

## Intramolecular Photoreactions of 2-Formylbenzamides and 2-Formylbenzylamines

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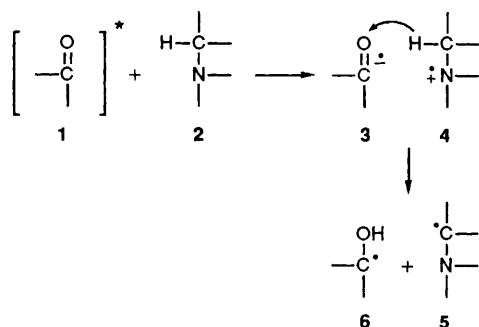
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Irradiation of 2-formylbenzylamine **7** in the presence of fumarates affords adducts corresponding to trapping of quinodimethane intermediate **9**, while photolysis of 2-formylbenzamides leads to amino lactones **16**.

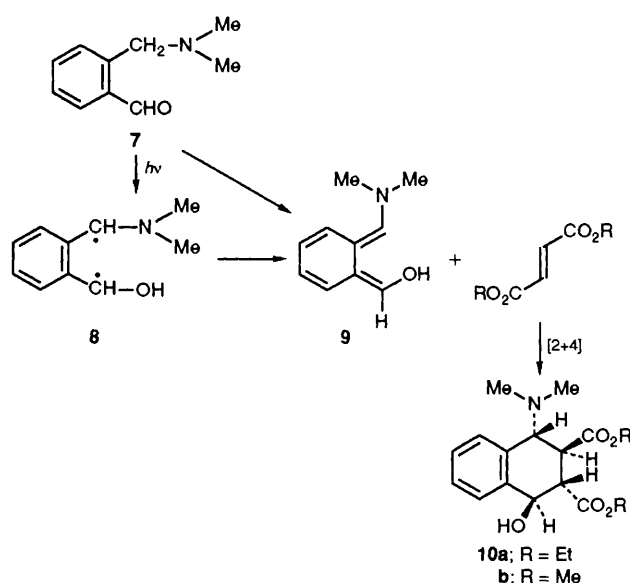
In continuation of our interest in elusive intramolecular hydrogen transfer reactions,<sup>1,2</sup> we have studied various photoreactions of 2-formylbenzylamines and -benzamides. Wagner has shown that in contrast to the extensively studied and facile hydrogen transfer from amines to ketones (**1** + **2** → **5** + **6**), Scheme 1, the corresponding intramolecular reaction often fails because the initial electron transfer is not followed by a proton shift.<sup>3,4</sup> We argued that there would be an additional driving force for the latter step if the resulting radical centre has captodative stabilisation from aryl and nitrogen moieties.<sup>5</sup>

Irradiation of a benzene solution of 2-formyl-*N,N*-dimethylbenzylamine **7**<sup>6</sup> ( $1.2 \times 10^{-3}$  mol dm<sup>-3</sup>) containing 1.5 equiv. of diethyl fumarate or dimethyl fumarate in fact afforded **10a** or **10b**, respectively, Scheme 2.<sup>†,‡</sup> Trapping of a quinodimethane intermediate, albeit in low yield,<sup>§</sup> is clear evidence that a 1,5-hydrogen shift occurs (**7** → **8** → **9**).

An additional unusual feature of this reaction is that in the adducts **10a** and **10b**, the C<sub>1</sub> and C<sub>2</sub> protons are *trans*, which corresponds to an *endo* [2 + 4] addition to a *Z*-hydroxyquinodimethane.<sup>7</sup>



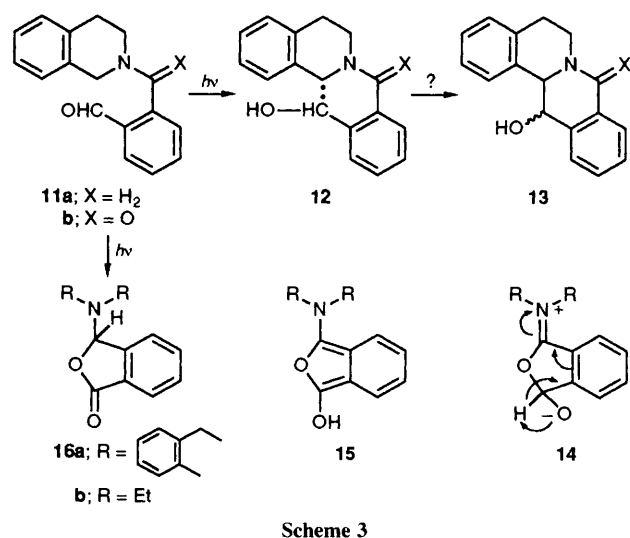
It seems that in aldehydes **11a** and **11b**, the  $\epsilon$ -hydrogen may be abstracted owing to captodative stabilisation of the resulting radical centre in **12**. Ring closure (**12** → **13**) could then provide easy access to the framework of the alkaloid opiocarpine **13**. However, irradiation of **11a**<sup>¶</sup> furnished a complex mixture in which **13** was not present in any significant amount.<sup>8</sup> Considering that abstraction of a  $\gamma$ -hydrogen may provide an easier reaction pathway for the excited state of **11a**, irradiation of the aldehyde **11b**,<sup>‡,¶</sup> in which the two  $\gamma$ -hydrogens are replaced with an oxygen atom, was carried out. However, the reaction took an unexpected course, forming



<sup>†</sup> Photoreactions were carried out with nitrogen-purged benzene solutions using a medium-pressure mercury-lamp in a Pyrex immersion well. Formation of adduct **10** was not quenched by *trans*-piperylene ( $5 \times 10^{-1}$  mol dm<sup>-3</sup>) indicating a singlet or very short lived triplet.

