[CONTRIBUTION FROM THE VENABLE CHEMICAL LABORATORY OF THE UNIVERSITY OF NORTH CAROLINA]

# β-Dimethylaminoethyl Esters of Organic Dithio Acids. III. Absorption Spectra

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The preparation of the β-dimethylaminoethyl esters of a number of organic dithio acids has been discussed in previous papers.[2,3] The absorption spectra of the ester citrates, hydrochlorides and methiodides in the ultraviolet and the visible are reported in the present paper. With but two exceptions the absorption was confined to wave lengths less than 400 mμ, the maximum of the principal band being shifted from about 300 to 400 mμ by the addition of various auxochrome groups. The spectra of four oxygen analogs and of tetramethylammonium iodide were determined for purposes of comparison. The absorption spectra of ethyl dithioacetate and ethyl dithiobenzoate have been previously reported by Hantzsch and Bucerius.[4]

TABLE I

ABSORPTION SPECTRA OF SOME β-DIMETHYLAMINOETHYL ESTERS OF DITHIO ACIDS

| No. | Compound | Wave length of maxima | | | |
|---|---|---|---|---|---|
| | | mμ | $\epsilon \times 10^{-4}$ | mμ | $\epsilon \times 10^{-4}$ |
| 1 | β-Dithioacetoxyethyldimethylammonium chloride | | | 302 | 0.89 |
| 1a | β-Dithioacetoxyethyltrimethylammonium iodide, "Dithioacetylcholine iodide" | 225 | 1.52 | 301 | 1.00 |
| 1b | β-Acetoxyethyltrimethylammonium bromide, "Acetylcholine bromide" | Negligible absorption at wave lengths > 220 mμ | | | |
| 2 | β-Dithiobenzoxyethyldimethylammonium chloride | | | 305 | 1.41 |
| 2a | β-Dithiobenzoxyethyltrimethylammonium iodide | 226 | 1.86 | 304 | 1.45 |
| 2b | β-Benzoxyethyldimethylammonium chloride | | | 232 | 1.22 |
| 3 | β-(*o*-Chlorodithiobenzoxy)-ethyldimethylammonium chloride | 243 | 0.33 | 312 | 1.01 |
| 5 | β-(*o*-Hydroxydithiobenzoxy)-ethyldimethylammonium citrate | 245 | 0.33 | 312 | 1.16 |
| 4 | β-(*p*-Chlorodithiobenzoxy)-ethyldimethylammonium citrate | ~230 | 0.57 | 311 | 1.82 |
| 10 | β-(*p*-Methyldithiobenzoxy)-ethyldimethylammonium citrate | ~236 | 0.49 | 316 | 1.73 |
| 7 | β-(*p*-Methoxydithiobenzoxy)-ethyldimethylammonium chloride | 246 | 0.61 | 336 | 1.83 |
| 7a | β-(*p*-Methoxydithiobenzoxy)-ethyltrimethylammonium iodide | 224 | 1.99 | 336 | 1.86 |
| 7b | β-(*p*-Methoxybenzoxy)-ethyldimethylammonium chloride | | | 260 | 1.68 |
| 6 | β-(*p*-Hydroxydithiobenzoxy)-ethyldimethylammonium chloride | 247 | 0.58 | 338 | 1.82 |
| 12 | β-(3-Methoxy-4-hydroxy-dithiobenzoxy)-ethyldimethylammonium chloride | 255 | 0.84 | 360 | 1.15 |
| 11 | β-(3,4-Methylenedioxy-dithiobenzoxy)-ethyldimethylammonium chloride | 258 | 1.06 | 365 | 1.13 |
| 8 | β-(*p*-Aminodithiobenzoxy)-ethyldimethylammonium citrate | 258 | 0.54 | 346 | 0.92 |
| | | | | 397 | 1.86 |
| 8b | β-(*p*-Aminobenzoxy)-ethyldiethylammonium chloride, "Novocaine" | | | 290 | 1.81 |
| 9 | β-(*p*-Dimethylaminodithiobenzoxy)-ethyldimethylammonium chloride | ~221 | 0.81 | 330 | 0.60 |
| | | 262 | 0.63 | 440 | 2.87 |
| 9a | β-(*p*-Dimethylaminodithiobenzoxy)-ethyltrimethylammonium iodide | 226 | 2.09 | 330 | 0.59 |
| | | | | 440 | 2.88 |
| | Tetramethylammonium iodide | 226 | 1.33 | | |

~ indicates an inflection point.

