PHOTOCHEMICAL REACTIONS OF QUINOXALIN-2-THIONES

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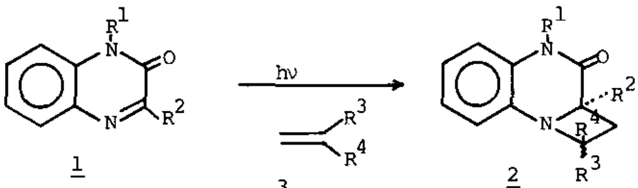
Abstract —— In contrast with their oxo-analogues (1), quinoxalin-2-thiones (3) undergo photo-induced addition to cyclohexene (4a), methacrylonitrile (4b), and methyl methacrylate (4c) to give 2-substituted quinoxalines (6-14).

It has been demonstrated that a variety of thiones can undergo photo-induced addition to various olefins.[1,2] However, the photochemical properties of thioamides[3] and thioimides[4] have been scarcely studied. Thus, we report on investigation of the photochemical reactions of quinoxalin-2-thiones (3) which illustrates an example of the dramatic difference in the photochemical behaviors of carbonyl[5] and thiocarbonyl compounds. Recently, we reported that on irradiation quinoxalin-2-ones (1) reacted regioselectively with electron-deficient olefins to afford the 1:1-adducts of C=N double bond of 1 and olefin, azetidine derivatives (2).[5]



1

2

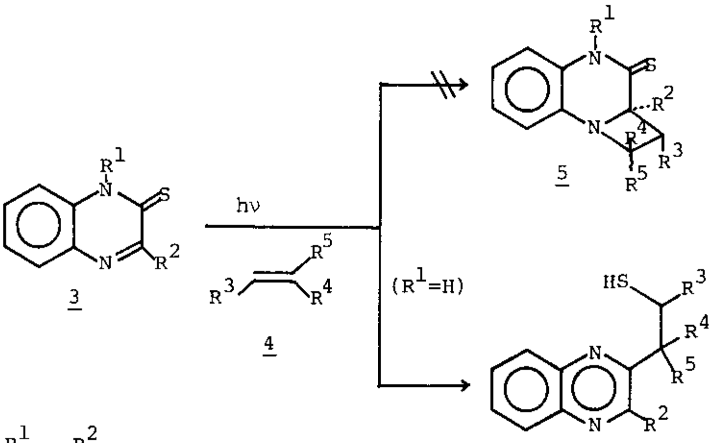
R^1, R^2=H, Me, Ph

R^3=H, Me

R^4=CN, CO_2Me, $CO_2CH{=}CH_2$

Irradiation of 3-methylquinoxalin-2-thione [3a; λ_{max}(EtOH) 218 (ε=16400), 275 (9800), and 392 nm (6200)] (200 mg) in ethylene glycol dimethyl ether (50 ml) in the presence of large excess cyclohexene (∿1 ml) with a high pressure mercury lamp (Eikosha EHB-300 W) through a Pyrex filter under nitrogen for 10 h gave 2-(2-mercaptocyclohexyl)-3-methylquinoxaline (6) [mp 101-102°C; λ_{max}(EtOH) 205 (ε=35000), 237 (30500), 312 (sh, 7000), and 318 nm (8300); ν_{max}(KBr) 2555, 1557, 1485, 1100, and 763 cm^{-1};

$\delta_H(CDCl_3)$ 1.25-2.63 (m, 8H), 1.60 (d, 1H, J=5.9 Hz), 2.75 (s, 3H), 3.39-3.73 (m, 2H), 7.45-7.71 (m, 2H), and 7.88-8.13 (m, 2H); $\delta_C(CDCl_3)$ 21.1(t), 22.5(q), 24.6(t), 25.2(t), 34.5(t), 40.0(d), 45.3(d), 128.0(d), 128.5(d), 128.9(d), 140.3(s),140.4 (s), 152.3(s), and 156.9(s); m/e (chemical ionozation) 259 (QM^+)] in 48% isolated yield, along with the unchanged thione (3a). The structure of 6 was elucidated on the basis of spectral properties and elemental analysis.[6] Oguchi and his co-workers described that irradiation of a mixture of 3-methylquinoxalin-2-thione (3a) and cyclohexene (4a) gave 2-cyclohexylthio-3-methylquinoxaline (16) and 2-(3-methylquinoxalyl)disulfide (17) via radical mechanism.[7] The ^{13}C-n.m.r. spectrum of 6 showed two tertiary carbons at δ 40.0(d) and 45.3(d) and four secondary carbons at δ 21.1(t), 24.6(t), 25.2(t), and 34.5(t) and no thiocarbonyl carbon signal,[8] so we concluded that the photoproduct thus obtained is 2-(2-mercaptocyclohexyl)-3-methylquinoxaline (6). Similarly, irradiation of the quinoxalin-2-thiones (3b-c) in the presence of cyclohexene (4a) gave the corresponding 2-substituted quinoxaline (7-8).



