoka, *J. Org. Chem.*, *57* (1992) 2034.
376 C. Mukai, A. Mihira and M. Hanaoka, *Chem. Pharm. Bull.*, *39* (1991) 2863.
377 C. Mukai, K. Suzuki, K. Nagani and M. Hanaoka, *J. Chem. Soc., Perkin Trans. 1*, (1992) 141.
378 H. Ito, T. Nakamura, T. Taguchi and Y. Hanzawa, *Tetrahedron Lett.*, *33* (1992) 3769.
379 H. Ito, T. Taniguchi and Y. Hanzawa, *Tetrahedron Lett.*, *33* (1992) 1295.
380 H. Ito, T. Taguchi and Y. Hanzawa, *Tetrahedron Lett.*, *33* (1992) 7873.
381 H. Ito, T. Taguchi and Y. Hanazawa, *Tetrahedron Lett.*, *33* (1992) 4469.
382 H. Maeta and K. Suzuki, *Tetrahedron Lett.*, *33* (1992) 5969.
383 H. Maeta, T. Hashimoto, T. Hasigawa and K. Suzuki, *Tetrahedron Lett.*, *33* (1992) 5965.
384 T. Takahashi, N. Suzuki, M. Hasega, Y. Natto, K.-I. Aoyagi and M. Saburi, *Chem. Lett.*, (1992) 331.
385 Y. Masuyama, A. Hayakawa and Y. Kurusu, *J. Chem. Soc., Chem. Commun.*, (1992) 1102.
386 J.P. Takahara, Y. Masuyama and Y. Kurusu, *J. Am. Chem. Soc.*, *114* (1992) 2577.
387 Y. Shen and Y. Zhou, *Synth. Commun.*, *22* (1992) 657.
388 W.B. Motherwell and D.A. Sandham, *Tetrahedron Lett.*, *33* (1992) 6187.
389 D.E. Stack and R.D. Rieke, *Tetrahedron Lett.*, *33* (1992) 6575.
390 M. Arai, T. Nemoto, Y. Ohashi and E. Nakamura, *Synlett*, (1992) 309.
391 Y. Kataoka, J. Miyai, K. Oshima, K. Takai and K. Utimoto, *J. Org. Chem.*, *57* (1992) 1973.
392 Y. Kataoka, J. Miyai, M. Tezuka, K. Takai and K. Utimoto, *J. Org. Chem.*, *57* (1992) 6796.
393 K. Takai, S. Miwatashi, Y. Kataoka and K. Utimoto, *Chem. Lett.*, (1992) 99.
394 G.M. Yang, G.-M. Su and R.-S. Liu, *Organometallics*, *11* (1992) 3444.
395 M.H. Cheng, Y.-H. Ho, S.-L. Wang, C.Y. Cheng, S.-M. Peng, G.-H. Lee and R.-S. Liu, *J. Chem. Soc., Chem. Commun.*, (1992) 45.
396 P. Cintas, *Synthesis*, (1992) 248.
397 D.M. Hodgson and C. Wells, *Tetrahedron Lett.*, *33* (1992) 4761.
398 C. Jubert, S. Nowotny, D. Kornemann, I. Antes, C.E. Tucker and P. Knochel, *J. Org. Chem.*, *57* (1992) 6384.
399 S.B. Heaton and G.B. Jones, *Tetrahedron Lett.*, *33* (1992) 1693.
400 S.P. Saberi and S.E. Thomas, *J. Chem. Soc., Perkin Trans. 1*, (1992) 259.
401 C.J. Richards and S.E. Thomas, *Tetrahedron: Asymmetry*, *3* (1992) 143.
402 T. Bach, D.N.A. Fox and M.T. Reetz, *J. Chem. Soc., Chem. Commun.*, (1992) 1634.
403 T. Kauffmann and H. Kieper, *Chem. Ber.*, *125* (1992) 907.
404 T. Kauffmann, H. Kieper and H. Pieper, *Chem. Ber.*, *125* (1992) 899.
405 Y. Ding and G. Zhao, *J. Chem. Soc., Chem. Commun.*, (1992) 941.
406 R.D. Theys and M.M. Hossain, *Tetrahedron Lett.*, *33* (1992) 3447.
407 L. Filippini, M. Gusmeroli and R. Riva, *Tetrahedron Lett.*, *33* (1992) 1755.
408 Y. Aoyagi, A. Inoue, I. Koizumi, R. Hashimoto, K. Tokunaga,

K. Gohma, J. Komatsu, K. Sekine, A. Mayaiuzi, J. Kunoch, R. Honma, Y. Akita and A. Ohta, *Heterocycles*, *33* (1992) 257.

409 A.V. Rama Rao, T.K. Chakraborty and S.P. Joshi, *Tetrahedron Lett.*, *33* (1992) 4045.

410 M.J. Shiao, W.L. Chia, T.L. Shing and T.J. Chow, *J. Chem. Res., Synop.*, (1992) 247.

411 S. Sengupta, M. Leite, D.S. Raslan, C. Quesnelle and V. Snieckus, *J. Org. Chem.*, *57* (1992) 4066.

412 M.S. Loft, D.A. Widdowson and T.J. Mowlein, *Synlett*, (1992) 135.

413 J.A. Morley and N.F. Woolsey, *J. Org. Chem.*, *57* (1992) 6487.

414 M. Persson and U. Hacksell, *J. Chem. Soc., Perkin Trans. 1*, (1992) 131.

415 E.P. Kundig, R. Liu and A. Ripa, *Helv. Chim. Acta*, *75* (1992) 2657.

416 E.P. Kundig, A. Ripa and G. Bernadinelli, *Angew. Chem., Int. Ed. Engl.*, *31* (1992) 1071.

417 J. Aubé, J.A. Heppert, M.L. Milligan, M.J. Smith and P. Zenk, *J. Org. Chem.*, *57* (1991) 3563.

418 M.C. Senechal-Torquer, D. Senechal, J.Y. LeBihan, D. Gentric and B. Caro, *Bull. Soc. Chim. Fr.*, *129* (1992) 1121.

419 S.G. Davies, C.L. Goodfellow and K.H. Sutton, *Tetrahedron: Asymmetry*, *3* (1992) 1303.

420 B. Malezieux, G. Jaouen, J. Salann, J.A.S. Howell, M.G. Palin, P. McArdle, M. O'Gava and D. Cunningham, *Tetrahedron: Asymmetry*, *3* (1992) 375.

421 H.G. Schmalz, B. Millies, S.W. Bats and G. Dürmer, *Angew. Chem., Int. Ed. Engl.*, *31* (1992) 631.

422 S.G. Davies, T.J. Donohoe and J.M.J. Williams, *Pure Appl. Chem.*, *64* (1992) 379.

423 F. Balssa, K. Aniss and F. Rose-Munch, *Tetrahedron Lett.*, *33* (1992) 1901.

424 W.H. Miles and H.R. Brinkman, *Tetrahedron Lett.*, *33* (1992) 589.

425 G.R. Krow, W.H. Miles, P.M. Smiley, W.S. Lester and Y.J. Kim, *J. Org. Chem.*, *57* (1992) 4041.

426 F. Moulines, B. Gloagnen and D. Astruc, *Angew. Chem., Int. Ed. Engl.*, *31* (1992) 458.

427 M.R.J. Elsegood, J.W. Steed and D.A. Tocher, *J. Chem. Soc., Dalton Trans.*, (1992) 1797.

428 D.A. Owen, *Diss. Abstr. Int. B*, *52* (1991) 3072.

429 H.-J. Knölker, M. Bauermeister and J.-P. Pannek, *Chem. Ber.*, *125* (1992) 2783.

430 G.R. Stephenson, D. Owen, H. Finch and S. Swanson, *Aust. J. Chem.*, *45* (1992) 121.

431 G.R. Stephenson, R.D. Thomas and F. Cassidy, *Synlett*, (1992) 247.

432 M.J. Dunn, R.F.W. Jackson and G.R. Stephenson, *Synlett*, (1992) 905.

433 S.T. Astley and G.R. Stephenson, *Synlett*, (1992) 507.

434 G.A. Potter and R. McCagne, *J. Chem. Soc., Chem. Commun.*, (1992) 635.

435 A.J. Pearson, A.M. Gelormini and A.A. Pinkerton, *Organometallics*, *11* (1992) 936.

436 M. Laabassi, *Bull. Soc. Chim. Fr.*, *129* (1992) 151.

437 A.J. Pearson and M.P. Burello, *Organometallics*, *11* (1992) 448.

438 A.J. Pearson and K. Srinivasan, *Synlett*, (1992) 983.

439 A.J. Pearson and K. Srinivasan, *Tetrahedron Lett.*, *33* (1992) 7295.

440 M.C.P. Yeh, C.-J. Tsou, C.-N. Chuang and H.-W. Lin, *J. Chem. Soc., Chem. Commun.*, (1992) 890.

441 S.-S.P. Chou, C.-H. Hsu and M.-C. Pyeh, *Tetrahedron Lett.*, *33* (1992) 643.

442 B.M. Trost and T. Zhi, *Tetrahedron Lett.*, *33* (1992) 1831.

443 M. Franck-Neumann, P.-J. Colson, P. Geoffroy and K.M. Taba, *Tetrahedron Lett.*, *33* (1992) 1903.

444 K. Nunn, P. Mosset, R. Gra and R.W. Saalfrank, *J. Org. Chem.*, *57* (1992) 3359.

445 W.A. Donaldson, R. Craig and S. Spanton, *Tetrahedron Lett.*, *33* (1992) 3967.

446 L. Lattuada, E. Licandro, S. Maiorana, A. Pspagni and A. Zanotta-Gerosa, *Synlett*, (1992) 315.

447 E. Licandro, S. Maiorana, A. Papagni and A. Zanotta-Gerosa, *J. Chem. Soc., Chem. Commun.*, (1992) 1623.

448 S. Aoki, T. Fujimura and E. Nakamura, *J. Am. Chem. Soc.*, *114* (1992) 2985.

449 B.A. Anderson, W.D. Wulff, T.S. Powers, S. Tribbott and A. Rheingold, *J. Am. Chem. Soc.*, *114* (1992) 10784.

450 A. Wienand, H.-U. Reissig, H. Fischer, D. Pflumm and C. Troll, *J. Organomet. Chem.*, *427* (1992) C9.

451 P. Hofmann, M. Haemmerle and G. Unfried, *New J. Chem.*, *15* (1991) 769.

452 S. Chamberlain and W.D. Wulff, *J. Am. Chem. Soc.*, *114* (1992) 10667.

453 K.H. Dötz, T. Schäfer, F. Kroll and K. Harms, *Angew. Chem., Int. Ed. Engl.*, *31* (1992) 1236.

454 S.U. Tumer, J.W. Herndon and L.A. McMullen, *J. Am. Chem. Soc.*, *114* (1992) 8394.

455 H. Fischer, O. Podschadly, A. Früh, C. Troll, R. Stumpf and A. Schlagtes, *Chem. Ber.*, *125* (1992) 2667.

456 B.L. Balzer, M. Cazanone and M.G. Finn, *J. Am. Chem. Soc.*, *114* (1992) 8735.

457 B.L. Balzer, M. Cazanone, M. Sabat and M.G. Finn, *Organometallics*, *11* (1992) 1759.

458 D.B. Grotjahn, F.E.K. Kroll, T. Schäfer, K. Harms and K.H. Dötz, *Organometallics*, *11* (1992) 298.

459 K.H. Dötz, T.O. Schäfer and K. Harms, *Synthesis*, (1992) 146.

460 E. Chelain, R. Goumont, L. Hamon, A. Parker, M. Rudler, H. Rudler, J.-C. Daran and J. Vaissermann, *J. Am. Chem. Soc.*, *114* (1992) 8088.

