

Biselenienyl Series. II (1). Synthesis and Resolution of  
2,2'-Dinitro-3,3'-biselenienyl-4,4'-dicarboxylic acid (2).

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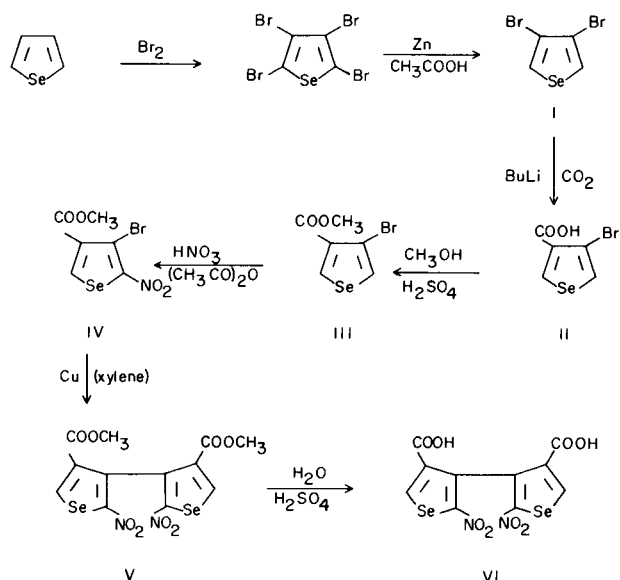
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2,2'-Dinitro-3,3'-biselenienyl-4,4'-dicarboxylic acid (VI), the first recorded compound of the 3,3'-biselenienyl series, has been prepared and resolved into its optical antipodes by fractional crystallization of its brucine salt.

On the basis of the quasi-racemate method of Fredga and the O.R.D. spectra, to the dextro-rotatory acid is assigned the R configuration.

In relation to researches previously carried out on 2,2'-biselenienyl (1) and to the much wider field of study on biphenyloid compounds with 5-membered heterocyclic rings (1,3) (heteroatom: sulphur, selenium) we here describe the synthesis and resolution of 2,2'-dinitro-3,3'-biselenienyl-4,4'-dicarboxylic acid, which is the first recorded product derived from the yet unknown 3,3'-biselenienyl.

The synthesis of the above mentioned acid was carried out according to the following scheme:



The structures of the compounds in the scheme (excepting that of 2,3,4,5-tetrabromoselenophene which was already known (4)) were established mainly on the

basis of their U.V. spectroscopic properties: the compounds I-VI have spectra very similar to those of the corresponding thiophene derivatives already reported (5). The structure of the acid (VI) was confirmed by means of its proton resonance spectrum. For compound VI it is highly probable that phenomena of atropisomerism are present, in that the position and the notable steric hindrance of the substituents should prevent free rotation of the rings around the pivot bond (6).

The resolution of this compound was achieved by

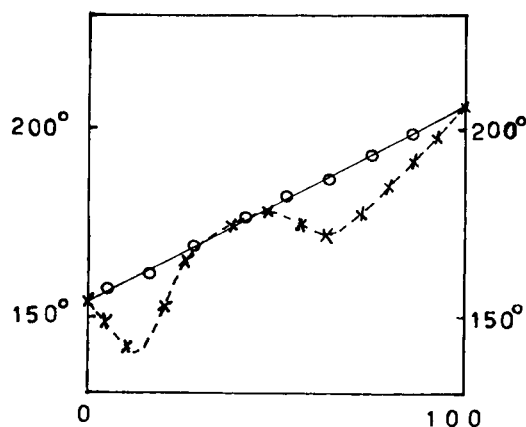


Fig. 1. Whole line: (R)-(+)-2,2'-dinitro-3,3'-bithienyl-4,4'-dicarboxylic acid dimethyl ester and (+)-2,2'-dinitro-3,3'-biselenienyl-4,4'-dicarboxylic acid dimethyl ester. Broken line: (R)-(+)-2,2'-dinitro-3,3'-bithienyl-4,4'-dicarboxylic acid dimethyl ester and (-)-2,2'-dinitro-3,3'-biselenienyl-4,4'-dicarboxylic acid dimethyl ester.

fractional recrystallization (from ethanol) of its brucine salt. The enantiomeric acids so obtained presented the same specific rotation:  $[\alpha]_{D}^{25} = \pm 44^{\circ}$  in ethanol.

This is the most valid proof for indicating the optical purity of the enantiomers. This can be confirmed by the I.R. spectra (7). In fact the spectrum of the racemic mixture shows a band system between  $1200-1260\text{ cm}^{-1}$ , which was absent in the enantiomers. Furthermore a difference in the spectra was seen in the low frequency region. These observations confirm the purity of the enantiomers at least within the precision limits of I.R.

