

# Synthesis of 1,3-Oxathiole and 2(3*H*)-Oxazolone Derivatives by Cycloaddition of $\alpha$ -Keto Carbenoids to Heterocumulenes

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Dedicated to Professor Salo Gronowitz on the occasion of his 65th birthday.

The 1,3-dipolar cycloaddition of  $\alpha$ -keto carbenoids to polar double bonds of heterocumulenes would provide a direct access to five-membered ring heterocyclic compounds. This concept was demonstrated as early as 1961 by Huisgen in the limited case of the aromatic resonance-stabilized keto carbene **2** produced from precursor **1**. Thermolysis and photolysis of **1** in carbon disulfide and phenyl isothiocyanate as dipolarophiles yielded the oxathioles **3a** and **3b** respectively.<sup>1,2</sup>

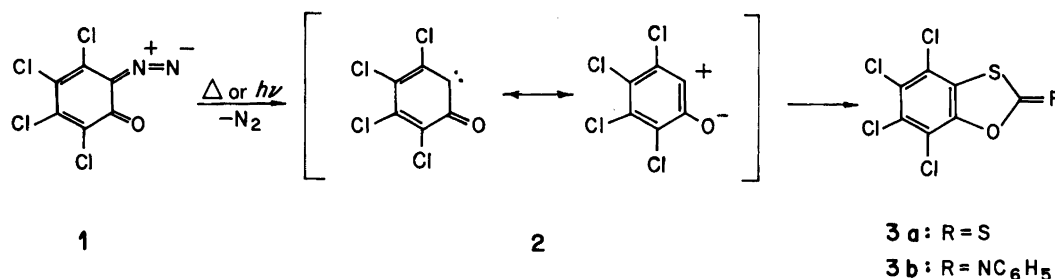
More recent investigation by Yates<sup>3</sup> showed that thermal decomposition of various open-chain  $\alpha$ -diazo ketones in boiling carbon disulfide followed a much more complex reaction course leading to 1,3-dithiolanes **4** and 1,3-dithietanes **5**, but not to 1,3-oxathioles.

Studying the reactions of diazoacetophenone (**6**, R = C<sub>6</sub>H<sub>5</sub>) and ethyl diazopyruvate (**6**, R = CO<sub>2</sub>Et) with CS<sub>2</sub>, we found that no decomposition occurred even after 3–5 weeks of reflux. Thermal unreactivity of some diazo ketones bearing no substituent on the diazo carbon atom has already been noted by Yates.<sup>3</sup>

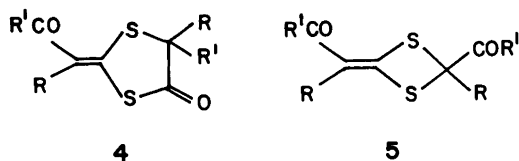
Catalytic amounts of rhodium acetate, however, had a multiple effect on the course of the reaction. First, the above diazo ketones (**6**) decomposed rapidly in CS<sub>2</sub> at

room temperature and second, the 1,3-dipolar cycloaddition of the intermediate keto carbene was promoted to yield the 1,3-oxathioles **7a** and **7b** as major isolable products. Similarly, substituted 2-phenylimino-1,3-oxathioles **8a** and **8b** were obtained when the decomposition was effected in phenyl isothiocyanate. The signal at around 200 ppm, characteristic for C=S, was present in the <sup>13</sup>C NMR spectra of the oxathioles **7a** and **7b** but not in the spectra of **8a** and **8b**. These compounds showed strong infrared absorptions at around 1665 and 1650 cm<sup>-1</sup> characteristic for C=N and C=C, respectively, in 2-imino-1,3-oxathiole derivatives.<sup>4</sup> By using phenyl isocyanate as the dipolarophile, the products did not show the infrared absorption corresponding to C=N. Instead, a strong band at around 1750 cm<sup>-1</sup> appeared which is characteristic for the amide carbonyl bond in 2(3*H*)-oxazolones<sup>5,6</sup> and indicative for the structures **9a** and **9b** but not for **9c** (Scheme 1).<sup>7</sup> One can recognize that the addition of these heterocumulenes is regioselective, the C=S bond being involved in the isothiocyanate molecule and the N=C bond in the isocyanate.\*

Recently, the reaction between *N,N*-diethyl-*N'*-*p*-tolylthiourea and ethyl  $\alpha$ -chloroacetoacetate was investigated



\* Similar regioselectivity has been observed in a relevant reaction between diethyl diazomalonate and benzoyl isothiocyanate<sup>8</sup> and in the internal cyclization of keto isocyanates to oxazolone derivatives.<sup>9</sup>



by Singh et al.,<sup>10</sup> and, based on spectral evidence, the oxathiole structure **10** was suggested for one of the minor products. This compound could then be synthesized from ethyl diazoacetoacetate and 4-tolyl isothiocyanate in the presence of rhodium acetate in increased yields. The structure was confirmed by X-ray analysis. This structure, featuring *syn*-disposition of the tolyl group and the ring sulfur atom is suggestive, albeit not proof, of the configuration around the C=N bond as depicted in formulae **8a** and **8b**.

