Tetrahedron Letters No.24, pp. 1975-1978, 1969. Pergamon Press. Printed in Great Britain.

THERMAL SIGMATROPIC REARRANGEMENTS OF ALLYL 2-QUINOLYL SULFIDES AND N-ALLYLTHIOCARBOSTYRILS

Yasuo Makisumi and Takashi Sasatani

Shionogi Research Laboratory, Shionogi & Co., Ltd., Fukushima-ku, Osaka, Japan

(Received in Japan 10 April 1969; received in UK for publication 20 April 1969)

The thio-Claisen rearrangement of allyl 4-quinolyl sulfides results in the formation of 2,3-dihydrothieno[3.2-c]quinolines via the intermediate, 3-allyl-4(1H)-quinolinthiones (1,2), in contrast to the Claisen rearrangement of allyl 4-quinolyl ethers to give 3-allyl-4(1H)-quinolones (>90%) accompanying small amounts of their cyclization products, 2,3-dihydrofuro[3.2-c]quinolines (3,4). We report now the thermal behavior of allyl 2-quinolyl sulfides and N-allylthiocarbostyrils in comparison with the Claisen rearrangement of allyl 2-quinolyl ethers to give N-allylcarbostyrils (5).

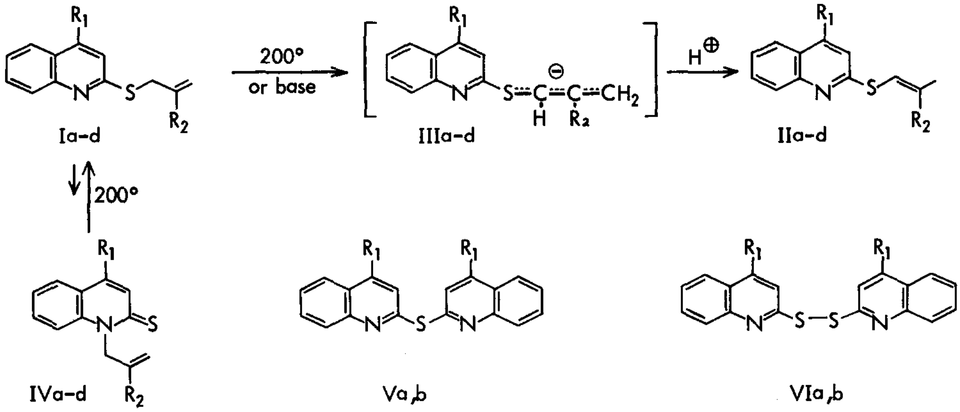
Allyl 2-quinolyl sulfide (Ia), b.p$_{0.3}$ 119-120°, and its 4-methyl derivative (Ib), b.p$_{0.3}$ 130°, were prepared by reaction of sodium 2-quinolylmercaptide and its 4-methyl derivative with allyl bromide at room temperature in quantitative yields. Similarly, methallyl 2-quinolyl sulfide (Ic), b.p$_{0.3}$ 123°, and its 4-methyl derivative (Id), b.p$_{0.6}$ 141-142°, were obtained from the mercaptides and methallyl chloride.

When the allyl sulfides Ia,b and the methallyl sulfides Ic,d were heated at 200° (inner temp.) for 6 hr in 1-methylnaphthalene, the corresponding propenyl sulfides IIa,b and isobutenyl sulfides IIc, b.p$_{0.035}$ 124-125°, and IId, m.p. 90.5-91.5°, were obtained in about 75% yields, respectively. Chromatography on alumina of IIa gave cis-IIa, b.p$_{0.2}$ 120°; picrate, m.p. 138.5-139.5°, and trans-IIa, b.p$_{0.04}$ 122°; picrate, m.p. 179.5-180°, in the ratio of ca. 1 : 1. IIb was also separated to cis-IIb, oil; picrate, m.p. 127-128°, and trans-IIb, m.p. 66-67°. The structure of these products was confirmed by the NMR spectrum as shown in Table. Moreover, the trans-propenyl sulfides IIa,b showed the IR absorption due to the trans-CH=CH-S grouping (6) at 943-944 cm^{-1}.

