β-PROPIOTHIOLACTONE

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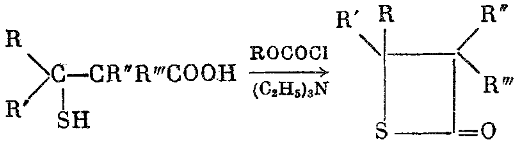
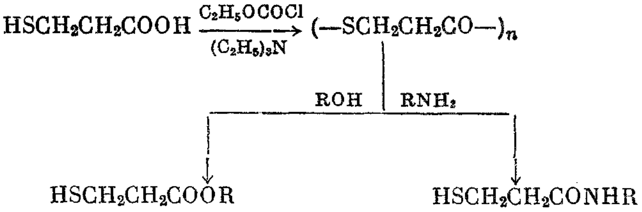
Previously we had shown that β-mercapto acids form homologs of β-propiothiolactone when reacted with chlorocarbonic ester in the presence of triethylamine [1, 2].



However, the first member of this class, the unsubstituted β-propiothiolactone, could not be obtained from β-mercaptopropionic acid by this method; the thiolactone that is formed here invariably condenses to a solid polymer. The structure of the polymer was confirmed by its reactions with amines and alcohols to form the amides and esters of β-mercaptopropionic acid.

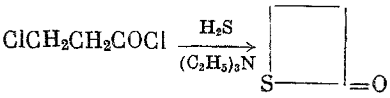


$$HSCH_2CH_2COOH \xrightarrow[(C_2H_5)_3N]{C_2H_5OCOCl} (-SCH_2CH_2CO-)_n$$

$$(-SCH_2CH_2CO-)_n \xrightarrow{ROH} HSCH_2CH_2COOR \qquad (-SCH_2CH_2CO-)_n \xrightarrow{RNH_2} HSCH_2CH_2CONHR$$

Somewhat later we proposed a new method for the preparation of β-propiothiolactones by the reaction of the acid chlorides of β-halocarboxylic acids with hydrogen sulfide in the presence of triethylamine [3].

With this method we were able to obtain the pure β-propiothiolactone in 60% yield from the acid chloride of β-chloropropionic acid in methylene chloride. The method enables us to make a study of this new class of compounds.



A variation of this method was proposed in the Goodrich patents [4, 5], where the same β-propiothiolactones could be obtained in low yields by the reaction of the alkali metal sulfides with the acid chlorides of β-halopropionic acids. It should be mentioned that, when β-propiothiolactone is obtained by our method in the presence of excess triethylamine, the polymer is formed preferentially. In the pure state, β-propiothiolactone is stable even when heated for a short time on the steam bath; it is difficultly soluble in cold water (1 g in 70 ml), and more readily soluble in hot water.

β-Propiothiolactone is cleaved with much greater difficulty in the presence of acid catalysts than when basic catalysts are used. With small amounts of NaOH, even in dilute water solutions, β-propiothiolactone gives the polymer. It is easily cleaved by amines with the formation of the amides of β-mercaptopropionic acid.

EXPERIMENTAL

β-Propiolactone. Dry hydrogen sulfide was passed into a solution of 0.2 mole of β-chloropropionyl chloride in 640 ml of methylene chloride.

Then in a stream of hydrogen sulfide was added in drops a solution of 0.4 mole of dry triethylamine in 100 ml of absolute ether, the mixture was allowed to stand at room temperature for 1 h, the triethylamine hydrochloride was precipitated by the addition of 800 ml of ether, and the filtrate, if it reacted slightly alkaline, was washed with 1 N HCl solution and then dried over magnesium sulfate. We obtained a 60.4% yield of β-propiothilactone; b. p. 53° (12 mm); n_D^{20} 1.5265. From [5]: b. p. 50-53° (12 mm); n_D^{20} 1.5269.

To 0.02 mole of β-mercaptopropionic acid in 200 ml of absolute ether at −20° were added 0.02 mole of triethylamine and 0.02 mole of ethyl chlorocarbonate in 25 ml of absolute ether. The temperature was gradually raised up to room temperature. Both from the triethylamine hydrochloride after dissolving in water, as well as from the ether filtrate, only the solid polymer was isolated in quantitative yield, m. p. 135-145°. Found: C 40.78; H 4.95%. C_3H_4OS. Calculated: C 40.90; H 4.53%.

β-Mercaptopropionic Acid p-Anisidide. A solution of 2.51 g of β-propiothiolactone in 25 ml of ether was added to an ether solution of 7.38 g of p-anisidine and the mixture was allowed to stand at room temperature for 24 h. We obtained 2.6 g of β-mercaptopropionic acid p-anisidide, m. p. 86-88° (from a mixture of petroleum ether and methylene chloride). Literature data [6]: m. p. 74-75°. From the ether mother liquor, after evaporation in the air, we obtained 0.4 g of the disulfide of the β-mercaptopropionic acid anisidide, m. p. 186-187° (from acetonitrile).

