UNUSUAL CYCLOADDITION OF SOME 1-ACYL INDOLES TO AN o-QUINONE MONOIMIDE

David St C. Black,^{*a} Donald C. Craig,^a Harold W. Heine,^b Naresh Kumar,^a and Elizabeth A. Williams^c ^aSchool of Chemistry, University of New South Wales, PO Box 1,

Kensington, NSW, 2033, Australia ^bDepartment of Chemistry, Bucknell University, Lewisburg, Pennsylvania, 17837, U.S.A.

^CGeneral Electric Company, Corporate Research and Development, Schenectady, N.Y., 12301, U.S.A.

ABSTRACT - 1-Acyl indoles act as dienophilic components of a [4+2]-cycloaddition when treated with an o-quinone monoimide: an X-ray crystal structure determination established the structure of one of the adducts.

1-Methyl-, 2-methyl-, and 1,2-dimethylindoles (<u>la-c</u>) have been shown to undergo a facile electrophilic substitution by the o-quinone monoimide (2) to give compounds $(3a-c)^{1}$.



In sharp contrast, a [4+2]-cycloaddition occurs when l-acetyl-, l-benzoyl-, and l-benzenesulfonyl-indole (<u>4a-c</u>) are treated with the quinone imide (<u>2</u>) in dichloromethane at room temperature. Quantitative yields of the respective cycloadducts (<u>5a</u>) m.p. 243-4^o, (<u>5b</u>) m.p. 133-4^o, and a 40% yield of adduct (<u>5c</u>) m.p. 300-1^o were obtained when a 3:1 ratio of the l-acyl indole to imide was used.



The indolo-benzoxazine cycloadduct structures were elucidated by analytical and spectroscopic data and in the case of adduct ($\underline{5a}$) by an X-ray crystal structure determination² (see Figure 1).



Figure 1. Molecular structure of 6-acety1-2,4-dichloro-5,5a,6,10b-tetrahydro-5 (4-nitrobenzoy1)-indolo[3,2-b][1,4]benzoxazine (5a). The ¹³C n.m.r. chemical shift values for adduct ($\underline{5a}$) at 72.30 and 83.08 p.p.m. respectively indicate a carbon linked to two nitrogen atoms (C14) and a carbon linked to an oxygen atom and a phenyl group (C7).^{3,4} Similar values were observed for the other two adducts, viz. ($\underline{5b}$) 71.60 and 81.37 p.p.m. and ($\underline{5c}$) 72.64 and 82.52 p.p.m.

The indolo-benzoxazine ring system appears only to have been reported once before,⁵ its formation occurring from a phenylhydrazino-benzoxazine.

The formation of adducts $(\underline{5a-c})$ provides the first example of 1-acyl indoles acting as dienophiles in an inverse electron demand Diels-Alder reaction. It is also significant that the electron-withdrawing N-acyl groups alter the polarity of the indole and that the C2 rather than the C3 of the indole becomes the site of greatest nucleophilicity. In this respect the 1-acylindoles behave like benzofuran which reacts with the imide (2) to give adduct (<u>6</u>).^{3,4} Indoles also act as dienophiles in the [4+2]-cycloaddition of 3-alkyland 2,3-dialkyl-indoles to <u>o</u>-benzoquinone in chloroform containing acetic acid^{6,7} giving the adducts (<u>7</u>).



It is of interest to compare the reactions of the quinone imide $(\underline{2})$ with 1-methyland 1-acetyl-indoles to the [3+2]-cycloaddition reactions of the moderately electrophilic nitrile oxides with the same indoles. ^{8,9} Admixture of 1-methylindole and mesitonitrile oxide in benzene for one month gave adduct (<u>8a</u>) as the only product.⁸ Similar reaction of 1-acetylindole gave, after two months, adduct (<u>8b</u>) as the major product, together with a trace of adduct (<u>9</u>), the isomer that would have been expected if the regiochemistry of the [3+2]-cycloaddition followed that observed in the [4+2]-cycloaddition leading to adducts (5a-c).



This research was partially supported by the Australian Research Grants Scheme.

References:

- H.W. Heine, C. Olsson, J.D. Bergin, J.B. Foresman, and E.A. Williams, J. Org. Chem. 1987, <u>52</u>, 97.
- 2. Crystal data for $(\underline{5a})$: $C_{23} H_{15} Cl_2 N_3 O_5$, M 484.3, monoclinic, space group $P2_1/c$, a 8.489(1), B 18.351(1), c 14.321(1)Å, β 104.81(1)^O, z 4,4089 measured reflexions (CuK α), 2998 observed (1>3 σ (1)), R 0.039, R_W 0.056. The atomic coordinates for this work are available on request from the Director of the Cambridge Crystallographi Data Centre, University Chemical Laboratory, Lensfield Road, Cambridge CB2 1EW. Any request should be accompanied by the full literature citation for this communication.
- 3. H.W. Heine, B.J. Barchiesi, and E.A. Williams, J. Org. Chem., 1984, 49, 2560.
- 4. H.W. Heine and E.A. Williams, Recl. Trav. Chim. Pays-Bas, 1986, 105, 403.
- 5. R.W. Hendess, J. Org, Chem., 1971, 36, 2449.
- 6. T. Komatsu, T. Nishio, and Y. Omote, Chem. and Industry, 1978, 95.
- 7. Y. Omote, A. Tomotake, and C. Kashima, Tetrahedron Lett. 1984, 25, 2993.
- F.M. Albini, E. Albini, T. Bandiera, and P. Caramella, J. Chem. Research (S), 1984.
 36; J. Chem. Research (M), 1984, 0443.
- 9. L. Bruché and G. Zecchi, J. Org. Chem., 1983, 48, 2772.

(Received in UK 22 September 1987)