

**A NOVEL 1,6-CYCLIZATION OF IMIDAZOLIUM *N*-ALLYLIDES (2)<sup>1</sup>:  
FORMATION OF THE MESOMERIC BETAINE, 7-IMINOIMIDAZO-  
[1,2-*a*]PYRIDINIUMIDE**

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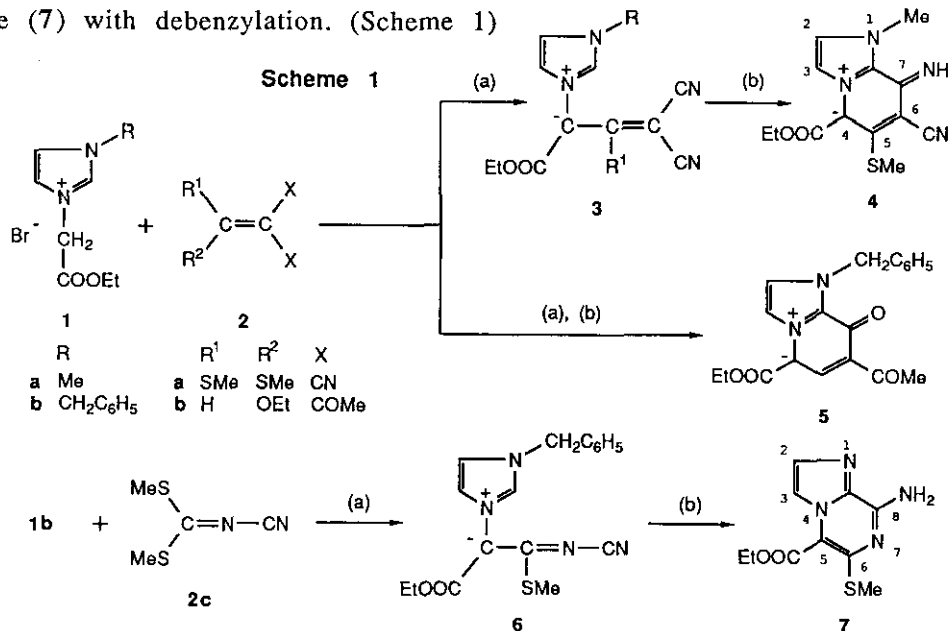
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**Abstract** - Treatment of imidazolium *N*-allylide (3) in refluxing 1,2,4-trimethylbenzene resulted in 1,6-cyclization to give the mesomeric betaine, 7-iminoimidazo[1,2-*a*]pyridiniumide (4). On the other hand, heating of 1-cyanoimidoylmethylimidazolium *N*-ylide (6) in refluxing 1,2,4-trimethylbenzene underwent 1,6-cyclization and debenylation to give 8-aminoimidazo[1,2-*a*]pyrazine (7). Furthermore, treatment of the imidazolium salt (1a) and ethyl ethoxymethylenenitroacetate (2d) with K<sub>2</sub>CO<sub>3</sub> in DMSO afforded the mesomeric betaine, imidazo[1,2-*a*]pyridiniumide (12), whereas the reaction of 1a and nitroketene dithioacetal (2e) with K<sub>2</sub>CO<sub>3</sub> in DMSO resulted in 1,5-dipolar cyclization to produce pyrrolo[1,2-*a*]imidazole (13) and pyrrolo[1,2-*a*]pyrazine (14).

Pyridinium and imidazolium *N*-allylides are well known to undergo thermal 1,5-dipolar cyclization and aromatization giving the corresponding indolizines and pyrroloimidazoles.<sup>2-10</sup> With regard to imidazolium *N*-allylides, a novel 1,6-cyclization has been found in the thermolysis of imidazolium *N*-allylides in our previous

paper.<sup>1</sup> Thus, the thermolysis of imidazolium *N*-allylides with the ester group at the 3-position of the allyl group resulted in 1,6-cyclization to give the mesomeric betaines, 7-oxoimidazo[1,2-*a*]pyridiniumimides. As a part of our continuing work on the thermolysis of imidazolium *N*-allylides, we here report the thermolysis of imidazolium *N*-allylide (3) with the cyano group instead of the ester group at the 3-position of the allyl group to produce the mesomeric betaine, 7-iminoimidazo[1,2-*a*]pyridiniumimide (4) involving 1,6-cyclization.

