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A general synthesis of alkyl 6-methyl- and 6-phenylpyrazolo[3,2-c]-s-triazolo-7-carboxylates by photochemical Wolff rearrangement of 6-methyl- and 6-phenyl-7-diazo-8-oxo-s-triazolo[4,3-b]pyridazine in an alcohol is described.

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Diazo compounds are an extremely versatile class of organic compounds (1). Heterocyclic diazo compounds are important synthons for the synthesis of a variety of heterocyclic systems (2,3) and intermediates in aza transfer reactions (4,5).

Recently we have shown that from 3-diazo-4-oxo-3,4-dihydroquinoline, when irradiated in the presence of an alcohol or a primary or secondary amine, the corresponding 3-indolecarboxylate or 3-indolecarboxamide is formed by a photochemical Wolff rearrangement (6,7,8). We now wish to report that this reaction pathway can also be used as a general route for the synthesis of alkyl 6-substituted-pyrazolo[3,2-c]-s-triazolo-7-carboxylates (3) starting from 6-methyl- and 6-phenyl-7-diazo-8-oxo-s-triazolo[4,3-b]pyridazine (1, R = CH₃ or C₆H₅). In the past, the compounds of type 3 (R = CH₃, C₆H₅, OC₂H₅; R₁ = H) have been prepared by irradiation of 1 (R = CH₃, C₆H₅, CH₂C₆H₅, OC₂H₅) in hydrochloric acid solution. Ethyl 6-methylpyrazolo[3,2-c]-s-triazolo-7-carboxylate (3, R = CH₃, R₁ = C₂H₅) and benzyl 6-methylpyrazolo[3,2-c]-s-triazolo-7-carboxylate (3, R = CH₃, R₁ = CH₂C₆H₅) were obtained by photolysis in ethanol and termolysis in benzyl alcohol, respectively (9).

When a solution of 6-substituted-7-diazo-8-oxo-s-triazolo[4,3-b]pyridazine (1, R = CH₃ or C₆H₅) (9) is irradiated in alcohol at 254 nm, the corresponding alkyl 6-substituted-pyrazolo[3,2-c]-s-triazolo-7-carboxylates (3) were obtained in good yield.

All reactions were completed in 6 to 20 hours, depending on the substituent at position 6 of the starting compound and on the alcohol used in the reaction. The

reaction is fastest in the case of 1 [(R = CH₃) when irradiated in methanol and slowest in the case of 1] (R = C₆H₅) in *t*-butyl alcohol or ioamyl alcohol. Mechanistically, the transformation is supposed to be a photo Wolff rearrangement (10) involving the formation of an intermediate singlet carbene (11) which is rearranged to the ketene. This then adds a molecule of alcohol to form the corresponding ester. The reported procedure is a simple one and represents a facile one-step synthesis of esters of pyrazolo[3,2-c]-s-triazolo-7-carboxylic acid. Compounds synthesized by this method are listed in Table 1 and their spectroscopic data is shown in Table 2.

On the other hand, when 1 (R = CH₃, C₆H₅) was heated in an alcohol (methanol or ethanol) for 20 hours, only dediazonation took place and 6-substituted-8-hydroxy-s-triazolo[4,3-b]pyridazines 4 (R = CH₃ or C₆H₅) (12) were isolated as the only products. Rearranged esters of type 3 could not be detected by tlc.

Attempts to prepare 6-substituted-pyrazolo[3,2-c]-s-triazolo-7-carboxamides by irradiation of 6-substituted-7-diazo-8-oxo-s-triazolo[4,3-b]pyridazines in the presence of either primary or secondary amines were unsuccessful.