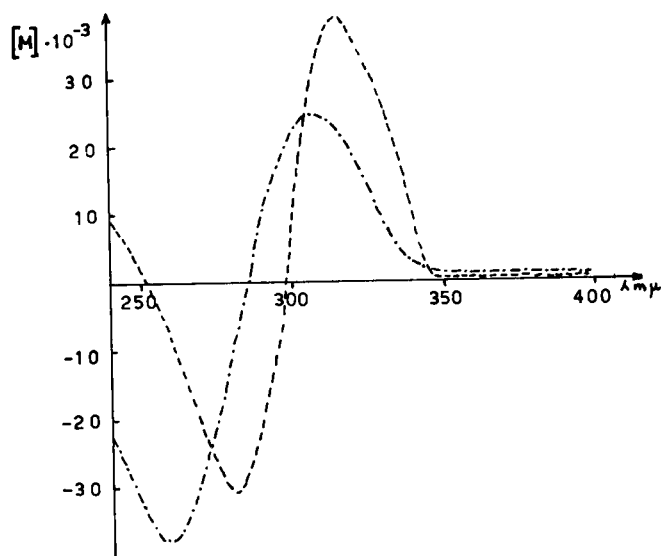


Fig. 2. O.R.D. curves: ---- (R)-(+)-2,2'-dinitro-3,3'-bithienyl-4,4'-dicarboxylic acid and --- (+)-2,2'-dinitro-3,3'-biselenienyl-4,4'-dicarboxylic acid.

spectra, and show that the racemic mixture is a racemate.

The relative R or S configurations (8) were assigned to the enantiomers of 2,2'-dinitro-3,3'-biselenienyl-4,4'-dicarboxylic acid by comparison with those already known of the 2,2'-dinitro-3,3'-bithienyl-4,4'-dicarboxylic acids (5) and by applying the quasi racemate method of Fredga (9). Because the enantiomeric acids decompose at the temperature of the melting point, we have carried out thermal analyses on their dimethyl esters. We so determined the melting temperatures of numerous mixtures of enantiomeric dimethyl esters of VI and of (R)-(+)-2,2'-dinitro-3,3'-bithienyl-4,4'-dicarboxylic acid (5). The melting-point curves (Figure 1) of the mixtures of dextrorotatory esters are characteristic of substances that are completely soluble in the solid state. On the contrary, the melting-

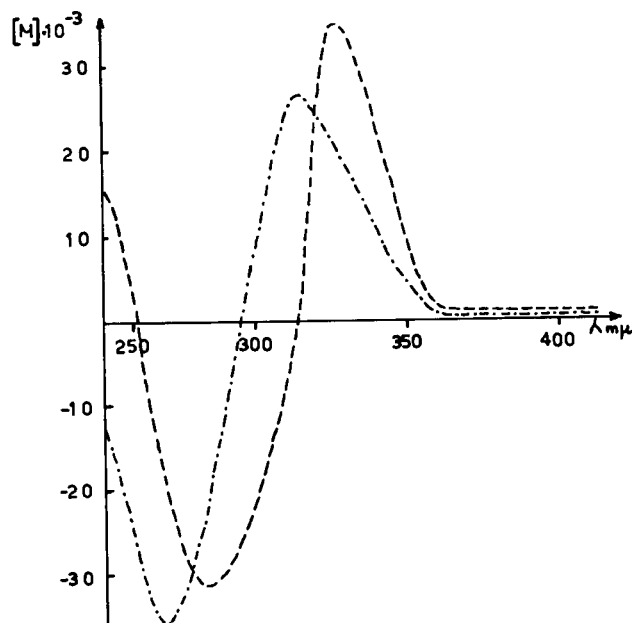


Fig. 3. O.R.D. curves: ---- (R)-(+)-2,2'-dinitro-3,3'-bithienyl-4,4'-dicarboxylic acid dimethyl ester and --- (+)-2,2'-dinitro-3,3'-biselenienyl-4,4'-dicarboxylic acid dimethyl ester.

point curves of the mixtures of esters with an opposite rotatory power, indicate that a quasi racemate is formed when both components are present in the same molar ratio. On the basis of this it was possible to assign the R configuration to the dimethyl ester of the (+)-2,2'-dinitro-3,3'-biselenienyl-4,4'-dicarboxylic acid and therefore to the corresponding acid. Consequently the relative S configuration could be attributed to the (-)-2,2'-dinitro-3,3'-biselenienyl-4,4'-dicarboxylic acid and to its dimethyl ester.

