Pergamon

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Palladium Catalysed Cyclisation-Allene Insertion-Anion Capture Cascades.

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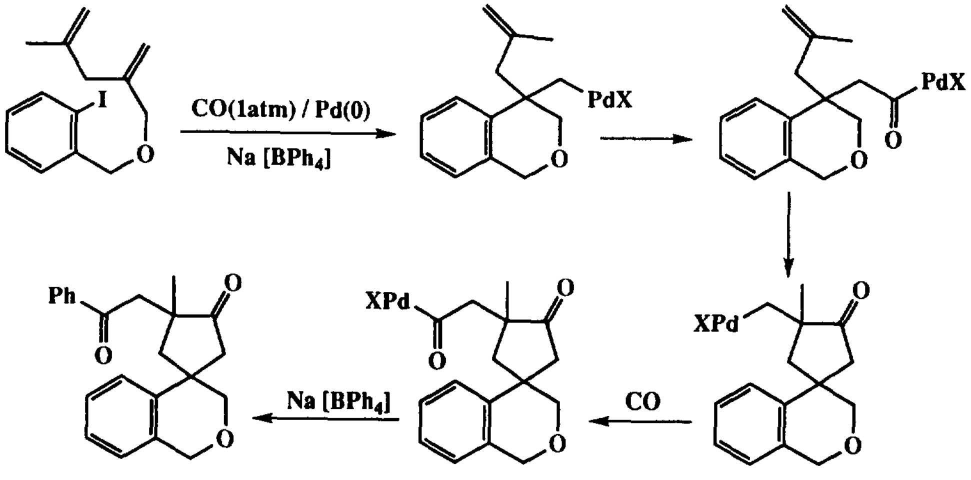
Abstract: Pd(0) catalysed termolecular queuing processes involving oxidative addition to aryl iodides followed by 5- or 6-exo-trig cyclisation, allene (1atm) insertion, and capture of the resulting π-allylpalladium(II) species by secondary amines occurs in good yield.

Palladium catalysed processes employing allenes as substrates have been somewhat neglected compared with alkenes, alkynes, and 1,3-dienes. Recently strong interest has begun to develop in these under-utilised substrates. Tsuji has shown that allenylpalladium species can be generated *in situ* from propargyl carbonates and these intermediates are now being actively developed[1]. We[2], and others[3], have begun exploring the chemistry of preformed allenes in both cyclisation and cycloaddition processes.

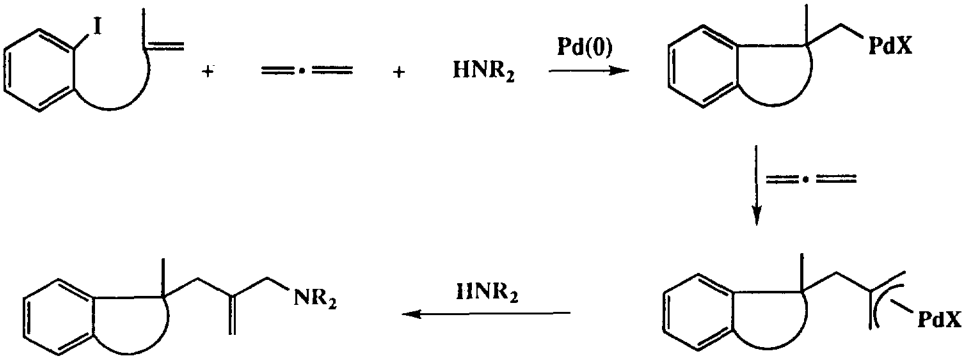
In this communication we describe the implementation of allene as a relay switch component in our cascade cyclisation-anion capture methodology. We have recently described analogous relay switch processes in which carbon monoxide performed the relay switch function[4] and an example of this is shown in Scheme 1 (unpublished) which occurs in 70% overall yield.[5]