EXPERIMENTAL

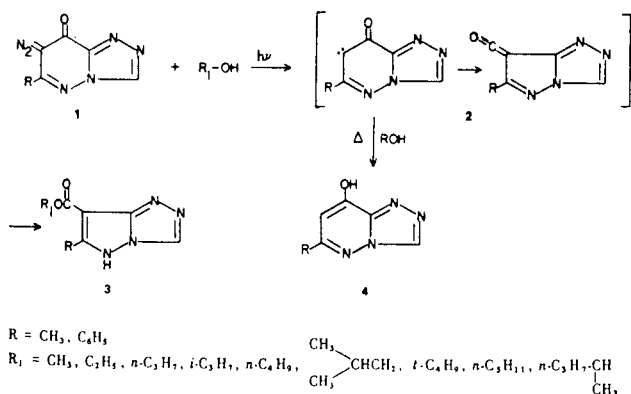
Melting points were taken on a Kofler micro hot stage. All nmr spectra were obtained with a JEOL C-60 HL spectrometer at probe temperature; TMS was used as an internal standard. Mass spectra were recorded on a Hitachi-Perkin-Elmer RMU-6L mass spectrometer.

Preparation of Alkyl 6-Substituted-Pyrazolo[3,2-c]-s-triazolo-7-carboxylates (3).

General Procedure.

A mixture of 6-substituted-7-diazo-8-oxo-s-triazolo[4,3-b]pyridazine (9) (100 mg.) and the corresponding alcohol (20 ml.) was irradiated at 254 nm in a Rayonet photochemical reactor until the showed no starting material present. For tlc, Merck DC-Fertigplatten Kieselgel 60-F 254 were used and a mixture of chloroform and methanol (9:1) was used as a solvent. The filtered reaction mixture was evaporated *in vacuo* and the solid residue was crystallized from appropriate solvent as indicated in Table 1.

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Table 1
Preparation of Alkyl 6-Substituted-Pyrazolo[3,2-c]-s-triazolo-7-carboxylates