461 C.A. Merlic, E.E. Burns, D. Xu and S.Y. Chen, *J. Am. Chem. Soc.*, *114* (1992) 8722.

462 S. Köbbing and J. Mattay, *Tetrahedron Lett.*, *33* (1992) 927.

463 M.R. Sestrick, M. Miller and L.S. Hegedus, *J. Am. Chem. Soc.*, *114* (1992) 4079.

464 B. Alcaide, G. Dominguez, J. Rodriguez-Lopez and M.A. Sierra, *Organometallics*, *11* (1992) 1979.

465 D.F. Harvey, K.P. Lund and D.A. Neil, *J. Am. Chem. Soc.*, *114* (1992) 8424.

466 D.F. Harvey and M.F. Brown, *J. Org. Chem.*, *57* (1992) 5559.

467 G. Müller and G. Jas, *Tetrahedron Lett.*, *33* (1992) 4417.

468 R. Aumann, *Chem. Ber.*, *125* (1992) 1861.

469 R. Aumann, C. Krüger and R. Goddard, *Chem. Ber.*, *125* (1992) 1627.

470 Z.-W. Guo and A. Zamojski, *Tetrahedron Lett.*, *33* (1992) 1105.

471 M.N. Mattson and P. Helquist, *Organometallics*, *11* (1992) 4.

472 B.H. Lipshutz and S. Sengupta, *Org. React. (N.Y.)*, *41* (1992) 135.

473 B.E. Rossiter and N.M. Swingle, *Chem. Rev.*, *92* (1992) 771.

474 L.W. Boteju, K. Wegner and V.J. Hruby, *Tetrahedron Lett.*, *33* (1992) 7491.

475 O. Melnyk, E. Stephan, G. Pourcelot and P. Cresson, *Tetrahedron*, (1992) 841.

476 T. Ibuka, H. Yoshizawa, H. Habashita, N. Fujii, Y. Chounan, M. Tanaka and Y. Yamamoto, *Tetrahedron Lett.*, *33* (1992) 3783.

477 S. Hanessian and K. Sumi, *Synthesis*, (1991) 1083.

478 Y. Yamamoto, Y. Chounana, S. Nishii, T. Ikuba and H. Kitahara, *J. Am. Chem. Soc.*, *114* (1992) 7652.

479 M.T. Reetz, J. Kanand and N. Griekenow, *Angew. Chem., Int. Ed. Engl.*, *31* (1992) 1626.

480 R. Tamura, K.-I. Watake, N. Ono and Y. Yamamoto, *J. Org. Chem.*, *57* (1992) 4895.

481 B. Christenson, C. Ullenius, M. Håkansson and S. Jagner, *Tetrahedron*, *48* (1992) 3623.

482 M. Uemura, H. Oda, T. Minami, M. Shiro and Y. Hayashi, *Organometallics*, *11* (1992) 3705.

483 G. Quinkert, T. Müller, A. Königer, O. Schultheis, B. Sichenberger and G. Dürner, *Tetrahedron Lett.*, *33* (1992) 3469.

484 M. Sawamura, H. Hamashima and Y. Ito, *J. Am. Chem. Soc.*, *114* (1992) 8295.

485 B.H. Lipshutz and R. Keil, *J. Am. Chem. Soc.*, *114* (1992) 7919.

486 J.R. Hauske, P. Dorff, S. Julin, G. Martinelli and J. Bussolari

487 P. Wipf, J.H. Smitrovich and C.-W. Moon, *J. Org. Chem.*, *57* (1992) 3178.

488 J.P. Marino, M.V.M. Emonds, P.J. Stengel, A.R.M. Oliveira, F. Simonelli and J.T.B. Ferriera, *Tetrahedron Lett.*, *33* (1992) 49.

489 G. Maas and T. Mayer, *Synthesis*, (1991) 1209.

490 M. Bruncko and D. Crich, *Tetrahedron Lett.*, *33* (1992) 6251.

491 S. Okamoto, S. Katayama, N. Ono and F. Sato, *Tetrahedron: Asymmetry*, *3* (1992) 1525.

492 A.P. Davis and T.J. Egan, *Tetrahedron Lett.*, *33* (1992) 8125.

493 P. Blanchard, M.S. El. Korbti, J.-L. Fourrey and M. Robert-Gero, *Tetrahedron Lett.*, *33* (1992) 3319.

494 C. Jukert and P. Knochel, *J. Org. Chem.*, *57* (1992) 5431.

495 R.K. Dieter and C.W. Alexander, *Tetrahedron Lett.*, *33* (1992) 5693.

496 K. Yamamoto, S. Yamada and K. Yamaguchi, *Tetrahedron Lett.*, *33* (1992) 7521.

497 A.I. Meyers and L. Snyder, *J. Org. Chem.*, *57* (1992) 3814.

498 J. Kant and V. Farina, *Tetrahedron Lett.*, *33* (1992) 3563.

499 E. Piers and J. Renaud, *Synthesis*, (1992) 74.

500 P.S. van Heerden, B.C.B. Bezuidenhoudt, J.A. Steenkamp and D. Ferreira, *Tetrahedron Lett.*, *33* (1992) 2383.

501 S. Sonoda, H. Houchigai, M. Asaoka and H. Takai, *Tetrahedron Lett.*, *33* (1992) 3145.

502 K.A. Swiss, W. Hinkley, C.A. Maryanoff and D.C. Liotta, *Synthesis*, (1992) 127.

503 G. Courtemanche, A. Alexakis, J. Vaissermann and J.F. Normant, *J. Organomet. Chem.*, *423* (1992) 281.

504 S.-K. Kang, Y.-W. Park, D.H. Lee, H.-S. Sim and J.-H. Jeon, *Tetrahedron Asymmetry*, *3* (1992) 705.

505 S.-K. Kang, S.-G. Kim and J.-S. Lee, *Tetrahedron Asymmetry*, *3* (1992) 1139.

506 T. Harada, S. Imanaka, Y. Ohyama, Y. Matsuda and A. Oku, *Tetrahedron Lett.*, *33* (1992) 5807.

507 M.J. Totleben, D.P. Curran and P. Wipf, *J. Org. Chem.*, *57* (1992) 1740.

508 J. Barker, S.L. Cook, M.E. Lasterra-Sanchez and S.E. Thomas, *J. Chem. Soc., Chem. Commun.*, (1992) 830.

509 B. Giese, B. Carboni, T. Göbel, R. Muhn and F. Wetterich, *Tetrahedron Lett.*, *33* (1992) 4545.

510 S. Toros, B. Heil, G. Galik and Z. Tuba, *Tetrahedron Lett.*, *33* (1992) 3667.

511 R. Takeuchi, N. Ishii, M. Sugiura and N. Sato, *J. Org. Chem.*, *57* (1992) 4189.

512 S. Toros, I. Gemes-Pecsi, B. Heil, S. Maho and Z. Tuba, *J. Chem. Soc., Chem. Commun.*, (1992) 858.

513 A. Llebaria, F. Camps and J.M. Moreto, *Tetrahedron Lett.*, *33* (1992) 3683.

514 D. Anastasiou, E.M. Campi, H. Chaouk, W.R. Jackson and Q.J. McCubbin, *Tetrahedron Lett.*, *33* (1992) 2211.

515 I. Ojima, Z. Zhang, A. Korda, P. Ingallina and N. Clos, *Adv. Chem. Ser.*, *230* (1992) 277.

516 Y. Masuyama, Y. Nimura and Y. Kurusu, *Tetrahedron Lett.*, *33* (1992) 6477.

517 X.-M. Wu, K. Funakoshi and K. Sakai, *Tetrahedron Lett.*, *33* (1992) 6331.

518 M. Franck-Neumann, E.L. Michelotti, R. Simler and J.M. Vernier, *Tetrahedron Lett.*, *33* (1992) 7361.

519 M. Franck-Neumann and J.-M. Vernier, *Tetrahedron Lett.*, *33* (1992) 7365.

520 J.A. Morley and N.F. Woolsey, *J. Org. Chem.*, *57* (1992) 6487.

521 D.S. Ryu, K.H. Song, J.T. Lee and J.Il. Kim, *Bull. Korean Chem. Soc.*, *13* (1992) 354.

522 E.J. Moore, W.R. Pretzer, T.T. O'Connell, J. Harris, L. La Bounty, L. Chou and S.S. Grimmer, *J. Am. Chem. Soc.*, *114* (1992) 5888.

523 Y. Ishii and M. Hidai, *J. Organomet. Chem.*, *428* (1992) 279.

524 K. Itoh, M. Miura and M. Nomura, *Tetrahedron Lett.*, *33* (1992) 5369.

525 B. Gabriele, M. Costa, G. Salerno and G.P. Chiusoli, *J. Chem. Soc., Chem. Commun.*, (1992) 1007.

526 R. Takeuchi, M. Sugiura, N. Ishii and N. Sato, *J. Chem. Soc., Chem. Commun.*, (1992) 1358.

527 I. Matsuda, J. Sakakibara, H. Inoue and H. Nagshima, *Tetrahedron Lett.*, *33* (1992) 5799.

528 H. Arzoumanian, F. Cochini, D. Nuel, J.F. Fetrigani and N. Rosas, *Organometallics*, *11* (1992) 493.

529 L. Pages, A. Llebaria, F. Camps, E. Molins, C. Miravitlles and J.M. Moreto, *J. Am. Chem. Soc.*, *114* (1992) 10449.

530 F. Camps, A. Llebaria, J.M. Moreto and L. Pages, *Tetrahedron Lett.*, *33* (1992) 113.

531 E. Brocato, C. Castagnoli, M. Catellani and G.P. Chiusoli, *Tetrahedron Lett.*, *33* (1992) 7433.

532 H.-J. Knölbes, J. Heber and C.H. Mahler, *Synlett*, (1992) 1002.

533 B.Y. Lee and Y.K. Jung, *Hwahak Kwa Kongop Ui Chinbo*, *31* (1991) 584.

534 S.W. Brown, *Dis. Abstr. Int. B*, *52* (1991) 3063.

535 X. Verdagner, A. Moyano, M.A. Peryas, A. Riera, A.G. Green, J.F. Piniella and A. Alvarez-Larena, *J. Organomet. Chem.*, *433* (1992) 305.