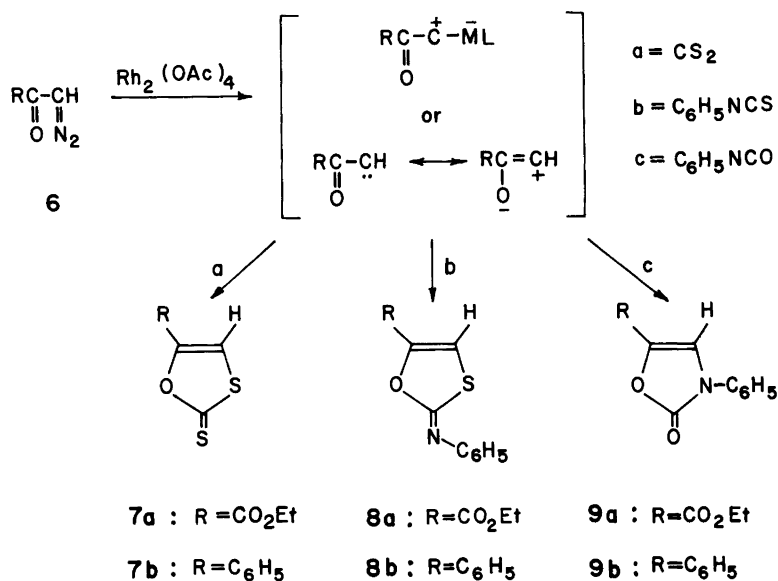
### Experimental

Melting points were measured in open capillaries and are uncorrected. IR spectra were recorded with a Perkin-Elmer Infracord spectrophotometer. <sup>1</sup>H NMR spectra were taken on a Varian T-60 spectrometer and <sup>13</sup>C NMR spectra were measured on a Bruker WP-60 spectrometer

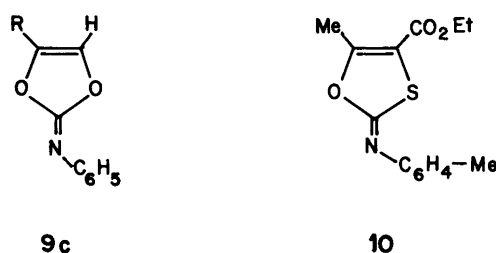
at 15.08 MHz, both in CDCl<sub>3</sub>, with Me<sub>4</sub>Si as an internal reference.

*General procedure for the reaction between diazo ketones and heterocumulenes.* The solution of the diazo compound (10 mmol) in freshly distilled heterocumulene was added dropwise to a stirred suspension of Rh<sub>2</sub>(OAc)<sub>4</sub> (0.1 mmol) in a minimum volume of the same heterocumulene under N<sub>2</sub> at room temperature. When the addition was complete, stirring was continued for ca. 20 h. The reaction was monitored by the disappearance of the diazo band at around 2120 cm<sup>-1</sup> in the IR spectrum. In some cases additional heating of the mixture to 60–70°C was necessary to complete the reaction. Removal of the solvent at reduced pressure gave the crude product, which was purified, unless otherwise noted, by chromatography on silica gel (Woelm, deactivated with 10% water). The eluent is noted in each case.

*5-Ethoxycarbonyl-1,3-oxathiole-2-thione (7a)* was obtained by decomposition of ethyl diazopyruvate in CS<sub>2</sub>. Eluent: light petroleum–CH<sub>2</sub>Cl<sub>2</sub> (1:1). Yield 72%, m.p. 84–85°C (light petroleum). Anal. C<sub>6</sub>H<sub>6</sub>O<sub>3</sub>S<sub>2</sub>: C, H. Calc. S, 33.79. Found S, 33.48. IR (CHCl<sub>3</sub>): 1725 cm<sup>-1</sup>.



Scheme 1.



## SHORT COMMUNICATION

$^1\text{H}$  NMR:  $\delta$  1.4 (3 H, t), 4.45 (2 H, q), 7.57 (1 H, s).  $^{13}\text{C}$  NMR:  $\delta$  202.0 (C=S), 156.3, 146.8, 121.5, 63.6, 14.6.

