mass spectrum, m/z (relative intensity) 290 (M^+, 25), 275 (7), 205 (28), 119 (100), 91 (82); exact mass calcd for $C_{19}H_{30}O_2$ 290.2247, found 290.2244.

Ring-Cleavage Product 21. A ring-cleavage reaction was performed, starting from 157.8 mg (0.543 mmol) of **19**, by a procedure similar to the one described above. Flash chromatography (20–25%) gave 191.2 mg (86%) of **21**: oil; ^{1}H NMR δ 0.84 (3 H, d, J = 6.4 Hz, CH_3), 0.89 (3 H, d, J = 6.0 Hz, CH_3), 1.10–1.95 [13 H, m, including d (3 H, J = 6.4 Hz, CH_3) at 1.15], 2.05–2.56 (4 H, m), 2.80 (1 H, br s), 2.93 (1 H, d, J = 15.6 Hz, CH_2COPh), 2.93 (1 H, br s), 3.04 (1 H, m, CH_2O), 3.36 (3 H, m, CH_2O), 3.57 (1 H, d, J = 15.6 Hz, CH_2COPh), 6.09 (2 H, m, 2 CH=), 7.13 (3 H, m, Ar), 7.99 (2 H, m, Ar); IR (liquid film) 3560 (br) 1680 (s), 1020 (s), 1000 (s), 750 (s), 685 cm^{-1} (s); mass spectrum, 410 (M^+, <1), 257 (48), 137 (60), 105 (100); exact mass calcd for $C_{27}H_{38}O_3$ 410.2822, found 410.2821.

Mono-THP Derivative 22. This material was prepared, starting from **21**, in 87% overall yield by a procedure similar to the one described in the preparation of **11**. **22**: ^{1}H NMR δ 1.15–1.80 (9 H, m), 2.54 (2 H, m), 2.82 (2 H, m), 3.08–3.85 (6 H, m), 4.56 (1 H, br s), 6.03 (2 H, br s); IR (liquid film) 3410 (br), 3060 (m), 1030 (s), 730 cm^{-1} (s). The optical purity of **22** was also determined after the conversion of **22** into the corresponding (*R*)-(+)-MTPA ester followed by the removal of the THP group. **(*R*)-MTPA ester**: oil; ^{1}H NMR δ 1.30 (1 H, br d, J = 8.4 Hz), 1.48 (1 H, t, d, J = 1.7 and 8.4 Hz), 2.32–2.63 (2 H, m), 2.80 (1 H, br s), 2.91 (1 H, br s), 3.35 (2 H, d, J = 7.3 Hz), 3.53 (3 H, q, J = 1.2 Hz), 4.04 (1 H, dd, J = 6.4 and 10.6 Hz), 4.18 (1 H, dd, J = 9.4 and 10.6 Hz), 6.08 (1 H, dd, J = 3.2 and 5.6 Hz), 6.16 (1 H, dd, J = 3.2 and 5.6 Hz), 7.42 (3 H, m), 7.50 (3 H, m). **Mono (*R*)-MTPA ester derived from diol 16**: oil; ^{1}H NMR δ 1.30 (1 H, m), 1.48 (1 H, m), 2.3–2.6 (2 H, m), 2.84 (1 H, br), 2.91 (1 H, br s), 3.33 and 3.35 [2 H, br d (J = 7.4 Hz) and d, respectively], 3.53 and 3.55 (3 H, q, J = 1.2 Hz), 4.0–4.25 (2 H, m), 6.12 (2 H, m), 7.42 (3 H, m), 7.50 (3 H, m).

