Photocycloaddition of 3-Acetoxy-2-acetylbenzo[*b*]furan to Alkenes; the Synthesis of Benz[*b*]oxepin-5-ones

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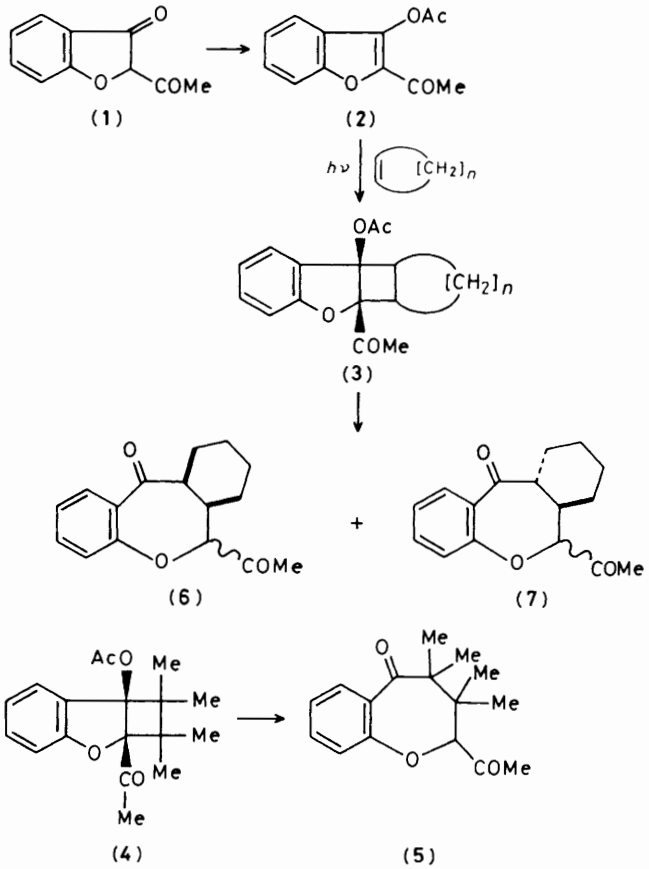
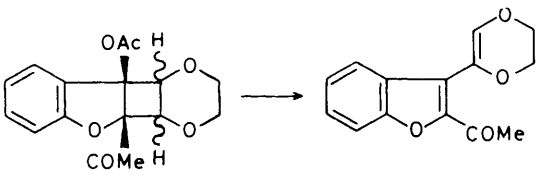
Cyclobutane derivatives, formed by [$_{\pi}2$ + $_{\pi}2$] photoaddition of 3-acetoxy-2-acetylbenzo[*b*]furan to alkenes, undergo base- and acid-catalysed retro-aldol cleavage to yield benz[*b*]oxepin-5-ones.

The formation of cyclobutane derivatives by [$_{\pi}2$ + $_{\pi}2$] photocycloaddition of conjugated enones to alkenes has been extensively investigated and the process has proved to be of considerable synthetic value. The use of enolized β-dicarbonyl compounds is of particular interest as the resulting 2-acylcyclobutan-1-ols undergo facile retro-aldol cleavage, leading, in the case of cyclic β-diketones, to ring expanded products.[1] Application of this reaction sequence to heterocyclic β-dicarbonyl compounds has been restricted to 4-hydroxycoumarin,[2] 4-hydroxyquinol-2(1*H*)-ones,[3,4] and the analogous β-keto sulphone derivative 3-acetoxybenzo[*b*]thiophene 1,1-dioxide.[5] No examples of addition to enol derivatives of 2-acylcycloalkanones containing ring heteroatoms have been reported; these systems are readily available and successful additions would therefore provide a valuable route to medium-ring heterocycles.