3

4

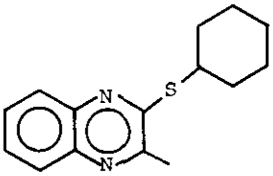
5

6-14

	R1	R2
3a	H	Me
3b	H	Ph
3c	H	H
3d	Me	Me

	R3	R4	R5
4a	-(CH$_2$)$_4$-		H
4b	H	Me	CN
4c	H	Me	CO$_2$Me

Furthermore, 2-substituted quinoxalines (9-14) were obtained in 35-63% yields when the quinoxalin-2-thione (3a-c) was irradiated in the presence of electron-deficient olefins such as methacrylonitrile (4b) and methyl methacrylate (4c) under the same conditions as described above. On the other hand, 1,3-dimethylquinoxalin-2-thione



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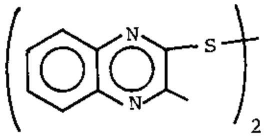

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(3d) was inert to the photolysis in ethylene glycol dimethyl ether in the presence of olefins (4a-c) under the similar conditions

Table. Yield of the 2-Substituted Quinoxalines (6-14)

					Yield (%)[a]		
Compd.	R^2	R^3	R^4	R^5	Product	Recovered (3)	
6	Me	$-(CH_2)_4-$		H	48	5	
7	Ph	$-(CH_2)_4-$		H	50	∿0	
8	H	$-(CH_2)_4-$		H	43	25	(15)[b] 32
9	Me	H	Me	CN	54	23	
10	Ph	H	Me	CN	35	trace	
11	H	H	Me	CN	35	trace	
12	Me	H	Me	CO_2Me	59	trace	
13	Ph	H	Me	CO_2Me	35	15	
14	H	H	Me	CO_2Me	63	trace	

[a] Isolated yield. [b] The yield of 3-phenylquinoxalin-2-one (15)

A reasonable mechanism for the formation of 2-substituted quinoxalines (6-14) is presented in Scheme, which the thietane (18), formed initially by the photochemical [2+2]cycloaddition of thiocarbonyl to olefin,[9] undergoes aromatization to give the final products (6-14). This ready mode of carbon-carbon bond formation described here would provide a convenient method for the preparation of the 2-substituted quinoxalines.

REFERENCES AND FOOTNOTES

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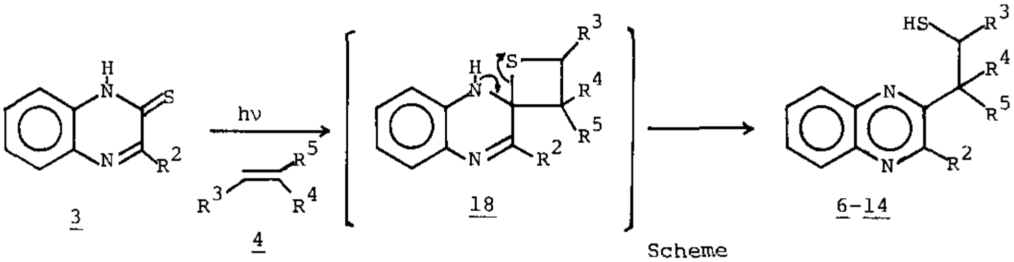

Scheme

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8. ^{13}C-n.m.r. spectrum of 3a; δ_H (DMSO-D_6) 24.7(q), 115.7(d), 125.6(d), 128.0(d), 130.1(d), 131.6(s), 134.9(s), 161.4(s), and 175.1(s).

9. The regiochemistry of photocycloaddition is in accord with the previously published works in thioamide[3a] and thioimide[4b,f] photochemistry.

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