(2*S*,3*R*)-Lactone 23. To a solution of oxalyl chloride (98 μL, 1.12 mmol) in CH_2Cl_2 (1 mL) were added a CH_2Cl_2 solution (0.27 mL) of dimethyl sulfoxide (196 mg, 78.1 mmol) and a CH_2Cl_2 solution (0.27 mL) of **22** (110.2 mg, 0.426 mmol) at −75 °C, and the mixture was stirred for 20 min. To this was added 330 μL (2.37 mmol) of triethylamine, and then the mixture was stirred at room temperature for 1 h. After aqueous workup (brine/CH_2Cl_2), the crude material was dissolved in aqueous 30% EtOH (10 mL) containing 23 mg of PTS and the mixture was heated at 50 °C for 40 min. After aqueous workup (brine/ethyl acetate) followed by concentration in vacuo, the crude mixture was treated with pyridinium chlorochromate (150 mg, 0.70 mmol) in CH_2Cl_2 (3 mL) at room temperature for 3 h. After the usual workup, purification by flash chromatography (50%) gave 11.5 mg (18% overall yield) of **23**: oil; $[\alpha]^{25}_D$ +136° (c 1.00, $CHCl_3$) [lit.[2b] $[\alpha]^{25}_D$ +143.2 (c 5.2, $CHCl_3$)]; ^{1}H NMR ($CDCl_3$) δ 1.45 (1 H, br d, J = 8.4 Hz), 1.64 (1 H, br d, J = 8.4 Hz), 3.00–3.37 (4 H, m), 3.78 (1 H, dd, J = 3.1 and 9.5 Hz), 4.29 (1 H, dd, J = 8.2 and 9.5 Hz), 6.30 (2 H, br s); IR (liquid film) 1750 (s), 1175 (s), 1045 (s), 1000 cm^{-1} (s).

Registry No. **6a**, 41235-26-1; **6b**, 39789-20-3; **6c**, 119972-72-4; **6d**, 119972-73-5; **7a**, 119972-74-6; **7b**, 119972-75-7; **7c**, 119972-76-8; **7d**, 119972-77-9; **8a**, 120053-10-3; **8b**, 120053-11-4; **8c**, 120053-12-5; **8d**, 120053-13-6; **9a**, 119972-78-0; **9b**, 119972-79-1; **9c**, 119972-80-4; **9d**, 119972-81-5; **10a**, 120053-14-7; **10b**, 120053-15-8; **10c**, 119972-82-6; **10d**, 119972-83-7; **11**, 120053-19-2; **11** acetate, 119972-90-6; **12**, 119972-88-2; **13**, 120053-18-1; **14**, 58502-00-4; (*R*)-**15**, 64363-90-2; **16**, 699-97-8; **16** (mono (*R*)-MTPA ester), 119972-97-3; **17**, 119972-91-7; **18**, 43187-61-7; **19**, 119972-92-8; **20**, 120142-40-7; **21**, 119972-94-0; **22**, 119972-95-1; **22** ((*R*)-MTPA ester), 119972-96-2; **23**, 95340-88-8; *l*-menthone, 14073-97-3; acetophenone enol, 13735-81-4; (1*S*,2*R*)-2-(methoxymethoxy)-cyclopentyl (*R*)-α-methoxy-α-(trifluoromethyl)phenylacetate, 119972-84-8; (1*R*,2*S*)-2-(methoxymethoxy)cyclopentyl (*R*)-α-methoxy-α-(trifluoromethyl)phenylacetate, 120053-16-9; (1*S*,2*R*)-2-(methoxymethoxy)cyclohexyl (*R*)-α-methoxy-α-(trifluoromethyl)phenylacetate, 119972-85-9; (1*R*,2*S*)-2-(methoxymethoxy)cyclohexyl (*R*)-α-methoxy-α-(trifluoromethyl)phenylacetate, 120053-17-0; (1*R*,2*S*)-2-(methoxymethoxy)cyclooctyl (*R*)-α-methoxy-α-(trifluoromethyl)phenylacetate, 119972-86-0; (1*S*,2*R*)-2-(methoxymethoxy)cyclooct-5-enyl (*R*)-α-methoxy-α-(trifluoromethyl)phenylacetate, 119972-87-1; (1*R*,2*S*)-2-(methoxymethoxy)cyclooct-5-enyl (*R*)-α-methoxy-α-(trifluoromethyl)-phenylacetate, 120142-38-3; (1*R*,2*S*)-2-hydroxycyclohexyl (*R*)-α-methoxy-α-(trifluoromethyl)phenylacetate, 119972-89-3; (1*S*,2*R*)-2-hydroxycyclohexyl (*R*)-α-methoxy-α-(trifluoromethyl)phenylacetate, 120142-39-4; *l*-menthone dimethyl acetal, 119972-93-9.

