

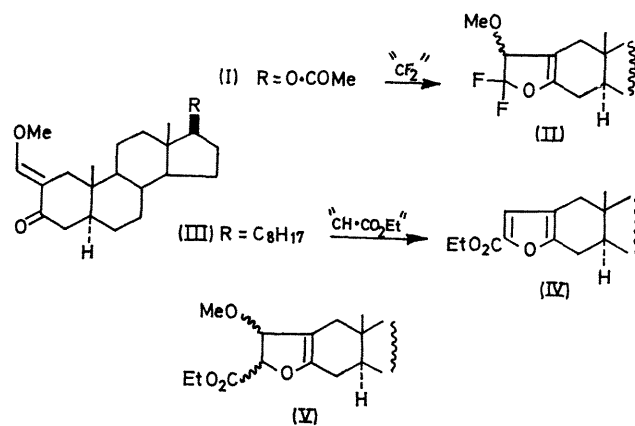
Reaction of Difluorocarbene with 2-Benzylidenecyclohexanones to afford Phenylfluorofurans

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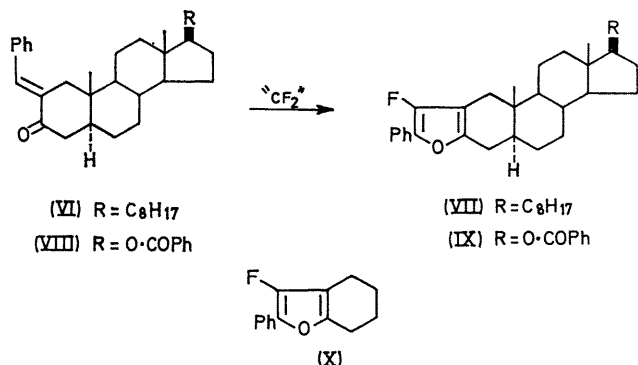
Summary Difluorocarbene reacted with several 2-benzylidenecyclohexanones giving phenylfluorofurans: *trans*-1-benzoyl-2,2-difluoro-3-phenylcyclopropane, when heated for 1½ h at 216°, gave 3-fluoro-2,5-diphenylfuran in high yield.

CARBENES and carbenoids rarely react with unsaturated systems to afford products formally derived by or *via* 1,4-addition.¹ However difluorocarbene reacts with the 2-methoxymethylene ketone (I) giving both isomers of the dihydrofuran (II) (combined yield 70%),² and "ethoxy-carbonylcarbene" reacts with the 2-methoxymethylene ketone (III) to afford the furan (IV) (29%), presumably *via* the dihydrofurans (V).³ Recent work⁴ suggests that the reagent in the latter case initially attacks the carbonyl group of the substrate. We now report that furan derivatives



are also obtained when 2-benzylidene-5 α -cholestan-3-one

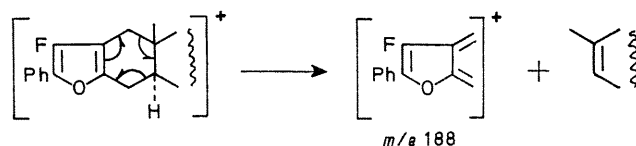
(VI) and some related ketones are treated with difluorocarbene; they are not, however, formally derived by or *via* 1,4-addition.



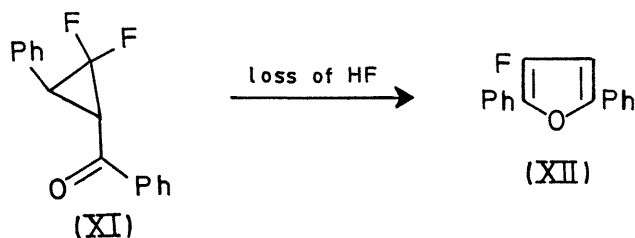
Treatment of 2-benzylidene-5 α -cholestan-3-one (VI) in refluxing triglyme (*ca.* 216°)⁵ with 30 equiv. of difluorocarbene generated by the thermal decomposition of sodium chlorodifluoroacetate,⁶ afforded, after column chromatography, one main product, m.p. 172–174°, (29%)[†] which was identified as the phenylfluorofuran (VII) from the following data. The molecular weight (high-resolution mass spectrometry)[‡] and C, H, and F analyses were in agreement with the formula C₃₅H₄₉FO. The only signals in the ¹H n.m.r. spectrum (solution in CDCl₃) at lower field than δ 2.70 p.p.m. were due to a phenyl group. The i.r. spectrum (solution in CHCl₃) contained no carbonyl band, but had bands at 1654 and 1607 cm⁻¹. The i.r. spectra of several polyfluorofurans have bands in this region.⁷ The base peak in the mass spectrum was the molecular ion. A prominent peak (40%) at *m/e* 188 is attributed to a retro-Diels–Alder cleavage and a metastable peak at *m/e* 70.2 supports this.⁸ The u.v. spectrum, λ_{max} (EtOH) 226sh, 274sh, 286, and 298sh nm (log ϵ 3.85, 3.80, 4.19, 4.29, and 4.16), is similar to that of 2-phenylfuran[§] and unlike that of 3-phenylfuran.[¶]