536 M.E. Krafft and C.A. Juliano, *J. Org. Chem.*, *57* (1992) 5106.

537 M.E. Krafft and C. Wright, *Tetrahedron Lett.*, *33* (1992) 151.

538 M.E. Krafft, I.L. Scott and R.H. Romero, *Tetrahedron Lett.*, *33* (1992) 3829.

539 M.E. Kraft, R.H. Romero and I.L. Scott, *J. Org. Chem.*, *57* (1992) 5277.

540 A.S. Gybin, W.A. Smit, R. Caple, A.L. Verenterov, A.S. Shashkov, L.G. Vorontstova, M.G. Kurella, V.S. Chertkon, A.A. Carapetyan, A.Y. Kosnikov, M.S. Alexanyan, S.V. Linderman, J.N. Panov, A.V. Maleev, Y.T. Struckhov and S.M. Sharpe, *J. Am. Chem. Soc.*, *114* (1992) 5555.

541 F. Camps, A. Llebaria, J.M. Moreto and L. Pages, *Tetrahedron Lett.*, *33* (1992) 109.

542 G.G. Melikyan, O. Vostrowsky, W. Bauer and H. Jurgens Bestmann, *J. Organomet. Chem.*, (1992) C24.

543 C. Mukai, M. Uchiyama and M. Hanaoka, *J. Chem. Soc., Chem. Commun.*, (1992) 1014.

544 S.L. Kireev, V.A. Smit, B.I. Ugrak and O.M. Nefedov, *Izv. Akad. Nauk SSSR, Ser. Khim.*, (1991) 2565.

545 E.G. Rowley and N.E. Schore, *J. Org. Chem.*, *57* (1992) 6853.

546 S. Takano, K. Inomata and K. Ogasawara, *Chem. Lett.*, (1992) 443.

547 S. Takano, I. Inomata and K. Ogaswara, *J. Chem. Soc., Chem. Commun.*, (1992) 169.

548 T. Okano, N. Okabe and J. Kijii, *Bull. Chem. Soc. Jpn.*, *65* (1992) 2589.

549 H.R. Gao, Y. Xu, S.J. Liao and D.R. Yu, *Chin. Chem. Lett.*, *3* (1992) 351.

550 M. Imbeaux, H. Mestdagh, K. Mowghair and L. Rolando, *J. Chem. Soc., Chem. Commun.*, (1992) 1678.

551 V. Grushin and H. Alper, *J. Chem. Soc., Chem. Commun.*, (1992) 611.

552 E.A. Karakhanov, E.A. Runova, E.B. Neimerovets, G.V. Berezkin and L.E. Rozantseva, *Neftekhimiya*, *32* (1992) 229.

553 M.I. Terekhova, T.E. Kron, N.E. Petrova and E.S. Petrov, *Zh. Org. Khim.*, *27* (1991) 2368.

554 Y. Hatanaka, S. Fukushima and T. Hiyama, *Tetrahedron*, *48* (1992) 2113.

555 H. Watanabe, Y. Hashizume and K. Uneyama, *Tetrahedron Lett.*, *33* (1992) 4333.

556 A. Devasagayaraj and M. Periasany, *Tetrahedron Lett.*, *33* (1992) 1227.

557 R. Hernandez, D. Melian and E. Suaréz, *Synthesis*, (1992) 653.

558 U. Gerlach and T. Wollmann, *Tetrahedron Lett.*, *33* (1992) 5499.

559 S. Cacchi and A. Lupi, *Tetrahedron Lett.*, *33* (1992) 3939.

560 G.T. Crisp and A.G. Meyer, *J. Org. Chem.*, *57* (1992) 6972.

561 G.P. Roth and J.A. Thomas, *Tetrahedron Lett.*, *33* (1992) 1959.

562 S. Cenini and C. Crotti, *Catal. Met. Complexes*, *12* (1991) 311.

563 K.D. Kim, S.M. Lee, N.S. Cho, J.S. Oh, C. Lee and J.S. Lee, *J. Mol. Catal.*, *75* (1992) L1.

564 C. Davies and M. Kilner, *J. Catal.*, *136* (1992) 403.

565 N.A. Bumagin, K.V. Nikitin and I.P. Beletskaya, *Dokl. Akad. Nauk SSSR*, *320* (1991) 887.

566 M. DeWang and H. Alper, *J. Am. Chem. Soc.*, *114* (1992) 7018.

567 T.W. Leung and B.D. Dombek, *J. Chem. Soc., Chem. Commun.*, (1992) 205.

568 L.E. Overman and M.J. Sharp, *J. Org. Chem.*, *57* (1992) 1035.

569 K. Itoh, N. Hamaguchi, M. Miura and M. Nomura, *J. Mol. Catal.*, *75* (1992) 117.

570 S.-Z. Wang, K. Yamamoto, H. Yamada and T. Takahashi, *Tetrahedron*, *48* (1992) 2333.

571 M. Miyazawa, S.-Z. Wang, H. Takeda and K. Yamamoto, *Synlett*, (1992) 323.

572 Y. Tamaro, K. Yasni, H. Takanabe, S. Tanaka and K. Fugami, *Angew. Chem., Int. Ed. Engl.*, *31* (1992) 644.

573 Y. Tsuji and T. Ishii, *J. Organomet. Chem.*, *425* (1992) 41.

574 C.S. Chin, H.J. Jung and S.G. Hong, *Bull. Korean Chem. Soc.*, *13* (1992) 391.

575 Y. Watanabe, F. Okuda, K. Nishiyama, K. Zhang, F. Maeguchi and T. Kondo, *Yuki Gosei Kagaku Kenkyusho Koenshu*, *6* (1992) 43.

576 N. Chatani, T. Murai, T. Ikeda, T. Sano, Y. Kajikawa, K. One and S. Murai, *Tetrahedron*, *48* (1992) 2013.

577 P.J. Rybczynski, *Diss. Abstr. Int. B*, *52* (1991) 3074.

578 L. Marko, *Transition Met. Chem. (London)*, *17* (1992) 474.

579 N. Chatani, S.-I. Ikeda, K. Ohe and S. Murai, *J. Am. Chem. Soc.*, *114* (1992) 9710.

580 S.-I. Ikeda, N. Chantani and S. Murai, *Organometallics*, *11* (1992) 3494.

581 I. Ojima, R.J. Donovan and W.R. Shay, *J. Am. Chem. Soc.*, *114* (1992) 6580.

582 J.E. Baldwin, R.M. Adlington and S.H. Ramcharitar, *Tetrahedron*, *48* (1992) 2957.

583 H. Nakazawa, Y. Matsuoka, I. Nakagawa and K. Miyoshi, *Organometallics*, *11* (1992) 1385.

584 A. Merzouk, F. Guibe and A. Loffet, *Tetrahedron Lett.*, *33* (1992) 477.

585 T. Koch and M. Hesse, *Synthesis*, (1992) 931.

586 C. Chapnis, B. Winter and K.H. Schulte-Alte, *Tetrahedron Lett.*, *33* (1992) 6135.

587 T. Tsuda, *Kagaku Kogyo*, *43* (1992) 654.

588 V.N. Kalinin, I.A. Cherepanov and S.K. Moiseev, *Mendeleev Commun.*, (1992) 113.

589 C. Bruneau and P.H. Dixneuf, *J. Mol. Catal.*, *74* (1992) 97.

590 A.K. Fazlur-Rahman, J.-C. Tsai and K.M. Nicholas, *J. Chem. Soc., Chem. Commun.*, (1992) 1334.

591 T. Tsuda, T. Yamamoto and T. Saegusa, *J. Organomet. Chem.*, *429* (1992) C46.

592 T. Tsuda, *Organomet. News*, (1991) 208.

593 D. Walther, G. Bräunlich, R. Kemp and J. Sieler, *J. Organomet. Chem.*, *436* (1992) 109.

594 S. Dérien, J.-C. Clinet, E. Duñach and J. Périchon, *J. Organomet. Chem.*, *424* (1992) 213.

595 A.M. Al-Jarallah, J.A. Anabtawi, M.A.B. Siddiqui, A.M. Aitani and A.W. Al-Sa'doun, *Catal. Today*, *14* (1992) whole issue.

596 S.M. Pillai, G.L. Tembe and M. Ravindranathan, *Appl. Catal., A*, *81* (1992) 273.

597 K. Nomura and M. Ishino, *J. Mol. Catal.*, *73* (1992) L15.

598 K. Nomura and M. Ishino, *J. Mol. Catal.*, *68* (1991) L5.

599 I.P. Kovalev, Y.N. Kolmogorov, Y.A. Strelenko, A.V. Ignatenko, M.G. Vinogradov and G.I. Nikishin, *J. Organomet. Chem.*, *420* (1991) 125.

600 P. Denis, J.F. Croizy, A. Mortreux and F. Petit, *J. Mol. Catal.*, *68* (1991) 159.

601 C.-H. Jan, Z. Lu and R.H. Crabtree, *Tetrahedron Lett.*, *33* (1992) 7119.

602 H.F. Klein, M. Mager, S. Bley, U. Flörke and H.-J. Haupt, *Organometallics*, *11* (1992) 3174.

603 M. Bochmann and A.J. Jaggar, *J. Organomet. Chem.*, *424* (1992) C5.

604 M. Bochmann and S.J. Lancaster, *J. Organomet. Chem.*, *434* (1992) C1.

605 W. Spaleck, M. Antberg, J. Rohrmann, A. Winter, B. Bachmann, P. Kiprov, J. Behm and W.A. Herrmann, *Angew. Chem., Int. Ed. Engl.*, *31* (1992) 1346.

606 E.B. Coughlin and J.E. Bercaw, *J. Am. Chem. Soc.*, *114* (1992) 7606.

607 X. Yang, C.L. Stern and T.J. Marks, *Angew. Chem., Int. Ed. Engl.*, *31* (1992) 1374.

608 G. Erker and B. Temme, *J. Am. Chem. Soc.*, *114* (1992) 4004.

609 B. Rieger, *J. Organomet. Chem.*, *428* (1992) C33.

610 M.R. Kesti, G.W. Coates and R.M. Waymouth, *J. Am. Chem. Soc.*, *114* (1992) 9679.

611 A. Sen, J.S. Brumbaugh and M. Lin, *J. Mol. Catal.*, *73* (1992) 297.

612 A. Batistini, G. Consiglio and U.W. Suter, *Angew. Chem., Int. Ed. Engl.*, *31* (1992) 302.

613 M. Brookhardt, F.C. Rix, J.M. DeSimone and J.C. Borborak, *J. Am. Chem. Soc.*, *114* (1992) 5894.

614 C. Pisano, A. Mezzetti and G. Consiglio, *Organometallics*, *11* (1992) 20.

615 C. Pisano, S.C.A. Nefdens and G. Consiglio, *Organometallics*, *11* (1992) 1975.

616 A. Batistini and G. Consiglio, *Organometallics*, *11* (1992) 1767.

617 E. Dalcanale, Z. An, L.P. Battaglia, M. Catellani and G.P. Chinsoli, *J. Organomet. Chem.*, *437* (1992) 375.

618 B.E. Eaton, B. Rollman and J.A. Kaduk, *J. Am. Chem. Soc.*, *114* (1992) 6245.

619 E.A. Petrushkina, V.I. Bregadze, Y.F. Oprunenko and A.V. Orlinkov, *Metalloorg. Khim.*, *5* (1992) 946.

620 E.A. Petrushkina, V.I. Bregadze, Y.F. Oprunenko, T.M. Shcherbina and A.P. Laretina, *Metalloorg. Khim.*, *4* (1991) 1336.

