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Regiospecific silylation of 2,5-dibromothiophene: a reinvestigation

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Abstract—Lithiation of 2,5-dibromothiophene by LDA with ensuing silylation proceeds regiospecifically in accordance with the halogen dance mechanism to yield 3,5-dibromo-2-trimethylsilylthiophene or 3,4-dibromo-2,5-bis(trimethylsilyl)thiophene depending on the ratio of reagents. The outcome of the reaction was confirmed by further chemical transformations of the latter compound to 2,5-bis(trimethylsilyl)thiophene and 2,5-bis(trimethylsilyl)thiophene-1,1-dioxide. The structures of the compounds obtained were determined by ^{1}H, ^{13}C and ^{29}Si NMR, and X-ray analysis in the case of a sulfone. © 2001 Elsevier Science Ltd. All rights reserved.

The interaction of aromatic and heteroaromatic (furan, thiophene, pyrazole, imidazole, isothiazole, pyridine) bromides with bases such as lithium, sodium or potassium amides under appropriate conditions can lead to the formation of rearranged products. These reactions were considered in the literature as halogen migration, halogen scrambling, halogen dance or base-catalyzed halogen dance reactions.[1] Some examples of regioselective halogen dance rearrangements for different thiophene derivatives have been published.[2] The structure of lithiothiophene, formed in the reaction of 2,5-dibromothiophene with lithium diisopropylamide (LDA) in THF or ether at −70°C, was found to be 3,5-dibromo-2-lithiothiophene as a result of base-catalyzed halogen dance mechanism. The following treatment of this lithio derivative with methyl iodide, ethyl iodide, allyl bromide, *N*,*N*-dimethylformamide, chloroformates, various oxiranes, cyclohexanone or dimethyl disulfide was used to prepare the corresponding 2-substituted 3,5-dibromothiophenes.[2a] However, according to the literature data,[3] quenching of the lithio derivative obtained from 2,5-dibromothiophene with trimethylchlorosilane gave 2,5-dibromo-3-trimethylsilylthiophene **1**. Later Fröhlich[2a] showed that 3,5-dibromo-2-trimethylsilylthiophene **2** prepared from 2,3-dibromothiophene (LDA, −78°C, THF, Me_3SiCl) has the same spectroscopic characteristics as the compound wrongly ascribed as thiophene **1**,[3] indirectly confirming the halogen dance mechanism in the case of 2,5-dibromothiophene silylation.

We attempted to prepare thiophene **1** by this method (LDA, −78°C, THF, Me_3SiCl). The results of ^{1}H and ^{13}C NMR spectroscopy did not allow us to determine the structure of the reaction product definitely; however, ^{29}Si NMR spectroscopic data for this compound ($\delta = -4.68$ ppm) clearly confirmed the formation of the isomeric 3,5-dibromo-2-trimethylsilylthiophene **2**[4] bearing a silyl group at position 2 of the heterocycle, since the signals (δ ^{29}Si) for the trimethylsilyl group in position 3 of the thiophene ring are shifted to a higher field (−7 to −8 ppm). The lithiation of compound **2** by LDA in THF at −78°C also proceeds with a halogen dance rearrangement to yield symmetrical 3,4-dibromo-2,5-bis(trimethylsilyl)thiophene **3**,[5] due to the fact that the ^{29}Si chemical shift of this derivative is −4.23 ppm. Compound **3** was prepared using direct metallation of 2,5-dibromothiophene with two equivalents of LDA (45% yield), as well as by lithiation of tetrabromothiophene with two equivalents of BuLi (40% yield) and subsequent silylation (Scheme 1).

Additional confirmation of the position of the silyl group in thiophene **3** was obtained by its debromination (BuLi, −78°C, THF; H_2O) to 2,5-bis(trimethylsilyl)thiophene **4**.[6] Oxidation of silyl derivative **4** by *m*-chloroperbenzoic acid in methylene chloride at room temperature gave the corresponding sulfone **5**.[6]

The structure of thiophene-1,1-dioxide **5** was determined by X-ray crystallography[7] (Fig. 1). In the crystal the molecules of sulfone **5** lie in special positions. Both crystallographically independent molecules in the crystals lie in mutually perpendicular mirror planes *m*. Molecules **A** pack perpendicularly to the *y* crystallographic axis while molecules **B** are perpendicular to the

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Keywords: bromine dance reaction; lithiation; thiophene; X-ray crystal structure.

