Stereoselective addition of CCl_4 to 2*S*-methoxycarbonyl-*N*-(*trans*-cinnamoyl)pyrrolidine in the presence of $Fe(CO)_5$ or $Fe_2(CO)_9$

R. G. Gasanov, S. O. Videnskaya, and L. V. Il'inskaya*

A. N. Nesmeyanov Institute of Organoelement Compounds, Russian Academy of Sciences,
28 ul. Vavilova, 117813 Moscow, Russian Federation.
Fax: +7 (095) 135 5085

Addition of CCl_4 to 2*S*-methoxycarbonyl-*N*-(*trans*-cinnamoyl)pyrrolidine in the presence of $Fe(CO)_5$ or $Fe_2(CO)_9$ results in predominant formation of one of four possible optical isomers of the adduct $PhCHClCH(CCl_3)C(O)R$ (R = 2*S*-methoxycarbonylpyrrolidyl).

Key words: stereoselective radical addition, iron carbonyls.

In recent years, addition of acyclic carbon-centered radicals R$^{\cdot}$ to unsaturated compounds has been applied successfully to the synthesis of compounds with a definite configuration of chiral carbon atoms.[1,2] To obtain adducts by addition of the R$^{\cdot}$ radicals to α,β-disubstituted alkenes, when the customary initiators of the radical processes are used, iodo and bromo derivatives are chosen as telogenes[2—4] in order to increase the rate of transfer of halogen from telogene to the radical-adduct. Application of $Fe(CO)_5$ allowed us to involve CCl_4 in these reactions due to participation of the iron-containing intermediates in the redox-catalysis.[3,4] The ratio of *syn-/anti*-diastereomers formed in these processes depends on the size of R$^{\cdot}$ and the substituent at the radical center in the radical-adduct.[3,5] To obtain an excess of one of two enantiomers of *syn- or anti*-diastereomer in these reactions, alkenes with chiral substituents having C_2 symmetry at the α- and β-carbon atoms[6] or transition metal complexes with chiral ligands are used.[7]

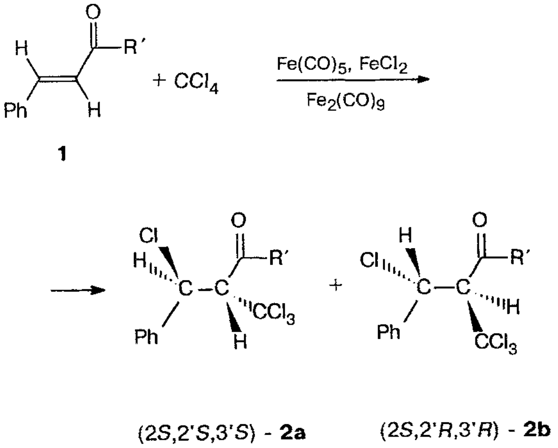
Various α,β-disubstituted unsaturated compounds may be inserted into the coordination sphere of transition metal carbonyls (TMC) and also of iron carbonyls.[8] Use of iron carbonyls would increase in yields of adducts in the addition of halogenated derivatives to 1,2-disubstituted unsaturated compounds and also allows carry out the stage of addition stereoselectively due to insertion of an unsaturated molecule with a chiral ligand into the coordination sphere of the metal.

To achieve this goal, we studied the addition of CCl_4 to *trans*-$PhCH{=}CHC(O)R'$ (**1**) (where R' is 2*S*-metoxycarbonylpyrrolidyl) using $Fe(CO)_5$, $Fe_2(CO)_9$, and $FeCl_2$ in thermal and photochemical initiations.

Results and Discussion

Adduct $PhCHClCH(CCl_3)C(O)R'$ (**2**) is the main product of addition of CCl_4 to compound **1** in the presence of $Fe(CO)_5$, $Fe_2(CO)_9$, or $FeCl_2$ at 80 °C. According to ^1H NMR spectra, adduct **2** exists as one diastereomer, which is a mixture of two enantiomers (Scheme 1). Comparison of ^{13}C and ^1H NMR spectra of adduct **3** with the corresponding spectra of the adduct $PhCHClCH(CCl_3)C(O)R''$ (R'' is pyrrolidyl), for which the absolute 2*S*,3*S*- and 2*R*,3*R*-configuration was established by X-ray analysis,[9] demonstrates that compound **2** is an *anti*-diastereomer (see below). The ratio of enantiomers **2a**:**2b** depends on the initial concentration of iron carbonyls and the reaction temperature. Thus, at a ratio of telogene : **1** = 1 and a concentration of $Fe(CO)_5$ of *ca.* 2—5 mol % with respect to the monomer, the mentioned isomers are formed in equal amounts (^1H NMR analysis of adduct **2**). However, when the concentration of $Fe(CO)_5$ (or $Fe_2(CO)_9$) is 20 mol %, the ratio of isomers is 1.2:1. The photochemical initiation of addition of CCl_4 to compound **1**, taken in equal concentration, and 20 mol % of $Fe(CO)_5$ affords adduct **2** as the major product with a ratio of enantiomers **2a**:**2b** = 1.4:1 (^1H NMR analysis).

Scheme 1



Translated from *Izvestiya Akademii Nauk. Seriya Khimicheskaya,* No. 7, pp. 1390—1392, July, 1995.

1066-5285/95/4407-1342$12.50

The predominant formation of one of enantiomers in this process at high concentrations of iron carbonyls may be explained by stereo- and regioselectivity[4] of the stage of addition of the $^{\cdot}CCl_3$ radicals to the α-carbon atom of compound **1**, which may be a chiral ligand of the π-alkene iron complex under experimental conditions chosen, not the influence of the chiral substituent in compound **1** on the stereoselectivity of the addition stage.[6]

In fact, addition of CCl_4 to compound **1** in the presence of $FeCl_2$ at the same initial concentrations of CCl_4 and compound **1** and the same experimental conditions, the ratio of isomers **2a** : **2b** in product **2** is 1 : 1.

