

Two-photon route to *N*-vinylisoindolinones from isoquinolin-1(2*H*)-one and electron deficient ethenes

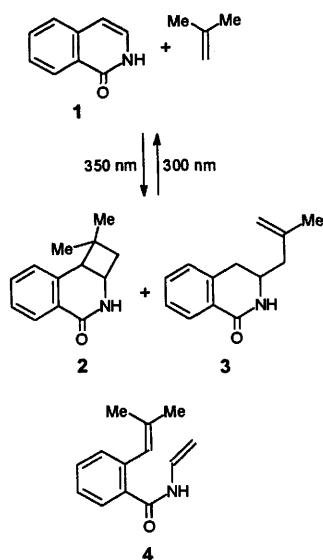
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Isoquinolin-1(2*H*)-one undergoes regiospecific and highly stereoselective ($2\pi+2\pi$) photocycloaddition with electron deficient ethenes at wavelengths longer than 290 nm: with 254 nm radiation, the adducts rearrange to *N*-vinylisoindolinones and undergo retroaddition.

Isoquinolin-1-ones are known to undergo photoaddition to a variety of ethenes.^{1–8} The products are ($2\pi+2\pi$) cycloadducts which in some cases may have useful synthetic applications.^{4,6,8} The photoaddition of isobutene to isoquinolin-1-one **1** is reported to give **2** regiospecifically^{1,4} with the ene-type adduct **3** as a trace by-product from the intermediate 1,4-diradical.⁴



Irradiation of the ($2\pi+2\pi$) cycloadducts at 300 nm results in retro-addition and the formation of minor amounts of **3**, but specifically, none of the ring-opened isomer **4** is observed.⁴ The photoadditions to 3- and 4-substituted isoquinolin-1-ones are regiospecific but yield a mixture of the diastereoisomers with little or no selectivity.^{2,8} We now report that the regio-specific photoreaction of isoquinolin-1(2*H*)-one **1** with electron deficient ethenes not only occurs with remarkable stereoselectivity but also yields 1:1 adduct isomers which are dependent on the wavelength of irradiation as a result of the short wavelength lability of the primary product.

Exposure of a methanol or dioxane solution of isoquinolin-1-one (0.5% w/v) and acrylonitrile (1.5% v/v) under nitrogen to 254 nm radiation gave appreciable amounts of polymeric material and induced a slow formation of several volatile products, the major (*ca.* 70%) of which was readily isolated by flash chromatography and was a 1:1 adduct of the reactants (M^+ 198 mu, mp 147 °C). The spectral data were inconsistent with a ($2\pi+2\pi$) cycloadduct and indicated the presence of

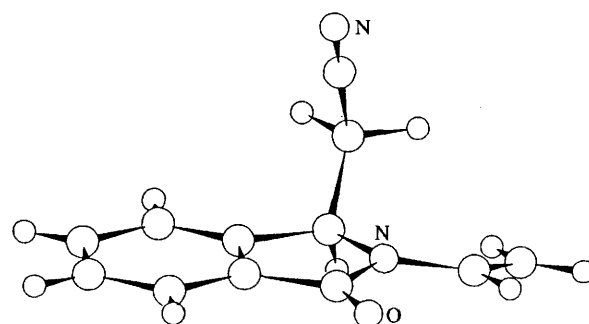


Fig. 1 Crystal structure of *N*-vinylisoindolinone **5**

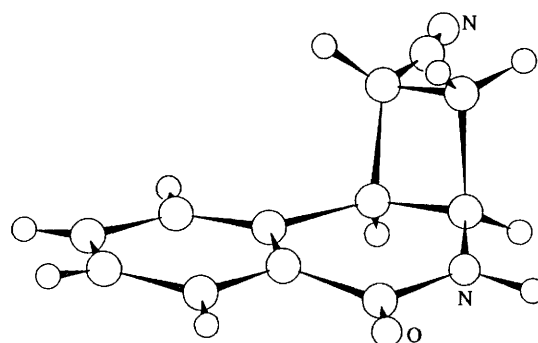
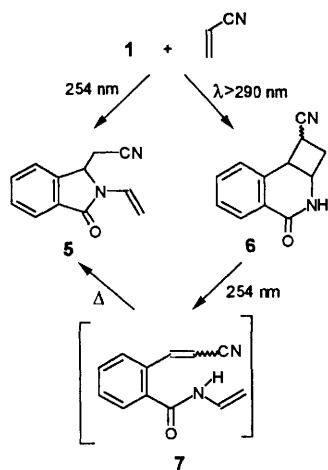


Fig. 2 Crystal structure of cycloadduct **6**

vinyl^{9a} and $\text{CH}-\text{CH}_2-\text{CN}$ ^{9b} groupings as well as the retention of the amide functionality. Confirmation of the assignment of the 1:1 adduct from spectral analysis as the *N*-vinylisoindolinone **5** was obtained from X-ray crystallographic determination of a single crystal (Fig. 1).¹⁰

Clearly the *N*-vinylisoindolinone **5** is not a primary photochemical product and indeed, selective excitation of nitrogen degassed solutions of the isoquinolinone and acrylonitrile at wavelengths longer than 290 nm (Pyrex filtered medium pressure mercury arc) produced two different adduct isomers in an approximate ratio of 10:1 (¹H NMR spectroscopy) and essentially quantitative yield. Similar results were achieved from exposure of solutions of the reactants in Pyrex flasks to sunlight. The spectral data of the 1:1 adduct mixture were overall consistent with the two stereoisomers of the ($2\pi+2\pi$) cycloadduct structure **6**. Assignment of the stereochemistry of the major isomer (mp 183–184 °C) purified by fractional crystallisation from ethanol, was not, however, totally unambiguous from spectral analysis, but an X-ray crystal determination of a single crystal showed this adduct was the *exo* isomer (Fig. 2);¹⁰ the minor isomer is, therefore, deduced to have *endo* stereochemistry.