## Experimental

**Absorption Spectra.**—All spectra were determined with a Beckman quartz spectrophotometer, model DU, using a one-cm. quartz cell. A hydrogen discharge tube was used as the ultraviolet source and a tungsten lamp was employed in the visible range. Optical density measurements were made at 2 to 4 mμ intervals except in the neighborhood of maxima and minima, where the intervals were decreased to 1 to 2 mμ. Figures 1–6 show the molecular extinction coefficients plotted against wave length in mμ for aqueous solutions of the dithio ester derivatives. The molecular extinction coefficient, ε, was calculated from the equation: $\epsilon = D/lc$, where $D$ = optical density, $l$ = absorption cell thickness in cm., and $c$ = the concentration of the sample in moles per liter. Concentrations of about 0.00004 molar were used in the ultraviolet; solutions of approximately ten times this concentration were used in the visible.

**Dithio Ester Derivatives.**—The preparation and purifications of the dithio ester derivatives is reported elsewhere.[2,3]

**Acetylcholine Bromide.**—An Eastman Kodak Company product was used.

**Novocaine.**—A Winthrop Chemical Company product was used.

**β-(*p*-Methoxybenzoxy)-ethyldimethylammonium Chloride.**—Anisoyl chloride (0.05 mole) was added cautiously with stirring to β-dimethylaminoethanol (0.05 mole) dissolved in 25 ml. of dry acetone. The reaction mixture was cooled and the solid product was washed thoroughly with dry ether. A yield of 11.7 g. (90%) was obtained. Recrystallization from an absolute ethanol–ether mixture gave white needles melting at 158.5–159.5°.

*Anal.* Calcd. for $C_{12}H_{18}ClNO_3$: N, 5.39. Found: N, 5.34.

**β-Benzoxyethyldimethylammonium Chloride.**—The ester hydrochloride was synthesized by the procedure outlined above. White needles melting at 147.5° were obtained. A melting point of 148° is reported in ref. 5.

## Discussion

Absorption curves are shown in Figs. 1–6. Table I lists the wave lengths in mμ of the absorp-

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[1] du Pont Fellow in Chemistry, 1949–1950.

[2] Bost and Shealy, THIS JOURNAL, **73**, 24 (1951).

[3] Bost and Shealy, *ibid.*, **73**, 25 (1951).

[4] Hantzsch and Bucerius, *Ber.*, **59**, 793 (1926).

(5) Hochster Farbw., German Patent 190,688, *Chem. Zentr.*, **78**, II, 2005 (1907).

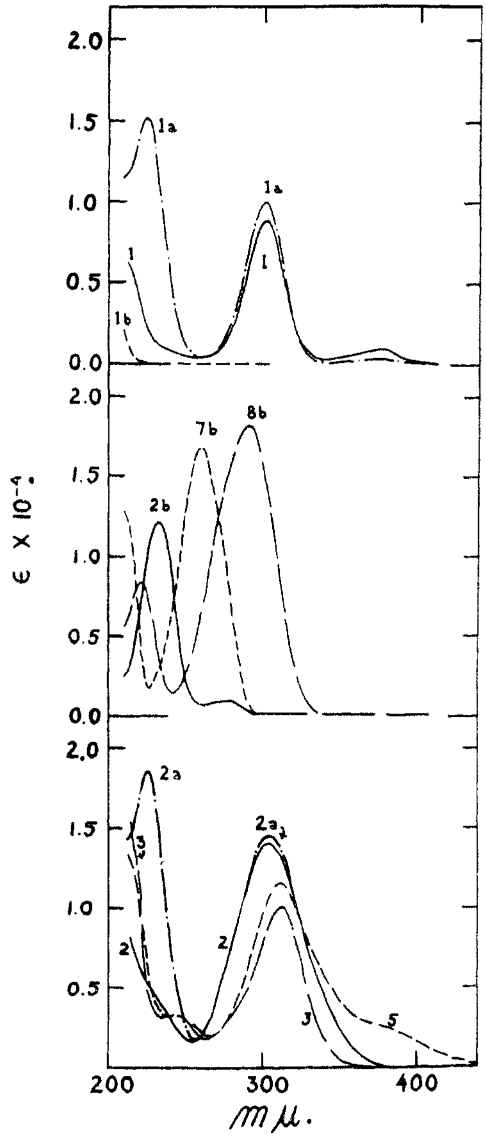

Fig. 1 (top).—Absorption in water of: 1, β-dithioacetoxyethyldimethylammonium chloride; 1a, β-dithioacetoxyethyltrimethylammonium iodide; 1b, β-acetoxyethyltrimethylammonium bromide.