Carbon–Carbon Bond Formation in Reactions of PhIO•HBF_4/Silyl Enol Ether Adduct with Alkenes or Silyl Enol Ethers

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A new method for generation of reactive α-ketomethyl aryliodonium intermediates from silyl enol ethers and PhIO·HBF_4 has been developed. Reactions of PhIO·HBF_4/silyl enol ether adduct with alkenes (1-hexene, cyclohexene, α-methylstyrene, allyltrimethylsilane, 2,3-dimethyl-2-butene) yielded products of allylic alkylation or (in case of 2,3-dimethyl-2-butene) a substituted dihydrofuran. Reactions of adducts from PhIO/HBF_4 and silyl enol ethers of acetophone, *p*-chloroacetophenone, *p*-methylacetophenone, and *p*-nitroacetophenone with various silyl enol ethers led to unsymmetrical 1,4-butanediones as major products.

There is a considerable current interest in polyvalent iodine chemistry.[1] Although I(III) reagents have been used for solution of a wide variety of synthetic tasks, the main application is usually connected with different oxidations.[1] But in recent years it has been shown that polyvalent iodine chemistry can be applied for more complicated purposes such as transformation of alkenes[2,3] or

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Table I. Reactions of PhIO•HBF$_4$/Silyl Enol Ether Adducts (3) with Silyl Enol Ethers or Alkenes

