

Salo Gronowitz* and Marcel Temciuc

Organic Chemistry 1, Chemical Center, Box 124, University of Lund, S-221 00 Lund, Sweden

Lennart Eberson*

MAX-Chemistry, Chemical Center, Box 124, S-221 00 Lund, Sweden

Received September 6, 1994

The two isomeric tris(trichlorothieryl)carbinols have been synthesized. Upon treatment with acid the tris(trichlorothieryl)carbenium ions were formed, which upon reduction with iodide gave the tris(trichlorothieryl)methyl radicals, which were studied by epr-spectroscopy. The β -isomer, the tris(2,4,5-trichloro-3-thienyl)methyl radical, was much more stable than the α -isomer and showed great similarity to the perchlorotrityl radical.

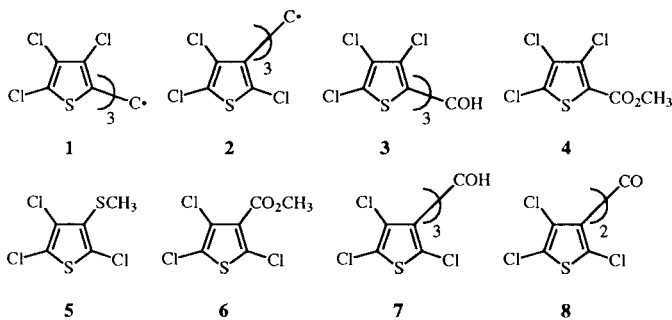
J. Heterocyclic Chem., **32**, 65 (1995).

Introduction.

Stable free radicals, such as perchlorotrityl radicals and related radicals have been prepared and extensively studied by Ballester and coworkers [1] (for a review, *cf* refs [2,3]). However, the corresponding tris(perchlorothieryl)methyl radicals, tris(3,4,5-trichloro-2-thienyl)methyl (1) and tris(2,4,5-trichloro-3-thienyl)methyl (2) have not, as far as we know, been studied, although the epr-spectra of the parent tris(thienyl)methyl radicals have been reported [4]. Recently the dimerization of the diphenyl-2-thienylmethyl radical has also been studied [5].

Syntheses.

Halogen metal-exchange of tetrachlorothiophene with butyllithium at -70° gave 3,4,5-trichloro-2-thienyllithium [6], which upon treatment with 1/3 equivalent of methyl chloroformate gave tris(3,4,5-trichloro-2-thienyl)carbinol (3) in 21% yield. The use of two equivalents gave methyl 3,4,5-trichloro-2-thiophenecarboxylate (4) in 65% yield. This compound has previously been prepared from 2-cyano-3,4,5-trichlorothiophene [7].



2,3,5-Trichlorothiophene [8] could successfully be metalated at -78° with lithium diisopropylamide in the β -position to 2,4,5-trichloro-3-thienyllithium. No halogen dance was observed under these conditions, in contrast to

the metalation of, for instance, 2,5-dibromothiophene with lithium diisopropylamide [9]. Reaction with dimethyl disulfide gave 3-methylthio-2,4,5-trichlorothiophene (5) in 44% yield. The reaction with two equivalents of methyl chloroformate gave the previously unknown methyl 2,4,5-trichloro-3-thiophenecarboxylate (6) in 27% yield. Finally treatment of the 3-lithium derivative with 1/3 of an equivalent of methyl chloroformate gave the desired tris(2,4,5-trichloro-3-thienyl)carbinol (7) in 9% yield together with 16% of bis(2,4,5-trichloro-3-thienyl)-ketone (8).

The carbinols 3 and 7 were converted to the radicals by treatment of their solutions in acetonitrile/trifluoromethanesulfonic acid with tetrabutylammonium iodide, which is an adoption of a published method [10].

Epr Spectroscopy.

The α isomer 1.

A solution of the carbinol (≈ 2 mM) in acetonitrile/trifluoromethanesulfonic acid (95/5) had a strong violet color (λ_{\max} 590 nm) which changed to blue (λ_{\max} 610 nm) upon addition of an excess of tetrabutylammonium iodide. The color slowly faded (rate constant ≈ 0.06 min $^{-1}$), partly due to precipitation of the radical. The epr-spectrum of the radical was a fairly weak, broad unresolved line with $DH_{pp} = 0.27$ mT and with the g value almost identical to that of diphenylpicrylhydrazyl (2.0037). The radical was unstable under these conditions, disappearing within tens of minutes at 23° .

The radical could also be prepared in dichloromethane saturated with trifluoromethanesulfonic acid, by the same procedure as above. The spectrum had the same appearance as in acetonitrile. By accumulation of spectra at -40° , the ^{13}C coupling constants could also be determined to be 2.09, 1.31 and 1.07 mT. The peak at 2.09 mT was of lower intensity than the two others.