These configurations were confirmed by measuring the O.R.D. of (R)-(+)-2,2'-dinitro-3,3'-bithienyl-4,4'-dicarboxylic acid and its dimethyl ester as well as those of the biselenienylic acid enantiomers and their corresponding dimethyl esters. These curves, shown in Figures 2 and 3, indicate the presence of positive Cotton effects in the corresponding dextrorotatory bithienylic and biselenienylic derivatives. This fact (5,10), because of the isospectrality of bithienylic and biselenienylic derivatives, confirms the relative configurations assigned by us.

#### EXPERIMENTAL

##### 3,4-Dibromoselenophene (I).

Following the work of S. Gronowitz and coworkers (11) on the corresponding thiophene compound, the title compound was prepared from 2,3,4,5-tetrabromoselenophene by dehalogenation

with zinc dust and acetic acid. Contrary to what was previously reported by Yu. K. Yur'ev and coworkers (12), we obtained a mixture of 3-bromoselenophene (yield = 48%, b.p. 70-71° at 12 mm.) and 3,4-dibromoselenophene (yield = 35%, b.p. 121-122° at 12 mm.) separable by fractional distillation.

*Anal.* Calcd. for  $C_4H_2Br_2Se$ : C, 16.63; H, 0.70; Br, 55.36. Found: C, 16.70; H, 0.75; Br, 55.20.

### 3-Bromo-4-selenophenecarboxylic Acid (II).

This compound was prepared from 3,4-dibromo-selenophene by reaction with *n*-butyllithium and successive carbonation of the organolithium compound as was described for the thiophene isolog (13); colourless needles from water, m.p. 157° (yield = 70%).

*Anal.* Calcd. for  $C_5H_3BrO_2Se$ : C, 23.65; H, 1.19; Br, 31.50; MW, 254. Found: C, 23.70; H, 1.25; Br, 31.63; MW, 255.

### 3-Bromo-4-selenophenecarboxylic Acid Methyl Ester (III).

A 3-bromo-4-selenophenecarboxylic acid (71.5 g.) solution in ethylene chloride (350 ml.), methanol (110 ml.) and concentrated sulfuric acid (16 ml.) was refluxed for 20 hours. From the organic layer, after washing with a 2 *N* sodium bicarbonate solution (100 ml.) and distillation of the solvent, a residue was obtained that crystallized from ligroine and gave colourless prisms, m.p. 66° (yield = 90%).

*Anal.* Calcd. for  $C_6H_5BrO_2Se$ : C, 26.89; H, 1.88; Br, 29.85. Found: C, 27.00; H, 1.92; Br, 30.02.

### 2-Nitro-3-bromo-4-selenophenecarboxylic Acid Methyl Ester (IV).

The nitrating mixture (nitric acid *d* = 1.52, 10.6 ml.; acetic anhydride, 28 ml.) was slowly added, at -15°, to the methyl ester (6.9 g.) dissolved in acetic anhydride (7.4 ml.). After being kept at -15° for 20 minutes, the mixture was poured over crushed ice. The precipitate so obtained was washed with water, dried and then crystallized from benzene and ligroine; colourless needles, m.p. 156° (yield = 82%).

*Anal.* Calcd. for  $C_6H_4BrNO_4Se$ : C, 23.02; H, 1.29; Br, 25.56; N, 4.47. Found: C, 23.10; H, 1.35; Br, 25.89; N, 4.53.

### 2,2'-Dinitro-3,3'-biselenienyl-4,4'-dicarboxylic Acid Dimethyl Ester (V).

A solution of 2-nitro-3-bromo-4-selenophenecarboxylic acid methyl ester (8.8 g.) in anhydrous xylene (31 ml.) was refluxed (3 hours) with activated copper bronze (5.8 g.). From the solution obtained by hot filtration, after being cooled, a solid crystallized, which was recrystallized from xylene; colourless needles, m.p. 196° (yield = 40%).

*Anal.* Calcd. for  $C_{12}H_8N_2O_8Se_2$ : C, 30.90; H, 1.72; N, 6.01. Found: C, 31.10; H, 2.01; N, 5.88.

### 2,2'-Dinitro-3,3'-biselenienyl-4,4'-dicarboxylic Acid (VI).

The ester V (2 g.) was saponified by boiling (3 hours) in sulphuric acid solution (200 ml. of water and 100 ml. of concentrated sulfuric acid). The solution was cooled and the precipitate was filtered off and recrystallized from water; yellow prisms, m.p. 294° (yield = 95%).

