1,2-Asymmetric induction in the addition of $XCCl_3$ to *trans*-cynnamoyl-*N*-pyrrolidine

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In the reaction of $XCCl_3$ (X = Br (**1**), Cl (**2**)) with *trans*-PhCH=CHC(O)Y (Y = *N*-pyrrolidyl) (**3**) in the presence of $Fe(CO)_5$ as the catalyst (or benzoyl peroxide in the case of **1**) at 80°, the addition of CCl_3 radicals occurs regioselectively at the α-carbon atom of **3**, and the transfer of X occurs stereoselectively to give only one diastereomer of adduct **4** or **5** due to 1,2-asymmetric induction. In the case of the addition of **2** to olefin **3**, initiation by peroxide is inefficient.

Key words: 1,2-asymmetric induction, stereoselectivity, regioselectivity, 1,2-disubstituted amides of unsaturated carboxylic acids, addition

The 1,2-asymmetric induction arising in the addition of carbon-centered free radicals to 1,2-unsaturated compounds[1] or in the reduction of compounds of the type $R^1R^2CHCXR^3C(O)R$ (X = Br, I),[2,3] is advantageously used for asymmetric synthesis.[3,4] In the stereoselective processes of addition to 1,2-disubstituted olefins, iodine derivatives R—I are normally used as telogens (see Ref. 2), and the second chiral center is formed by the abstraction of iodine from the telogen by the adduct radical.

It has been of interest to use 1,2-asymmetric induction to involve polyhalo derivatives in asymmetric synthesis by adding them to α,β-disubstituted olefins.

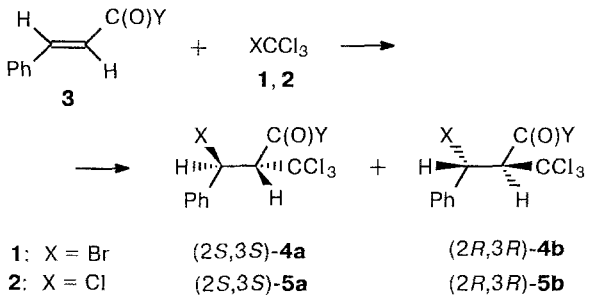
Mono- and binuclear carbonyls of transition metals (CTM) are efficient catalysts for the addition of a variety of haloalkanes to unsaturated compounds.[5,6] An advantage of CTM over traditional initiators of free-radical reactions is that metal carbonyl intermediates are involved in the transfer of halogen to the radical adduct.

In the present work we studied the addition of $XCCl_3$ (X = Br (**1**), Cl (**2**) to *trans*-PhCH=CHC(O)Y (Y is N-pyrrolidyl) (**3**) in the presence of $Fe(CO)_5$ and benzoyl peroxide (BP). Chiral centers are formed when the CCl_3 radical adds to olefin **3**, and the radical adduct is then stabilized by the formation of the carbon—halogen bond.

Results and Discussion

The reaction of telogen **1** with olefin **3** in the presence of $Fe(CO)_5$ or BP at 80 °C afforded adduct (**4**) as a single diastereomer (Scheme 1). The structure of the product was confirmed by the ^{13}C and ^1H NMR spectra, which coincided with those described previously[7] when the structure of adduct **4** was determined by X-ray diffraction analysis.

Scheme 1



The corresponding adduct $PhCHClCH(CCl_3)C(O)Y$ (**5**) could be obtained by the reaction of **2** with olefin **3** under the above-described conditions only in the presence of $Fe(CO)_5$. The inefficiency of peroxide initiation in this case may be explained by the fact that the radical adduct $PhC^{\cdot}HCH(CCl_3)C(O)Y$ (**A**) cannot abstract chlorine from CCl_4. In fact,[8] the unsubstituted benzyl radical, $PhC^{\cdot}H_2$ does not abstract chlorine from CCl_4. The structure of adduct **5** was confirmed by the ^{13}C and ^1H NMR spectra, which coincided with those described previously[7] when the structure of adduct **5** was determined by X-ray diffraction analysis, and by the mass spectrum, which exhibited intense peaks with *m/z* 125 and 127 (22.6 %), corresponding to the $[PhCHCl]^+$ ion.