The starting imidazolium *N*-allylide (3) and 1-cyanoimidoylmethylimidazolium *N*-allylide (6) used in the present work were prepared by the reaction of 1-ethoxycarbonylmethylimidazolium bromides (1a, b) with ketene dithioacetals (2a, c) in the presence of K<sub>2</sub>CO<sub>3</sub>. A solution of 3 in 1,2,4-trimethylbenzene was refluxed to afford the mesomeric betaine, 7-iminoimidazo[1,2-*a*]pyridiniumimide (4) with 1,6-cyclization. Interestingly, the salt (1b) reacted with 2b in the presence of K<sub>2</sub>CO<sub>3</sub>, followed by heating in refluxing 1,2,4-trimethylbenzene to give the mesomeric betaine, 7-oxoimidazo[1,2-*a*]pyridiniumimide (5). On the other hand, compound (6) was heated in refluxing 1,2,4-trimethylbenzene to produce 8-aminoimidazo[1,2-*a*]pyrazine (7) with debenzylation. (Scheme 1)

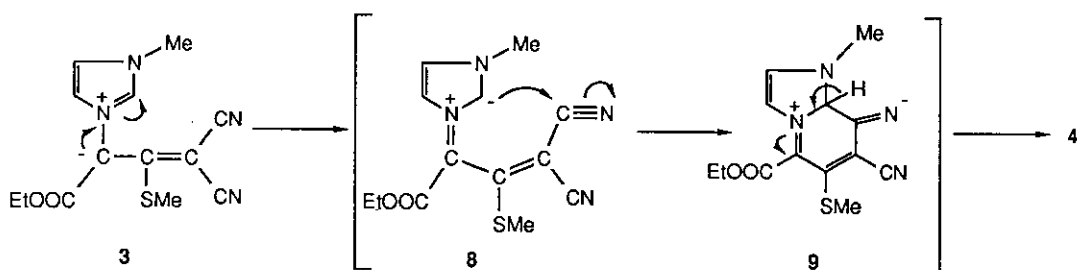


**Reagents and Conditions:**

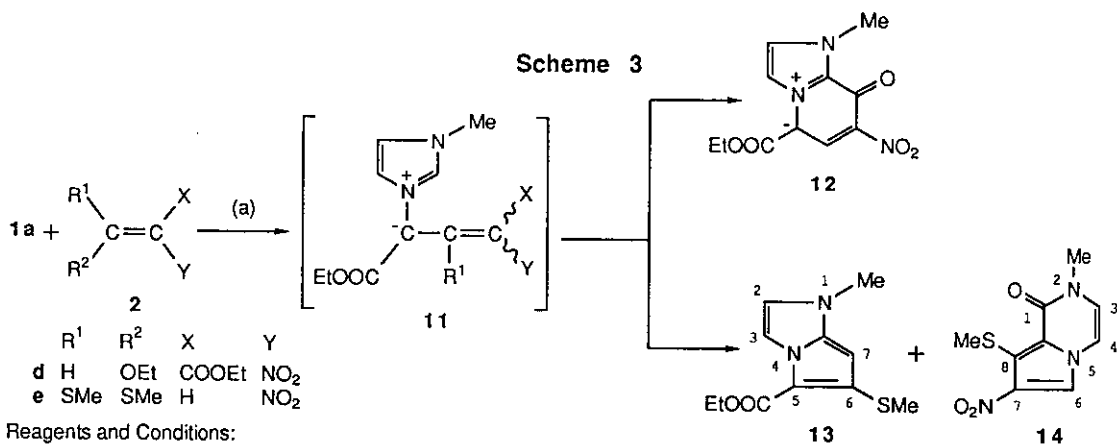
(a) K<sub>2</sub>CO<sub>3</sub>, CHCl<sub>3</sub>, 25°C, 1 week;

(b) heating in refluxing 1,2,4-trimethylbenzene, 24 h.