<sup>‡</sup> Satisfactory spectral data and elemental analysis by high resolution mass spectrometry ( $\pm 1$  mmu) were obtained for **7**, **10a**, **10b**, **11a**, **11b**, **16a** and **16b**. **10a**, IR (CHCl<sub>3</sub>): 3478 (OH), 1728 cm<sup>-1</sup> (C=O); <sup>1</sup>H NMR (CDCl<sub>3</sub>, 300 MHz):  $\delta$  1.20 (t, 3H, CO<sub>2</sub>Et), 1.40 (t, 3H, CO<sub>2</sub>Et), 2.25 (s, 6H, NMe<sub>2</sub>), 3.05 (t, 1H, C<sub>2</sub>H), 3.43 (dd, 1H, C<sub>3</sub>H), 4.05–4.10 (m, 2H, CO<sub>2</sub>Et), 4.15 (d, 1H, *J* 7 Hz, ArCHN), 4.20–4.30 (m, 2H, CO<sub>2</sub>Et), 5.15 (d, 1H, *J* 9.18 Hz, ArCHOH), 7.20–7.30 (m, 2H, ArH), 7.35 (d, 1H, ArH), 7.60 (d, 1H, ArH). Irradiation at  $\delta$  3.05 collapsed the quartet at  $\delta$  3.43 to a doublet (*J* 7 Hz) and the doublet at  $\delta$  5.15 to a singlet while irradiation at  $\delta$  3.43 converted the triplet at  $\delta$  3.05 to a doublet (*J* 9 Hz); *m/z* 335 (M<sup>+</sup>), 317, 290, 272, 227, 217 (base); *m/z* 335.1738 (calc. 335.1734). **16a**, m.p. 177–178 °C; IR (Nujol): 1742 cm<sup>-1</sup> (C=O); <sup>1</sup>H NMR (CDCl<sub>3</sub>):  $\delta$  2.80–3.25 (m, 4H, ArCH<sub>2</sub>CH<sub>2</sub>N) 3.95 (s, 2H, ArCH<sub>2</sub>N), 6.50 (s, 1H, ArCH), 7.20–8.20 (m, 8H, ArH); *m/z* 265 (M<sup>+</sup>), 264, 221 (base); *m/z* 265.1096 (calc. 265.1103).

<sup>§</sup> Pure adducts were obtained, through silica gel column chromatography, in 15% chemical yield. These yields are a composite of those for the formation of the quinodimethane intermediate and its trapping. No reaction between  $\gamma$ -amino aldehyde **7** and the dienophile was observed in the absence of irradiation.



<sup>¶</sup> Compounds **11a** and **11b** were prepared by thermal condensation of 2-formylbenzylbromide and benzoylchloride with 1,2,3,4-tetrahydroisoquinoline.

the amino lactone **16a** in near quantitative yield.‡,|| Photolysis of 2-formyl-*N,N*-diethylbenzamide similarly afforded the amino lactone **16b**, Scheme 3.

Formation of these products amounts to a 1,4-transfer of a hydrogen from the aldehydic carbon to the amidic carbon. This may be rationalised in terms of a 1,5-hydrogen shift and ring closure of the thus-formed ketene quinodimethane, in a manner similar to that proposed for the photoisomerisation of *o*-phthalaldehyde.<sup>9</sup> However, this mechanism has remained a matter of controversy.<sup>10</sup> Its applicability in the present instance is more unlikely because amides, as compared with aldehydes, or even esters, show low proclivity for hydrogen abstraction.<sup>11</sup> Therefore, alternative pathways involving initial C–O bond formation (**11** → **14** → **15** → **16** or **11** → **15** → **16**) merit serious consideration.

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- 6 Prepared by addition of *n*-butyllithium to a solution of *N,N*-dimethylbenzylamine in dry diethyl ether followed by dimethylformamide. For this methodology see, C. T. Vishwanathan and C. A. Wilkie, *J. Organomet. Chem.*, 1973, **54**, 1. UV, IR, <sup>1</sup>H NMR and fluorescence spectral data showed no interaction between the amino and the carbonyl group.
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|| Structure was confirmed by admixture m.p. (177–178 °C) and superimposable IR, <sup>1</sup>H NMR and MS data with an authentic sample secured by thermal condensation of 3-ethoxyphthalide with 1,2,3,4-tetrahydroisoquinoline.