**5-Phenyl-1,3-oxathiole-2-thione (7b)**. The reaction between diazoacetophenone and  $\text{CS}_2$  and purification of the crude product by chromatography on neutral alumina [eluent: light petroleum- $\text{CH}_2\text{Cl}_2$  (9:1)] gave the title compound in 35% yield; m.p. 92–93°C (2-propanol) (lit.<sup>11</sup> m.p. 91–93°C).  $^1\text{H}$  NMR:  $\delta$  6.7 (1 H, s), 7.25–7.7 (5 H, m).  $^{13}\text{C}$  NMR:  $\delta$  202.8 (C=S), 155.7, 130.2, 129.1, 125.2, 125.0, 102.8.

**5-Ethoxycarbonyl-2-phenylimino-1,3-oxathiole (8a)** was prepared by decomposing ethyl diazopyruvate in phenyl isothiocyanate. Eluent: light petroleum- $\text{CH}_2\text{Cl}_2$  (1:2). Yield 49%, m.p. 97–97.5°C (cyclohexane). Anal.  $\text{C}_{12}\text{H}_{11}\text{NO}_3\text{S}$ : C, H, N. Calc. S, 12.86. Found S, 12.72. IR ( $\text{CHCl}_3$ ): 1660, 1645 (sh, C=C), 1660 (C=N), 1720  $\text{cm}^{-1}$ .  $^1\text{H}$  NMR:  $\delta$  1.35 (3 H, t), 4.4 (2 H, q), 7.0–7.5 (6 H, m).  $^{13}\text{C}$  NMR:  $\delta$  157.0, 148.3, 140.6, 130.3, 126.0, 125.6, 121.5, 114.2, 62.7, 14.7.

**5-Phenyl-2-phenylimino-1,3-oxathiole (8b)** was obtained from diazoacetophenone and phenyl isothiocyanate. Eluent: light petroleum- $\text{CH}_2\text{Cl}_2$  (4:1). Yield 35%, m.p. 136–137°C (benzene) (lit.<sup>12</sup> m.p. 137–138°C). IR ( $\text{CHCl}_3$ ): 1600, 1650 (C=C), 1670 (C=N)  $\text{cm}^{-1}$ .  $^1\text{H}$  NMR:  $\delta$  6.4 (1 H, s), 7.15–7.85 (10 H, m).

**5-Ethoxycarbonyl-3-phenyl-2(3H)-oxazolone (9a)**. Catalytic decomposition of ethyl diazopyruvate in phenyl isocyanate and trituration of the crude product with ether gave **9a** in 37% yield; m.p. 130–131°C (methylcyclohexane). Anal.  $\text{C}_{12}\text{H}_{11}\text{NO}_4$ : H, N. Calc. C, 61.80. Found C, 62.20. IR ( $\text{CHCl}_3$ ): 1640, 1720, 1765  $\text{cm}^{-1}$ .  $^1\text{H}$  NMR:  $\delta$  1.4 (3 H, t), 4.4 (2 H, q), 7.25 (1 H, s), 7.35–7.65 (5 H, m).

**3,5-Diphenyl-2(3H)-oxazolone (9b)**. The decomposition of diazoacetophenone in phenyl isocyanate and trituration of the crude product with methanol gave **9b** in 43%

yield, m.p. 171–172°C (methanol) (lit.<sup>13</sup> m.p. 172°C). IR ( $\text{CHCl}_3$ ): 1750  $\text{cm}^{-1}$ .  $^1\text{H}$  NMR:  $\delta$  7.18 (1 H, s), 7.25–7.5 (10 H, m).

**4-Ethoxycarbonyl-5-methyl-2-(4-tolyl)imino-1,3-oxathiole (10)**. Ethyl diazoacetate was reacted with 4-tolyl isothiocyanate and, after removal of the excess of isothiocyanate the residue was extracted with hexane. Evaporation of the solvent left an oily residue which solidified on refrigeration. Yield 40%, m.p. 61°C (hexane) (lit.<sup>10</sup> m.p. 62–63°C). Anal.  $\text{C}_{14}\text{H}_{15}\text{NO}_3\text{S}$ : C, H. Calc. N, 5.05; S, 11.54. Found: N, 5.42; S, 12.12. IR ( $\text{CHCl}_3$ ): 1600, 1660, 1720  $\text{cm}^{-1}$ .  $^1\text{H}$  NMR:  $\delta$  1.3 (3 H, t), 2.35 (3 H, s), 2.5 (3 H, s), 4.2 (2 H, q), 6.8–7.3 (4 H, m).

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