621 T.-A. Mitsudo, S.-W. Zhang, T. Kondo and Y. Watanabe, *Tetrahedron Lett.*, *33* (1992) 341.

622 C. Moberg, K. Nordström and P. Helquist, *Synthesis*, (1992) 685.

623 J. Polacek, H. Antropiusova, L. Petrusova and K. Mach, *J. Mol. Catal.*, *70* (1991) 9.

624 P.A. Wender and M.J. Tebbe, *Synthesis*, (1991) 1089.

625 K.-U. Baldenius, H.T. Dieck, W.A. König, D. Icheln and T. Runge, *J. Organomet. Chem.*, *423* (1992) 286.

626 J.M. Takacs, J. Zu and S. Chandramouli, *J. Am. Chem. Soc.*, *114* (1992) 773.

627 J.M. Takacs and Y.C. Myoung, *Tetrahedron Lett.*, *33* (1992) 317.

628 B.M. Trost and C. Pedregal, *J. Am. Chem. Soc.*, *114* (1992) 7292.

629 B.M. Trost, J. Dumas and M. Villa, *J. Am. Chem. Soc.*, *114* (1992) 9836.

630 B. Trost and Y. Shi, *J. Am. Chem. Soc.*, *114* (1992) 791.

631 T. Takahashi, K. Aoyagi, R. Hara and N. Suzuki, *Chem. Lett.*, (1992) 1693.

632 J.M. Davis, R.J. Whitby and A. Jaxa-Chamiec, *Tetrahedron Lett.*, *33* (1992) 5655.

633 U. Wischmeyer, K.S. Knight and R.M. Waymouth, *Tetrahedron Lett.*, *33* (1992) 7735.

634 R.B. Grossman and S.L. Buchwald, *J. Org. Chem.*, *57* (1992) 5803.

635 J.L. Mascareñas, A.M. Garcia, L. Castedo and A. Mourino, *Tetrahedron Lett.*, *33* (1992) 7589.

636 G. Agnel, Z. Owczarczyk and E.-I. Negishi, *Tetrahedron Lett.*, *33* (1992) 1543.

637 T. Kanabara, T. Kushida, N. Saito, I. Kuwajima, K. Kubota and T. Yamamoto, *Chem. Lett.*, (1992) 583.

638 T. Maruyama, Z.-H. Zhou, K. Kubota and T. Yamamoto, *Chem. Lett.*, (1992) 643.

639 E.C. Constable and R. Chotalia, *J. Chem. Soc., Chem. Commun.*, (1992) 64.

640 T. Yamamoto, M. Shimura, K. Osakada and K. Kubota, *Chem. Lett.*, (1992) 1003.

641 T.-A. Chen and R.D. Rieke, *J. Am. Chem. Soc.*, *114* (1992) 10087.

642 M. Iyoda, Y. Kuwatani, N. Ueno and M. Oda, *J. Chem. Soc., Chem. Commun.*, (1992) 158.

643 Z. Wu, S. Lee and J.S. Moore, *J. Am. Chem. Soc.*, *114* (1992) 8730.

644 J.S. Moore and J. Zhang, *Angew. Chem., Int. Ed. Engl.*, *31* (1992) 923.

645 V. Grossbenny and R. Ziessel, *Tetrahedron Lett.*, *33* (1992) 8075.

646 K. Tamao, K. Kobayashi and Y. Ito, *Synlett*, (1992) 539.

647 T.-A. Mitsudo, S.-W. Zhang, N. Satake, T. Kondo and Y. Watanabe, *Tetrahedron Lett.*, *33* (1992) 5533.

648 Z. Zhou, M. Costa and G.P. Chinsoli, *J. Chem. Soc. Perkin Trans. 1*, (1992) 1399.

649 K.-C. Kong and C.-H. Cheng, *Organometallics*, *11* (1992) 1972.

650 J. Inanaga, Y. Sugimoto and T. Hanamoto, *Tetrahedron Lett.*, *33* (1992) 7035.

651 A. Padwa and S.L. Xu, *J. Am. Chem. Soc.*, *114* (1992) 5881.

652 P. Legzdins, W.S. McNeil, E.G. Vessez and R.J. Batchaton, F.W.B. Einstein, *Organometallics*, *11* (1992) 2718.

653 A.T. McNichols and P.J. Stang, *Synlett*, (1992) 971.

654 S. Wu, *Huaxue Shiji*, *14* (1992) 161.

655 R. Gleiter, *Angew. Chem., Int. Ed. Engl.*, *31* (1992) 27.

656 R. Gleiter, R. Merger and B. Nuber, *J. Am. Chem. Soc.*, *114* (1992) 8921.

657 T. Tsuda, K.-I. Maruta and Y. Kitaike, *J. Am. Chem. Soc.*, *114* (1992) 1498.

658 M.E. Welker, *Chem. Rev.*, *92* (1992) 97.

659 R. Taube and S. Wache, *J. Organomet. Chem.*, *428* (1992) 431.

660 K. Masuda, K. Nakano, T. Fukahovi, H. Nagashima and K. Itoh, *J. Organomet. Chem.*, *428* (1992) C21.

661 D.L. Gin, V.P. Conticello and R.H. Grubbs, *J. Am. Chem. Soc.*, *114* (1992) 3167.

662 P. Brun and A. Tenaglia, *J. Mol. Catal.*, *70* (1991) L1.

663 U.M. Dzhemilev, R.I. Khusnutdinov, V.A. Dokichev, D.K. Galeev, A.I. Malikov, G.A. Tolstikov and O.M. Nefedov, *Izv. Akad. Nauk SSSR, Ser. Khim.*, (1991) 2572.

664 P.A. van der Schaaf, W.J.J. Smeets, A.L. Spek and G. van Koten, *J. Chem. Soc., Chem. Commun.*, (1992) 717.

665 W.J. Feast, V.C. Gibson and E.L. Marshall, *J. Chem. Soc., Chem. Commun.*, (1992) 1157.

666 S.T. Nguyen, L.K. Johnson, R.H. Grubbs and J.W. Ziller, *J. Am. Chem. Soc.*, *114* (1992) 3974.

667 V.P. Conticello, D.L. Gin and R.H. Grubbs, *J. Am. Chem. Soc.*, *114* (1992) 9708.

668 J.G. Hamilton and J.J. Rooney, *J. Chem. Soc., Chem. Commun.*, (1992) 370.

669 Y. Nakayama, K. Mashima and A. Nakamura, *J. Chem. Soc., Chem. Commun.*, (1992) 1496.

670 H.H. Fox and R.R. Schrock, *Organometallics*, *11* (1992) 2763.

671 M.R. Kesti and R.M. Waymouth, *J. Am. Chem. Soc.*, *114* (1992) 3565.

672 C.P. Tsonis, *React. Kinet. Catal. Lett.*, *46* (1992) 359.

673 D.B. Furman, M.K. Munshieva, A.O. Ivanov, A.Y. Belyankin, L.N. Morozova, L.S. Isaeva, D.B. Tagiev, D.N. Kravtsov and O.V. Bragin, *Izv. Akad. Nauk SSSR, Ser. Khim.*, (1991) 541.

674 G.A. Foulds, A.M. Bennett, D.A. Thornton, S.J. Brown, L.M. Clutterbuck, C. Hinton, G.B. Humphreys and A.F. Masters, *Polyhedron*, *11* (1992) 1285.

675 N.P. Reddy, H. Yamashita and M. Tanaka, *J. Am. Chem. Soc.*, *114* (1992) 6596.

676 K. Albrecht, O. Reiser, M. Weber and A. de Meijere, *Synlett*, (1992) 521.

677 M.R. Gagne, R.H. Grubbs, J. Feldman and J.W. Ziller, *Organometallics*, *11* (1992) 3933.

678 T.J. Deeming and B.M. Novak, *J. Am. Chem. Soc.*, *114* (1992) 4400.

679 T. Tanase, T. Onizumi, K. Kobayashi and Y. Yamamoto, *J. Chem. Soc., Chem. Commun.*, (1992) 707.

680 Y. Ito, E. Ihara and M. Murakami, *Angew. Chem., Int. Ed. Engl.*, *31* (1992) 1509.

681 J. Barlengua, C. del Bozo Losada and B. Olano, *Tetrahedron Lett.*, *33* (1992) 7579.

682 E.S. Finkel'shtein, V.I. Bykov and E.B. Portnykh, *J. Mol. Catal.*, *76* (1992) 33.

683 G.P. van der Kelen, L. Vanderyse and F.M.G. Vanwijnsberghe, *Pol. J. Chem.*, *65* (1991) 657.

684 A. Keller, *J. Mol. Catal.*, *70* (1991) 143.

685 G.C. Fu and R.H. Grubbs, *J. Am. Chem. Soc.*, *114* (1992) 7324.

686 M.D.E. Forbes, J.T. Patton, T.L. Meyers, H.D. Maynard, D.W. Smith Jr., G.R. Schulz and K.B. Wagener, *J. Am. Chem. Soc.*, *114* (1992) 10978.

