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INTERMOLECULAR PHOTOREACTION OF ARENECARBOTHIOAMIDE WITH 3-METHYL- AND 2,4-DIMETHYLFURANS: A NOVEL FORMATION OF 2-ARYLTHIOPHENE DERIVATIVES THROUGH PHOTOINDUCED REACTION[1]

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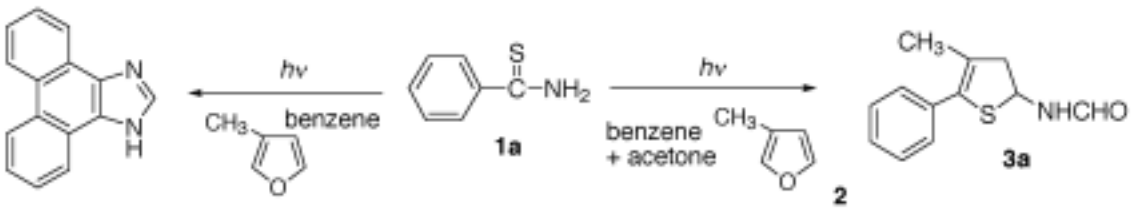
Abstract- Photoreaction of arenecarbothioamides (**1**) with 3-methylfuran (**2**) in benzene-acetone mixed solvent gave 5-aryl-2,3-dihydrothiophene derivatives (**3**) accompanied by pyrrole compounds.

In a previous paper, we have reported that irradiation of a benzene solution of benzenecarbothioamide and furan resulted in the formation of 3-benzoylfuran *via* intermolecular thietane formation.[2] However, irradiation in methanol solution of the same substrates afforded 2-phenylpyrrole derivative.[3] Furthermore, upon irradiation of benzene solution of arenecarbothioamide (**1a**) and 3-methylfuran (**2**) a construction of the tetracyclic imidazole system was found.[4] Thus, the pathways toward various heterocycles were affected by the properties of solvents and furans used.

In this paper we wish to report the novel photoinduced formation of 2-arylthiophene derivatives in benzene-acetone mixed solvent.

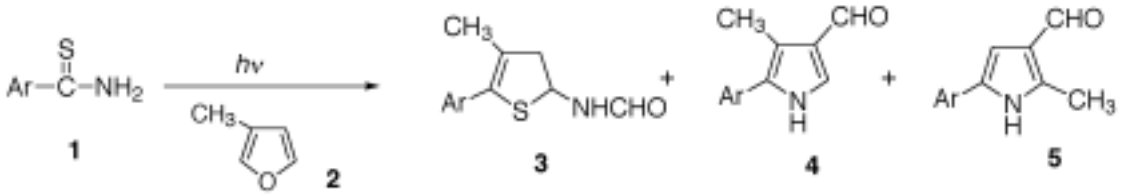
The photoreaction of **1a** with **2** in benzene-acetone mixed solvent[5] gave a product of an unpredictable type, 5-phenyl-2,3-dihydrothiophene derivative (**3a**) in 32 % yield accompanied by two pyrrole compounds (**4a**: 8 %, **5a**: 2 %), and no tetracyclic imidazole was detected (Scheme 1).[6] Similarly, the photoreactions of pyridinecarbothioamide (**1b**, **c**) were performed. As expected,

Scheme 1



the corresponding 5-pyridyl-2,3-dihydrothiophene derivatives (**3b**, **3c**) were obtained in moderate yields (27, 34 %), accompanied by pyrroles (**4b** and **5b** from **1b**; **4c** and **5c** from **1c**), respectively (Table 1).

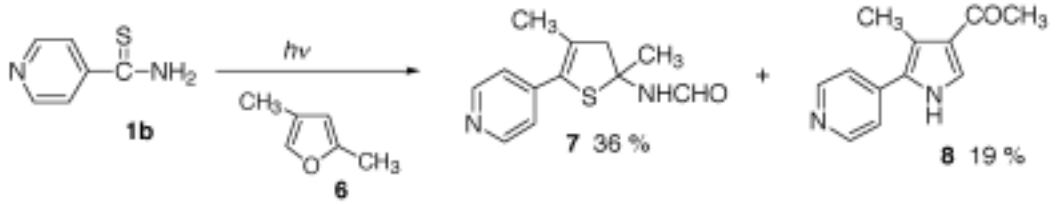
Table 1. Photoreaction of arenecarbothioamide (**1**) with 3-methylfuran (**2**)



Ar =	3	4	5
1a	32 %	8 %	2 %
1b	27 %	12 %	2 %
1c	34 %	6 %	3 %

To investigate the generality of this reaction, photoreaction of **1b** with 2,4-dimethylfuran (**6**) was performed under similar conditions. Similarly, 5-pyridinyl-2,3-dihydrothiophene derivative (**7**)[7] was obtained in 36 % yield accompanied by pyrrole compound (**8**) (Scheme 2). Further, the irradiation of **1a** with 2-methylfuran in benzene-acetone was examined. 4-Benzoyl-2-methylfuran[2] was only obtained in 41 % yield, and no dihydrothiophenes.