reagent	substrate	product (yield, %)[a]	mass spectra, *m/e*	^{1}H NMR,[b] δ
3a	**2b**	**4a** (42)	272, 274 (M^+), 139, 141 (ClC_6H_4CO), 111, 113 (ClC_6H_4), 105 (PhCO), 77 (Ph)	8.1–7.4 (9 H, m), 3.45 (4 H, s)
	2c	**4d** (27)	282 (M^+), 150 ($NO_2C_6H_4CO$), 105 (PhCO), 77 (Ph)	8.3–7.5 (9 H, m), 3.5 (4 H, s)
	2d	**4c** (34)	268 (M^+), 163 ($CH_3OC_6H_4COCH_2CH_2$), 135 ($CH_3OC_6H_4CO$), 107 ($CH_3OC_6H_4$), 105 (PhCO), 77 (Ph)	8.0–7.0 (9 H, m), 3.8 (3 H, s), 3.45 (4 H, s)
	2e	**4b** (40)	252 (M^+), 119 ($CH_3C_6H_4CO$), 105 (PhCO), 77 (Ph)	7.9–7.2 (9 H, m), 3.45 (4 H, s), 3.65 (3 H, s)
	5	**6a** (50)[c]	216 (M^+), 173, 159, 133, 120, 105 (PhCO), 77 (Ph)	7.9–7.5 (5 H, m) 3.6 (2 H, m), 3.16 (1 H, m), 2.4 (2 H, m), 2.1–1.4 (6 H, m)
	7	**8a** (40)	202 (M^+), 160, 105 (PhCO), 77 (Ph)	7.9–7.5 (5 H, m), 3.5 (2 H, m), 2.6 (1 H, m), 2.5–1.6 (6 H, m)
	9	**10** (20)[c,d]	202 (M^+), 159 (M – C_3H_7), 133 ($PhCOCH_2CH_2$), 105 (PhCO), 77 (Ph)	7.9–7.5 (5 H, m), 5.48 (2 H, m), 3.04 (2 H, t, J = 7.7 Hz), 2.0 (2 H, m), 1.8–0.9 (7 H, m)
	11	**12** (90)[c]	200 (M^+), 105 (PhCO), 77 (Ph)	7.9–7.5 (5 H, m), 5.72 (2 H, m), 3.64 and 3.72 (2 H, 2 d, J = 7.4, and 6.3), 2.95 (1 H, m), 2.0–1.1 (6 H, m)
	13	**14** (63)[c]	160 (M^+), 105 (PhCO), 77 (Ph), 55 ($CH_2CH_2CH{=}CH_2$)	7.9–7.5 (5 H, m), 5.92 (1 H, m), 5.05 (2 H, m), 3.08 (2 H, t, J = 7.5 Hz), 2.5 (2 H, m)
	15	**16** (59)[c]	236 (M^+), 132, 105 (PhCO), 77 (Ph)	8.0–7.2 (10 H, m), 4.8 (2 H, m), 2.9 (2 H, m) 2.3 (2 H, m)
	17	**18** (80)[c]	202 (M^+), 187 (M – Me), 172 (M – 2Me), 129 (M – 2Me – CO), 77 (Ph)	7.0–7.5 (5 H, m), 7.2 (1 H, s), 1.3 (6 H, s), 1.1 (6 H, s)
3b	**2a**	**4a** (46)		
	2d	**4f** (51)	302, 304 (M^+), 139, 141 (ClC_6H_4CO), 135 ($CH_3OC_6H_4CO$), 111, 113 (ClC_6H_4), 107 ($CH_3OC_6H_4$)	8.0–6.9 (8 H, m), 3.8 (3 H, s), 3.45 (4 H, s)
	2e	**4e** (43)	286, 288 (M^+), 139, 141 (ClC_6H_4CO), 119 ($CH_3C_6H_4CO$), 111, 113 (ClC_6H_4), 91 ($CH_3C_6H_4$)	8.0–7.2 (8 H, m), 3.5 (4 H, s), 2.65 (3 H, s)
	7	**8b** (44)	236, 238 (M^+), 194, 196 (M – $COCH_2$), 139, 141 (ClC_6H_4CO), 111, 113 (ClC_6H_4), 97	7.9–7.4 (4 H, m), 3.46 (2 H, m), 2.6 (1 H, m) 2.4–1.6 (6 H, m)
3c	**2b**	**4g** (38)	317 (M^+), 150 ($NO_2C_6H_4CO$), 139, 141 (ClC_6H_4CO), 111, 113 (ClC_6H_4)	8.4–7.4 (8 H, m), 3.5 (4 H, s)
	2d	**4h** (61)[e]	313 (M^+), 150 ($NO_2C_6H_4CO$), 135 ($CH_3OC_6H_4CO$), 107 ($CH_3OC_6H_4$)	8.2–6.9 (8 H, m), 3.8 (3 H, s), 3.45 (4 H, s)
	7	**8c** (75)	247 (M^+), 205 (M – $COCH_2$), 150 ($O_2NC_6H_4CO$)	8.3–8.0 (4 H, m), 3.5 (2 H, m), 2.6 (1 H, m), 2.4–1.6 (6 H, m)
3d	**2a**	**4c** (31)		
	7	**8d** (30)	232 (M^+), 190 (M – $COCH_2$), 149 ($CH_3OC_6H_4COCH_2$), 135 ($CH_3OC_6H_4$)	7.9 (2 H, m), 6.9 (2 H, m), 3.8 (3 H, s), 3.45 (2 H, m), 2.6 (1 H, m), 2.4–1.6 (6 H, m)
3e	**5**	**6b** (50)	230 (M^+), 187 (M – $3CH_2$), 173 (M – $4CH_2$), 145 (M – $4CH_2$ – CO), 133 ($CH_3C_6H_4COCH_2$), 119 ($CH_3C_6H_4$)	7.8 (2 H, m), 7.25 (2 H, m), 3.5 (2 H, m), 3.15 (1 H, m), 2.33 (3 H, s), 2.5–1.4 (8 H, m)
	7	**8e** (55)	216 (M^+), 174 (M – $COCH_2$), 133 ($CH_3C_6H_4COCH_2$), 119 ($CH_3C_6H_4$)	7.8 (2 H, m), 7.3 (2 H, m), 3.45 (2 H, m), 2.6 (1 H, m), 2.4 (3 H, s), 2.4–1.6 (6 H, m)