687 K.S. Park and S.K. Ihm, *Polym. Bull. (Berlin)*, *27* (1992) 399.

688 T. Karlen and A. Ludi, *Helv. Chim. Acta*, *75* (1992) 1604.

689 N. Iranpoor and E. Mottaghinejad, *J. Organomet. Chem.*, *423* (1992) 399.

690 T. Murai, Y. Kasai, K. Hidehara and S. Kato, *J. Org. Chem.*, *57* (1992) 5542.

691 C. Guo and X. Lu, *Synlett*, (1992) 405.

692 C. Guo and X. Lu, *Tetrahedron Lett.*, *33* (1992) 3659.

693 Z. Chen and R.L. Halterman, *J. Am. Chem. Soc.*, *114* (1992) 2276.

694 A.S.R. Anjaneyulu and B.M. Isaa, *Indian J. Chem., Sect. B*, *31B* (1992) 15.

695 M. Falck-Pedersen, T. Benneche and K. Undheim, *Acta Chem. Scand.*, *46* (1992) 1215.

696 J. Clayden, E.W. Collington and S. Warren, *Tetrahedron Lett.*, *33* (1992) 7039.

697 M. Mehmandoust, Y. Petit and M. Larcheveque, *Tetrahedron Lett.*, *33* (1992) 4313.
698 P. Metz, C. Mues and A. Schoop, *Tetrahedron*, *48* (1992) 1071.
699 J.L. van der Baan, J. van der Louw, M. Wiersma and F. Bickelhaupt, *Tetrahedron Lett.*, *33* (1992) 1377.
700 A. Bourgeois-Cury, D. Doan and J. Gore, *Tetrahedron Lett.*, *33* (1992) 1277.
701 X. Lu, J. Ji, C. Guo and W. Shen, *J. Organomet. Chem.*, *428* (1992) 259.
702 F. Gilloir and M. Malacria, *Tetrahedron Lett.*, *33* (1992) 3859.
703 N. Iwasawa, *Chem. Lett.*, (1992) 473.
704 H. Nemoto, M. Nagamochi and K. Fukumoto, *J. Chem. Soc., Chem. Commun.*, (1992) 1695.
705 K. Ikura, I. Ryu, N. Kambe and N. Sonoda, *J. Am. Chem. Soc.*, *114* (1992) 1520.
706 K. Yasui, K. Fugami, S. Tanaka, Y. Tamaru, A. Ii, Z.-I. Yoshida and M. Saidi, *Tetrahedron Lett.*, *33* (1992) 789.
707 I. Saura-Llamas and J.A. Gladysz, *J. Am. Chem. Soc.*, *114* (1992) 2136.
708 S. Motallebi and P. Mueller, *Chimia*, *46* (1992) 119.
709 J.P. Gerber, A. Goosen and C.W. McCleland, *J. Chem. Res., Synop.*, (1991) 331.
710 R.I. Khusnutdinov, N.A. Shchadneva and U.M. Dzhemilev, *Izv. Akad. Nauk SSSR, Ser. Khim.*, (1991) 2897.
711 M.J. Dickens, T.J. Mowlein, D.A. Widdowson, A.M.Z. Slawin and D.J. Williams, *J. Chem. Soc., Perkin Trans. 1*, (1992) 323.
712 Y. Kataoka, Y. Oguchi, K. Yoshizumi, S. Miwatashi, K. Takai and K. Utimoto, *Bull. Chem. Soc. Jpn.*, *65* (1992) 1543.
713 S.I. Murahashi, S. Sasao, E. Saito and T. Naota, *J. Org. Chem.*, *57* (1992) 2521.
714 T. Ibuka, *Organomet. News*, (1991) 96.
715 J.R. Miller, S.R. Pulley, L.S. Hegedus and S. DeLombaert, *J. Am. Chem. Soc.*, *114* (1992) 5602.
716 T.V. Rajanbabu and A.L. Casalnuovo, *J. Am. Chem. Soc.*, *114* (1992) 6265.
717 L.T. Liu, *Diss. Abstr. Int. B*, *52* (1991) 3069.
718 A. Srivastava, Y.-A. Ma, R. Pankayatselvan, W. Dinges and K.M. Nicholas, *J. Chem. Soc., Chem. Commun.*, (1992) 853.
719 T. Hosokawa, M. Takano, Y. Kuroki and S.-I. Murahashi, *Tetrahedron Lett.*, *33* (1992) 6643.
720 G. Jähne, A. Müller, H. Kroha, M. Rosner, O. Holzhäwser, C. Meischner, M. Helsberg, I. Winkler and G. Riess, *Tetrahedron Lett.*, *33* (1992) 5335.
721 V. Bolitt, B. Chaguiv and D. Sinou, *Tetrahedron Lett.*, *33* (1992) 2481.
722 C. Baldoli, P. DelButtero and S. Maiorana, *Tetrahedron Lett.*, *33* (1992) 4049.
723 P.J. Walsh, A.M. Baranger and R.G. Bergman, *J. Am. Chem. Soc.*, *114* (1992) 1708.
724 K. Nomura, *J. Mol. Catal.*, *73* (1992) L1.
725 G.-Z. Wang and J.-E. Backvall, *J. Chem. Soc., Chem. Commun.*, (1992) 980.
726 C.A. Willoughby and S.L. Buchwald, *J. Am. Chem. Soc.*, *114* (1992) 7562.
727 J.M. Vernier, L.S. Hegedus and D.B. Miller, *J. Org. Chem.*, *57* (1992) 6914.
728 L.S. Hegedus, E. Lastra, Y. Narukawa and D.C. Snustad, *J. Am. Chem. Soc.*, *114* (1992) 2991.
729 K. Burgess and M.J. Ohlmeyer, *Adv. Chem. Ser.*, *230* (1992) 163.
730 D.A. Evans, G.C. Fu and B.A. Anderson, *J. Am. Chem. Soc.*, *114* (1992) 6679.
731 K. Burgess, W.A. van der Donk, S.A. Wescott, T.B. Marder, R.T. Baker and J. Calabres, *J. Am. Chem. Soc.*, *114* (1992) 9350.
732 D.A. Evans, G.C. Fu and A.H. Hoveyda, *J. Am. Chem. Soc.*, *114* (1992) 6671.
733 S.A. Wescott, H.P. Blom, T.B. Marder and R.T. Baker, *J. Am. Chem. Soc.*, *114* (1992) 8863.
734 J. Zhang, B. Lou, G. Guo and L. Dai, *Xuaxue Xuebao*, *50* (1992) 910.
735 Y. Matsumoto, M. Naito and T. Hayashi, *Organometallics*, *11* (1992) 2732.
736 J. Du and Z. Gao, *Youji Huaxue*, *12* (1992) 561.
737 H. Waldmann, *Nachr. Chem., Tech. Lab.*, *40* (1992) 702.
738 K.B. Sharpless, W. Amberg, Y.L. Bennani, G.A. Crispino, J. Harting, K.-S. Jeong, H.-L. Kwong, K. Morihawa, Z.-M. Wang, D. Xu and X.-L. Zhong, *J. Org. Chem.*, *57* (1992) 2768.
739 K.-S. Jeong, P. Sjö and K.B. Sharpless, *Tetrahedron Lett.*, *33* (1992) 3833.
740 D. Xu, G.A. Crispino and K.B. Sharpless, *J. Am. Chem. Soc.*, *114* (1992) 7570.
741 T. Tschamber, F. Bachenstrase, H. Fritz and J. Streith, *Helv. Chim. Acta*, *75* (1992) 1052.
742 F. Yokokawa, Y. Hamada and T. Shiori, *Synlett*, (1992) 703.
743 E. Keinan, S.C. Sinha, A. Sinha-Bagchi, Z.M. Wang, X.-L. Zhang and K.B. Sharpless, *Tetrahedron Lett.*, *33* (1992) 6411.
744 O. Sato and M. Hirama, *Synlett*, (1992) 705.
745 C. Brosa, R. Peracaula, R. Puig and M. Ventura, *Tetrahedron Lett.*, *33* (1992) 7057.
746 Y. Imada, T. Saito, T. Kawakami and S.-I. Murahashi, *Tetrahedron Lett.*, *33* (1992) 5081.
747 K. Fuji, K. Tanaka and H. Miyamoto, *Tetrahedron Lett.*, *33* (1992) 4021.
748 D.R. Reddy and E.R. Thornton, *J. Chem. Soc., Chem. Commun.*, (1992) 172.
749 T. Hashiyama, K. Morikawa and K.B. Sharpless, *J. Org. Chem.*, *57* (1992) 5067.
750 J.S. Yadar, T. Sekharam and D. Srinivas, *Tetrahedron Lett.*, *33* (1992) 7973.
751 T. Mukaiyama, K. Imagawa, T. Yamada and T. Takai, *Chem. Lett.*, (1992) 231.
752 K. Krohn, K. Brueggmann, D. Doering and P.G. Jones, *Chem. Ber.*, *125* (1992) 2439.
753 A.J. Pearson, S. Mallik, A.A. Pinkerton, J.P. Adams and S. Zheng, *J. Org. Chem.*, *57* (1992) 2910.
754 H. Nishiyama, S. Yamaguchi, M. Kondo and K. Itoh, *J. Org. Chem.*, *57* (1992) 4306.
755 S.C. Berk and S.L. Buchwald, *J. Org. Chem.*, *57* (1992) 1957.
756 S.M. Kadam, S.K. Nayak and A. Banerji, *Tetrahedron Lett.*, *33* (1992) 5129.
757 M.A. Keegstra, T.H.A. Peters and L. Brandsma, *Tetrahedron*, *48* (1992) 3633.
758 K. Smith and D. Jones, *J. Chem. Soc., Perkin Trans. 1*, (1992) 407.
759 A.V. Rama Rao, T.K. Chakvoborty, K. Laxma Reddy and V.S. Rao, *Tetrahedron Lett.*, *33* (1992) 4799.
760 M.A. Keegstra, *Tetrahedron*, *48* (1992) 2681.
761 A.J. Pearson, J.G. Park and P.Y. Zhu, *J. Org. Chem.*, *57* (1992) 3583.
762 M.S. Holden and K.A. Cole, *Synth. Commun.*, *22* (1992) 2579.
763 R.C. Cambie, S.J. Janssen, P.S. Rutledge and P.D. Woodgate, *J. Organomet. Chem.*, *434* (1992) 97.
764 A.J. Pearson and J.G. Park, *J. Org. Chem.*, *57* (1992) 1745.
765 A.J. Pearson and H. Shin, *Tetrahedron*, *48* (1992) 7527.
766 J.-F. Carpenter, Y. Castanet, J. Brocard, A. Mortreux and F. Petit, *Tetrahedron Lett.*, *33* (1992) 2001.
767 S.-I. Murahashi, T. Naota, N. Miyaguchi and T. Nakato, *Tetrahedron Lett.*, *33* (1992) 6991.

768 J.-Y. Lai, X.-X. Shi and L.-X. Dai, *J. Org. Chem.*, *57* (1992) 3485.

769 A.J. Pearson, Y.-S. Lai and K. Srinivasan, *Aust. J. Chem.*, *45* (1992) 109.

770 L. Tottie, P. Baeckstrom, C. Moberg, J. Tegenfeldt and A. Heumann, *J. Org. Chem.*, *57* (1992) 6579.

771 W.D. McGhee and D.P. Riley, *Organometallics*, *11* (1992) 900.

772 S. Lumin, J.R. Falck, J. Capdevila and A. Karara, *Tetrahedron Lett.*, *33* (1992) 2091.

773 V. Kumar, V. Gopalakrishnan and K.N. Ganeshi, *Bull. Chem. Soc. Jpn.*, *65* (1992) 1665.

774 C. Goux, P. Lhoste and D. Sinou, *Synlett*, (1992) 725.

775 A.M. Lluch, L. Jordi, F. Sanchez-Baeza, S. Ricart, F. Camps, A. Messegner and J.M. Moreto, *Tetrahedron Lett.*, *33* (1992) 3021.