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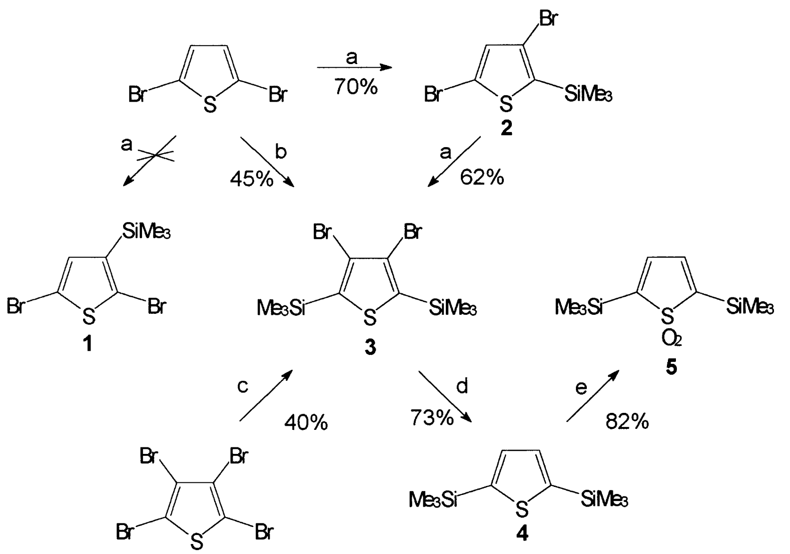

Scheme 1. (a) (i) LDA, THF, −78°C; (ii) Me_3SiCl. (b) (i) 2LDA, THF, −78°C; (ii) $2Me_3SiCl$. (c) (i) 2BuLi, THF, −78°C; (ii) $2Me_3SiCl$. (d) (i) 2BuLi, THF, −78°C; (ii) H_2O. (e) *m*-CPBA, CH_2Cl_2, 20°C.

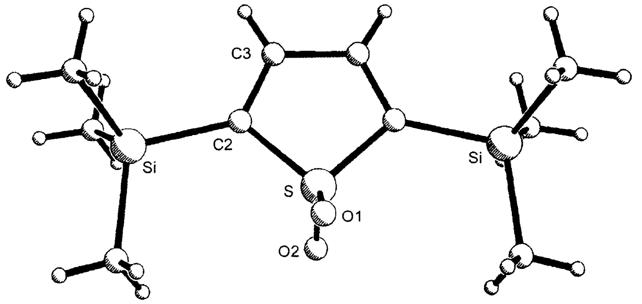

Figure 1. Molecular structure of 2,5-bis(trimethylsilyl)thiophene-1,1-dioxide **5**. Selected bond distances (Å) and angles (°): S–C(2), 1.775(5), 1.7648(5); C(2)–C(3), 1.2691(8), 1.299(7); C(3)–C(4), 1.4622(12); Si–C(2), 1.8862(6), 1.7648(5); C(2)–S–C(2′), 95.84(3).

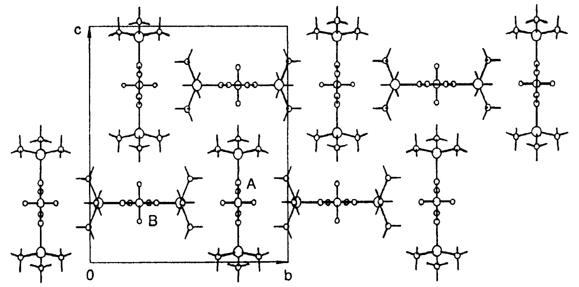

Figure 2. Molecular packing of sulfone **5**.

z axis (Fig. 2). The five-membered heterocycle is planar. The oxygen atoms of the SO_2 unit lie roughly the same distance above and below the five-membered ring. The main geometric parameters of the studied sulfone **5** are in good agreement with those previously found for 2,5-disubstituted thiophene-1,1-dioxides structures.[6a,c,8] Silylsulfone **5** is similar to 2-trimethylsilyl-5-trimethylgermyl- and 2,5-bis(trimethylgermyl)thiophene-1,1-dioxides in terms of molecular packing; however, it differs from 2-*tert*-butyl-5-trimethylsilylthiophene-1,1-dioxide.