[a] Yields were determined by GC analyses. [b] All spectra were measured in $CDCl_3$ (TMS) as internal standard at 200 MHz. [c] Yield of isolated product. [d] 1:1 mixture of cis and trans isomers according to GC data. [e] **4h**, mp 145–146 °C, is in agreement with that reported first in ref 8.

alkyliodides[4] into tosylates,[2–4] triflates,[3,4] perchlorates;[3,4] α-functionalization of ketones[5] and β-dicarbonyl compounds;[6] synthesis of allyl azides from allylsilanes;[7] and even creation of new carbon–carbon bonds.[8–11,13–15] The last kind of reaction is one of the most important for organic synthesis and has attracted substantial attention of different groups of researchers. Formation of new car-

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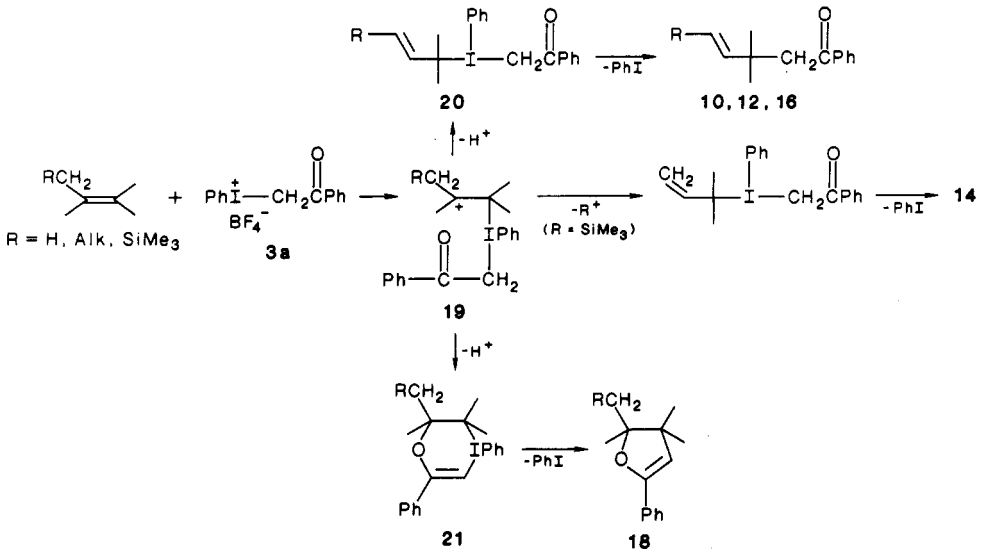
Scheme I



bon–carbon bonds is possible in the reactions of organic substrates with iodonium percursors which can be either stable iodonium salts or reaction intermediates with general formula $ArI^+R\ X^-$. At present four main types of stable iodonium salts are known, in which R = aryl, alkynyl, vinyl, and perfluoroalkyl. All these reagents can react with organic substrates with formation of a new C–C bond.[8-11] Diaryliodonium salts are relatively unreactive, but it was shown that they can arylate β-dicarbonyl compounds.[8] Alkynyliodonium[9] and vinyliodonium[10] salts can give coupling products with organocopper reagents. Perfluoroalkyliodonium salts react under mild conditions with aromatic compounds,[11a] alkynes,[11a] alkenes,[11c] and silyl enol ethers[11d] introducing the perfluoroalkyl group into an organic substrate.