Scheme 2

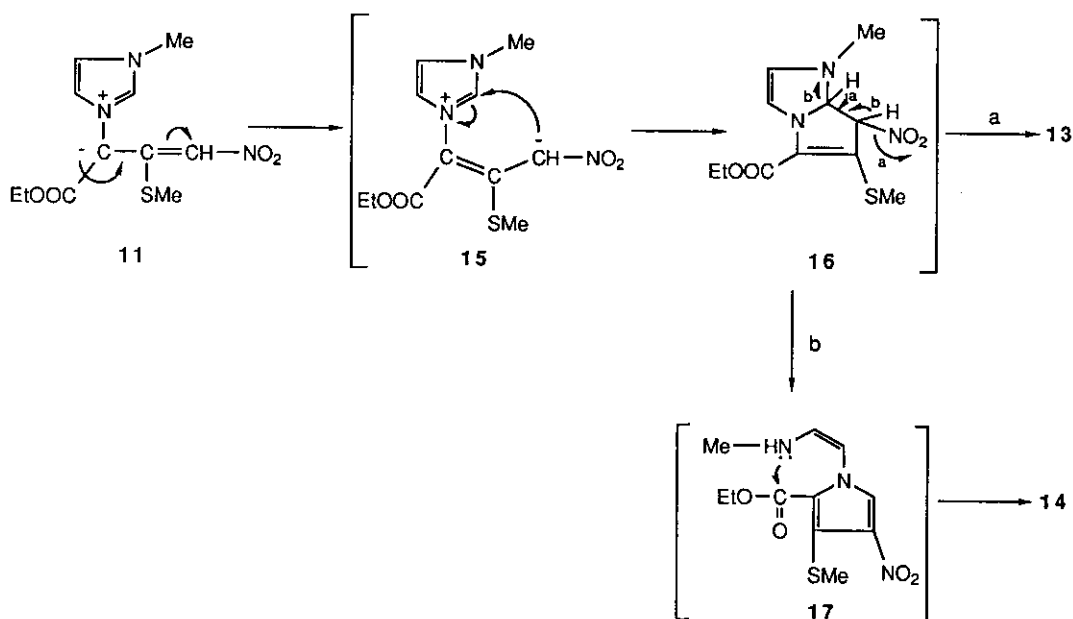


Scheme 3



Reagents and Conditions:  
(a) K<sub>2</sub>CO<sub>3</sub>, DMSO, 25°C, 1 week.

Scheme 4



The formation of **4** may be rationalized by the outline in Scheme 2. As pointed out in our previous paper,<sup>1</sup> the mechanism for the formation of **4** may proceed *via* intermediate (**8**). Thus, the intermediate (**8**) may cyclize to give **4** *via* intermediate (**9**).

Next, we attempted the reaction of **1a** with ethyl ethoxymethyleninitroacetate (**2d**) or nitroketene dithioacetal (**2e**). The treatment of **1a** and **2d** with K<sub>2</sub>CO<sub>3</sub> in DMSO did not give imidazolium *N*-allylide (**11**) but afforded the mesomeric betaine (**12**). On the other hand, the reaction of **1a** with **2e** in the presence of K<sub>2</sub>CO<sub>3</sub> in DMSO produced pyrrolo[1,2-*a*]imidazole (**13**) and pyrrolo[1,2-*a*]pyrazine (**14**) with 1,5-dipolar cyclization (Scheme 3). As pointed out by Acheson<sup>5</sup> and Meth-Cohn,<sup>10</sup> the formation of **13** and **14** may be rationalized as outlined in Scheme 4.

## EXPERIMENTAL

Melting points were determined with a Mitamura Mel-Temp and are uncorrected. Infrared (ir) spectra were recorded as KBr pellets on a JASCO IRA-2 spectrophotometer. Ultraviolet (uv) spectra were recorded on a Hitachi 323 spectrophotometer. Proton nuclear magnetic resonance (<sup>1</sup>H-nmr) spectra were obtained on a JMN-FX-90Q (90 MHz) spectrometer with tetramethylsilane as internal standard. Chemical shifts are reported in parts per million (δ). Elemental analyses (C, H, N) of all compounds described here were performed on a Yanagimoto MT-2 CHN recorder. Mass spectra (ms) were measured on a JMS-DX-303G spectrometer.

### 1-Methylimidazolium *N*-(3,3-dicyano-1-ethoxycarbonyl-2-methylthio)-allylide (**3**)

A mixture of **1a** (1.00 g, 4 mmol), **2a** (0.68 g, 4 mmol), and K<sub>2</sub>CO<sub>3</sub> (1.10 g, 8 mmol) in CHCl<sub>3</sub> (40 ml) was stirred at room temperature for a week and the mixture was then evaporated under reduced pressure. To the residue was added ice-water (100 ml). The precipitate was filtered, washed with water, dried and recrystallized from CHCl<sub>3</sub>-MeOH to give **3**.