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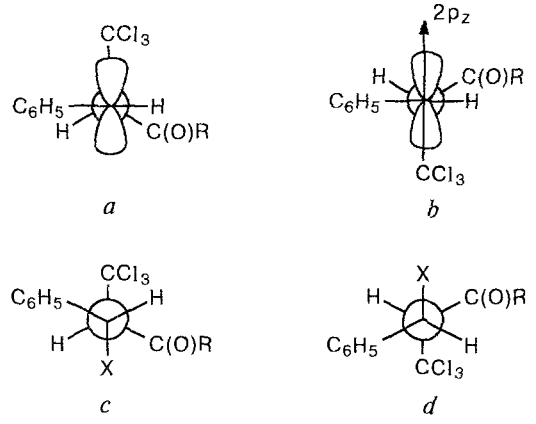
Thus, $Fe(CO)_5$ can act as an efficient catalyst of the synthesis of diastereomerically pure compounds carried out by the addition of polychloroalkanes to 1,2-disubstituted olefins.

The precursors of compounds **4** and **5** are the products of the initial attack at the α-carbon atom of olefin **3** by CCl_3 radicals to give radical **A**, which is obviously more stable than the alternative product, $PhCH(CCl_3)C^{\cdot}HC(O)Y$ resulting from the attack at the β-carbon atom. One may assume (see, for example, Ref. 2) that the most favorable conformation of radical **A** is described by two enantiomeric forms (*a*, *b*). It is clear that the transfer of the halogen from the donor to radical **A** occurs preferably from its less shielded side (forms *c*, *d*).



The results of the X-ray structural study[7] are in full agreement with these assumptions: the molecules of the isostructural racemates **4a,b** and **5a,b** (see Scheme 1) have the *anti*-conformation with respect to the C(2)—C(3) bond and identical *R,R* or *S,S* relative configurations.

Thus, the stereoselectivity of the addition of compound **1** or **2** to **3** is determined by 1,2-asymmetric induction at the step in which the halogen is transferred from the donor to the radical adduct.

The results obtained indicate that the addition of halogen-containing compounds to α,β-disubstituted olefins using CTM and complexes based on them is a promising method for the regio- and stereoselective synthesis of diastereomerically pure compounds.

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Experimental

^{13}C and ^{1}H NMR spectra were recorded on a Bruker WP-200 spectrometer. Olefin **3** was prepared by the reaction of cinnamoyl chloride with pyrrolidine.

***N*-(3-Bromo-3-phenyl-2-trichloromethylpropionyl)pyrrolidine (4). A.** With $Fe(CO)_5$ as the catalyst. Compound **1** (1.96 g, 9.9 mmol), compound **3** (1.3 g, 6.46 mmol), and $Fe(CO)_5$ (0.146 g, 0.76 mmol) were added to 20 mL of benzene with stirring under an argon flow. The mixture was heated for 4 h at 80 °C. The course of the reaction was monitored by TLC (Silufol plates, an acetone—hexane mixture (1:4) as the eluent). Column chromatography on SiO_2 (with the same eluent) afforded 0.2 g of unchanged compound **3** (15.5 %) and 1.33 g of product **4** (51.5 %). Found (%): C, 41.75; H, 3.77; N, 3.40; Hal, 46.7. $C_{14}H_{15}NOBrCl_3$. Calculated (%): C, 42.08; H, 3.78; N, 3.51; Hal, 46.42. ^{1}H NMR ($(CD_3)_2CO$), δ: 7.71 and 7.79 (m, 5 H, Ph); 5.71 (d, 1 H, CHBr, J = 10.36 Hz); 4.74 (d, 1 H, $CHCCl_3$, J = 10.36 Hz); 3.9 (2 H, NCH_2); 3.49 (2 H, NCH_2); 1.9 (4 H, C_2H_4); ^{13}C NMR (CCl_4), δ: 164.36 (C=O), 136.04, 129.42, 128.73, 127.92 (Ph), 96.25 (CCl_3), 66.13 ($CHCCl_3$), 52.64 (CHBr), 46.97, 45.87, 25.94 and 24.3 ($(CH_2)_4N$).