It has been known that allyl phenyl sulfides isomerize to the propenyl sulfides on heating with base (7,8). Thus, base-catalyzed isomerization of Ia-d to IIa-d was finished by heating of Ia-d in ethanol with sodium ethoxide in good yields. As the thermal [1.3] sigmatropic shift is not allowed by the Woodward-

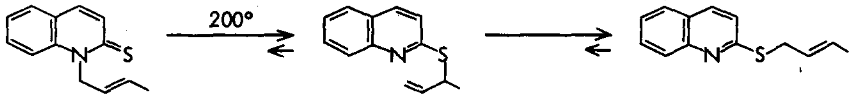
Hoffmann selection rule (9), this thermal isomerization should be interpreted as a reaction which occurs by a stepwise mechanism through carbanion intermediate (III). The facility of this isomerization is attributed to the stabilization of the carbanion (III) due to the resonance with the allylic π-orbital and the sulfur d-orbital.

Careful investigation of the remainder of the reaction mixture in the thermal reaction of Ia by chromatography on alumina afforded rearranged product, N-allylthiocarbostyril (IVa) in about 1% yield in addition to small amounts of bis-(2-quinolyl)sulfide (Va) and bis-(2-quinolyl)disulfide (VIa). The other allyl sulfides Ib-d also gave the corresponding N-allylthiocarbostyrils (IVb-d), besides the sulfides Va,b and the disulfides VIa,b. N-Allylthiocarbostyril (IVa), m.p. 78~79°, and its 4-methyl derivative (IVb), m.p. 97-98°, and N-methallylthiocarbostyril (IVc), m.p. 97-99°, and its 4-methyl derivative (IVd), m.p. 133-135°, were synthesized by thiation of the corresponding N-allylcarbostyrils with phosphorus pentasulfide in pyridine.



a: $R_1 = R_2 = H$, b: $R_1 = Me$, $R_2 = H$, c: $R_1 = H$, $R_2 = Me$, d: $R_1 = R_2 = Me$

Heating of IVa in 1-methylnaphthalene at 200° afforded a mixture of the allyl sulfide Ia and the propenyl sulfide IIa in good yields. Gas chromatographic analysis of this reaction indicated that IVa rearranged initially to Ia, which in turn isomerized to IIa as shown in Fig. 1. The rearrangement of IVa to Ia is corresponding to a reversed thio-Claisen rearrangement, whose mechanism was then examined on thermal behavior of N-crotylthiocarbostyril (IVe), b.p$_{0.25}$ 164°, prepared by the thiation of N-crotylcarbostyril. Although rearrangement of IVe in 1-methylnaphthalene at 200° gave a mixture of α-methylallyl 2-quinolyl sulfide (If) and crotyl 2-quinolyl sulfide (Ie), the reaction profile in Fig. 2 demonstrated that this reaction initiated by the concerted rearrangement of IVa to If, which proceeded with the inversion of the migrating allylic group, followed by isomerization of the initially formed If to Ie. Moreover, the isomerization of If to Ie was realized on treatment of If under the rearrangement conditions; e.g., heating of If at 200° for 1.5 hr afforded 80% of Ie along with 4% of the thio-Claisen product IVe. Pyrolysis of Ie at 200° resulted in the recovery (ca. 95%) of Ie accompanying small amounts of the isomerization product If.

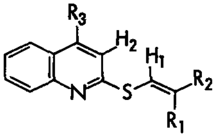


IVe If Ie

The structure of the sulfides Ie and If was proved by identification with the samples prepared by an unambiguous method; the crotyl sulfide Ie, b.$p_{1.0}$ 145°; $\nu_{max}^{CHCl_3}$ 1670, 967 cm^{-1} (-CH=CH-), obtained from the reaction of sodium 2-quinolylmercaptide with crotyl chloride. The reaction of the mercaptide with 2-chloro-3-butene afforded the α-methylallyl sulfide If, b.$p_{0.45}$ 134–136°; $\nu_{max}^{CHCl_3}$ 1633, 987, 920 cm^{-1} (-CH=CH_2); τ 8.43 (3H-doublet, J = 7.0 Hz, Me), 5.15 (1H-multiplet, allylic proton), and 4.95, 4.71, 3.90 (3H, olefinic protons), and Ie, due to the competition of S_N2 and S_N2' reactions (10), in the ratio of 4 : 1.