**3**, mp 189 °C, 1.11 g (96%);  $^1\text{H-nmr}$  ( $\text{CDCl}_3$ )  $\delta$  1.28(3H, t,  $J=7$  Hz,  $\text{CH}_2\text{CH}_3$ ), 2.53(3H, s, SCH<sub>3</sub>), 3.95(3H, s, NCH<sub>3</sub>), 4.18(2H, t,  $J=7$  Hz,  $\text{CH}_2\text{CH}_3$ ), 7.14-7.19(2H, m, C<sub>4,5</sub>-H), 8.17(1H, t,  $J=2$  Hz, C<sub>2</sub>-H); ir(KBr) 1670(CO), 2170(CN), 2200(CN)  $\text{cm}^{-1}$ ; uv(EtOH)  $\lambda_{\text{max}}$ (log  $\epsilon$ ) 299(3.83), 370(4.35) nm. *Anal.* Calcd for C<sub>13</sub>H<sub>14</sub>N<sub>4</sub>O<sub>2</sub>S: C, 53.78; H, 4.86; N, 19.30. Found: C, 53.70; H, 4.87; N, 19.14.

**6-Cyano-1,7-dihydro-4-ethoxycarbonyl-7-imino-1-methyl-5-methylthioimidazo[1,2-*a*]pyridin-3*a*-ium-4-ide (4)**

A solution of **3** (0.58 g, 2 mmol) in 1,2,4-trimethylbenzene (60 ml) was refluxed for 24 h and the solution was then evaporated under reduced pressure. To the residue was added ice-water (50 ml). The precipitate was filtered, washed with water, dried and recrystallized from EtOH give **4**.

**4**, mp 150 °C, 0.17 g (30%);  $^1\text{H-nmr}$  ( $\text{CDCl}_3$ )  $\delta$  1.41(3H, t,  $J=7$  Hz,  $\text{CH}_2\text{CH}_3$ ), 2.55(3H, s, SCH<sub>3</sub>), 4.38(2H, q,  $J=7$  Hz,  $\text{CH}_2\text{CH}_3$ ), 4.48(3H, s, NCH<sub>3</sub>), 7.18(1H, d,  $J=2$  Hz, C<sub>2</sub>-H), 8.50(1H, d,  $J=2$  Hz, C<sub>3</sub>-H); ir(KBr) 1670(CO), 2190(CN), 3260(NH)  $\text{cm}^{-1}$ ; uv(EtOH)  $\lambda_{\text{max}}$ (log  $\epsilon$ ) 243(4.14), 260(4.17), 360(4.27) nm. *Anal.* Calcd for C<sub>13</sub>H<sub>14</sub>N<sub>4</sub>O<sub>2</sub>S: C, 53.78; H, 4.86; N, 19.30. Found: C, 54.05; H, 4.96; N, 19.00.

**1-Benzyl-1,7-dihydro-4-ethoxycarbonyl-6-acetyl-7-oxoimidazo[1,2-*a*]pyridin-3*a*-ium-4-ide (5)**

A mixture of **1b** (1.30 g, 4 mmol), **2b** (0.62 g, 4 mmol), and K<sub>2</sub>CO<sub>3</sub> (1.10 g, 8 mmol) in CHCl<sub>3</sub> (40 ml) was stirred at room temperature for a week and ice-water (100 ml) was added. The mixture was separated and the aqueous layer was extracted with CHCl<sub>3</sub> (2x30 ml). The combined organic phase was washed with water, dried (Na<sub>2</sub>SO<sub>4</sub>), and evaporated under reduced pressure. The residue was heated in refluxing 1,2,4-trimethylbenzene (60 ml) for 24 h and the solution was then evaporated under reduced pressure. To the residue was added ice-water (50 ml) and the mixture was extracted with CHCl<sub>3</sub> (3x30 ml). The combined extracts were washed with water (50 ml), dried (Na<sub>2</sub>SO<sub>4</sub>), and evaporated under reduced pressure. The tarry residue was submitted to column chromatography on silica gel. From a CHCl<sub>3</sub>-acetone (10:1) fraction, compound (**5**) was obtained.