Product	R	R ₁	Yield %	M.p.	Solvent for Crystallization	Molecular Formula	Analyses		
							C	H	N
3a	CH ₃	CH ₃	68	240	Methanol	C ₇ H ₈ N ₄ O ₂	Calcd. 46.66 Found 46.90	4.48 4.79	31.30 31.21
3b	CH ₃	C ₂ H ₅	80	219 (a)	Ethyl Acetate	C ₈ H ₁₀ N ₄ O ₂	Calcd. 49.48 Found 49.18	5.19 5.08	28.85 29.03
3c	CH ₃	<i>n</i> -C ₃ H ₇	71	190	Cyclohexane-Ethyl Acetate (2:1)	C ₉ H ₁₂ N ₄ O ₂	Calcd. 51.91 Found 52.23	5.81 6.05	26.91 26.82
3d	CH ₃	<i>i</i> -C ₃ H ₇	59	194	Cyclohexane-Ethyl Acetate (2:1)	C ₉ H ₁₂ N ₄ O ₂	Calcd. 51.91 Found 52.27	5.81 5.86	26.91 27.08
3e	CH ₃	<i>n</i> -C ₄ H ₉	72	175	Cyclohexane-Ethyl Acetate (2:1)	C ₁₀ H ₁₄ N ₄ O ₂	Calcd. 54.04 Found 53.94	6.35 6.37	25.21 24.73
3f	CH ₃	$\begin{matrix} \text{CH}_3 \\ \diagdown \\ \text{C} \\ \diagup \\ \text{CH}_3 \end{matrix} \begin{matrix} \text{---} \\ \text{---} \\ \text{---} \end{matrix} \begin{matrix} \text{---} \\ \text{---} \\ \text{---} \end{matrix} \text{CH-CH}_2$	48	196	Cyclohexane-Ethyl Acetate (2:1)	C ₁₀ H ₁₄ N ₄ O ₂	Calcd. 54.04 Found 54.14	6.35 6.47	25.21 25.48
3g	CH ₃	<i>t</i> -C ₄ H ₉	63	220	<i>n</i> -Heptane	C ₁₀ H ₁₄ N ₄ O ₂	Calcd. 54.04 Found 54.31	6.35 6.49	25.21 25.37
3h	CH ₃	<i>n</i> -C ₅ H ₁₁	81	155	<i>n</i> -Heptane	C ₁₁ H ₁₆ N ₄ O ₂	Calcd. 55.91 Found 55.63	6.83 6.62	23.72 23.91
3i	CH ₃	<i>n</i> -C ₃ H ₇ -CH CH ₃	77	162	<i>n</i> -Heptane	C ₁₁ H ₁₆ N ₄ O ₂	Calcd. 55.91 Found 55.68	6.83 6.76	23.72 24.01
3j	C ₆ H ₅	CH ₃	82	202	Cyclohexane-Ethyl Acetate	C ₁₂ H ₁₀ N ₄ O ₂	Calcd. 59.50 Found 59.65	4.16 4.37	23.13 22.86
3k	C ₆ H ₅	C ₂ H ₅	79	165	Cyclohexane-Toluene (3:1)	C ₁₃ H ₁₂ N ₄ O ₂	Calcd. 60.93 Found 60.74	4.72 4.88	21.87 22.08
3l	C ₆ H ₅	<i>n</i> -C ₃ H ₇	54	140	<i>n</i> -Heptane-Toluene (3:1)	C ₁₄ H ₁₄ N ₄ O ₂	Calcd. 62.21 Found 62.07	5.22 4.98	20.73 20.53
3m	C ₆ H ₅	<i>i</i> -C ₃ H ₇	57	160	Cyclohexane	C ₁₄ H ₁₄ N ₄ O ₂	Calcd. 62.21 Found 62.46	5.22 5.52	20.73 20.59
3n	C ₆ H ₅	<i>n</i> -C ₄ H ₉	61	115	Chloroform- <i>n</i> -Heptane (1:4)	C ₁₅ H ₁₆ N ₄ O ₂	Calcd. 63.36 Found 63.13	5.67 5.75	19.71 19.75
3o	C ₆ H ₅	$\begin{matrix} \text{CH}_3 \\ \diagdown \\ \text{C} \\ \diagup \\ \text{CH}_3 \end{matrix} \begin{matrix} \text{---} \\ \text{---} \\ \text{---} \end{matrix} \text{CH-CH}_2$	47	145	Chloroform- <i>n</i> -Heptane (1:4)	C ₁₅ H ₁₆ N ₄ O ₂	Calcd. 63.36 Found 63.12	5.67 5.45	19.71 19.66
3p	C ₆ H ₅	<i>t</i> -C ₄ H ₉	66	210	Cyclohexane-Ethyl Acetate (3:1)	C ₁₅ H ₁₆ N ₄ O ₂	Calcd. 63.26 Found 63.31	5.67 5.56	19.71 19.55
3r	C ₆ H ₅	<i>n</i> -C ₅ H ₁₁	45	165	Toluene- <i>n</i> -Heptane (1:4)	C ₁₆ H ₁₈ N ₄ O ₂	Calcd. 64.41 Found 64.43	6.08 6.23	18.78 18.65
3s	C ₆ H ₅	<i>n</i> -C ₃ H ₇ -CH CH ₃	72	160	Toluene- <i>n</i> -Heptane (1:4)	C ₁₆ H ₁₈ N ₄ O ₂	Calcd. 64.41 Found 64.32	6.08 6.35	18.78 18.75

(a) Lit. (9) m.p. 217°.

Table 2

Spectroscopic Data for Alkyl 6-Substituted-Pyrazolo[3,2-c]-s-triazolo-7-carboxylates

