FORMATION OF BENZOTHIA CROWNS IN REACTION OF THE DIALLYL DERIVATIVE OF 2-MERCAPTO-4-METHYLPHENOL WITH SCl_2

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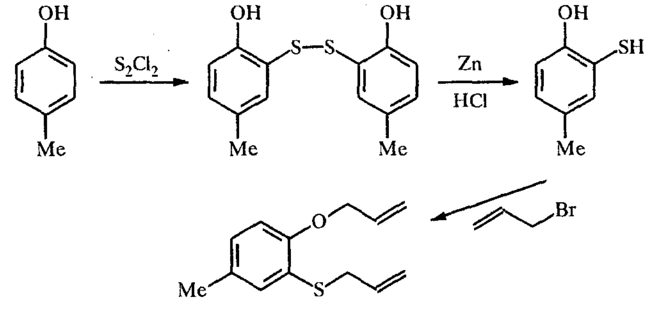
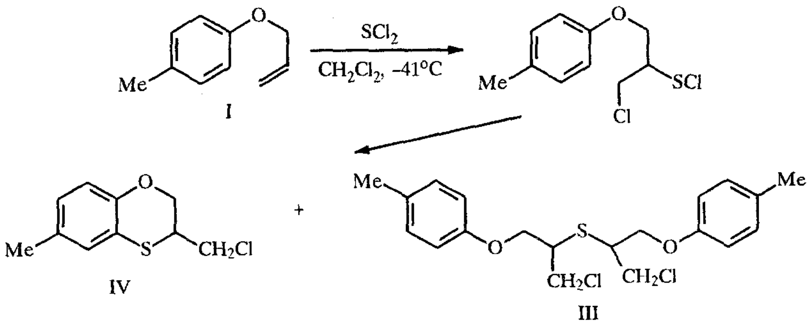
The reaction of SCl_2 with 1-allyloxy-2-allylthio-4-methylbenzene gave a mixture of 2,9,11,18-tetra-chloromethyldi(4-methylbenzo)-1,7,10,13-tetrathia-18-crown-6 and 2,9,11,18-tetrachloromethyldi-(4-methylbenzo)-1,7,10,15-tetrathia-18-crown-6.

A common method for the synthesis of sulfur heterocycles is the reaction of SCl_2 with unsaturated compounds [1]. Muhlstadt et al. [2] used the reaction of SCl_2 with the diallyl ether of pyrocatechol for the synthesis of dibenzo-18-crown-6 containing two sulfur atoms in the large ring. In the present work, we carried out the reaction of sulfur dichloride with the allyl ether of 4-methylphenol (I) and diallyl derivative of 2-mercapto-4-methylphenol (II) in order to expand the synthetic scope for the use of the diallyl derivatives of aromatic compounds to obtain macrocycles. Derivative (II) was obtained according to the following scheme:



II

The reaction of ethers I and II with SCl_2 was carried out at −40°C in CH_2Cl_2. The concentrations of the starting allyl derivatives was about 1 mole/liter, which provides for predominance of the intermolecular reaction. The reaction of ether I with SCl_2 gave bis[1-chloromethyl-2-(4-methylphenoxy)ethyl] sulfide (III) in 64% yield and the intramolecular cyclization product, 3-chloromethyl-6-methylbenzo-1,4-oxathiine (IV), in only 15% yield.



A crystalline product with mp 135-145°C was obtained in the reaction of thioether II with SCl_2. Mass spectral analysis indicated that the molecular mass of this product was 644. The intensity of the molecular ion peak was low and did not exceed