Scheme 2



With respect to the formation of the pyrrole derivatives, we have already proposed that the reaction would proceed in several steps involving initial [2+2] cycloaddition between the C=N double bond and furan, leading to the aryloxazepine, which subsequently is rearranged to the arylpyrrole.[3]

Structures of 5-aryl-2,3-dihydrothiophene derivatives (**3**, **7**) were assigned on the basis of the spectral data and HRMS analyses. For an example, the mass spectrum of **7** [*N*-(2,4-dimethyl-5-pyridin-4-yl-2,3-dihydrothiophen-2-yl)formamide] showed the molecular ion peak at M^+ 234, suggesting the intermolecular addition of **1b** to **6**. In the IR spectrum of **7**, the absorption bands of an NH and an amide carbonyl group appeared at 3340 and 1650 cm^{-1}, respectively. The ^{1}H-NMR spectrum of **7** showed two singlets (two 3H protons at 1.73 ppm and 2.05 ppm) and two

doublets (2.73 ppm and 3.07 ppm with 17.3 Hz as coupling constant), which indicated the presence of two methyl groups and a diastereotopic methylene, respectively. Further, ^{1}H-^{1}H COSY, ^{13}C-NMR, DEPT, and ^{1}H-^{13}C COSY experiments suggested the presence of the partial structures as illustrated in Figure 1. The entire structure of **7** was determined by the analysis of the HMBC (^{1}H-detected heteronuclear multiple bond connectivity) correlation. To further confirm the

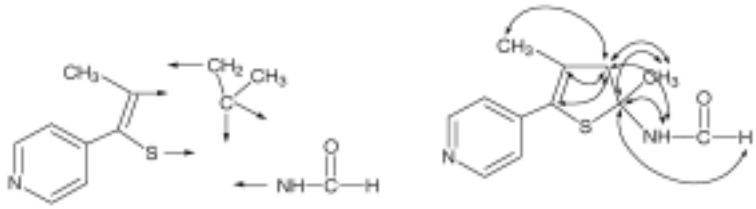
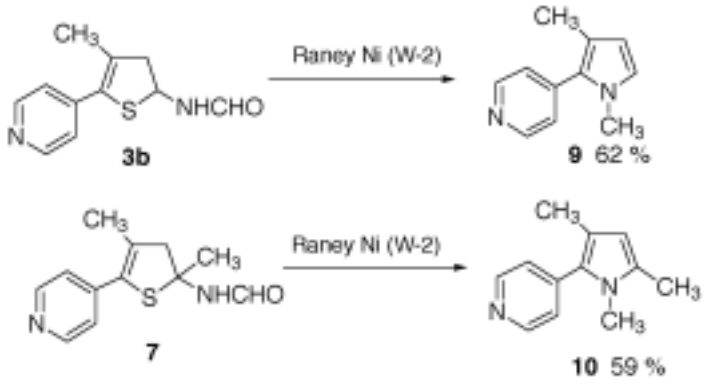


Figure 1. Estimated partial structures and HMBC correlation of **7**

structures of these 5-pyridinyl-2,3-dihydrothiophene derivatives, desulfurizations of **3b** and **7** were performed by refluxing with Raney Ni in ethanol, respectively. Each reactant was purified with column chromatography, giving rise to pyrrole derivatives (**9**, **10**) (Scheme 3).[8] Probably pyrrole derivatives (**9**, **10**) arise from the initially formed *N*-formylpyrrole by desulfurization, followed by reduction of a formyl group. These results also supported the structures of **3b** and **7**.

Scheme 3



2-Arylthiophene is also obtained as by-product in benzannulation reaction of arenecarbothioamides,[9] however the pathway of the thiophene formation is unclear yet.

It is noteworthy that thioamides are potentially useful photochemical substrate in syntheses of not only nitrogen-containing heterocycles but also sulfur-containing heterocycles.

ACKNOWLEDGEMENTS

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5. Irradiation of Thioamides (**1**). General Procedure:
   A mixture of **1a** (1.37 g, 10 mmol) and **2** (4.1 g, 50 mmol) in a mixed solvent of benzene (150 mL) and acetone (100 mL) was irradiated for 20 h with a 500 W high pressure mercury lamp through a Pyrex filter under N_2. After removal of the solvent *in vacuo*, the residue was chromatographed over a silica gel column (hexane–ethyl acetate, 5 : 1; v/v).
6. In the case of acetone solvent, the same substrates afforded also **3a** in 24 % yield.
7. *N*-(2,4-Dimethyl-5-pyridin-4-yl-2,3-dihydrothiophen-2-yl)formamide (**7**): colorless oil; IR (Nujol) 3340, 1650 cm^{-1}; ^{1}H- NMR ($CDCl_3$) δ 1.73 (s, 3H), 2.05 (s, 3H), 2.73 (d, 1H, *J*=17.3 Hz), 3.07 (d, 1H, *J*=17.3 Hz), 6.61 (s, 1H), 7.18 (dd, 2H, *J*=2.0, 4.4 Hz), 8.74 (dd, 2H, *J*=2.0, 4.4 Hz), 8.93 (s, 1H); ^{13}C-NMR ($CDCl_3$) δ13.3 (q), 25.0 (q), 49.8 (t), 96.3 (s), 124.2 (dx2), 134.3 (s), 136.6 (s), 150.5(dx2), 178.4 (d); MS *m/z* 234 (M^+); HRMS Calcd for $C_{13}H_{13}NOS$: 234.0827. Found: 234.0818.
8. 4-(1,3,5-Trimethyl-1*H*-pyrrol-2-yl)pyridine (**10**): colorless oil; ^{1}H-NMR ($CDCl_3$) δ 2.09 (s, 3H), 2.26 (s, 3H), 3.44 (s, 3H), 5.86 (s, 1H), 7.17 (dd, 2H, *J*=1.5, 2.9 Hz), 8.59 (dd, 2H, *J*=1.5, 2.9 Hz); ^{13}C-NMR ($CDCl_3$) δ12.0 (q), 12.9 (q), 32.0 (q), 109.1 (d), 118.3 (s), 124.3 (dx2), 127.6 (s), 131.2 (s), 140.8 (s), 149.7 (dx2); MS *m/z* 186 (M^+); HRMS Calcd for $C_{12}H_{14}N_2$: 186.1157. Found: 186.1157.
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