776 B.C. Soderberg and B.A. Bowden, *Organometallics*, *11* (1992) 2221.

777 D.K. Thompson, N. Suzuki, L.S. Hegedus and Y. Satoh, *J. Org. Chem.*, *57* (1992) 1461.

778 S.-I. Murahashi, Y. Oda and T. Naota, *Chem. Lett.*, (1992) 2237.

779 K. Maruyama, Y. Mukayama, K. Yoda, T. Mashino and A. Nishinga, *J. Chem. Soc., Chem. Commun.*, (1992) 1617.

780 U. Belluco, R.A. Michelin, R. Ros, R. Bertani, G. Facchin, M. Mozzon and L. Zanotto, *Inorg. Chim. Acta*, *198-200* (1992) 883.

781 H. Takahata, *Yakugaku Zasshi*, *112* (1992) 229.

782 T. Hosokawa and S. Murahashi, *Heterocycles*, *33* (1992) 1079.

783 K.M. Doxsee, J.K.M. Mouser and J.B. Farahi, *Synlett*, (1992) 13.

784 H.-J. Knölker, *Synlett*, (1992) 371.

785 D.R. Gupta, Kamaluddin and S. Naithani, *Rev. Roum. Chim.*, *37* (1992) 261.

786 S.L. Colletti and R.L. Halterman, *Tetrahedron Lett.*, *33* (1992) 1005.

787 T. Tatsumi, M. Nakamura and H. Tominaga, *Catal. Sci. Technol., Proc. Tokyo Conf., 1st*, (1991) 213.

788 D.D. Agarwal, *Indian J. Chem., Sect. B*, *31B* (1992) 517.

789 M.M.T. Khan and R.S. Shukla, *J. Mol. Catal.*, *72* (1992) 361.

790 M.L. D'Amico, K. Rasmussen, D. Sisneros, C. Magnussen, H. Wade, J.G. Russell and L.L. Borer, *Inorg. Chim. Acta*, *191* (1992) 167.

791 T. Hayashi, F. Ozawa and Y. Kobatake, *Kagaku (Kyoto)*, *47* (1992) 564.

792 L. Deng and E.N. Jacobsen, *J. Org. Chem.*, *57* (1992) 4320.

793 D.S. Thompson, B. Schrott and K.A. Jorgensen, *J. Chem. Soc., Chem. Commun.*, (1992) 1072.

794 T. Oda, R. Irie, T. Katsuki and H. Okawa, *Synlett*, (1992) 641.

795 T. Takai, E. Hata, K. Yorozu and T. Mukaiyama, *Chem. Lett.*, (1992) 2077.

796 Y. Naruta, F. Tani and K. Maruyama, *Tetrahedron Lett.*, *33* (1992) 6323.

797 J.P. Collman, X. Zhang, V.J. Lee and J.I. Brauman, *J. Chem. Soc., Chem. Commun.*, (1992) 1647.

798 T. Yamada, K. Imagawa and T. Mukaiyama, *Chem. Lett.*, (1992) 2109.

799 P.G. Potvin and S. Bianchet, *J. Org. Chem.*, *57* (1992) 6629.

800 G. Lin and C. Zeng, *Huaxue Xuebao*, *50* (1992) 78.

801 L. Wang and K.B. Sharpless, *J. Am. Chem. Soc.*, *114* (1992) 7568.

802 Y. Fort, A. Olszewski-Ortar and P. Caubere, *Tetrahedron*, *48* (1992) 5099.

803 S.C. Case-Green, S.G. Davies and C.J.R. Hedgecock, *Synlett*, (1991) 779.

804 K.N. Juneau, *Diss. Abstr. Int. B*, *52* (1991) 3068.

805 Y. Narukawa, K.N. Juneau, D. Snustad, D.B. Miller and L.S. Hegedus, *J. Org. Chem.*, *57* (1992) 5453.

806 B. Alcaide, G. Dominguez, J. Plumet and M.A. Sierra, *J. Org. Chem.*, *57* (1992) 447.

807 D.K. Thompson, N. Suzuki, L.S. Hegedus and Y. Satoh, *J. Org. Chem.*, *57* (1992) 1461.

808 M.P. Doyle, M.N. Protopopova, W.R. Winchester and K.L. Daniel, *Tetrahedron Lett.*, *33* (1992) 7819.

809 S. Saito, T. Hara, N. Takahashi, M. Hirai and T. Moriwabe, *Synlett*, (1992) 237.

810 F.-T. Luo, I. Schreuder and R.-T. Wang, *J. Org. Chem.*, *57* (1992) 2213.

811 R.D. Walkup, L. Guan, S.W. Kim and Y.S. Kim, *Tetrahedron Lett.*, *33* (1992) 3969.

812 J.E. Backvall and P.G. Andersson, *J. Am. Chem. Soc.*, *114* (1992) 6374.

813 J. van der Louw, J.L. van der Baan, G.J.J. Out, F.J.J. deKanter, F. Bickelhaupt and G.W. Klumpp, *Tetrahedron*, *48* (1992) 9901.

814 J. van der Louw, J.L. van der Baan, H. Stichter, G.J.J. Out, F.J.J. de Kanter, F. Bickelhaupt and G.W. Klumpp, *Tetrahedron*, *48* (1992) 9877.

815 A.L. Coelho, M.L.A.A. Vasconcellos, B.C. Simas, J.A. Rabi and P.R.R. Costa, *Synthesis*, (1992) 914.

816 A. McKillop, R.J.K. Taylor, R.J. Watson and N. Lewis, *Synlett*, (1992) 1005.

817 D. Greé, R. Greé, T.B. Lowinger, J. Martelli, J.T. Negri and L.A. Paquette, *J. Am. Chem. Soc.*, *114* (1992) 8841.

818 S. Tang and R.M. Kennedy, *Tetrahedron Lett.*, *33* (1992) 5299.

819 S. Tang and R.M. Kennedy, *Tetrahedron Lett.*, *33* (1992) 5303.

820 R.M. Kennedy and S. Tang, *Tetrahedron Lett.*, *33* (1992) 3729.

821 S. Ozaki, H. Matsushita and H. Ohmori, *J. Chem. Soc., Chem. Commun.*, (1992) 1120.

822 I.P. Kovalev, V.V. Ipatkin, Y.A. Strelenko, A.V. Inatenko and G. Nikishin, *Tetrahedron Lett.*, *33* (1992) 1791.

823 M.-H. Cheng, G.-M. Yang, J.-F. Chow, G.-H. Lee, S.-M. Peng and R.-S. Liu, *J. Chem. Soc., Chem. Commun.*, (1992) 934.

824 S. Torii, L.H. Xu and H. Okamoto, *Synlett*, (1992) 515.

825 N.G. Kundu, M. Pal, J.S. Mahanty and S.K. Oasgupta, *J. Chem. Soc., Chem. Commun.*, (1992) 41.

826 Y. Kataoka, M. Tezuka, K. Takai and K. Utimoto, *Tetrahedron*, *48* (1992) 3495.

827 W. Tochtermann, K. Luttmann, N. Sdunnus, E.-M. Peters, K. Peters and H.G. von Schnering, *Chem. Ber.*, *125* (1992) 1485.

828 K. Okuro, M. Furune, M. Miura and M. Nomura, *J. Org. Chem.*, *57* (1992) 4754.

829 T. Gracza and V. Jäger, *Synlett*, (1992) 191.

830 T. Gracza, T. Hasenöhnl, U. Stahl and V. Jägee, *Synthesis*, (1992) 1108.

831 T. Mandai, K. Ohta, N. Babu, M. Kawada and J. Tsujii, *Synlett*, (1992) 671.

832 A.R. Sidduri and P. Knochel, *J. Am. Chem. Soc.*, *114* (1992) 7579.

833 P. Bhatarah and E.H. Smith, *J. Chem. Soc., Perkin Trans. 1*, (1992) 2163.

834 Z.-M. Wang, X.-L. Zhang, K.B. Sharpless, S.C. Sinha, A. Sinha Bagchi and E. Keinan, *Tetrahedron Lett.*, *33* (1992) 6407.