The β -isomer 2. A solution of the carbinol (≈ 2 mM) in acetonitrile/trifluoromethanesulfonic acid (95/5) had λ_{\max}

at 440 nm which changed to a reddish yellow solution (λ_{\max} 380 and 430 nm) upon addition of an excess of tetrabutylammonium iodide. This solution displayed an intense unresolved epr signal which was stable for many hours. Its g value was 2.0037 and DH_{pp} was 0.11 mT. The ^{13}C coupling constants were 2.35, 1.26 and 0.57 mT, the peaks showing an approximate 1:3:3 intensity ratio. The spectrum was also recorded at -40° in dichloromethane, as described above, and gave the same parameters as in acetonitrile.

As a comparison, the perchlorotriyl radical has $g = 2.0025$ and ^{13}C coupling constants of 2.37, 1.24 and 1.04 mT, the largest one being assigned to coupling to the α -carbon on the basis of its lower intensity [1].

EXPERIMENTAL

Melting points are uncorrected. The ^1H and ^{13}C nmr spectra were recorded on a Varian XL-300 spectrometer. The mass spectra were measured on a JEOL-SX 102 spectrometer. Column chromatography was carried out with Merck silica gel 60 (230-400 mesh ASTM). The epr spectra were recorded using the Upgrade Version ESP 3220-200 SH of the Bruker ER-200D spectrometer. The microwave power was 0.4 mW and the modulation amplitude 0.01-0.03 mT.

Methyl 3,4,5-Trichloro-2-thiophenecarboxylate (4).

To a solution of 2.22 g (10 mmoles) of tetrachlorothiophene in 75 ml of anhydrous ether at -78° , 6.0 ml of 2.0 M butyllithium in cyclohexane diluted with anhydrous ether was added and the mixture was stirred for one hour. Methyl chloroformate (1.89 g, 20 mmoles) in 5.0 ml of anhydrous ether was added and the mixture stirred at -78° for 30 minutes. The mixture was allowed to warm to room temperature and poured into saturated ammonium chloride solution. The organic layer was separated, the aqueous layer was extracted twice with 20 ml of ether, the combined organic phases were dried over magnesium sulfate and the solvent evaporated *in vacuo* to give 1.59 g (65%) of colorless crystals, mp $74-75^\circ$ after recrystallization from hexane (lit [7] $75-76^\circ$); ir (potassium bromide): 1725 cm^{-1} ; ^1H nmr (deuteriochloroform): δ 3.89 (s, 3H); ^{13}C nmr (deuteriochloroform): δ 52.7, 123.3, 126.0, 129.8, 130.9, 159.5.

Tris(3,4,5-trichloro-2-thienyl)carbinol (3).

To the 3,4,5-trichloro-2-thienyllithium solution prepared as described above, 0.283 g (3.00 mmoles) of methyl chloroformate in 5 ml of anhydrous tetrahydrofuran was added. After 2 hours at -78° , the mixture was allowed to warm to room temperature over night. The same work-up as described above gave a solid product which was washed with a small amount of pentane. Chromatography using ether/chloroform (98:2) as eluent gave 0.412 g (21%) of the carbinol, mp $133-134^\circ$ after recrystallization from hexane; ^1H nmr (deuteriochloroform): δ 2.23 (s, ^1H); ^{13}C nmr (deuteriochloroform): δ 74.4, 122.4, 124.6, 126.4, 134.9; ms: m/z 588 (M^+).

Anal. Calcd. for $\text{C}_{13}\text{HCl}_3\text{OS}_3$: C, 26.54; Cl, 54.23; S, 16.35. Found: C, 26.55; Cl, 54.35; S, 16.53.

3-Methylthio-2,4,5-trichlorothiophene (5).

To a solution of 0.91 g (10 mmoles) of diisopropylamine in 50 ml of anhydrous tetrahydrofuran under nitrogen cooled to -20° , 6.0 ml of 2 M butyllithium in cyclohexane was added dropwise. After stirring for 15 minutes, the mixture was cooled to -78° and 1.876 g (10.0 mmoles) of 2,3,5-trichlorothiophene in 5 ml of anhydrous tetrahydrofuran was added and stirred at the same temperature for one hour. A solution of 0.94 g (10 mmoles) of dimethyl disulfide in 5.0 ml of tetrahydrofuran was added and the mixture stirred at -78° . The mixture was allowed to warm to room temperature and poured into a saturated ammonium chloride solution. The organic phase was separated, the aqueous phase extracted two times with 10 ml of ether and the combined organic phases were dried over magnesium sulfate. Distillation *in vacuo* gave 1.03 g (44%) of the title compound as a yellow oil, bp $102-104^\circ/0.8\text{ mm Hg}$. ^1H nmr (deuteriochloroform): δ 2.36 (s, 3H); ^{13}C nmr (deuteriochloroform): δ 18.1, 121.0, 127.4, 129.9, 130.0.