In contrast to fluorinated derivatives, alkyliodonium salts are frequently unstable at room temperature, although a few stable examples have been synthesized by G. Olah.[12] It has been shown, for example, that $PhI^+CH_3\ SbF_6^-$ can exist only several hours at 20 °C, and then decomposition readily occurs.[12a] But there is strong evidence that alkyliodonium salts participate as unstable intermediates in many reactions of polyvalent iodine reagents including transformations leading to new C–C bond formation. There are several ways of generation of alkyliodonium salts in situ as reactive intermediates in the latter type of reaction. Recently we have shown that iodonium ylides can react with Lewis acids yielding reactive iodonium intermediates which can transform alkenes or silyl enol ethers into products with new C–C bond.[13] We even could separate and identify a relatively stable product of the addition of SO_3 to an iodonium ylide and study its reactions with alkenes.[13a] A second way of generation of iodonium salts in situ was developed by R. Moriarty.[14] In this case silyl enol ethers and $PhIO/BF_3$ were used as precursors for generation of α-ketomethyl aryliodonium intermediates which immediately reacted with the excess of the silyl enol ether to give a product of symmetric coupling.[14] In the present paper we describe a method for the generation of iodonium intermediates from silyl enol ethers and $PhIO/HBF_4$ and their reactions with alkenes or silyl enol ethers (preliminary communication, see ref 15).

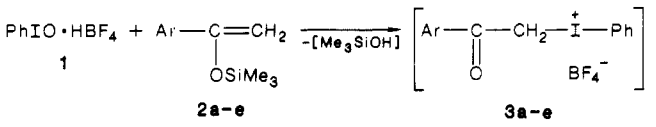
Results and Discussion

We have found that iodosobenzene reacts with HBF_4·Me_2O in methylene chloride at −50 to 0 °C with formation of a yellow solution of the highly electrophilic complex **1**. This complex is unstable at room temperature and decomposes within a few minutes to give a black tar. But at low temperatures it is stable and very reactive toward unsaturated substrates. Addition of 1 equiv of a silyl enol ether **2** to this solution at −78 °C caused immediate decolorization with formation of a white suspension. No stable product could be isolated from this mixture, but results of its reactions with unsaturated compounds suggest the structure of the α-ketomethyl phenyliodonium salt **3** for this reagent. We have studied reactions of this reagent with various silyl enol ethers and alkenes. Reactions were carried out by a rapid addition of reagent **3d** at −78 °C to a stirred solution of a substrate (silyl enol ether or alkene) in methylene chloride. Products were separated by column chromatography on silica gel and identified with NMR and mass spectra. Yields of products and their spectral characteristics are summarized in Table I.

Initially the coupling reactions of iodonium salts **3** with silyl enol ethers were examined. Attempts to generate reagent **3** from silyl enol ethers of aliphatic ketones (pinacolone, cyclohexanone, cyclopentanone) and $PhIO{\cdot}HBF_4$ were unsuccessful: we did not obtain any product of coupling after addition of this mixture to a substrate. But reactions of iodonium salts **3** generated with silyl enol ethers of acetophenones **2a–e** gave more positive results, yielding products of coupling with the second silyl enol ether (1 equiv).

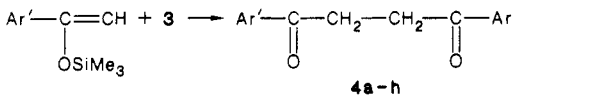
Average yield of coupling products **4**, **6**, **8** was about 50%, and the usual byproducts were corresponding acetophenones and products of symmetric couplings (less than 10%). Yields of products sharply depended upon reaction conditions (ratio of starting reagents, temperature, etc.). We could not find any correlation between yields and nature of the substituent in the aromatic ring of the silyl enol ether. It is worth emphasizing that this method works well for coupling of acetophenones with cyclohexanone and cyclopentanone. The recently reported coupling with $PhIO{\cdot}BF_3$ did not work in this case.[14] For the formation of 1,4-diketones **4**, **6**, **8** we propose the same mechanism as suggested by Moriarty.[14]