B. With PB as the initiator. Compound **3** (1 g, 5 mmol), compound **1** (1.96 g, 9.9 mmol), and BP (0.12 g, 0.5 mmol) were added to 5 mL of benzene with stirring under an argon flow. The solution was transferred to a glass tube and blown with oxygen-free argon for 30 min. Then the tube was sealed and heated for 8 h at 80 °C. The reaction products and the unchanged starting compound **3** were isolated as described above to give 0.65 g (33 %) of **4** and to recover 0.65 g (65 %) of **3**. The ^{13}C and ^{1}H NMR spectra are similar to those recorded in the previous run.

***N*-(3-Chloro-3-phenyl-2-trichloromethylpropionyl)pyrrolidine (5). A.** With $Fe(CO)_5$ as the catalyst. Compound **3** (1.3 g, 6.46 mmol), compound **2** (7.95 g, 51.6 mmol), and $Fe(CO)_5$ (0.146 g, 0.75 mmol) were added to 20 mL of benzene with stirring under an argon flow. The mixture was heated for 8 h at 80 °C. The course of the reaction was monitored as described above and 0.6 g (46 %) of **3** and 0.49 g (21 %) of product **5** were isolated in a similar way. ^{1}H NMR ($(CD_3)_2CO$), δ: 7.73 and 7.39 (m, 5 H, Ph); 5.66 (d, 1 H, CHCl, J = 10.2 Hz); 4.63 (d, 1 H, $CHCCl_3$, J = 10.2 Hz); 3.82 (2 H, NCH_2) and 3.45 (2 H, NCH_2); 1.91 (m, 4 H, C_2H_4); ^{13}C NMR ($CDCl_3$), δ: 165.18 (C=O), 137.41, 129.13, 128.01 (Ph), 96.42 (CCl_3), 66.54 ($CHCCl_3$), 61.74 (CHCl), 47.11, 45.79, 25.9 and 24.51 ($(CH_2)_4N$). MS, m/z (I_{rel} (%)) 354 (16.8), 353 (2.1), 352 $[5]^+$ (13.2); 127 (5.7), 125 $[PhCHCl]^+$ (16.9); 70 $[NC_4H_8]^+$ (100).

B. With PB as the initiator. Compound **3** (1.3 g, 6.46 mmol), compound **2** (7.95 g, 51.6 mmol), and BP (0.15 g, 0.64 mmol) were added to 20 mL of benzene with stirring under an argon flow. The reaction and isolation of the products were carried out as described above. 1.23 g (95 %) of compound **3** was recovered.

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References

1. G. Thoma, D. P. Curran, S. V. Geib, B. Giese, W. Damm, and F. Wetterich, *J. Am. Chem. Soc.*, 1993, **115**, 8585.
2. K. Durkin, D. Liotta, J. Rancouzt, J-F. Lavallee, L. Boisvert, and Y. Guindon, *J. Am. Chem. Soc*, 1992, **114**, 4912.
3. N. A. Porter, B. Giese, and D. P. Curran, *Acc. Chem. Res*, 1992, **24**, 296.

4. D. J. Hart and R. Krishnamurthy, *J. Org. Chem,* 1992, **54**, 4457.
5. R. Davis and I. F. Grover, *J. Chem. Soc. Dalton Trans,* 1982, 2281.
6. R. G. Gasanov, and E. G. Sadykhov, *Kinet. Katal.*, 1986, **27**, 984 [*Kinet. Catal.*, 1986, **27** (Engl. Transl.)].
7. R. G. Gasanov, S. O. Videnskaya, L. V. Il'inskaya, Yu. N. Belokon', A. P. Pisarevskii, and Yu. T. Struchkov, *Dokl. Akad. Nauk*, 1994, **336**, 55 [*Dokl. Chem.*, 1994, **336** (Engl. Transl.)].
8. R. Davis, J. L. A. Durrant, and C. C. Rowland, *J. Organomet. Chem,* 1986, **316**, 147.

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