835 S.L.B. Wang, J. Su, W.D. Wulff and K. Hoogsteen, *J. Am. Chem. Soc.*, *114* (1992) 10665.

836 R. Aumann, *Chem. Ber.*, *125* (1992) 1141.

837 T. Ibata and K. Fukushima, *Chem. Lett.*, (1992) 2197.

838 V. Kumar, J.A. Dority, E.R. Bacon, B. Singh and G.Y. Lesher, *J. Org. Chem.*, *57* (1992) 6995.

839 A. Arcadi, S. Cacchi and F. Marinelli, *Tetrahedron Lett.*, *33* (1992) 3915.

840 M. Akazome, T. Kondo and Y. Watanabe, *Chem. Lett.*, (1992) 769.
841 P.G. Andersson and J.-E. Backväll, *J. Am. Chem. Soc.*, *114* (1992) 8696.
842 T. Gallagher, I.W. Davies, S.W. Jones, D. Lathbury, M.F. Mahon, K.C. Molloy, R.W. Shaw and P. Vernon, *J. Chem. Soc., Perkin Trans. 1*, (1992) 433.
843 C.H. Heathcock, J.A. Staford and D.L. Clark, *J. Org. Chem.*, *57* (1992) 2575.
844 M. Mori and S. Watanuki, *J. Chem. Soc., Chem. Commun.*, (1992) 1082.
845 K.H. Dötz and J. Christoffers, *J. Organomet. Chem.*, *426* (1992) C58.
846 R.P. Beckett, S.G. Davies and A.A. Mortlock, *Tetrahedron: Asymmetry*, *3* (1992) 123.
847 J.Q. Zhou and H. Alper, *J. Org. Chem.*, *57* (1992) 3328.
848 J.H. Tidwell and S.L. Buchwald, *J. Org. Chem.*, *57* (1992) 6380.
849 M. Mori, N. Uesaka and M. Shibasaki, *J. Org. Chem.*, *57* (1992) 3519.
850 P. Leo McGrane and T. Livinghouse, *J. Org. Chem.*, *57* (1992) 1323.
851 A.I. Meyers, A.J. Robichaud and M.J. McKennon, *Tetrahedron Lett.*, *33* (1992) 1181.
852 R.J. Perry, B.D. Wilson and R.J. Miller, *J. Org. Chem.*, *57* (1992) 2883.
853 T. Hayashi, M. Sawamura and Y. Ito, *Tetrahedron*, *48* (1992) 1999.
854 Y. Tamaru, H. Tanagawa, S. Itoh, M. Kimura, S. Tanaka, K. Fugami, T. Sekiyama and Z.-I. Yoshida, *Tetrahedron Lett.*, *33* (1992) 631.
855 M. Kimura, K. Fugami, S. Tanaka and Y. Tamaru, *J. Org. Chem.*, *57* (1992) 6377.
856 Y. Tamaru, T. Bando, Y. Kawamura, K. Okamura, Z.-I. Yoshida and M. Shiro, *J. Chem. Soc., Chem. Commun.*, (1992) 1498.
857 T. Kondo, S. Kotachi and Y. Watanabe, *J. Chem. Soc., Chem. Commun.*, (1992) 1318.
858 R.A.T.M. van Benthem, H. Hiemstra and W.N. Speckamp, *J. Org. Chem.*, *57* (1992) 6083.
859 S.-H. Lin, S.-M. Peng and R.-S. Liu, *J. Chem. Soc., Chem. Commun.*, (1992) 615.
860 K.J. Doyle and C.J. Moody, *Tetrahedron Lett.*, *33* (1992) 7769.
861 J.-O. Baeg and H. Alper, *Organometallics*, *57* (1992) 157.
862 A. Alexakis, P. Mangeney, I. Marek, F. Rose-Munch, E. Rose, A. Semra and F. Roberts, *J. Am. Chem. Soc.*, *114* (1992) 8288.
863 N.R. Kotecha, S.V. Ley and S. Mantegani, *Synlett*, (1992) 395.
864 K.-H. Chu, W. Zhen, X.-Y. Zhu and M. Rosenblum, *Tetrahedron Lett.*, *33* (1992) 1173.
865 T. Hosokawa, S. Aoki and S.-I. Murahashi, *Synthesis*, (1992) 558.
866 F. Camps, L. Jordi, J.M. Moreto, S. Ricart, A.M. Castaño and A.M. Echavarren, *J. Organomet. Chem.*, *426* (1992) 189.
867 J.A. Turpin and L.O. Weigl, *Tetrahedron Lett.*, *33* (1992) 6563.
868 G.D. Harris Jr., R.J. Herr and S.M. Weinreb, *J. Org. Chem.*, *57* (1992) 2528.
869 B.M. Trost, L. Li and S.D. Guile, *J. Am. Chem. Soc.*, *114* (1992) 8745.
870 L.-L. Gundersen, T. Bennechi, F. Rise, A. Gogoll and K. Undheim, *Acta Chem. Scand.*, *46* (1992) 761.
871 V.N. Kalinin, M.V. Shostakovsky and A.B. Ponomaryov, *Tetrahedron Lett.*, *33* (1992) 373.
872 F.T. Luo and R.-T. Wang, *Tetrahedron Lett.*, *33* (1992) 6835.
873 S. Torii, L.H. Xu, M. Sadakane and H. Okumoto, *Synlett*, (1992) 513.
874 L.A. Villaneuva, K.A. Abboud and J.M. Boncella, *Organometallics*, *11* (1992) 2963.
875 K.-Y. Ko, K.I. Lee and W.J. Kim, *Tetrahedron Lett.*, *33* (1992) 6651.
876 R. Aumann and P. Hinterding, *Chem. Ber.*, *125* (1992) 2765.
877 W.-Y. Su, C.L. LeBas, A.C. Kopechy and J.F. Knifton, *Tetrahedron Lett.*, *33* (1992) 871.
878 Y. Lin, X. Zhu and Y. Zhou, *J. Organomet. Chem.*, *429* (1992) 269.
879 S.C. Shim, C.H. Doh, J.H. Yoon, D.Y. Lee and Y.Z. Youn, *Bull. Korean Chem. Soc.*, *12* (1991) 649.
880 G.G. Cox, J.J. Kulagowski, C.J. Moody and E.-R.H.B. Sie, *Synlett*, (1992) 975.
881 D. Anastasiou and W.R. Jackson, *Aust. J. Chem.*, *45* (1992) 21.
882 S.D. Najdi, M.M. Olmstead and N.E. Schore, *J. Organomet. Chem.*, *431* (1992) 335.
883 U.M. Dzhemilev, R.V. Kunakova, N.Z. Baibulatova, A.E. Tarasenko and E.M. Mustafina, *Izv. Akad. Nauk SSSR, Ser. Khim.*, (1992) 160.
884 S.H. Bergens, P. Noheda, J. Whelan and B. Bosnich, *J. Am. Chem. Soc.*, *114* (1992) 2121.
885 F. Francalanci, W. Cabri, S. De Bernardinis, S. Penco and R. Santi, *Catal. Met. Complexes*, *12* (1991) 207.
886 F. Wang, K. Chiba and M. Tada, *J. Chem. Soc., Perkin Trans. 1*, (1992) 1897.
887 J. Ollivier, P.P. Piras, A. Stolk, P. Aufrane, A. de Meijere and J. Salaun, *Tetrahedron Lett.*, *33* (1992) 3307.
888 T. Mandai, S. Suzuki, T. Murakami, M. Fujita, M. Kawada and J. Tsuji, *Tetrahedron Lett.*, *33* (1992) 2987.
889 T. Mandai, T. Matsumoto, M. Kawada and J. Tsuji, *J. Org. Chem.*, *57* (1992) 6090.
890 T. Mandai, T. Matsumoto, M. Kawada and J. Tsuji, *J. Org. Chem.*, *57* (1992) 1326.
891 B.M. Trost and G.B. Tometzki, *Synthesis*, (1991) 1735.
892 T. Mandai, T. Matsumoto, Y. Nakao, A. Teramoto, M. Kawada and J. Tsuji, *Tetrahedron Lett.*, *33* (1992) 2549.
893 G.S. Jones and W.J. Scott, *J. Am. Chem. Soc.*, *114* (1992) 1491.
894 Z. Ni and A. Padwa, *Synlett*, (1992) 869.
895 B.M. Trost and M.S. Rodriguez, *Tetrahedron Lett.*, *33* (1992) 4675.
896 T. Inokuchi, H. Kawafuchi and S. Torii, *Synlett*, (1992) 510.
897 G. Solladie and V. Berl, *Tetrahedron Lett.*, *33* (1992) 3477.
898 T. Tanazawa and J. Schwartz, *Tetrahedron Lett.*, *33* (1992) 6783.
899 A.G. Godfrey and B. Ganem, *Tetrahedron Lett.*, *33* (1992) 7461.
900 K.-T. Wong and T.-Y. Luh, *J. Am. Chem. Soc.*, *114* (1992) 7308.
901 M.C. Wang and T.Y. Luh, *J. Org. Chem.*, *57* (1992) 2178.
902 S. Karlsson, A. Hallberg and S. Gronowitz, *J. Organomet. Chem.*, *430* (1992) 53.
903 Y. Kataoka, K. Takai, K. Oshima and K. Utimoto, *J. Org. Chem.*, *57* (1992) 1615.
904 L. Venanzi, R. Lehmann, R. Keil and B.H. Lipshutz, *Tetrahedron Lett.*, *33* (1992) 5857.
905 J.-P. Robin and Y. Landais, *Tetrahedron*, *48* (1992) 819.
906 J.M. O'Connor and J. Ma, *J. Org. Chem.*, *57* (1992) 5075.
907 D.G. Miller and D.D.M. Wayner, *Can. J. Chem.*, *70* (1992) 2485.
908 J. Mitra and A.K. Mitra, *Indian J. Chem., Sect. B*, *31B* (1992) 693.
909 A. Pasquarello, G. Poli and C. Scolastico, *Synlett*, (1992) 93.
910 N.H. Kiers, B.L. Feringa and P.W.N.M. van Leewwen, *Tetrahedron Lett.*, *33* (1992) 2403.
911 H. Takayama, T. Koike, N. Aimi and S.-I. Sakai, *J. Org. Chem.*, *57* (1992) 2173.
912 T. Baig, J. Jenck and P. Kalck, *J. Chem. Soc., Chem. Commun.*, (1992) 1552.