One of isomers, which is in minor concentration in the mixture, was isolated from the reaction mixture by crystallization from hexane and it was characterized completely by X-ray analysis of monocrystal; it has $2S,2'R,3'R$-configuration.

Thus, the mechanism of formation of the product of addition of CCl_4 to compound **1** in the presence of iron carbonyls may be described by two parallel independent pathways. Redox-catalysis[3] is realized in one pathway, and a coordination redox mechanism is realized in another one. At low concentrations of iron carbonyls and in the presence of $FeCl_2$ the reaction proceeds through the first pathway, and at higher concentrations of $Fe(CO)_5$ or $Fe_2(CO)_9$ with respect to the telogene and the monomer, the process runs through the second pathway.

Experimental

Synthesis of (2*S*-methoxycarbonyl)-*N*-(3-phenyl-3,4,4,4-tetrachloroisobutyryl)pyrrolidine (2a,b). CCl_4 (0.6 g, 3.9 mmol), compound **1** (1 g, 3.85 mmol), CH_2Cl_2 (4 mL), and $Fe(CO)_5$ (0.15 g, 0.77 mmol) or $Fe_2(CO)_9$ (0.28 g, 0,77 mmol) or $FeCl_2$ (0.98 g, 0.77 mmol) were placed in cylindrical glass ampoules. The reaction mixtures were degassed by freezing and evacuation (10^{-2} Torr) with subsequent defrosting (several cycles). Degassed solutions in sealed ampoules were placed into metal vessels and heated in a thermostat at 80 °C. In the cases of $Fe(CO)_5$ and $FeCl_2$, the reaction mixtures were heated for 36 h, and the mixture with $Fe_2(CO)_9$ was heated for 16 h. Then the reaction mixture was cooled in liquid nitrogen, and the ampoules were opened. CH_2Cl_2 and CCl_4 were removed from dark brown reaction mixtures using a rotary evaporator. The residue was dissolved in a small volume of acetone and applied on a column with SiO_2 (eluted by acetone : hexane, 1 : 4). When iron carbonyls were used, adduct **2** (0.58 g, 1.4 mmol, 36 %) was obtained; the recovery of compound **1** was 0.48 g (1.85 mmol). Then the reaction mixture was eluted with acetone, and then with methanol. After removal of the solvents on a rotor evaporator, a dark brown resin (0.7 g) was obtained. In the reaction of CCl_4 with compound **1** in the presence of $FeCl_2$, 0.7 g (2.7 mmol) of **1** was recovered; adduct **2** (0.3 g, 0.72 mmol, 19%) and a resin (0.4 g) were formed.

Photochemical reactions were carried out in a quartz long-necked flask. The reaction mixtures were degassed by freezing and evacuation with the subsequent defrosting and filling with argon (several cycles). The reaction mixture was irradiated with a PRK-2 mercury lamp (glass filters, λ 366 nm were used), while evolution of formed CO into atmosphere was allowed. After 8 h of irradiation, the reaction mixture was treated as described above.

The NMR spectra were registered with a Bruker WP-200 spectrometer. ^1H NMR of **2a** and **2b** ($(CD_3)_2CO$, δ, J): 7.73 and 7.39 (m, 5 H, C_6H_5); 5.63 and 5.60 (d, 1 H, C_6H_5CHCl, J = 10.20 Hz); 4.67 and 4.65 (d, 1 H, $CH(CCl_3)$, J = 10.2 Hz); 4.52 and 4.48 (q, 1 H, NCH); 4.01 and 3.99 (m, 2 H, NCH_2); 3.67 and 3.68 (s, 3 H, OCH_3); 2.2 (m, 4 H, C_2H_4).

References

1. N. A. Porter, B. Giese, and D. P. Curran, *Acc. Chem. Res.*, 1991, **24**, 296.
2. D. P. Gurran, E. Eichenberger, M. Acetonellis, M. G. Roepel, and G. Thoma, *J. Am. Chem. Soc.*, 1994, **116**, 4279.
3. R. G. Gasanov, S. O. Videnskaya, L. V. Il'inskaya, and Yu. N. Belokon', *Izv. Akad. Nauk, Ser. Khim.*, 1994, 1783 [*Russ. Chem. Bull.*, 1994, 1783 (Engl. Transl.)].
4. R. G. Gasanov, S. O. Videnskaya, V. V. Pinyaskin, and I. V. Stankevich, *Izv. Akad. Nauk, Ser. Khim.*, 1995, 452 [*Rus. Chem. Bull.*, 1995 (Engl. Transl.)].
5. G. Thoma, D. P. Gussan, S. V. Geib, B. Giese, W. Damm, and F. Wetterich, *J. Am. Chem. Soc.*, 1993, **115**, 8585.
6. B. Giese, M. Zehnder, M. Roth, and H.-G. Zeitz, *J. Am. Chem. Soc.*, 1990, **112**, 6741.
7. N. Kamigata and M. Kameyama, *J. Synt. Org. Chem. (Japan)*, 1980, **47**, 436.
8. L. V. Rybin and M. I. Rybinskaya, *Usp. Khim.*, 1993, **62**, 680 [*Russ. Chem. Rev.*, 1993 (Engl. Transl.)].
9. R. G. Gasanov, S. O. Videnskaya, L. V. Il'inskaya, Yu. N. Belokon', A. R. Pisarevskii, and Yu. T. Struchkov, *Dokl. Akad. Nauk*, 1994, **366**, 485 [*Dokl. Chem.*, 1994 (Engl. Transl.)].

Received December 14, 1994;
in revised form March 22, 1995