Fig. 2 (middle).—Absorption in water of: 2b, β-benzoxyethyldimethylammonium chloride; 7b, β-(*p*-methoxybenzoxy)-ethyldimethylammonium chloride; 8b, β-(*p*-aminobenzoxy)-ethyldiethylammonium chloride.

Fig. 3 (bottom).—Absorption in water of: 2, β-dithiobenzoxyethyldimethylammonium chloride; 2a, β-dithiobenzoxyethyltrimethylammonium iodide; 3, β-(*o*-chlorodithiobenzoxy)-ethyldimethylammonium chloride; 5, β-(*o*-hydroxydithiobenzoxy)-ethyldimethylammonium citrate.

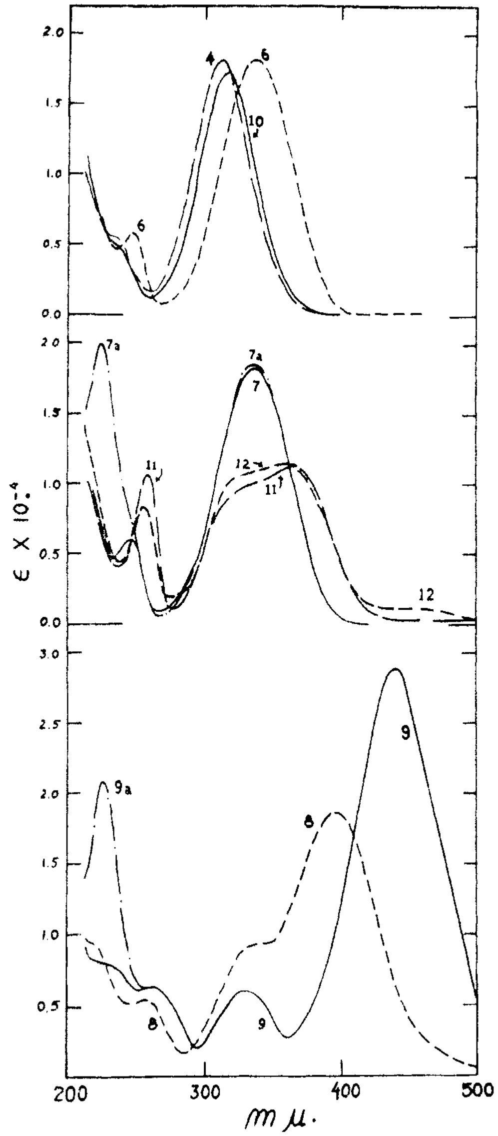

Fig. 4 (top).—Absorption in water of: 4, β-(*p*-chlorodithiobenzoxy)-ethyldimethylammonium citrate; 6, β-(*p*-hydroxydithiobenzoxy)-ethyldimethylammonium chloride; 10, β-(*p*-methyldithiobenzoxy)-ethyldimethylammonium citrate.

Fig. 5 (middle).—Absorption in water of: 7, β-(*p*-methoxydithiobenzoxy)-ethyldimethylammonium chloride; 7a, β-(*p*-methoxydithiobenzoxy)-ethyltrimethylammonium iodide; 11, β-(3,4-methylenedioxydithiobenzoxy)-ethyldimethylammonium chloride; 12, β-(3-methoxy-4-hydroxy-dithiobenzoxy)-ethyldimethylammonium chloride.

Fig. 6 (bottom).—Absorption in water of: 8, β-(*p*-aminodithiobenzoxy)-ethyldimethylammonium citrate; 9, β-(*p* - dimethylaminodithiobenzoxy) - ethyldimethylammonium chloride; 9a, β-(*p*-dimethylaminodithiobenzoxy)-ethyltrimethylammonium iodide.

tion maxima and the molecular extinction coefficients at each maximum.

Examination of Fig. 2 shows an absorption maximum at 232 mμ for compound 2b, $C_6H_5COOCH_2CH_2N(CH_3)_2 \cdot HCl$. The introduction of ortho–para directing substituents into the phenyl ring results in both bathochromic and hyperchromic shifts. Thus, a methoxyl group in the para position shifts the absorption maximum to 260 mμ ($\epsilon = 1.68 \times 10^{-4}$), and a para-amino group shifts it to 290 mμ ($\epsilon = 1.81 \times 10^{-4}$). A comparison with compound 1b, $CH_3COOCH_2CH_2N(CH_3)_3Br$, is interesting. The latter shows no appreciable absorption at wave lengths greater than 220 mμ. This fact would indicate that the primary absorption bands observed are, as suggested by Doub and Vandenbelt,[6] of benzenoid origin, probably being due to a displacement of the 203.5 mμ band of benzene.