913 B.M. Trost, W. Brieden and K.H. Baringhaus, *Angew. Chem., Int. Ed. Engl.*, *31* (1992) 1334.
914 A.J. Laurent and S. Lesniak, *Tetrahedron Lett.*, *33* (1992) 3311.
915 Y. Sabata, Y. Katayama and Y. Ishii, *Chem. Lett.*, (1992) 671.
916 E. Steckhan and C. Kandzia, *Synlett*, (1992) 139.
917 H. Kuniyasu, A. Ogawa, H. Higaki and N. Sonoda, *Organometallics*, *11* (1992) 3937.
918 K. Itoh, N. Hamaguchi, M. Miura and M. Nomura, *J. Chem. Soc., Perkin Trans. 1*, (1992) 2833.
919 T. Konosu and S. Oida, *Chem. Pharm. Bull.*, *40* (1992) 609.
920 H.K.B. Yu and J. Schwartz, *Tetrahedron Lett.*, *33* (1992) 6787.
921 L. Ni, J.A. Belot and M.E. Welker, *Tetrahedron Lett.*, *33* (1992) 177.
922 G.-Z. Wang and J.-E. Bäckvall, *J. Chem. Soc., Chem. Commun.*, (1992) 337.
923 M. Nandi, K.M. Sathe and A. Sarkar, *J. Chem. Soc., Chem. Commun.*, (1992) 793.
924 M.P. Doyle, K.G. High and C.L. Nesloney, *Chem. Ind. (Dekker)*, (1992) 47.
925 M.P. Doyle, G.A. Devora, A.O. Nefedov and K.G. High, *Organometallics*, *11* (1992) 549.
926 Y. Uozumi, S.-Y. Lee and T. Hayashi, *Tetrahedron Lett.*, *33* (1992) 7185.
927 M.R. Kesti and R.M. Waymouth, *Organometallics*, *11* (1992) 1095.
928 Y. Tsuji, R.M. Lago, S. Tomohiro and H. Tsaneishi, *Organometallics*, *11* (1992) 2353.
929 S.E. Denmark and D.C. Forbes, *Tetrahedron Lett.*, *33* (1992) 5037.
930 N.R. Curtis and A.B. Holmes, *Tetrahedron Lett.*, *33* (1992) 675.
931 M.J. Burk and J.E. Feaster, *Tetrahedron Lett.*, *33* (1992) 2099.
932 M. Tanaka, Y. Uchimaru and H.-J. Lautenschlager, *J. Organomet. Chem.*, *428* (1992) 1.
933 Y. Uchimaru, H.J. Lautenschlager, A.J. Wynd, M. Tanaka and M. Goto, *Organometallics*, *11* (1992) 2639.
934 N.P. Reddy, Y. Uchimaru, H.-J. Lautenschlager and M. Tanaka, *Chem. Lett.*, (1992) 45.
935 M. Ishikawa, H. Sakamoto, S. Okazaki and A. Naka, *J. Organomet. CHem.*, *439* (1992) 19.
936 J. Ohshita, A. Naka and M. Ishikawa, *Organometallics*, *11* (1992) 602.
937 M. Lautens, R.K. Better and A.J. Lough, *J. Org. Chem.*, *57* (1992) 422.
938 S.-I. Ikeda, N. Chatani, Y. Kajikawa, K. Ohe and S. Murai, *J. Org. Chem.*, *57* (1992) 2.
939 A. Barbero, P. Cuadrado, I. Fleming, A.M. Gonzalez and F.J. Pulido, *J. Chem. Soc., Chem. Commun.*, (1992) 351.
940 A. Barbero, P. Cuadrado, I. Fleming, A.M. Gonzalez and F.J. Pulido, *J. Chem. Soc., Perkin Trans. 1*, (1992) 327.
941 D.S. Dodd, H.D. Pierce Jr., A. Han and C. Oehlschlager, *J. Chem. Soc., Chem. Commun.*, (1992) 76.
942 A. Casarini, B. Jousseaume, D. Lazzeri, E. Porciatti, G. Reginato, A. Ricci and G. Seconi, *Synlett*, (1992) 981.
943 G.T. Crisp and P.T. Glink, *Tetrahedron Lett.*, *33* (1992) 4649.
944 T.N. Mitchell, B. Kowall, A. Killing and C. Nettleback, *J. Organomet. Chem.*, *439* (1992) 101.
945 H. Miyake and K. Yamamura, *Chem. Lett.*, (1992) 507.
946 B.H. Lipshutz, R. Keil and J.C. Barton, *Tetrahedron Lett.*, *33* (1992) 5861.
947 E.-I. Nakamura, K. Tanaka and S. Aoki, *J. Am. Chem. Soc.*, *114* (1992) 9715.
948 H. Kuniyasu, A. Ogawa, K.-I. Sato, I. Ruy and N. Sonoda, *Tetrahedron Lett.*, *33* (1992) 5525.
949 H.S. Chung and D.Y. Oh, *Tetrahedron Lett.*, *33* (1992) 5097.
950 K. Mochida, C. Hodata, H. Yamoshita and M. Tanaka, *Chem. Lett.*, (1992) 1635.
951 T.E. Cole, S. Rodewald and C.L. Watson, *Tetrahedron Lett.*, *33* (1992) 5295.
952 H. Lei, M.S. Stoakes and A.W. Schwabacher, *Synthesis*, (1992) 1255.
953 H.J. Metternich, E. Niecke and J.F. Nixon, *J. Chem. Soc., Chem. Commun.*, (1992) 627.
954 D. Bergstrom and T. Schmaltz, *J. Org. Chem.*, *57* (1992) 873.
955 C. Goux, P. Lhost and D. Sinou, *Tetrahedron Lett.*, *33* (1992) 8099.
956 C. Jixiang and G.T. Crisp, *Synth. Commun.*, *22* (1992) 683.
957 H. Kuniyasu, A. Ogawa, K.-I. Sato, I. Ryu, N. Kambe and N. Sonoda, *J. Am. Chem. Soc.*, *114* (1992) 5902.
958 M. Mathew, R. Echarri and S. Castillon, *Tetrahedron Lett.*, *33* (1992) 1093.
959 F. Liotta, C.R. Unelius, J. Kogak and T. Norin, *Acta Chem. Scand.*, *46* (1992) 686.
960 L.-L. Gundersen, T. Benneche and K. Undheim, *Tetrahedron Lett.*, *33* (1992) 1085.
961 O. Arjona, A. Candilejo, A. de Dios, R. Fernandez de la Pradilla and J. Plumet, *J. Org. Chem.*, *57* (1992) 6097.
962 C. Alayrac, C. Mioskowski, J.P. Salaun and F. Durst, *Synlett*, (1992) 73.
963 M. Pfeffer, *Pure Appl. Chem.*, *64* (1992) 335.
964 G. Erker, *Pure Appl. Chem.*, *64* (1992) 393.
965 S. Murahashi, *Pure Appl. Chem.*, *64* (1992) 403.
966 R.M. Kellogg, *Pure Appl. Chem.*, *64* (1992) 413.
967 P. Knochel, M.J. Rozema, C.E. Tucker, C. Retherford, M. Furlong and S.A. Rao, *Pure Appl. Chem.*, *64* (1992) 361.
968 Y. Kishi, *Pure Appl. Chem.*, *64* (1992) 343.
969 L. Hill, C.J. Richards, S.P. Saberi and S.E. Thomas, *Pure Appl. Chem.*, *64* (1992) 371.
970 G. Zassinovich, G. Mestroni and S. Gladiali, *Chem. Rev.*, *92* (1992) 1051.
971 H. Brunner, *Angew. Chem.*, *104* (1992) 1208.
972 M. Reetz, *Tetrahedron*, *48* (1992) 5557.
973 F. Sato and Y. Kobayashi, *Synlett*, (1992) 849.
974 T. Ibuka and Y. Yamamoto, *Synlett*, (1992) 769.
975 K.M.J. Brands and A.S. Kende, *Tetrahedron Lett.*, *33* (1992) 5887.
976 W.P. Griffith, *Chem. Soc. Rev.*, *21* (1992) 179.
977 L. Marko and F. Ungvary, *J. Organomet. Chem.*, *432* (1992) 1.
978 M. Sawamura and Y. Ito, *Chem. Rev.*, *92* (1992) 857.
979 R.L. Halterman, *Chem. Rev.*, *92* (1992) 965.
980 G. Zassinovich, G. Mestroni and S. Gladiali, *Chem. Rev.*, *90* (1992) 1051.
981 L.S. Hegedus, *J. Organomet. Chem.*, *422* (1992) 301.
982 D.J. Burton and Z.-Y. Yang, *Tetrahedron*, *48* (1992) 189.
983 D.M. Roundhill, *Chem. Rev.*, *92* (1992) 1.
984 H.R. Sonawane, N.S. Bellur, J.R. Ahuja and D.G. Kulkarni, *Tetrahedron: Asymmetry*, *3* (1992) 163.
985 F. Mathey, A. Marinetti and F. Mercier, *Synlett*, (1992) 363.
986 C. Rosini, L. Franzini, A. Raffaelli and P. Salvadori, *Synthesis*, (1992) 503.
987 T. Hayashi and Y. Uozumi, *Pure Appl. Chem.*, *64* (1992) 1911.
988 A.J. Canty, *Acc. Chem. Res.*, *25* (1992) 83.
989 E. Erdik, *Tetrahedron*, *48* (1992) 9577.
990 B.J. Lohray, *Tetrahedron: Asymmetry*, *3* (1992) 1317.
991 A.N. Kasatein, O.Yu. Tsypyshev, T.Yu. Romanova and G.A. Tolstikov, *Russ. Chem. Rev.*, *61* (1992) 537.
992 G.P. Chiusoli, M. Costa and Z. Zhou, *Gazz. Chim. Ital.*, *122* (1992) 441.
993 M. Chen, *Huaxue Shiji*, *14* (1992) 297.
994 G.R. Stephenson, *Annu. Rep. Prog. Chem., Sect. B*, *86* (1989) 227.
995 P.D. Lickiss, *Annu. Rep. Prog. Chem., Sect. B*, *86* (1989) 261.
996 K. Nagasawa, N. Ide, A. Satake, H. Nakagawa, H. Yamazaki,

M. Ooshima and I. Shimizu, *Tennen Yuki Kagobutsu Toronkai Koen Yoshishu*, (1991) 62.
997 K.H. Doetz and R.W. Hoffman, *Organic Synthesis via Organometallics. Proceedings of the 3rd Symposium in Marburg, July 11–14, 1990*, (1991) 323 pages.
998 H. Rudler, M. Audouin, E. Chelain, B. Denise, R. Goumont, A. Massoud, A. Parlier, A. Pacreau and M. Rudler, *Chem. Soc. Rev.*, *20* (1991) 503.
999 J. Boersma, *Chem. Mag. (Rijswijk, Neth.)*, (1991) 637.
1000 A. Heumann, *Catal. Met. Complexes*, *12* (1991) 133.
1001 G. van G. Koten, *Chem. Mag. (Rijswijk, Neth.)*, (1991) 631.
1002 K.M. Doxsee, J.K.M. Mouser and J.B. Farahi, *Synlett*, (1992) 13.
1003 M. Watanabe, *Toso Kenkyo Hokoku*, *36* (1992) 63.
1004 A. Mortreux, *Catal. Met. Complexes*, *12* (1991) 47.
1005 A. Domonceau, A.J. Hubert and A.F. Noels, *Catal. Met. Complexes*, *12* (1991) 237.
1006 J. Marchand-Brynaert, *Chim. Nouv.*, *9* (1991) 1049.
1007 S. Maiorana, C. Baldoli and E. Licandro, *Catal. Met. Complexes*, *12* (1991) 261.
1008 S. Woodward, *Organomet. Chem.*, *20* (1991) 353.
1009 D. Astruc, M.H. Desbois, B. Gloaguen, F. Moulines and J.R. Hamon, *Org. Synth. Organomet., Proc. 3rd Symp.*, (1991) 63.
1010 S. Habaue, A. Yanagisawa and H. Yamamoto, *Kagaku (Kyoto)*, *47* (1992) 212.
1011 J.H. Espenson, *Acc. Chem. Res.*, *25* (1992) 222.
1012 C.J. Richards, S.E. Thomas and M. Wills, *Gen. Synth. Methods*, *13* (1992) 250.
1013 J. Tsuji, *Transition Metals which changed Organic Synthesis: Fundamentals and Applications*, 291 (1991) pages.
1014 H. Wu, C. Li and S. Wang, *Daxue Huaxue*, *6* (1991) 20.
1015 A.K. Hughes, *Diss. Abstr. Int. B*, *52* (1991) 2021.
1016 S.J. Schauer, *Diss. Abstr. Int. B*, *52* (1991) 2023.
1017 I. Omae, *Kagaku Kogyo*, *43* (1992) 320.
1018 J.S. Song, *Diss. Abstr. Int. B*, *52* (1991) 2023.
1019 B.R. James, *Chem. Ind. (Dekker)*, *47* (1992) 245.
1020 M.H. Lyttle and D. Hudson, *Pept.: Chem. Biol., Proc. 12th Am. Pept. Symp.*, (1992) 583.
1021 L. Marko and F. Ungvary, *J. Organomet. Chem.*, *432* (1992) 1.
1022 J.W. Francis, *Diss. Abstr. Int. B*, *52* (1991) 3056.
1023 N. Toshima, T. Teranishi and Y. Saito, *Makromol. Chem., Macromol. Symp.*, *59* (1992) 327.
1024 A.N. Kasatkin, O.Yu. Tsypyshev, T.Yu. Romanova and G.A. Tolstikov, *Usp. Khim.*, *61* (1992) 978.
1025 Y. Watanabe, T. Mitsudo and T. Kondo, *Shokubai*, *34* (1992) 173.
1026 R.S. Drago, *Coord. Chem. Rev.*, *117* (1992) 185.
1027 O.V. Gerasimov and V.N. Parmon, *Usp. Khim.*, *61* (1992) 293.
1028 A. Sobkowiak, H.C. Tung and D.T. Sawyer, *Prog. Inorg. Chem.*, *40* (1992) 291.
1029 R.N. Grimes, *Inorganomet. Chem.*, (1992) 253.
1030 S.V. Ley, *Bull. Soc. Chim. Belg.*, *101* (1992) 641.
1031 H. Liu and W. Zai, *Fenzi Cuihua*, *6* (1992) 308.
1032 B.M. Trost, *Adv. Chem. Ser.*, *230* (1992) 463.
1033 T.L. Friebe, J.R. Johnson, D.J. Krysan, P.B. Mackenzie and M. Sabat, *Adv. Chem. Ser.*, *230* (1992) 529.