Subsequently the reactions of reagent **3a** (generated from silyl enol ether of acetophenone) with alkenes were studied. Reactions were performed by addition of a cold solution of reagent **3a** to a solution of alkene (2–3 equiv)



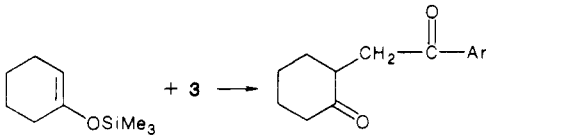
2a–e **3a–e**

a, Ar = Ph; **b**, Ar = *p*-ClC_6H_4; **c**, Ar = *p*-$NO_2C_6H_4$; **d**, Ar = *p*-$CH_3OC_6H_4$; **e**, Ar = *p*-$CH_3C_6H_4$



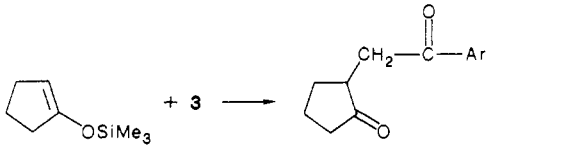
4a–h

a, Ar = Ph, Ar′ = *p*-ClC_6H_4; **b**, Ar = Ph, Ar′ = *p*-$CH_3C_6H_4$; **c**, Ar = Ph, Ar′ = *p*-$CH_3OC_6H_4$; **d**, Ar = Ph, Ar′ = *p*-$NO_2C_6H_4$; **e**, Ar = *p*-ClC_6H_4, Ar′ = *p*-$CH_3C_6H_4$; **f**, Ar = *p*-ClC_6H_4, Ar′ = *p*-$CH_3OC_6H_4$; **g**, Ar = *p*-$NO_2C_6H_4$, Ar′ = *p*-ClC_6H_4; **h**, Ar = *p*-$NO_2C_6H_4$, Ar′ = *p*-$CH_3OC_6H_4$



5 **6a,b**

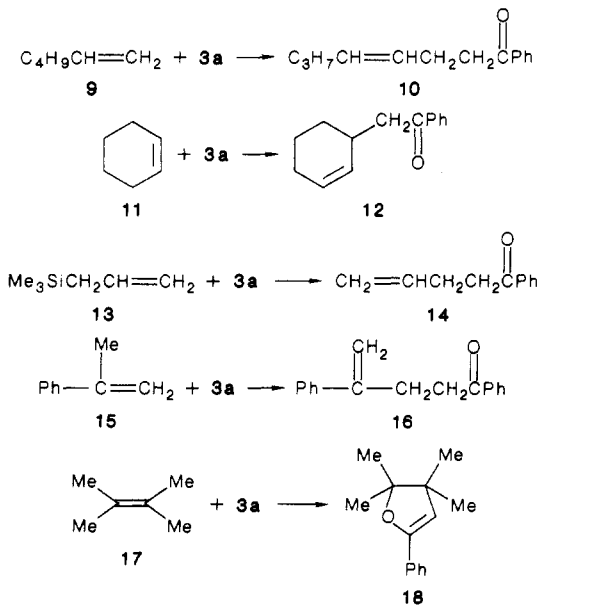
a, Ar = Ph; **b**, Ar = *p*-$CH_3C_6H_4$



8a–e

a, Ar = Ph; **b**, Ar = *p*-ClC_6H_4; **c**, Ar = *p*-$NO_2C_6H_4$; **d**, Ar = *p*-$CH_3OC_6H_4$; **e**, Ar = *p*-$CH_3C_6H_4$

in methylene chloride at room temperature. Depending on the structure of starting alkene, two different kinds of products were obtained: β-functionalized alkenes **10**, **12**, **14**, **16** or the dihydrofuran **18**. The best yields were obtained in the reactions of cyclohexene and 2,3-dimethyl-2-butene. In all cases GS and NMR analyses of reaction mixtures indicated the presence of trace amounts of rearranged products with different locations of the double bond (less than 5%).