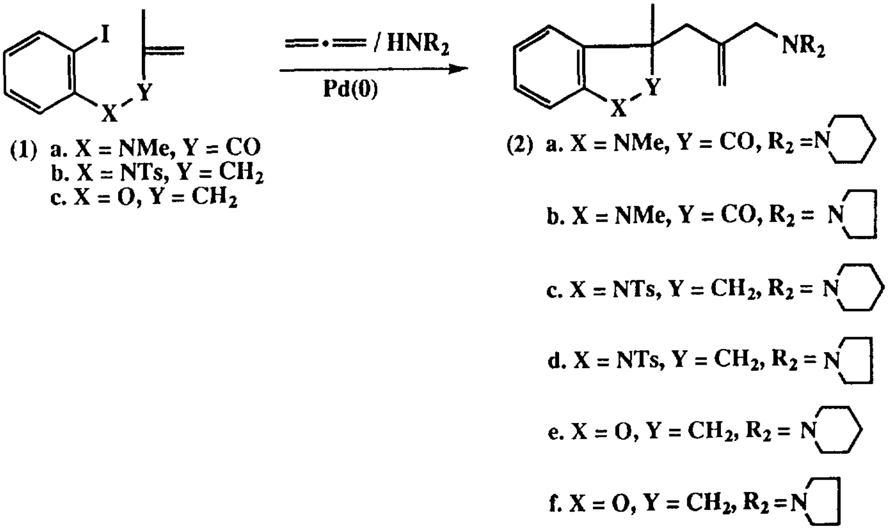
Scheme 1

The role of a relay switch component is to insert further functionality into the cyclisation-anion capture process whilst enabling the process to switch between intra- and inter-molecular pathways. These molecular queuing cascades require the relative rate of reaction of the various substrates to be in the correct order and these data are not available in the published literature.

Our initial studies have focused on the termolecular queuing processes generating allylic amines depicted in Scheme 2.



Scheme 2



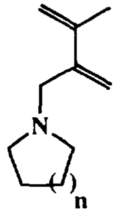
(1) a. X = NMe, Y = CO
b. X = NTs, Y = CH$_2$
c. X = O, Y = CH$_2$

(2) a. X = NMe, Y = CO, R$_2$ =N
b. X = NMe, Y = CO, R$_2$ = N
c. X = NTs, Y = CH$_2$, R$_2$ = N
d. X = NTs, Y = CH$_2$, R$_2$ = N
e. X = O, Y = CH$_2$, R$_2$ = N
f. X = O, Y = CH$_2$, R$_2$ =N

Reaction (toluene, 90°C, 20h) of (1a) with allene (1-1.2atm),[6] piperidine (2.5eq) and a catalyst system comprising 10mol% Pd(OAc)$_2$, 20mol% PPh$_3$, [Et$_4$N]Cl(1eq) and K$_2$CO$_3$(2mol eq) afforded (2a) in 82% yield.[7] Reaction of (1a) and pyrrolidine in an analogous manner afforded (2b) in 76% yield.

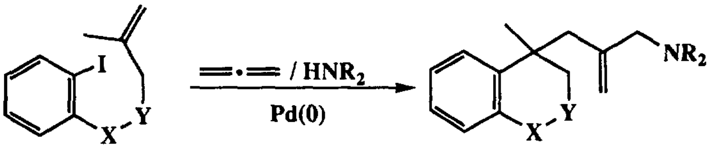
A similar series of reactions was conducted with (1b) but at 110°C (toluene, 20h). Thus (1b) and piperidine or pyrrolidine react to form (2c)(60%) and (2d) (72%). 2-Iodophenyl methallyl ether (1c) reacted with piperidine and pyrrolidine under similar conditions (toluene, 110°C, 20h), but only 0.5 atm pressure of allene, to afford (2e) (60%) and (2f)(60%).

The formation of (2a-f) by the above procedure is accompanied by varying amounts of the respective by-products (3a) and (3b) arising from reaction between the excess secondary amine and allene. This palladium catalysed process was first reported by Coulson in 1973.[8]



(3) a. n = 1

b. n = 2



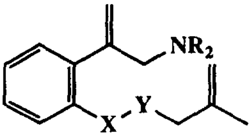
(4) a. X = CO, Y = NBn

b. X = CH$_2$, Y = O

(5) a. X = CO, Y = Bn, R$_2$ = 

b. X CH$_2$, Y = O, R$_2$ = 

c. X = CH$_2$, Y = O, R$_2$ = 



(6)

Cascades involving initial cyclisation forming a 6-membered ring were studied next to assess whether the anticipated slower cyclisation step would render direct allenylation-amine capture, leading to (6), a competitive process. Reaction (toluene, 120°C, 24h) of (4a) with allene and piperidine under analogous conditions to those employed for (1a-c) afforded the desired product (5a) in 50% yield. However, when (4b) was subjected to the same conditions it became apparent that the direct capture product (6, X=CH$_2$, Y=O) was being formed. Whilst reducing the allene pressure partially rectified this problem it was found more expeditious to conduct the reactions of (4b) with piperidine and pyrrolidine in xylene at 140°C under 1atm of allene. These conditions afforded (5b) and (5c) in 50% yield.

Further studies of these and related processes are underway.

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4. Grigg, R.; Redpath, J.; Sridharan, V.; Wilson, D.; *Tetrahedron Lett.*, 1994, **35**, 3197-3200; Brown, S.; Clarkson, S.; Grigg, R.; Sridharan, V.; *J. Chem. Soc., Chem. Commun.*, 1995, 1135-1136.
5. For a related example see: Grigg, R.; Redpath, J.; Sridharan, V.; Wilson, D.; *Tetrahedron Lett.*, 1994, **35**, 7661-7664.
6. Reactions were carried out with stirring in a Schlenk tube since allene diffuses readily through an ordinary balloon.
7. All new compounds gave satisfactory microanalytical and spectroscopic data.
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