R	Product R ₁	Ir (C=O) cm ⁻¹	Mass Spectrum (b) M ⁺	Nmr Spectra in Deuteriochloroform δ (ppm)		NIH (a)	J Hz
				H-3 (s)	R-6		
3a	CH ₃	1675	180 (50%)	8.57	2.48 (s)	4.9	
3b	CH ₃	1670	194 (23%)	8.97	2.44 (s)	3.9	J _{C₂H₅} = 6.5
3c	CH ₃	1660	208 (35%)	8.25	2.52 (s)	3.3	J _{C₂H₅} = 6.5 J _{CH₂CH₂} = 6.5
3d	CH ₃	1660	208 (30%)	8.25	2.56 (s)	5.0	J _{CHCH₃} = 6.5
3e	CH ₃	1660	222 (20%)	8.24	2.54 (s)	5.5	J _{C₂H₅} = 6.0 J _{CH₂CH₂} = 6.0
3f	CH ₃	1665	222 (25%)	8.40	2.63 (s)	3.8	J _{CHCH₂} = 6.0 J _{CH₃CH} = 6.0
3g	CH ₃	1675	222 (45%)	8.27	2.55 (s)	3.8	--
3h	CH ₃	1665	236 (38%)	8.55	2.67 (s)	4.0	J _{CH₂CH₃} = J _{CH₂CH₂} = 6.0
3i	CH ₃	1675	236 (32%)	8.47	2.62 (s)	4.1	J _{CH₂CH₃} = J _{CH₂CH₂} = J _{CHCH₂} = J _{CHCH₃} = 6.0
3j	C ₆ H ₅	1640	242 (60%)	8.45	7.9 (m) and 7.5 (m)	4.0	
3k	C ₆ H ₅	1640	256 (78%)	8.3	8.3-7.9 (m) and 7.8-7.25 (m)	4.6	J _{CH₂CH₃} = 6.0
3l	C ₆ H ₅	1630	270 (31%)	8.45	7.9 (m)	3.0	J _{CH₂CH₅} = J _{CH₂CH₂} = 6.0
3m	C ₆ H ₅	1630	270 (90%)	8.45	7.9 (m)	3.5	J _{CH₃CH} = 6.0

Table 2 (continued)
Spectroscopic Data for Alkyl 6-Substituted-Pyrazolo[3,2-c]-s-triazolo-7-carboxylates

R	Product R ₁	Ir (C=O) cm ⁻¹	Mass Spectrum (b) M ⁺	H-3 (s)	R-6	Nmr Spectra in Deuteriochloroform δ (ppm)	NH (a)	J Hz
3n	C ₆ H ₅ n-C ₄ H ₉	1630	284 (30%)	8.34	7.9 (m) and 7.4 (m)	0.95 [t, (CH ₂) ₃ CH ₃] 1.4 [m, CH ₂ (CH ₂) ₂ CH ₃] 4.16 [t, CH ₂ (CH ₂) ₂ CH ₃]	2.5	J _{C₂H₅} = J _{CH₂CH₂} = 6.0
3o	C ₆ H ₅ CH ₃ —CHCH ₂ CH ₃	1625	284 (8%)	8.55	7.9 (m) and 7.4 (m)	0.95 [d, (CH ₃) ₂ CHCH ₂] 1.95 [m, (CH ₃) ₂ CHCH ₂] 4.10 [d, (CH ₃) ₂ CHCH ₂]	3.5	J _{CH₃CH} = J _{CH₂CH} = 6.0
3p	C ₆ H ₅ t-C ₄ H ₉	1660	284 (34%)	8.42	7.9 (m) and 7.4 (m)	1.52 (s, CH ₃)	5.5	--
3r	C ₆ H ₅ n-C ₅ H ₁₁	1635	298 (55%)	8.46	7.9 (m) and 7.4 (m)	0.9 [m, (CH ₂) ₃ CH ₂ CH ₃] 1.55 [m, CH ₂ (CH ₂) ₂ CH ₂ CH ₃] 4.3 (t, CH ₂ -C ₄ H ₉)	3.8	J _{CH₃CH₂} = J _{CH₂CH₂} = 6.0
3s	C ₆ H ₅ n-C ₃ H ₇ -CH CH ₃	1630	298 (47%)	8.48	7.9 (m) and 7.4 (m)	0.95 [m, CH ₃ CH ₂ - and CH ₃ CH] 1.6 (m, CH ₂ CH ₂ CH ₃) 4.35 (m, CHCH ₃)	4.0	J _{CH₂CH₃} = J _{CH₂CH₂} = J _{CHCH₃} = 6.0

(a) Broad singlet. (b) The base peak for compounds **3a-3i** is m/e = 149, and m/e = 184 for compounds **3j-3s**.

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