For the reactions of reagent **3a** with alkenes we propose a carbocationic mechanism starting with electrophilic attack of iodine atom on the double bond with formation of the intermediate **19**. There are two possible subsequent transformations in this carbocation **19**: elimination of proton (or trimethylsilyl group in the case of allylsilane **13**) leading to covalent tricoordinated iodine intermediate **20** or cyclization with concomitant proton elimination with the formation of cyclic intermediate **21** (in the reaction of 2,3-dimethylbutane). Reductive elimination of iodosobenzene from intermediates **20**, **21** gives the final products **10**, **12**, **14**, **16**, or **18** (Scheme I).

In conclusion we have to emphasize that the reported method for the generation of highly reactive α-ketomethyl iodonium salts potentially could find synthetic application. Reactions of alkyliodonium salts with unsaturated compounds or C-nucleophiles might meet the requirements of a general approach to new carbon–carbon bond formation. Further research is needed for clarifying the details of the mechanism of the reported reactions.

Experimental Section

^{1}NMR spectra were recorded on a IBM AF FT NMR spectrometer (200 MHz). Mass spectra were obtained with a Hewlet-Packard 5970 A GC mass spectrometer.

Starting alkenes and silyl enol ethers of acetophenone, cyclohexanone, and cyclopentanone were obtained from Aldrich. Silyl enol ethers of *p*-chloro-, *p*-nitro-, *p*-methoxy-, and *p*-methylacetophenones were prepared by known procedures.[14] Iodosobenzene was prepared from iodosobenzenediacetate (Aldrich) by hydrolysis with aqueous sodium hydroxide.[16] Fresh tetrafluoroboric acid–dimethyl ether (Aldrich) was used. Methylene chloride was dried and distilled before use.

General Procedure. To a stirred solution of iodosobenzene (0.22 g, 1 mmol) in methylene chloride (5 mL) was added tetrafluoroboric acid–dimethyl ether (0.2 mL) at −50 °C. The mixture was warmed up to 0 °C until formation of a yellow solution and then cooled to −78 °C. To the resulting cold solution silyl enol ether (1 mmol) was added with stirring. The color of the reaction mixture changed immediately from light yellow to white. The cold solution of the reagent **3** formed was added to a stirred solution of a silyl enol ether (1 mmol) or an alkene (2–3 mmol) in methylene chloride (5 mL) at room temperature. The reaction mixture was stirred for 10 min, poured into water (50 mL), shaken, and extracted with methylene chloride (2 × 10 mL). The organic extract was dried (Na_2SO_4) and concentrated under reduced pressure. The products were separated by column chromatography on silica gel with acyl acetate–hexane mixtures as eluent. Yields of the products and their spectral characteristics are given in the table.

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Registry No. 1, 120312-56-3; **2a**, 13735-81-4; **2b**, 58518-76-6; **2c**, 74812-79-6; **2d**, 55991-65-6; **2e**, 54731-27-0; **3a**, 120312-58-5; **3b**, 120312-60-9; **3c**, 120312-62-1; **3d**, 120312-64-3; **3e**, 120312-66-5; **4a**, 60721-33-7; **4b**, 40794-87-4; **4c**, 60755-22-8; **4d**, 120312-67-6; **4e**, 120312-68-7; **4f**, 67756-16-5; **4g**, 120331-96-6; **4h**, 108791-69-1; **5**, 6651-36-1; **6a**, 33553-23-0; **6b**, 54669-83-9; **7**, 19980-43-9; **8a**, 54669-76-0; **8b**, 120312-69-8; **8c**, 120312-70-1; **8d**, 120312-71-2; **8e**, 120312-72-3; **9**, 592-41-6; *cis*-**10**, 120312-74-5; *trans*-**10**, 120312-75-6; **11**, 110-83-8; **12**, 31151-39-0; **13**, 762-72-1; **14**, 3240-29-7; **15**, 98-83-9; **16**, 120312-73-4; **17**, 563-79-1; **18**, 120312-76-7.

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