A suitable example for study is 2-acetyl-2,3-dihydrobenzo[*b*]furan-3-one (**1**)[6] which is easily converted into the corresponding enol acetate (**2**) with acetic anhydride. A solution of 3-acetoxy-2-acetylbenzo[*b*]furan (**2**) in methanol–cyclohexene (8:1) was irradiated with a 450 W medium-pressure mercury arc through Pyrex until the i.r. carbonyl stretching absorptions at 1680 and 1785 cm^{-1} were no longer evident. Removal of the solvent gave a complex mixture from which a single adduct (**3**; $n = 4$) was isolated in 61% yield as a viscous colourless oil by repeated chromatography on silica gel, with ν_{max} (CH_2Cl_2) 1742 and 1715 cm^{-1}, ^{1}H n.m.r. δ ($CDCl_3$) 1—2.6 (10H, br. m), 1.92 (3H, s), 2.26 (3H, s), and 6.9—7.6 (4H, m), and ^{13}C n.m.r. δ 203.7, 169.1, 160.6, 130.9, 126.5, 125.0, 121.6, 111.7, 96.9, 88.5, 49.2, 46.9, 28.0, 26.2, 25.5, and 20.9. p.p.m. The stereochemistry of this adduct is uncertain, but the major product of such additions is normally the *cis*, *cisoid*, *cis*, or the *cis*, *transoid*, *cis* stereoisomer. Analogous adducts (**3**; $n = 3$) and (**4**) were obtained with cyclopentene and 2,3-dimethylbut-2-ene in yields of 66 and 31%, respectively, whereas reaction with dihydro-1,4-dioxine gave two crystalline adducts, believed to be the *cisoid*- and *transoid*-isomers (**8**), in yields of 57 and 20%, respectively.



Retro-aldol cleavage of these cyclobutanes to give the corresponding benzoxepin-5-ones was successfully achieved in methanol in the presence of sodium hydrogen carbonate. A single benzoxepin-5-one, m.p. 66 °C, was obtained in this way in 87% yield from the cyclobutane (**4**) and assigned the struc-



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ture (**5**) on the basis of analytical and spectroscopic evidence; ν_{max} (CH_2Cl_2) 1715 and 1675 cm^{-1}, ^1H n.m.r. δ ($CDCl_3$) 1.06 (3H, s), 1.14 (6H, s), 1.23 (3H, s), 2.45 (3H, s), 4.00 (1H, s), and 7.0—7.8 (4H, br. m), and ^{13}C n.m.r. δ 207.2, 196.1, 158.6, 133.4, 128.4, 124.8, 120.6, 113.7, 78.1, 64.7, 34.9, 25.3, 25.0 (2), 20.8, and 20.4 p.p.m.

Ring opening of the cyclopentene and cyclohexene adducts (**3**) was effected under similar conditions but was complicated by the presence of three chiral centres in the resulting oxepines. In both cases, however, two crystalline epimeric oxepines were separated by column chromatography on silica gel. Careful examination of the ^1H n.m.r. spectra of the two products of ring opening of the cyclohexene adduct (**3**; $n = 4$), and in particular coupling constants of 1.0 and 11.5 Hz, respectively, for the vicinal bridgehead protons, supports the assignment of the *cis*- and *trans*-fused structures (**6**) and (**7**) for the benz-[*b*]oxepin-5-ones. These were obtained in yields of 63 and 22%, respectively. Similar spectral values were observed for the oxepines derived from the cyclopentene adduct, and in both cases identical mixtures of isomers were obtained by acid-catalysed ring cleavage (HCl in methanol).

Base-catalysed cleavage of the 1,4-dioxine adduct (**8**) failed to yield any recognisable product. Acid hydrolysis, however, did not give the expected benzoxepine but a red crystalline compound in 80% yield with m.p. 126—129 °C, ν_{max} (CH_2Cl_2) 1675 cm^{-1}, ^1H n.m.r. δ ($CDCl_3$) 2.35 (3H, s), 4.18 (4H, m), 6.58 (1H, s), and 7.0—7.6 (4H, br. m), ^{13}C n.m.r. δ 191.8, 153.1, 146.8, 138.8, 132.3, 130.2, 126.6, 125.0, 124.5, 120.4, 119.1, 64.2, 63.4, and 25.6 p.p.m., and m/z 244 (M^+); this was assigned the 2-acetyl-3-(5,6-dihydro-1,4-dioxin-2-yl)benzo-[*b*]furan structure (**9**). In this case, cleavage of the cyclobutane ring is accompanied by loss of acetic acid, a process which is obviously facilitated by the presence of the adjacent oxygen atom.

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