References

1. (a) Fröhlich, J.; Hametner, C.; Kalt, W. *Monatsh. Chem.* **1996**, *127*, 435–443; (b) Mallet, M.; Branger, G.; Marais, F.; Queguiner, G. *J. Organomet. Chem.* **1990**, *382*, 319–332; (c) Rocca, P.; Cochennec, C.; Marsais, F.; Thomas-dit-Dumont, L.; Mallet, M.; Godart, A.; Queguiner, G. *J. Org. Chem.* **1993**, *58*, 7832–7838; (d) Bunnett, J. F. *Acc. Chem. Res.* **1972**, *5*, 139–147; (e) Mallet, M.; Queguiner, J. G. *Tetrahedron* **1979**, *35*, 1625–1631.
2. (a) Fröhlich, J.; Kalt, W. *J. Org. Chem.* **1990**, *55*, 2993–2995; (b) Fröhlich, J.; Hametner, C.; Kalt, W. *Monatsh. Chem.* **1996**, *127*, 325–330.
3. (a) Davies, G. M.; Davies, P. S. *Tetrahedron Lett.* **1972**, *33*, 3507–3508; (b) Kano, S.; Yuasa, Y.; Yokomatsu, T.; Shibuya, S. *Heterocycles* **1983**, *20*, 2035–2037; (c) Pham, C. V.; Macomber, R. S.; Mark, Jr., H. B.; Zimmer, H. *J. Org. Chem.* **1984**, *49*, 5250–5253.
4. 3,5-Dibromo-2-trimethylsilylthiophene (**2**): 70% yield; MS, *m*/*e* 312 ($M^{\bullet+}$). ^1H NMR (200 MHz, $CDCl_3$/TMS) δ (ppm): 0.36 (s, Me_3Si, 9H), 7.01 (s, H^4, 1H); ^{13}C NMR (50.31 MHz, $CDCl_3$/TMS) δ (ppm): −0.9, 116.5, 119.5, 134.4, 137.6; ^{29}Si NMR (39.74 MHz, $CDCl_3$/TMS) δ (ppm): −4.68 (Me_3Si). Anal. calcd for $C_7H_{10}Br_2SSi$: C, 26.77; H, 3.21; S, 10.21. Found: C, 26.65; H, 3.24; S, 10.30.
5. 3,4-Dibromo-2,5-bis(trimethylsilyl)thiophene (**3**): 45% yield (from 2,5-dibromothiophene); 62% yield (from **2**); MS, *m*/*e* 386 ($M^{\bullet+}$). ^1H NMR (200 MHz, $CDCl_3$/TMS) δ (ppm): 0.38 (s, Me_3Si); ^{13}C NMR (50.31 MHz, $CDCl_3$/TMS) δ (ppm): −1.2, 122.2, 140.6; ^{29}Si NMR (39.74 MHz, $CDCl_3$/TMS) δ (ppm): −4.23 (Me_3Si). Anal. calcd for $C_{10}H_{18}Br_2SSi_2$: C, 31.09; H, 4.69; S, 8.30. Found: C, 31.15; H, 4.74; S, 8.33.
6. (a) Furukawa, N.; Hoshiai, H.; Shibutani, T.; Higaki, M.; Iwasaki, F.; Fujihara, H. *Heterocycles* **1992**, *34*, 1085–

1088; (b) O'Donovan, A. R. M.; Shepherd, M. K. *Tetrahedron Lett.* **1994**, *35*, 4425–4428; (c) Lukevics, E.; Arsenyan, P.; Belyakov, S.; Popelis, J.; Pudova, O. *Organometallics* **1999**, *18*, 3187–3193.

7. X-ray data: empirical formula $C_{10}H_{20}O_2SSi_2$; molecular weight 260.50; crystal system, orthorhombic; unit cell dimensions $a=15.363(3)$, $b=15.577(3)$ and $c=6.491(1)$ Å; $V=1553.4(5)$ Å^3; $Z=4$; space group *Pmmn*; $D_{calcd}=1.114$ g/cm^3; $F(000)=560$; data collection on a 'Syntex P2$_1$' diffractometer, Mo-radiation ($\lambda=0.71073$ Å); absorption coefficient 0.346 mm^{-1}; $2\theta_{max}=50.0°$; index ranges $0<h<18$, $0<k<18$ and $0<l<7$; number of independent reflections 1443; full-matrix least-squares on F^2; goodness-of-fit 0.901; extinction coefficient 0.018(2); final R-factor 0.0515. Atomic coordinates and components of temperature factor tensors are deposited at the Cambridge Crystallographic Data Centre (the CCDC deposition number is 153353).
8. Vorontsova, L. G. *Zh. Strukt. Khim.* **1966**, *7*, 240.