Anal. Calcd. for $\text{C}_5\text{H}_3\text{Cl}_3\text{S}_2$: C, 25.69; H, 1.28; S, 27.40. Found: C, 25.55; H, 1.13; S, 27.50.

Methyl 2,4,5-Trichloro-3-thiophenecarboxylate (6).

To the solution of 2,4,5-trichloro-3-thienyllithium prepared as described above at -78° , 1.89 g (20.0 mmoles) of methyl chloroformate in 5.0 ml of anhydrous tetrahydrofuran was added. After stirring at -78° for 30 minutes, the mixture was allowed to warm to room temperature and worked up as described above. Column chromatography of the residue on silica gel using petroleum ether as eluent gave 0.762 g (27%) of the title compound as colorless crystals, mp $37-38^\circ$ after recrystallization from pentane; ir (potassium bromide): 1725 cm^{-1} ; ^1H nmr (deuteriochloroform): δ 3.93 (s, 3H); ^{13}C nmr (deuteriochloroform): δ 52.5, 122.6, 123.2, 127.6, 132.0, 160.6.

Anal. Calcd. for $\text{C}_6\text{H}_3\text{Cl}_3\text{O}_2\text{S}$: C, 29.35; H, 1.23; S, 13.06. Found: C, 29.11; H, 1.16; S, 13.23.

Tris(2,4,5-Trichloro-3-thienyl)carbinol (7) and Bis(2,4,5-trichloro-3-thienyl)ketone (8).

To the solution of 2,4,5-trichlorothiennyllithium prepared as above at -78° , 0.283 g (3.00 mmoles) of methyl chloroformate in 5.0 ml of anhydrous tetrahydrofuran was added. After stirring at -78° , the solution was allowed to attain room temperature and was then worked up as described above. Chromatography on silica gel, using ether/chloroform (98:2) for elution followed by preparative hplc using heptane/chloroform (95:5) as eluent gave 0.176 g (9%) of 4 as colorless crystals mp $138-139^\circ$, after recrystallization from heptane; ^1H nmr (deuteriochloroform): δ 2.17 (s, H); ^{13}C nmr (deuteriochloroform): δ 75.1, 122.8, 124.3, 127.4, 132.0; ms: m/z 588 (M^+).

Anal. Calcd. for $\text{C}_{13}\text{HCl}_3\text{OS}_3$: C, 26.54; Cl, 54.23; S, 16.35. Found: C, 26.60; Cl, 54.31; S, 16.10.

A second fraction from the chromatography contained 0.32 g (16%) of compound 5, mp $95-96^\circ$, after recrystallization from ethanol; ir (potassium bromide): 1660 cm^{-1} ; ^{13}C nmr (deuteriochloroform): δ 122.6, 123.2, 131.5, 134.4, 179.1.

Anal. Calcd. for $\text{C}_9\text{Cl}_6\text{OS}_2$: Cl, 53.05; S, 15.99. Found: Cl, 52.93; S, 16.10.

Acknowledgement.

Grants from the Swedish Natural Science Research Council and from Nycomed Innovation AB, Malmö to S. G. are gratefully acknowledged.

REFERENCES AND NOTES

- [1] M. Ballester, J. Riera, J. Castāner, C. Badfa and L. M. Monsó, *J. Am. Chem. Soc.*, **93**, 2215 (1971).
- [2] M. Ballester, *Acc. Chem. Res.*, **18**, 380 (1986).
- [3] M. Ballester, *Adv. Phys. Org. Chem.*, **25**, 267 (1989).
- [4] A. Mangini, G. F. Padulli and M. Tiecco, *Tetrahedron Letters*, 4941 (1968).
- [5] A. Ishi, M. Sugino, J. Nakayama and M. Hoshino, *Heterocycles*, **31**, 1915 (1990).
- [6] M. R. Smith and H. Gilman, *Organometal. Org. Synth.*, **1**, 295 (1971).
- [7] S. G. Konkova, A. A. Safaryan and A. N. Akopyan, *Zh. Org. Khim.*, **18**, 348 (1982).
- [8] S. Gronowitz, A.-B. Hörnfeldt and M. Temciuc, *J. Heterocyclic Chem.*, in press.
- [9] H. Fröhlich and W. Kalt, *J. Org. Chem.*, **55**, 2993 (1990).
- [10] M. Ballester, J. Castāner, J. Riera, A. Rodriguez, C. Rovira and J. Veciana, *J. Org. Chem.*, **47**, 4498 (1982).