REACTIONS OF ALKYL FURFURYL ETHERS AND SULFIDES WITH n-BUTYLLITHIUM

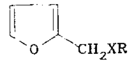
A. V. Anisimov, G. N. Murina, L. V. Mozhaeva,
N. B. Kazennova, and E. A. Viktorova

UDC 547.723

The direction of the reaction of alkyl furfuryl ethers and sulfides with n-butyllithium is in agreement with the results of basic H—D exchange in the same compounds: In the case of the ethers H—D exchange and metallation take place primarily in the free α position of the furan ring, whereas in the case of the sulfides these reactions take place primarily at the methylene group of the side chain located between the sulfur atom and the furan ring.

It is known that the furan ring is cleaved readily under the influence of acidic agents to give 1,4-dicarbonyl compounds [1] but is quite resistant to the action of basic substances, although cases in which aliphatic compounds with multiple bonds are formed under the influence of basic substances are known [2, 3].

In the present research we studied the action of n-butyllithium on alkyl furfuryl ethers and sulfides I-IV, the molecules of which contain two types of hydrogen atoms that are capable of being split out in the form of protons under the influence of strong bases.

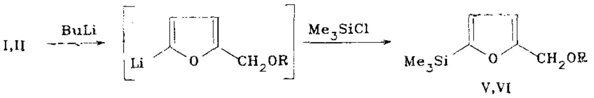


I X=O, R=Me; II X=O, R=Et; III X=S, R=Me; IV X=S, R=Et

The relative C—H acidities of the hydrogen atoms in II and III were estimated from data on basic H—D exchange, which was accomplished by the action of a 0.275 N solution of CH_3ONa in CH_3OD; the reaction products were analyzed by PMR spectroscopy. The results of basic H—D exchange show (Table 1) that the degree of such exchange is determined by the character of the heteroatom in the side chain of the furan compound. This effect is manifested in a change particularly in the α position. Replacement of the oxygen atom by sulfur increases the C—H acidity of the hydrogen atoms of the methylene group and decreases the C—H acidity of the hydrogen atoms in the α and, in particular, the β positions of the furan ring.

Thus according to the data on basic H—D exchange, the free α position of the furan ring should be the hypothetical site of electrophilic attack for furfuryl alkyl ethers I and II, whereas in the case of the corresponding sulfides III and IV metallation should take place at the methylene group.

In fact, in the reactions of ethers I and II with n-butyllithium the principal pathway of the transformation of these compounds was metallation of the free α position of the furan ring; this was confirmed by the structure of the substances isolated after treatment of the reaction mixtures with trimethylchlorosilane, viz., 2-methoxymethyl-5-trimethylsilylfuran (V) and 2-ethoxymethyl-5-trimethylsilylfuran (VI):



V,VI

V R=Me; VI R=Et

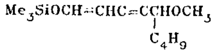
M. V. Lomonosov Moscow State University, Moscow 117234. Translated from Khimiya Geterotsiklicheskikh Soedinenii, No. 6, pp. 744-746, June, 1984. Original article submitted November 10, 1983.

0009-3122/84/2006-0599$08.50

TABLE 1. Results of Experiments on H–D Exchange (CH_3ONa in CH_3OD, exchange time 2 h)

Substrate	Temp., °C	Degree of exchange, %			
		in CH_2X	in XR	furan α-H	furan β-H
II	85	5	0	27	16
II	105	12	0	33	12
III	85	11	8	9	2
III	105	26	12	12	2

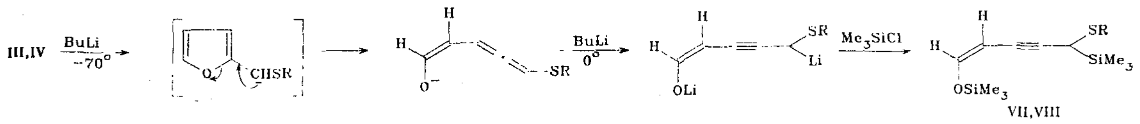
Chromatographic mass-spectrometric analysis of the reaction mixture obtained by the action of n-butyllithium on ether I showed that, in addition to I and V, substances with molecular masses of 130 and 240 are present in it. Peaks* at 130, 115, 73, and 57, which make it possible to assume that the substance is trimethylbutylsilane, are present in the mass spectrum of the substance with a molecular mass of 130. The absence in the mass spectrum of the second compound of an intense $(M - 1)^+$ ion peak makes it possible to assume that it is formed as a result of cleavage of the furan ring and that one of the possible structures for it may be



$$Me_3SiOCH{=}CHC{\equiv}C\underset{C_4H_9}{\underset{|}{C}}HOCH_3$$

The formation of these two substances is evidently associated with alkylation of trimethylchlorosilane and an anionoid intermediate formed in the opening of the furan ring of I by unchanged n-butyl bromide present in the n-butyllithium.

Compounds VII and VIII were isolated from the reaction mixtures obtained by the successive action of n-butyllithium and trimethylchlorosilane on sulfides III and IV. Chromatographic mass-spectrometric analysis of the reaction mixtures made it possible to detect only very small amounts (1-2%) of compounds formed in the metallization of the free α position of the furan ring, and it may therefore be assumed that the principal transformation of sulfides III and IV under the influence of n-butyllithium proceeds via the scheme



VII R=Me; VIII R=Et

The structures of VII and VIII are confirmed by the PMR spectroscopic data, and the constant of spin–spin coupling of the protons attached to the double bond indicates their cis orientation (J = 6 Hz).