17 β -Benzoyloxy-2-benzylidene-5 α -androstane-3-one (VIII) and 2-benzylidenecyclohexanone reacted similarly with difluorocarbene to afford, respectively, the furan (IX), m.p. 221–223°, (52%)[†] and the furan (X), a gum, (8%)[†] which were identified in a similar manner to (VII).

The phenylfluorofurans probably arise by 1,2-addition of the carbene to the olefinic double bond followed by thermal



rearrangement of the adduct and loss of hydrogen fluoride. This is supported by the observation that when a solution of *trans*-1-benzoyl-2,2-difluoro-3-phenylcyclopropane (XI)⁹ in triglyme is heated under reflux for 1½ h 3-fluoro-2,5-diphenylfuran (XII), m.p. 66–66.5° (76%, 96% allowing for recovered starting material), is formed. This product was identified similarly to (VII), (IX), and (X); particularly important evidence was the u.v. spectrum, λ_{max} (EtOH) 228, 236sh, 311 (infl.), 319, 325, and 340sh nm. (log ϵ 4.26, 4.11, 4.50, 4.53, 4.57, and 4.33), which is similar to that reported for 2,5-diphenylfuran¹⁰ and unlike that for 2,4-diphenylfuran.¹⁰



Several polyfluorofurans have recently been described.⁷ These compounds rapidly decomposed. Furan (X), although initially colourless, becomes brown within a day and furan (XII) becomes yellow within a few days. The steroidal furans (VII) and (IX), however, show no sign of decomposition after several months.

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[†] No systematic attempts were made to maximise yields.

[‡] We thank Dr. R. A. W. Johnstone, University of Liverpool, for this measurement.

[§] We find that 2-phenylfuran has λ_{max} (EtOH) 218, 223sh, 272sh, 279, 290sh nm. (log ϵ 3.97, 3.91, 4.26, 4.28, 4.10).

[¶] Professor H. W ynberg kindly informs us that 3-phenylfuran has λ_{max} (96% EtOH) 253 nm (log ϵ 4.03).

¹ Ylides react with unsaturated systems to afford products formally derived by or *via* 1,4-addition, see *e.g.*, B. Holt and P. A. Lowe, *Tetrahedron Letters*, 1966, 683; H. G. Lehmann, *ibid.*, 1968, 607; T. A. Harris, C. M. Harris, and J. C. Cleary, *ibid.*, 1968, 1427; P. Bravo, G. Gaudiano, and A. Umani-Ronchi, *ibid.*, 1969, 679; and E. Breuer and D. Melumad, *ibid.*, 1969, 1875.

² P. Hodge, J. A. Edwards, and J. H. Fried, *Tetrahedron Letters*, 1966, 5175.

³ D. L. Storm and T. A. Spencer, *Tetrahedron Letters*, 1967, 1865. See also, T. A. Spencer, R. M. Villarica, D. L. Storm, T. D. Weaver, R. J. Friary, J. Posler, and P. R. Shafer, *J. Amer. Chem. Soc.*, 1967, **89**, 5497.

⁴ S. T. Murayama and T. A. Spencer, *Tetrahedron Letters*, 1969, 4479.

⁵ Compound (VI) was recovered unchanged after a solution in triglyme had been heated under reflux for 1 hr.

⁶ *E.g.*, C. Beard, B. Berkoz, N. H. Dyson, I. T. Harrison, P. Hodge, L. H. Kirkham, G. S. Lewis, D. Giannini, B. Lewis, J. A. Edwards, and J. H. Fried, *Tetrahedron*, 1969, **25**, 1219.

⁷ J. Burdon, G. E. Chivers, and J. C. Tatlow, *J. Chem. Soc. (C)*, 1970, 2146.

⁸ Similar fragmentations occur with other Δ^2 -steroids. See *e.g.*, ref. 2 and H. Budzikiewicz, C. Djerassi, and D. H. Williams in "Structure Elucidation of Natural Products by Mass Spectrometry," vol. 2, Holden-Day Inc., San Francisco, 1964, pp. 98–101.

⁹ M. Derenberg and P. Hodge, unpublished work.

¹⁰ S. M. King, C. R. Bauer, and R. E. Lutz, *J. Amer. Chem. Soc.*, 1951, **73**, 2253.