

SHORT
COMMUNICATIONS

Unexpected Formation
of 3-Methylsulfanyl-2-phenyl-2-cyclobutenone
in the Reaction of 1,3-Dilithio-2-propynylbenzene
with Methoxymethyl Isothiocyanate

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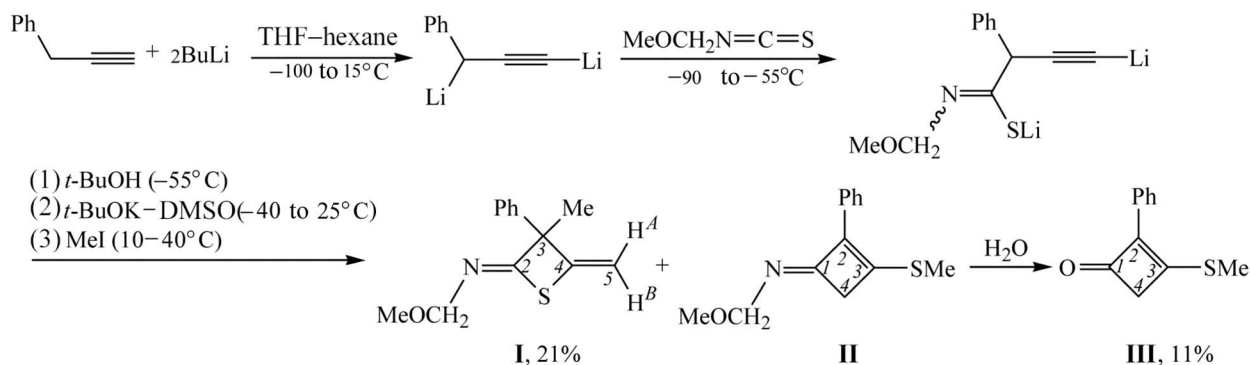
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We recently found [1] that the reaction of 1,3-dilithiated 2-propynylbenzene with methyl isothiocyanate, followed by treatment of the primary adduct with a proton donor, base, and methyl iodide, results in formation of three isomeric products: *N*-methyl-3-methylsulfanyl-2-phenyl-2-cyclobuten-1-imine, *N*,3-dimethyl-4-methylene-3-phenylthietan-2-imine, and 2-dimethylamino-3-phenylthiophene at a ratio of 68:16:16 (overall yield 68–77%). While continuing study of this unique reaction leading to four-membered cyclic systems, cyclobutenes and thietanes (whose formation was not observed previously in reactions of saturated carbanions with isothiocyanates [2]), we replaced methyl isothiocyanate by methoxymethyl isothiocyanate. The latter was successfully involved in reactions with lithiated allenes and acetylenes, which were reported in [3]. Unexpectedly, apart from iminothietane **I**, from the reaction mixture we isolated 3-methylsulfanyl-

2-phenyl-2-cyclobutenone (**III**) instead of *N*-methoxymethyl-3-methylsulfanyl-2-phenyl-2-cyclobuten-1-imine (**II**) (Scheme 1). No corresponding thiophene was detected among the products.

Obviously, cyclobutenone **III** is formed as a result of hydrolytic cleavage of iminocyclobutene **II**. This process is most likely to occur at the final stage of the standard treatment of the reaction mixture (with a saturated aqueous solution of ammonium chloride at room temperature over a period of ~1 min). This is the first and still the only example of extremely ready decomposition of imino derivatives formed by reactions of unsaturated carbanions with isothiocyanates [1–3]. The observed reaction not only deserves attention but may be regarded as a new simple synthetic route to previously unknown cyclobutenone derivatives which are difficult to obtain by other methods.

Scheme 1.



Reaction of 1,3-dilithio-2-propynylbenzene with methoxymethyl isothiocyanate and methyl iodide.

A solution of 5.8 g (50 mmol) of 2-propynylbenzene in 110 ml of THF was cooled to -100°C , and 110 mmol of butyllithium (68 ml of a 1.6 M solution in hexane) was added over a period of ~ 1 min under a stream of argon. The mixture was stirred for 10 min at 10 – 14°C and cooled to -90°C , a solution of 5.15 g (50 mmol) of methoxymethyl isothiocyanate in 5 ml THF was added in one portion, and the mixture was stirred for 5 min at -70 to -65°C . The cooling bath was removed, a mixture of 4 g (54 mmol) of *tert*-butyl alcohol and ~ 2 ml of diethyl ether was added at -55°C , and a solution of 6 g (54 mmol) of *t*-BuOK in 40 g of DMSO was added at -40°C (the temperature sharply rose to -20°C). The mixture was quickly (over a period of 2–3 min) heated from -20 to 25°C and immediately cooled to 10°C , and 22 g (150 mmol) of methyl iodide was added. The mixture was stirred for 1.5 h at 25 – 40°C , 100 ml of a saturated aqueous solution of ammonium chloride was added, the mixture was stirred for ~ 1 min, the organic phase was separated, and the aqueous phase was extracted with diethyl ether (2×50 ml). The extracts were combined with the organic phase, washed with three portions of a saturated solution of ammonium chloride (to remove DMSO), dried over MgSO_4 , and evaporated on a rotary evaporator. The residue was distilled under reduced pressure (0.2 – 0.4 mm) to isolate 4.62 g of a fraction boiling in the temperature range from 100 to 150°C and ~ 4 g of a dark polymeric still residue which was not analyzed. The liquid fraction was subjected to column chromatography on aluminum oxide using hexane–diethyl ether (3: 1) as eluent. We isolated 2.72 g of a liquid material containing (according to the ^1H NMR data) 92% of thietane **I** (yield 21%), 1.02 g of cyclobutenone **III** as yellow crystalline substance (yield 11%), and 0.5 g of unidentified products.