EXPERIMENTAL

The PMR spectra of solutions of the compounds in CCl_4 were recorded with a Varian T-60 spectrometer with hexamethyldisiloxane as the internal standard. The IR spectra of films of the compounds were obtained with an IKS-22 spectrometer. Chromatographic mass-spectrometric analysis was carried out with a Finnigan MAT-112 spectrometer (at an ionizing energy of 80 eV) and a Varian 3700 chromatograph with a glass capillary column with a length of 25 m and a diameter of 0.25 mm packed with OV-101 as the liquid stationary phase; the carrier gas was helium, and the column temperature was 160°C.

Ethers I and II were synthesized by the reaction of the sodium salt of furfuryl alcohol with the corresponding alkyl halide in excess furfuryl alcohol [4]. Sulfides III and IV were synthesized by the method in [5] by the reaction of furfuryl mercaptan with the corresponding alkyl halide in aqueous potassium hydroxide solution.

Reactions of Ethers I and II with n-Butyllithium. A solution of 0.04 mole of the furfuryl alkyl ether in 10 ml of absolute ether was added at –70°C to 85 ml of a titrated solution of n-butyllithium (0.08 mole) in absolute ether, after which the temperature of the reac-

---

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

tion mixture was raised to 0°C with constant stirring, and the mixture was stirred at this temperature for 5 min. It was then cooled again to –70°C and treated with trimethylchlorosilane, and stirring at this temperature was continued for 30 min. The temperature of the reaction mixture was then raised to room temperature, and the mixture was stirred at this temperature for 30 min. It was then poured into a saturated solution of sodium carbonate at 0°C, and the solution was extracted with hexane. The extract was dried with magnesium sulfate, the hexane was removed by distillation, and the residue was chromatographed on silica gel [hexane–carbon tetrachloride–ether (47:43:10)] to give the unchanged furfuryl alkyl ether and the silylation products.

2-Methoxymethyl-5-trimethylsilylfuran (V). This compound was obtained in 50% yield. PMR spectrum: 0.2 [9H, s, $(CH_3)_3Si$], 3.3 (3H, s, CH_3), 4.4 (2H, s, CH_2), 6.1-6.2 (1H, d, =CH), and 6.4-6.5 ppm (1H, d, =CH). Mass spectrum, m/z (%): 183 (68), 168 (89), 153 (58), 111 (33), 73 (52).

2-Ethoxymethyl-5-trimethylsilylfuran (VI). This compound was obtained in 17% yield. PMR spectrum: 0.3 [9H, s, $(CH_3)_3Si$], 1.2 (3H, m, CH_3), 3.5 (2H, q, CH_2), 4.4 (2H, s, CH_2), 6.2 (1H, d, =CH), and 6.5 ppm (1H, d, =CH). IR spectrum: 1255, 845, and 755 cm^{-1}. Mass spectrum, m/z (%): 198 (31), 183 (23), 153 (58), 139 (79), 97 (46), 73 (79).

Reactions of Sulfides III and IV with n-Butyllithium. The reactions were carried out by the method described above, except that, after the addition of the sulfide to the n-butyllithium solution, the temperature of the reaction mixture was adjusted to –30°C for furfuryl methyl sulfide (III) and to 0°C for furfuryl ethyl sulfide (IV). In addition to the starting sulfides, products of opening of the furan ring (described below) were isolated.

1-Methylthio-1-trimethylsilyl-5-trimethylsilyloxypent-4-en-2-yne. This compound was obtained in 14% yield. PMR spectrum: 0.2 [9H, s, $(CH_3)_3Si$], 0.4 [9H, s, $(CH_3)_3Si$], 2.0 (3H, 3, CH_3), 4.5 (1H, d, =CH), and 5.9-6.0 ppm (1H, d, =CH).

1-Ethylthio-1-trimethylsilyl-5-trimethylsilyloxypent-4-en-2-yne. This compound was obtained in 14% yield. PMR spectrum: 0.2 [9H, s, $(CH_3)_3Si$], 0.4 [9H, s, $(CH_3)_3Si$], 1.2-1.3 (3H, t, CH_3), 2.6 (2H, q, CH_2), 4.6 (1H, d, =CH), and 6.1 ppm (1H, d, =CH). Mass spectrum, m/z (%): 285 (10), 225 (6), 169 (6), 141 (19), 103 (10), 73 (100).

Deuterium–Hydrogen Exchange. The reaction was carried out under the influence of a solution of sodium methoxide in CH_3OD in sealed ampuls in an argon atmosphere with the addition of toluene as the internal standard for recording of the PMR spectra. An $8 \cdot 10^{-3}$ mole sample of absolute toluene and $5 \cdot 10^{-4}$ mole of a 0.25 N solution of CH_3ONa in CH_3OD were added to $8 \cdot 10^{-3}$ mole of the ether or sulfide, the reaction mixture was put into ampuls under an argon atmosphere, and the ampuls were sealed and heated. At the end of the heating period, the ampuls were cooled, and the PMR spectrum was recorded at 20°C with a Tesla spectrometer (60 MHz).

LITERATURE CITED

1. R. A. Ellison, Synthesis, No. 3, 397 (1973).
2. I. Kuwajima, J. Atsumi, and I. Azegami, J. Chem. Soc., Chem. Commun., No. 1, 76 (1977).
3. K. Atsumi and I. Kuwajima, J. Am. Chem. Soc., 101, 2208 (1979).
4. A. P. Salchinkin, Zh. Prikl. Khim., 36, 681 (1963).
5. O. Yataro and J. Yoshinori, Agric. Biol. Chem., 29, 345 (1965).