Under 254 nm radiation, the diastereoisomeric mixture of the ($2\pi+2\pi$) cycloadducts in dioxane or methanol solution



rapidly and quantitatively underwent an approximate 1:1 ratio of rearrangement to the isoindolinone isomer **5** and retroaddition. The conversion of **6** to **5** is considered to arise by photoinduced cleavage of the cyclobutane ring to **7** which then undergoes rapid cyclisation by intramolecular conjugate addition to the cinnamionitrile moiety. By this two-photon route, the isoindolinone **5** can be obtained in yields of >90% based on the recovered isoquinolinone. The overall process occurred with other dienophilic ethenes such as acrylates and fumaronitrile. The details of the conversion of **6** to **5** and the scope of this novel route to isoindolinones are under current investigation.

Acknowledgements

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References

- 1 G. R. Evanega and D. L. Fabiny, *Tetrahedron Lett.*, 1971, 1749.
- 2 T. Naito and C. Kaneko, *Tetrahedron Lett.*, 1981, 2671.
- 3 C. Kaneko and T. Naito, *Heterocycles*, 1982, **19**, 2183.

- 4 C. Kaneko, N. Katagiri, K. Uchiyama and T. Yamada, *Chem. Pharm. Bull.*, 1985, **33**, 4160.
- 5 T. Naito and C. Kaneko, *Chem. Pharm. Bull.*, 1985, **33**, 5328.
- 6 T. Chiba, Y. Takada, T. Naito and C. Kaneko, *Chem. Pharm. Bull.*, 1990, **38**, 2335.
- 7 T. Chiba, Y. Takada, C. Kaneko, F. Kiuchi and Y. Tsuda, *Chem. Pharm. Bull.*, 1990, **38**, 3317.
- 8 H. Sugimoto, Y. Kajizuka, M. Suzuki, H. Senboku and K. Kobayashi, *Heterocycles*, 1994, **37**, 283.
- 9 δ_{H} (90 MHz; CDCl₃; J/Hz) (a) 7.25 (1 H, dd, J 6 and 9), 4.75 (1 H, dd, J 6 and 14) and 4.62 (1 H, dd, J 9 and 14); (b) 5.0 (1 H, dd, J 3 and 5), 3.27 (1 H, dd, J 3 and 10) and 2.78 (1 H, dd, J 5 and 10); ν_{max} (Nujol mull)/cm⁻¹ 2220.
- 10 *Crystal data*. For **5**: C₁₂H₁₀N₂O, $M = 198.22$, $\lambda 0.71070$ Å, monoclinic, $P2_1/a$, $a = 6.912(7)$, $b = 16.270(7)$, $c = 8.570(7)$ Å, $\beta = 100.33(1)^\circ$, $U = 948.1$ Å³, $Z = 4$, $D_c = 1.389$ Mg m⁻³, $\mu = 0.091$ mm⁻¹, $F(000)$ 416 reflections collected 2268, independent reflections 1293 [$R(\text{int}) = 0.0405$], refined on F^2 to $R = 0.0735$, $wR_2 = 0.1849$ for data with $I > 2\sigma(I)$. For **6**: C₁₂H₁₀N₂O, $M = 198.22$, $\lambda 0.71070$ Å, triclinic, spacegroup PT, $a = 6.845(7)$, $b = 11.561(7)$, $c = 21.216(9)$ Å, $\alpha = 80.214(10)$, $\beta = 87.515(10)$, $\gamma = 73.699(10)^\circ$, $U = 1513(2)$ Å³, $Z = 6$, $D_c = 1.304$ Mg m⁻³, $\mu = 0.090$ mm⁻¹, $F(000)$ 624, independent reflections collected 4514, refined on F^2 to $R_1 = 0.1287$, $wR_2 = 0.2809$ for data with $I > 2\sigma(I)$. Data for both crystals were collected on a Marresearch Image Plate using Mo-K α radiation. The crystals were positioned at 75 mm from the Image Plate. 95 Frames were measured at 2° intervals with a counting time of 2 min. Data analysis was carried out with the XDS program.¹¹ Both structures were solved using direct methods with the SHELX86 program.¹² In both structures the non-hydrogen atoms were refined with anisotropic thermal parameters. The hydrogen atoms were included in geometric positions. In structure **6** there were three molecules in the asymmetric unit. Both structures were refined using SHELX.¹³ Atomic coordinates, bond lengths and angles and thermal parameters have been deposited at the Cambridge Crystallographic Data Centre (CCDC). For details of the deposition scheme, see 'Instructions for Authors', *J. Chem. Soc., Perkin Trans. 1*, 1996, Issue 1. Any request to the CCDC for this material should quote the full literature citation and the reference number 207/18.
- 11 W. Kabsch, *J. Appl. Crystallogr.*, 1988, **21**, 916.
- 12 SHELX86, G. M. Sheldrick, *Acta Crystallogr., Sect. A*, 1990, **46**, 467.
- 13 SHELXL, G. M. Sheldrick, 1993, program for crystal structure refinement, University of Göttingen.

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