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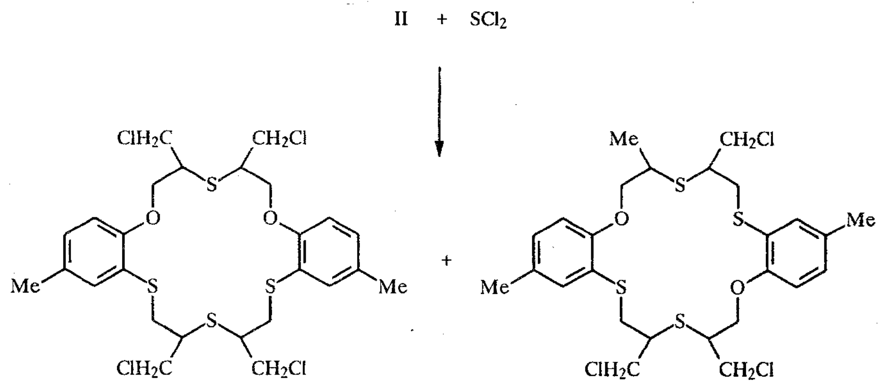
Chemistry Faculty, Moscow State University, Moscow 119899. Translated from Khimiya Geterotsiklicheskikh Soedinenii, No. 9, pp. 1276-1279, September, 1992. Original article submitted November 25, 1991.

1% of the maximal peak. The mass spectrum of this product also had a fragmentation ion peak 73,* which is a characteristic feature in the mass spectra of crown ethers [3]. The PMR spectrum of this compound contains signals for the all the proton groups characteristic for dibenzo-18-dithiacrown-6 obtained by Muhlstadt et al. [2]. The spectral data and the results of the reaction of SCl_2 with the diallyl ether of pyrocatechol [2] suggest that the major product in the reaction of thioether II with SCl_2 is a macrocyclic thioether with dibenzo-18-crown-6 structure formed, apparently, in two isomeric forms: 2,9,11,18-tetrachloromethyldi(4-methylbenzo)-1,7,10,13-tetrathia-18-crown-6 (V) and 2,9,11,18-tetrachloromethyldi(4-methyl-benzo)1,7,10,15-tetrathia-18-crown-6 (VI):

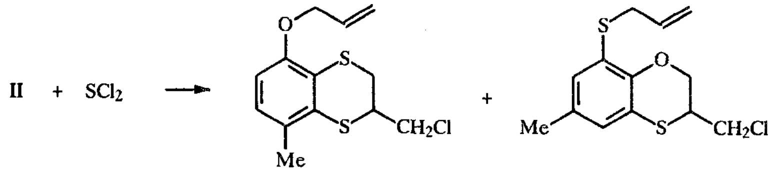


V

VI

The formation of two isomers, V and VI, occurs since the initial addition of SCl_2 to thioether II may proceed at the allyloxy or allylthio group, while the intermediate formed may also react with the starting molecule at each of these allyl groups. The methods available for use (thin-layer and column chromatography) did not permit us to separate thiacrowns V and VI as pure compounds. The different sequence of sulfur atoms in the macrocycles in V and VI presumably affects their tendency to complex with metal ions.

GC/MS analysis of the reaction product also showed two compounds with molecular mass 286 as impurities. Apparently, these compounds are products of thioether II with SCl_2 individually at each allyl group, namely, 2-chloromethyl-8-methyl-5-allyloxybenzo-4-thiine (VII) and 3-chloromethyl-6-methyl-8-allylthiobenzo-1,4-oxathiine (VIII):



VII

VIII

Thus, the reaction of SCl_2 with the allyl derivatives of aromatic hydroxy and mercapto compounds may be used to obtain sulfur heterocycles with heterocycles of various size.

EXPERIMENTAL

The ^1H NMR spectra were taken for 25% solutions of the samples in $CDCl_3$ on an AM-500 spectrometer with TMS or HMDS as the internal standard. The error in the determination of the chemical shifts was ±0.01 ppm. The GC/MS analysis in the electron impact mode was carried out on a Finnigan MAT-112S instrument. The ionizing energy was 80 eV. The chromatography was carried out on a glass column with $l = 50$ m and $d = 0.25$ cm packed with OV-101 as the stationary phase and temperature programming from 100 to 300°C.

The allyl ether of 4-methylphenol (I) was obtained by the reaction of 4-methylphenol with allyl bromide according to Claisen [4].

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*Here and subsequently, the m/z values are given for the ion peaks.