These results demonstrate that the rearrangement of N-allylthiocarbostyrils (IV) to allyl 2-quinolyl

Table NMR Spectral Data[a] of Propenyl 2-Quinolyl Sulfides (II)



Compd.	Chemical shift (τ)					Coupling constant (Hz)			
	R_1	R_2	H_1	H_2	R_3	$J_{R_1R_2}$	$J_{R_2H_1}$	$J_{R_1H_1}$	$J_{H_2R_3}$
cis-IIa	8.17* d-d	4.07 d-q	2.92 d-q	2.92 d	2.16 d	6.7	9.6[b]	1.5	8.5
cis-IIb	8.15* d-d	4.03 d-q	2.85 d-q	2.95 q	7.44* d	6.8	9.6[b]	1.5	1.0
trans-IIa	3.93 d-q	8.14* d-d	3.12 d-q	2.83 d	2.11 d	6.5	1.3	15.3[c]	8.4
trans-IIb	3.79 d-q	8.08* d-d	3.11 d-q	2.97 q	7.43* d	6.6	1.7	15.5[c]	1.0
IIc	8.03* d	8.11* d	3.33 m	2.80 d	2.12 d	0	1.4	0.8	8.2
IId	8.04* d	8.12* d	3.34 m	2.96 q	7.43* d	0	1.2	0.5	1.0

[a] All spectra were measured on a Varian A60 in $CDCl_3$ containing TMS as internal reference.

[b] cis-coupling. [c] trans-coupling. * τ value of Me signals.

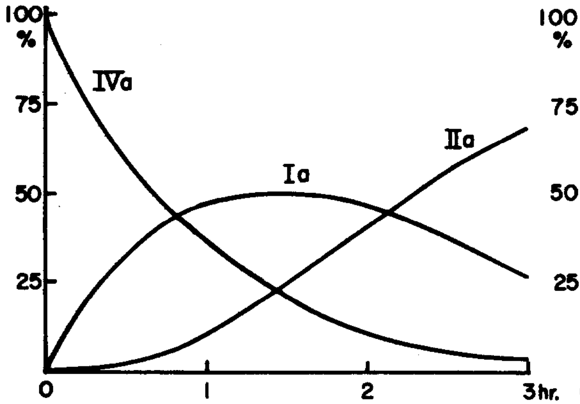


Fig. 1. Pyrolysis of IVa

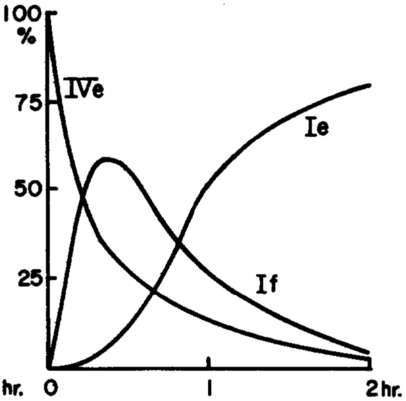


Fig. 2. Pyrolysis of IVe

sulfides (I) is a novel [3.3] sigmatropic reaction and that I are thermodynamically more stable than IV in the reversible [3.3] sigmatropic reactions between I and IV, although the equilibrium favors the thione form in the prototropic tautomerism between 2-mercaptoquinoline and thiocarbostyril (11,12).

On heating at 200° or 240° for several hours, N-benzylthiocarbostyril (IVg), m.p. 107-108°, and benzyl 2-quinolyl sulfide (Ig), b.p$_{0.5}$ 178°, were thermally stable and recovered in good yields.

REFERENCES

1. Y. Makisumi, Tetrahedron Letters 1966, 6399.
2. Y. Makisumi and A. Murabayashi, Tetrahedron Letters, accompanying communication.
3. Y. Makisumi, Chem. Pharm. Bull. (Tokyo) 12, 789 (1964).
4. Y. Makisumi, Chem. Pharm. Bull. (Tokyo) 12, 1424 (1964).
5. Y. Makisumi, Tetrahedron Letters 1964, 2833.
6. A. Deljac, Z. Stefanac and K. Balenovic, Tetrahedron, Suppl. 8, Part I, 33 (1966).
7. D. S. Tarbell and M. A. McCall, J. Am. Chem. Soc. 74, 48 (1952).
8. D. S. Tarbell and W. E. Lovett, J. Am. Chem. Soc. 78, 2259 (1956).
9. R. B. Woodward and R. Hoffmann, J. Am. Chem. Soc. 87, 2511 (1965).
10. R. H. DeWolfe and W. G. Young, The Chemistry of Alkenes, ed. S. Patai, p. 681. Interscience, New York (1964).
11. E. Spinner, J. Chem. Soc. 1960, 1237.
12. A. Albert and G. B. Barlin, J. Chem. Soc. 1959, 2384.