

Homolytic Annulation by Reaction of Imidoyl Radicals with Diethyl Azodicarboxylate: a New Route to Nitrogen Heterocycle Derivatives

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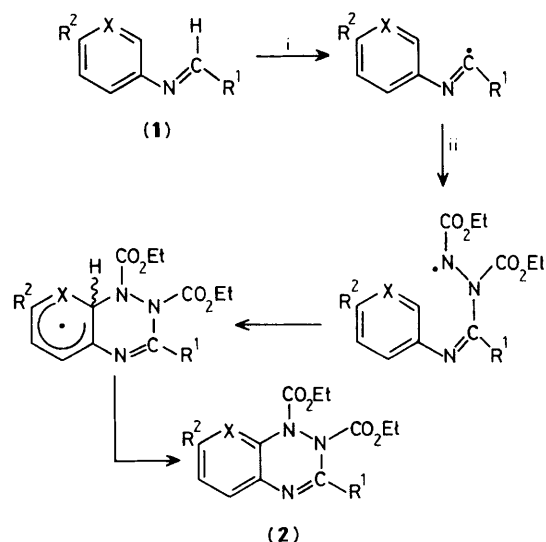
An easily effected aromatic annulation is described, involving the reaction of arylimidoyl radicals with diethyl azodicarboxylate to give 1,2-dihydro-1,2-diethoxycarbonyl-benzo- and -pyrido-1,2,4-triazines.

We have recently described a few aromatic annulations involving the reactions of arylimidoyl, *o*-methylthiophenyl, 2-biphenyl, and 2-phenyl-1-naphthyl radicals with alkynes to give quinolines,^{1,2} benzo[*b*]thiophenes,³ phenanthrenes, and chrysenes⁴ respectively. We now report a new annulation reaction effected by arylimidoyl radicals in reactions with diethyl azodicarboxylate and leading to nitrogen heterocyclic compounds.

Radical addition to the azo-group is well known,⁵ but there are few examples of radical ring closure by addition to a nitrogen–nitrogen double bond, all of them involving an intramolecular attack on the azo-moiety.⁶ Our reaction appears to be the first example of homolytic annulation *via* an intermolecular free-radical addition to the azo-group.

In a typical experiment the imine (1) (5 mmol) and di-isopropyl peroxydicarbonate (DPDC) (10 mmol) were kept at 60 °C in benzene (30 ml) solution with diethyl azodicarboxylate (DADC) (15 mmol) until decomposition of DPDC was complete. † From the reaction mixture the annulation product (2) was separated by column chromatography (Scheme 1 and Table 1) together with variable amounts of carbamates (3) and diethyl hydrazodicarboxylate.

In this case, the reaction mechanism seems to be quite different from that for the annulation performed with alkynes;² *e.g.* it does not seem to involve the spiro-radical (4). In



Scheme 1. Reagents: i, DPDC, benzene, 60 °C; ii, DADC.

† No reaction occurs between imines and diethyl azodicarboxylate when kept at 60 °C for several hours in the absence of DPDC.

Table 1. Substituted benzo- and pyrido-triazines.^a

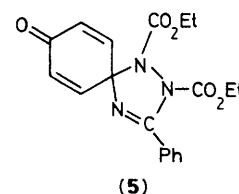
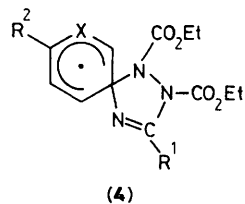
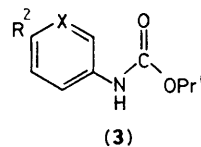
Compd.	X	R ¹	R ²	% Yield ^b	M.p. (°C)
(2a)	CH	Ph	H	45	73—75
(2b)	CH	Ph	OMe	72	135—137
(2c)	CH	Ph	Br	26	129—131
(2d)	CH	An ^c	H	47	107—108
(2e)	CH	An	OMe	73	117—118
(2f)	CH	An	Br	41	139—140
(2g)	CH	An	CO ₂ Et	36	151—152
(2h)	CH	Bu ^t	H	27	65—66
(2i) ^d	CH	Bu ^t	OMe	57	^e
(2j) ^d	N	Ph	OMe	47	163—165
(2k)	N	An	OMe	47	137—139
(2l) ^d	N	Bu ^t	OMe	27	^e

^a New compounds: satisfactory ¹H n.m.r., mass, and high resolution mass spectra were obtained. ^b Calculated for pure product based on starting imine. ^c An = 4-OMe-C₆H₄. ^d New compound, obtained by refluxing a benzene solution of a 1:1 mixture of amine and aldehyde with azeotropic distillation of water in the presence of catalytic amounts of toluene-*p*-sulphonic acid: (2i), m.p. 48—50 °C; (2j), m.p. 47—49 °C; (2l), b.p. 69—71 °C at 0.5 mmHg. ^e Viscous oil which could not be distilled.

fact, starting from the imines (1; R² = OMe, Br, CO₂Et) mixtures of isomeric products are not obtained, as should occur if the reaction proceeds *via* the intermediate (4); moreover, the imine (1; X = CH, R¹ = Ph, R² = Ph₃C-O), under the same conditions, affords 35% of benzotriazine (2; X = CH, R¹ = Ph, R² = Ph₃C-O) and no trace of the spiro-compound (5) can be detected.

The new annulation reaction represents a novel and efficient synthetic route to substituted 1,2-dihydro-1,2-diethoxycarbonyl-benzo- and -pyrido-1,2,4-triazines and their aromatic derivatives.‡ It is worth pointing out that starting

‡ Hydrolysis of (2a) with KOH in ethanol and decarboxylation at 230 °C in the presence of copper bronze afford 70% of 3-phenylbenzo-1,2,4-triazine, m.p. 122—123 °C (lit. m.p. 123 °C: F. Fichter and E. Schiess, *Chem. Ber.*, 1900, **33**, 747).



from imines (1; X = N) we obtain compounds (2; X = N) only and no trace of the other possible isomers. The extension to the synthesis of other heterocycles is being studied.

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