A mixture of 2.4 g of the polymer and 3.3 g of p-anisidine in 40 ml of benzene was heated under reflux for 7 h. The unreacted polymer was filtered, while the filtrate was evaporated in vacuo to dryness, and the residue was washed first with 1 N HCl solution (1.4 g of p-anisidine was isolated) and then with sodium bicarbonate solution. The β-mercaptopropionic acid anisidide (2.3 g) was separated from the disulfide (2 g) by dissolving in 1 N NaOH solution. The total yield was 75%. Found: C 56.82; H 6.27; S 14.87; N 6.78%. $C_{10}H_{13}NO_2S$. Calculated: C 56.87; H 6.16; S 15.16; N 6.65%. Found: N 6.81%. $C_{20}H_{24}N_2O_4S_2$. Calculated: N 6.66%.

β-Mercaptopropionic Acid Benzylamide. To 0.25 g of β-propiothiolactone in 10 ml of ether was added 0.5 g of benzylamine in 10 ml of ether and the mixture was allowed to stand at room temperature for 2 h. The obtained disulfide of the β-mercaptopropionic acid benzylamide was filtered, m. p. 159-160°. Found: C 60.68; H 6.19; S 16.46%. $C_{20}H_{24}N_2O_2S_2$. Calculated: C 61.85; H 6.18; S 16.49%.

The β-mercaptopropionic acid benzylamide was extracted from the ether solution with 1 N NaOH solution, m. p. 60-61° (by precipitation from NaOH solution with HCl). Found: C 61.07; H 6.62; S 15.62; N 7.25%. $C_{10}H_{13}NOS$. Calculated: C 61.53; H 6.66; S 16.41; N 7.18%.

Methyl β-Mercaptopropionate. 11 g of the polymer was added to an equivalent amount of sodium methylate in methanol. The mixture was heated for 4 h in a stream of nitrogen. After evaporation of the alcohol in vacuo the residue was dissolved in water, acidified with 2 N H_2SO_4 solution and extracted with ether. The ether extract was washed with aqueous sodium bicarbonate solution, dried over magnesium sulfate, and distilled. Here the methyl ester of β-mercaptopropionic acid was obtained, b. p. 52-55° (10 mm); n_D^{19} 1.4625. Literature data [7]: b. p. 54-55° (14 mm); n_D^{19} 1.4628.

β-Mercaptopropionic Acid Cyclohexylamide. To 2.51 g of β-propiothiolactone in 100 ml of ether was added an equivalent amount of cyclohexylamine in 50 ml of ether. The reaction was exothermic. After an hour the obtained disulfide of the β-mercaptopropionic acid cyclohexylamide was filtered. Here we obtained crystals with m. p. 170-171° (from dioxane). Literature data [8]: 170-171°. Found: N 7.47%. $C_{18}H_{32}N_2O_2S_2$. Calculated: N 7.52%. Extraction of the ether solution with 1 N NaOH solution gave the β-mercaptopropionic acid cyclohexylamide, m. p. 75-77° (from a mixture of petroleum ether and methylene chloride). Literature data [8]: m. p. 65-67°. The total yield was 63%. Found: C 57.60; H 9.04; S 17.26; N 7.49%. $C_9H_{17}NOS$. Calculated: C 57.75; H 9.09; S 17.11; N 7.48%.

Disulfide of β-Mercaptopropionic Acid Amide. With stirring, from 0.251 g of β-propiothiolactone and aqueous 10% ammonia solution at room temperature we obtained the amide of β-mercaptopropionic acid, which on standing in the air oxidized to the disulfide. The yield of the disulfide was quantitative, m. p. 178° (from water). Literature data [9]: m. p. 178-180°; [10]: 167-168°. Found: C 34.70; H 5.70%. $C_6H_{12}N_2O_2S_2$. Calculated: C 34.61; H 5.77%.

SUMMARY

An improved method was proposed for the preparation of the unsubstituted β-propiothiolactone and some of its cleavage reactions were studied.

LITERATURE CITED

1. M. G. Lin'kova, O. V. Kil'disheva, and I. L. Knunyants, Izv. AN SSSR, Otd. Khim. Nauk, 1955, 569.
2. I. L. Knunyants, O. V. Kil'disheva, and E. Ya. Pervova, Izv. AN SSSR, Otd. Khim. Nauk, 1955, 689.
3. M. G. Lin'kova, N. D. Patrina, and I. L. Knunyants, Dokl. AN SSSR, 127, 564 (1959).
4. B. F. Goodrich Company, French Patent, 1,158,590 (1958); Chem. Zentr., 1959, 15509.
5. B. F. Goodrich Company, British Patent, 840,658 (1960); C. A., 55, 1452b (1961).
6. J. E. Jansen, U. S. Patent, 2,709,706 (1955); C. A., 50, 5476b (1956).
7. A. M. Drummond and D. T. Gibson, J. Chem. Soc., 1926, 3076.
8. I. L. Knunyants and N. P. Gambaryan, Izv. AN SSSR, Otd. Khim. Nauk, 1958, 1219.
9. Bror Holmberg, Arkiv Kemi, Mineral. Geol., B 20, No. 2 (1945).
10. Ch. M. Buess, J. Amer. Chem. Soc., 77, 6613 (1955).

All abbreviations of periodicals in the above bibliography are letter-by-letter transliterations of the abbreviations as given in the original Russian journal. *Some or all of this periodical literature may well be available in English translation.* A complete list of the cover-to-cover English translations appears at the back of this issue.