***N*-Methoxymethyl-3-methyl-4-methylene-3-phenylthietan-2-imine (I).** Yellow viscous liquid, $n_D^{20} = 1.5710$. ^1H NMR spectrum, δ , ppm: 1.84 s (3H, Me), 3.36 s (3H, OMe), 4.76 s (2H, OCH_2), 5.18 d (1H, H_B , $^2J_{AB} = 4.4$ Hz), 5.29 d (1H, H_A), 7.29 t (1H, *p*-H), 7.34 t (2H, *m*-H), 7.59 d (2H, *o*-H). ^{13}C NMR spectrum, δ_C , ppm: 25.27 (Me), 57.17 (OMe), 75.62 (C_3), 85.67 (OCH_2), 104.71 ($=\text{CH}_2$), 125.74 (C^o), 127.52 (C^p), 128.82 (C^m), 140.29 (C^i), 146.91 (C^4), 162.57 (C^2). IR spectrum, ν , cm^{-1} : 500, 560, 629, 646, 699 s, 759, 782, 861, 924,

999 s, 1029, 1067, 1103 s, 1126 s, 1196, 1238, 1288, 1377 s, 1445 s, 1584, 1600, 1635 s ($\text{C}=\text{C}$), 1714 s ($\text{C}=\text{N}$), 2723, 2824, 2868, 2927, 2972, 3024, 3059, 3087.

3-Methylsulfanyl-2-phenyl-2-cyclobutenone (III). Light yellow crystals, mp 105°C (from hexane–methylene chloride, 5:1). ^1H NMR spectrum, δ , ppm: 2.52 s (3H, Me), 3.48 s (2H, CH_2), 7.21 t (1H, *p*-H), 7.32 t (2H, *m*-H), 7.60 d (2H, *o*-H). ^{13}C NMR spectrum, δ_C , ppm: 16.76 (Me), 51.12 (C^4), 126.58 (C^o), 127.90 (C^p), 128.68 (C^m), 130.11 (C^i), 138.88 (C^2), 166.89 (C^3), 181.61 ($\text{C}=\text{O}$). IR spectrum, ν , cm^{-1} : 466 w, 516, 575 w, 641 w, 695 s, 773 s, 840, 909 w, 962/976, 999 w, 1026 w, 1054, 1078, 1142, 1153 sh, 1180 w, 1264 s, 1285, 1312, 1335 w, 1421, 1444, 1482, 1574, 1603, 1726 s ($\text{C}=\text{O}$), 1809 w, 2119 w, 2856 w, 2926 w, 2954 w. Found, %: C 69.13; H 5.33; S 17.25. $\text{C}_{11}\text{H}_{10}\text{OS}$. Calculated, %: C 69.44; H 5.30; S 16.85.

Signals in the NMR spectra of compounds **I** and **III** were assigned using NOESY, HMQC, and HMBC two-dimensional techniques. Methoxymethyl isothiocyanate was synthesized in $\sim 65\%$ yield by heating methyl chloromethyl ether with KSCN in boiling pentane [4]. The ^1H and ^{13}C NMR spectra were recorded on a Bruker DPX-400 spectrometer at 400.13 and 100.69 MHz, respectively, using CDCl_3 as solvent and HMDS as internal reference. The IR spectra were obtained on a Bruker IFS-25 instrument from samples prepared as a thin film (compound **I**) and a KBr pellet (**III**).

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REFERENCES

1. Brandsma, L., Spek, A.L., Trofimov, B.A., Tarasova, O.A., Nedolya, N.A., Afonin, A.V., and Zinshenko, S.V., *Tetrahedron Lett.*, 2001, vol. 42, 4687; Tarasova, O.A., Brandsma, L., Nedolya, N.A., Afonin, A.V., Ushakov, I.A., and Klyba, L.V., *Russ. J. Org. Chem.*, 2003, vol. 39, p. 1451.
2. Brandsma, L., Nedolya, N.A., Tarasova, O.A., and Trofimov, B.A., *Khim. Geterotsykl. Soedin.*, 2000, p. 1443; Brandsma, L., *Eur. J. Org. Chem.*, 2001, p. 4569.
3. Nedolya, N.A., Schlyakhtina, N.I., Klyba, L.V., Ushakov, I.A., Fedorov, S.V., and Brandsma, L., *Tetrahedron Lett.*, 2002, vol. 43, p. 9679; Nedolya, N.A., Brandsma, L., Shlyakhtina, N.I., Fedorov, S.V., and Klyba, L.V., *Russ. J. Org. Chem.*, 2002, vol. 38, p. 957.