5, mp 182 °C, 0.04 g (3%);  $^1\text{H-nmr}$  ( $\text{CDCl}_3$ )  $\delta$  1.39(3H, t,  $J=7$  Hz,  $\text{CH}_2\text{CH}_3$ ), 2.78(3H, s,  $\text{COCH}_3$ ), 4.35(2H, q,  $J=7$  Hz,  $\text{CH}_2\text{CH}_3$ ), 6.25(2H, s,  $\text{CH}_2$ ), 7.20(1H, d,  $J=2$  Hz,  $\text{C}_2\text{-H}$ ), 7.37(5H, s, Ar-H), 8.65(1H, s,  $\text{C}_6\text{-H}$ ), 8.97(1H, d,  $J=2$  Hz,  $\text{C}_3\text{-H}$ );  $\text{ir(KBr)}$  1630(CO), 1690(CO)  $\text{cm}^{-1}$ ;  $\text{uv(EtOH)}$   $\lambda_{\text{max}}(\log \epsilon)$  243(4.06), 259(4.16), 268(4.15), 331(4.26), 359(4.17), 372(4.15) nm. High resolution ms Calcd for  $\text{C}_{19}\text{H}_{18}\text{N}_2\text{O}_4$ : 338.1266. Found: 338.1256.

**1-Benzylimidazolium *N*-[(*N*-cyano-1-methylthioimidoyl)-1-ethoxy-carbonyl]methylide (6)**

Compound (6) was prepared by the reaction of 1b (1.30 g, 4 mmol), 2c (0.58 g, 4 mmol), and  $\text{K}_2\text{CO}_3$  (1.10 g, 8 mmol) in  $\text{CHCl}_3$  (40 ml) using procedure above for the synthesis of 3.

6, mp 223 °C, 1.09 g (80%);  $^1\text{H-nmr}$  ( $\text{CDCl}_3$ )  $\delta$  1.15(3H, t,  $J=7$  Hz,  $\text{CH}_2\text{CH}_3$ ), 2.30(3H, s,  $\text{SCH}_3$ ), 4.08(2H, q,  $J=7$  Hz,  $\text{CH}_2\text{CH}_3$ ), 5.31(2H, s,  $\text{CH}_2$ ), 7.12(1H, t,  $J=2$  Hz,  $\text{C}_4\text{-H}$  or  $\text{C}_5\text{-H}$ ), 7.20(1H, t,  $J=2$  Hz,  $\text{C}_4\text{-H}$  or  $\text{C}_5\text{-H}$ ), 7.42(5H, s, Ar-H) 8.08(1H, t,  $J=2$  Hz,  $\text{C}_2\text{-H}$ );  $\text{ir(KBr)}$  1650(CO), 2140(CN)  $\text{cm}^{-1}$ ;  $\text{uv(EtOH)}$   $\lambda_{\text{max}}(\log \epsilon)$  265(4.12), 310(4.37) nm. *Anal.* Calcd for  $\text{C}_{17}\text{H}_{18}\text{N}_4\text{O}_2\text{S}$ : C, 59.63; H, 5.30; N, 16.36. Found: C, 59.50; H, 5.33; N, 16.21.

**8-Amino-5-ethoxycarbonyl-6-methylthioimidazo[1,2-*a*]pyrazine (7)**

Compound (7) was prepared from refluxing of 6 (0.68 g, 2 mmol) in 1,2,4-trimethylbenzene (60 ml) using procedure above for the synthesis of 4. The tarry residue was submitted to column chromatography on silica gel. From a  $\text{CHCl}_3$ -acetone (10:1) fraction, compound (7) was obtained.

7, mp 171 °C, 0.015 g (3%);  $^1\text{H-nmr}$  ( $\text{CDCl}_3$ )  $\delta$  1.49(3H, t,  $J=7$  Hz,  $\text{CH}_2\text{CH}_3$ ), 2.51(3H, s,  $\text{SCH}_3$ ), 4.49(2H, q,  $J=7$  Hz,  $\text{CH}_2\text{CH}_3$ ), 5.95(2H, br s,  $\text{NH}_2$ ), 7.55(1H, d,  $J=1$  Hz,  $\text{C}_2\text{-H}$ ), 8.59(1H, d,  $J=1$  Hz,  $\text{C}_3\text{-H}$ );  $\text{ir(KBr)}$  1660(CO), 3300(NH), 3400(NH)  $\text{cm}^{-1}$ ;  $\text{uv(EtOH)}$   $\lambda_{\text{max}}(\log \epsilon)$  220(4.02), 266(4.49), 272(4.53), 330(3.98), 343(4.06), 356(3.93) nm. High resolution ms Calcd for  $\text{C}_{10}\text{H}_{12}\text{N}_4\text{O}_2\text{S}$ : 252.0681. Found: 252.0679.