2-Mercapto-4-methylphenol was obtained by the reduction of 2,2′-dithiobis(4-methylphenol) in 74% yield according to a method proposed for the synthesis of 4,6-di-*tert*-butyl-2-mercaptophenol [5], mp 42-44°C. Mass spectrum: 142 (5), 140 (100), 107 (50), 97 (18), 77 (30).

1-Allyloxy-2-allylthio-4-methylbenzene (II). A mixture of 8.8 g (0.063 mole) 2-mercapto-4-methylphenol, 630 ml CH_2Cl_2, 630 ml water, 10.6 g (0.189 mole), 37.8 g (0.312 mole) allyl bromide, and 4.2 ml (0.012 mole) hexadecelytrimethylammonium chloride was stirred for 12 h at 20°C. The organic layer was separated and the aqueous layer was extracted with chloroform. The residue was mixed with water and extracted with ether. The ethereal fraction was washed with 20% aqueous NaCl and, then, water, and dried over $MgSO_4$.

Ether was distilled off to give 6.6 g (48%) crude product, which was purified by chromatography on silica gel using pentane as the eluent. Mass spectrum: 222 (1), 220 (26), 179 (42), 41 (100). PMR spectrum ($CDCl_3$): 7.0-7.2 (1H, m, arom.), 5.95-6.05 (1H, m, —CH=), 5.75-5.85 (1H, m, —CH=), 4.5 (2H, s, CH_2O), 3.4-3.5 (2H, m, CH_2S), 2.2 ppm (3H, s, CH_3). The yield of the purified product was 5 g (36%).

Reaction of the allyl ether of 4-methylphenol with SCl_2. A solution of 3.1 g (0.03 mole) SCl_2 in 5 ml dry CH_2Cl_2 was added with stirring to a solution of 4.5 g (0.03 mole) allyl ether of 4-methylphenol in 30 ml dry CH_2Cl_2 at −40°C. The reaction mixture was stirred for 2 h at −40°C and for 4 h at 20°C and then washed with 10% aq. KOH and water and dried over $MgSO_4$. The solvent was distilled off to give 5.9 g crude product as a yellow oil, which was separated on a column packed with silica gel 40/100 using 43:47:10 CCl_4—hexane—ether as the eluent. Elution gave bis[1-chloromethyl-2-(4-methylphenoxy)ethyl] sulfide (III). PMR spectrum ($CDCl_3$): 6.35-7.28 (8H, m, arom.), 4.25-4.45 (4H, m, $2CH_2O$), 3.45-3.58 (2H, m, 2CHS), 2.3-2.4 ppm (3H, s, CH_3). Mass spectrum: 402 (3), 400 (17), 398 (23), 291 (80), 255 (12), 215 (23), 183 (20), 147 (100), 91 (60), 77 (30). The yield of (III) was 64%.

3-Chloromethyl-6-methylbenzo-1,4-oxathiane (IV). Mass spectrum: 216 (38), 214 (100), 179 (100), 165 (100), 110 (40), 77 (10). The product yield was 15%.

Reaction of 1-allyloxy-2-allylthio-4-methylbenzene with SCl_2. A solution of 0.25 ml (0.004 mole) SCl_2 in 0.6 ml dry CH_2Cl_2 was added with stirring to a solution of 0.9 g (0.004 mole) 1-allyloxy-2-allylthio-4-methylbenzene in 4 ml dry CH_2Cl_2 and then stirred for 2 h at −40°C and 4 h at 20°C. The mixture was washed with 10% aq. NaOH and water until the wash water was neutral and dried over $MgSO_4$. After distilling off the solvent, the dry, yellow residue was heated with a small amount of methanol. Methanol was evaporated off and the residue was dried to give 0.6 g of a product with mp 135-145°C. PMR spectrum ($CDCl_3$): 7.0-7.15 (4H, m, arom.), 6.65-6.75 (2H, m, arom.), 4.1-4.3 (8H, m, CH_2O, CH_2S), 3.8-3.9 (8H, m, CH_2Cl), 3.2-3.5 (4H, m, CHS), 2.1-2.2 ppm (6H, s, CH_3). Mass spectrum: 644 (1), 179 (50), 139 (40), 73 (60).

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