*Anal.* Calcd. for  $C_{10}H_4N_2O_8Se_2$ : C, 27.40; H, 0.91; N, 6.39; MW, 438. Found: C, 27.42; H, 1.04; N, 6.58; MW, 439.

### Optical Resolution of 2,2'-Dinitro-3,3'-biselenienyl-4,4'-dicarboxylic Acid (VI).

The levorotatory brucine (9 g., 0.0228 mole) dissolved in 95% ethanol (685 ml.) was added at a temperature of 40° to a solution of 2,2'-dinitro-3,3'-biselenienyl-4,4'-dicarboxylic acid (5 g., 0.0114 mole) in ethanol (540 ml.). The solution was left at room temperature for 20 hours. The brucine salt which precipitated (5.7 g.) was filtered off. This salt was recrystallized from ethanol until the samples of acid, isolated from a small portion of its brucine salt, showed constant specific rotation. The results are listed in Table I.

The dextrorotatory acid was recrystallized from water as colourless needles, m.p. 288°. The specific rotatory power for the

TABLE I

Crystallization	1	2	3	4	5
g. of salt	5.7	4.82	4.39	3.96	3.20
ml. of ethanol	1225	470	250	250	235
$[\alpha]_D^{25}$ of acid in EtOH	+ 42°	+ 43°	+ 44°	+ 44°	+ 44°

TABLE II

Crystallization	1	2	3	4
g. of salt	4.73	4.10	3.50	3.00
ml. of ethanol	1225	180	140	100
$[\alpha]_D^{25}$ of acid in ethanol	-42°	-43°	-44°	-44°

dextrorotatory acid measured in some solvents were respectively (in bracket the weight of acid dissolved in 100 ml. of solvent):

$$[\alpha]_{\text{D}}^{25^{\circ}} = + 37^{\circ} \text{ (0.601 g., methanol)}$$

$$[\alpha]_{\text{D}}^{25^{\circ}} = + 44^{\circ} \text{ (0.480 g., ethanol)}$$

$$[\alpha]_{\text{D}}^{25^{\circ}} = + 46^{\circ} \text{ (0.176 g., acetone)}$$

$$[\alpha]_{\text{D}}^{25^{\circ}} = + 66^{\circ} \text{ (0.169 g., 0.1 N sodium hydroxide)}$$

After another 24 hours at room temperature another brucine salt (4.73 g.) was obtained from the mother liquor of brucine salt. It was purified by several recrystallizations from ethanol (see Table II) until the acid isolated from a small portion of its brucine salt showed a constant value for the specific rotation.

The levorotatory acid was also recrystallized from water as colourless needles, m.p.  $288^{\circ}$ .

(R)-(+)-2,2'-Dinitro-3,3'-biselenienyl-4,4'-dicarboxylic Acid Dimethyl Ester.

An excess of an ethereal solution of diazomethane was added to the (R)-(+)-2,2'-dinitro-3,3'-biselenienyl-4,4'-dicarboxylic acid (1 g.). After 6 hours at room temperature the excess diazomethane was removed. After being washed with 10% aqueous sodium bicarbonate, the solvent was distilled off from the residual ethereal solution. The remaining solid was crystallized from xylene; yellow prisms, m.p.  $204-205^{\circ}$ ;  $[\alpha]_{\text{D}}^{25^{\circ}} = + 63.5$  (0.45 g. in 100 ml. of acetone).

(S)-(-)-2,2'-Dinitro-3,3'-biselenienyl-4,4'-dicarboxylic Acid Dimethyl Ester.

Working in the above-mentioned way a product was obtained from the other enantiomer, which was crystallized from xylene as yellow prisms, m.p.  $204-205^{\circ}$ ;  $[\alpha]_{\text{D}}^{25^{\circ}} = - 63.5$  (0.30 g. in 100 ml. of acetone).

#### Melting Temperature Diagrams.

A weighed quantity of the two esters (see Figure 1) was dissolved in a few drops of acetone. After the solvent was evaporated at room temperature, the powdered residue was dried in a desiccator. The melting temperatures were determined by using a Kofler bank.

The O.R.D. curves were recorded on a Perkin Elmer P 22 spectropolarimeter and the I.R. spectra on a Perkin Elmer.

The U.V. and visible spectra were measured by a Zeiss PMQ II spectrophotometer. The spectra of the selenophenic and biselenienylic derivatives were very similar to those reported (5) for the thiophene and bithienyl analogues.

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