**1,7-Dihydro-4-ethoxycarbonyl-1-methyl-6-nitro-7-oxoimidazo[1,2-*a*]-pyridin-3a-ium-4-ide (12)**

A mixture of **1a** (1.00 g, 4 mmol), **2d** (0.76 g, 4 mmol), and  $K_2CO_3$  (1.10 g, 8 mmol) in DMSO (20 ml) was stirred at room temperature for 3 days and the mixture was added to ice-water (100 ml) and extracted with  $CHCl_3$  (3x30 ml). The combined extracts were washed with water, dried ( $Na_2SO_4$ ), and evaporated under reduced pressure. The residue was recrystallized from EtOH- $CHCl_3$  to give **12**.

**12**, mp 298 °C, 0.63 g (59%);  $^1H$ -nmr ( $CDCl_3$ )  $\delta$  1.42(3H, t,  $J=7$  Hz,  $CH_2CH_3$ ), 4.40(2H, q,  $J=7$  Hz,  $CH_2CH_3$ ), 4.52(3H, s, NCH<sub>3</sub>), 7.33(1H, d,  $J=2$  Hz, C<sub>2</sub>-H), 8.84(1H, s, C<sub>5</sub>-H), 9.03(1H, d,  $J=2$  Hz, C<sub>3</sub>-H); ir(KBr) 1690(CO), 1700(CO)  $cm^{-1}$ ; uv(EtOH)  $\lambda_{max}(\log \epsilon)$  240(4.09), 265(4.16), 272(4.18), 317(4.21), 328(4.30), 390(4.10) nm. *Anal.* Calcd for  $C_{11}H_{11}N_3O_5$ : C, 49.81; H, 4.18; N, 15.84. Found: C, 49.83; H, 4.18; N, 15.86.

**5-Ethoxycarbonyl-1-methyl-6-methylthio-1H-pyrrolo[1,2-a]imidazole (13)**  
and **1,2-Dihydro-2-methyl-8-methylthio-7-nitro-1-oxopyrrolo[1,2-a]-pyrazine (14)**

Compounds (**13**, **14**) were prepared by the reaction of **1a** (1.00 g, 4 mmol), **2e** (0.60 g, 4 mmol), and  $K_2CO_3$  (1.10 g, 8 mmol) in DMSO (20 ml) using procedure above for the synthesis of **12**. The residue was submitted to column chromatography on silica gel. From a benzene- $CHCl_3$  (20:1) fraction, product (**13**) was obtained. From a benzene- $CHCl_3$  (1:20) fraction, product (**14**) was obtained.

**13**, mp 123 °C, 0.29 g (30%);  $^1H$ -nmr ( $CDCl_3$ )  $\delta$  1.40(3H, t,  $J=7$  Hz,  $CH_2CH_3$ ), 2.48(3H, s, SCH<sub>3</sub>), 3.60(3H, s, NCH<sub>3</sub>), 4.35(2H, q,  $J=7$  Hz,  $CH_2CH_3$ ), 5.47(1H, s, C<sub>7</sub>-H), 6.63(1H, d,  $J=2$  Hz, C<sub>2</sub>-H), 7.53(1H, d,  $J=2$  Hz, C<sub>3</sub>-H); ir(KBr) 1660(CO)  $cm^{-1}$ ; uv(EtOH)  $\lambda_{max}(\log \epsilon)$  318(3.73) nm. *Anal.* Calcd for  $C_{11}H_{14}N_2O_2S$ : C, 55.44; H, 5.92; N, 11.76. Found: C, 55.32; H, 5.89; N, 11.62.

**14**, mp 236 °C, 0.29 g (30%);  $^1H$ -nmr ( $CDCl_3$ )  $\delta$  2.61(3H, s, SCH<sub>3</sub>), 3.45(3H, s, NCH<sub>3</sub>), 6.58(1H, d,  $J=6$  Hz, C<sub>5</sub>-H or C<sub>6</sub>-H), 6.87(1H, d,  $J=6$  Hz, C<sub>5</sub>-H or C<sub>6</sub>-H), 7.84(1H, s, C<sub>3</sub>-H); ir(KBr) 1640(CO)  $cm^{-1}$ ; uv(EtOH)  $\lambda_{max}(\log \epsilon)$  219(3.90), 231(3.86), 287(3.91), 380(3.62) nm. *Anal.* Calcd for  $C_9H_9N_3O_3S$ : C, 45.18; H, 3.79; N, 17.56. Found: C, 44.99; H, 3.77; N, 17.48.

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