In the dithio compounds the replacement of oxygen atoms by sulfur results in absorption at longer wave lengths. Compound 2, $C_6H_5CSSCH_2CH_2N(CH_3)_2 \cdot HCl$, shows (Fig. 3) a maximum at 305 mμ. However, replacement of the phenyl group by a methyl group does not cause a disappearance of the band, as was the case with oxygen compounds. Compound 1, $CH_3CSSCH_2CH_2N(CH_3)_2 \cdot HCl$, shows (Fig. 1) an absorption maximum at 302 mμ which is comparable to the absorption of the aromatic ester, though of less intensity. This would indicate that the primary absorption bands of the dithio ester derivatives are intimately related to the ester grouping. This is further confirmed by studies of "aged" solutions of compounds 1 and 1a. Both showed extensive decomposition after standing for a period of one week; decomposition was accompanied by the disappearance of the absorption bands at 302 and 301 mμ, respectively. Chemical evidence suggests that decomposition involves the dithio ester grouping.

Substitution in the phenyl nucleus of compound 2 resulted in bathochromic shifts of the primary absorption band. Table I reveals that the order of these shifts is approximate: *p*-dimethylamino > *p*-amino > 3,4-methylenedioxy > 3-methoxy-4-hydroxy > *p*-hydroxy ≈ *p*-methoxy > *p*-methyl > *p*-chloro ≈ *o*-chloro ≈ *o*-hydroxy. A rather interesting anomaly is observed in the ortho- and para-hydroxyl compounds. The para-hydroxyl compound, 6, absorbs at 338 mμ, while the ortho-hydroxyl compound, 5, absorbs at 312 mμ. Possible explanations are steric hindrance in the case of the ortho compound or the formation of a chelate ring which would modify the resonance of the molecule. Steric hindrance is contra-indicated by evidence from molecular models and by the fact that the ortho- and para-chloro compounds absorb at nearly the same wave lengths (312 and 311 mμ).

In general, the greater the bathochromic shift produced by a substituent in the phenyl ring of 2, the greater was the intensity of the absorption. There were, however, exceptions to the trend. The 3,4-methylenedioxy and 3-methoxy-4-hydroxy compounds, 11 and 12, showed a less intense absorption than the unsubstituted phenyl compound. This was accompanied by a broadening and partial resolution of the principal band; there was also increased development of a secondary band at about 255 mμ. Indications of this secondary band are seen in some of the other curves (compounds 6, 7, 8, 9, etc.). In the case of the ortho- and para-hydroxyl and ortho- and para-chloro compounds, the ortho isomers showed less intense absorption than the para. The value of $\epsilon$ for the ortho isomers was in both instances less than that for the unsubstituted phenyl compound.

Examination of the curves for the methiodides (compounds 1a, 2a, 7a and 9a) reveals that the absorption is closely similar to that of the hydrochlorides, with the exception of a maximum falling uniformly at 224–226 mμ. This 224–226 mμ band is evidenced in the spectrum of tetramethylammonium iodide and is explained by the absorption of the iodide ion.[7]

Periodic determinations of spectra showed no appreciable change in the absorption of aqueous solutions of phenyl and substituted phenyl dithio compounds after intervals as long as one week. As previously mentioned, aqueous solutions of the methyl compounds, 1 and 1a, showed rapid decomposition with disappearance of the band attributed to the dithio ester grouping. Normally, the increased resonance of the phenyl compounds would be expected to contribute to a greater stability.

## Summary

1. The absorption spectra of the citrates, hydrochlorides and methiodides of the β-dimethylaminoethyl esters of a number of organic dithio acids have been determined.

2. Evidence is presented to indicate that the principal absorption band between 300 and 400 mμ is due to the dithio ester grouping.

3. The shifts in absorption produced by various auxochrome groups have been studied.

4. It has been shown that the aromatic dithio ester derivatives are relatively stable in aqueous solution, while the methyl dithio ester derivatives appear to undergo extensive decomposition.

CHAPEL HILL, NORTH CAROLINA RECEIVED MAY 4, 1950

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[6] Doub and Vandenbelt, THIS JOURNAL, **69**, 2714 (1947).

[7] Scheibe, *Ber.*, **59**, 1321 (1926).