Irradiation of Diaryl Phosphates. A Potentially Useful New Reaction for the Preparation of Monoalkyl Phosphates

By RICHARD A. FINNEGAN* and JAMES A. MATSON

(Department of Medicinal Chemistry, School of Pharmacy, State University of New York at Buffalo, New York **14214)**

Summary U.v. irradiation of a series of simple dianisyl alkyl phosphates provided the corresponding monoalkyl phosphoric acids in excellent yields.

WE previously reported on a new photochemical coupling reaction of triaryl phosphate esters [equation (1)]. It was found that chemical and quantum yields of biaryl formation

$$(ArO)_3PO \xrightarrow{h\nu} Ar\text{–}Ar + ArOPO_3H_2 \qquad (1)$$

are enhanced by electron-donating substituents on the benzene rings, that alkyl groups are not involved in the coupling process, and that the reduction implicit in equation (1) is accompanied by oxidation of the solvent ethanol to acetaldehyde.[2] Although we were mainly interested in comparison of the coupling reaction with photodecarboxylation of aryl carboxylates,[3] it was clear that it could be used as a deblocking step in the preparation of phosphate monoalkyl esters [equation (2)].

$$(ArO)_2PO_2H + ROH \longrightarrow (ArO)_2PO_2R \xrightarrow{h\nu} Ar_2 + ROPO_3H_2 \qquad (2)$$

Table

Photolysis of dianisyl phosphates $(4\text{-}MeOC_6H_4O)_2PO_2R$

R	4,4′-Dimethoxy-biphenyl yield, %[a]	$ROPO_3H_2$ yield, %[b]
H (m.p. 94—96°)[c]	88 (66)	100
Et (b.p. 192—195° at 0·005 mm Hg)	81 (71)	90 (67, 83)
Pr^i (b.p. 155—160° at 0·0001 mm Hg)	100 (68)	99 (76, 61)
Bu (m.p. 47—48°)	100 (70)	91 (71, 46)
Cholesteryl (m.p. 109—110°)	93 (47)	96[d]

[a] Crude yield of crystalline material, identified by spectroscopic and t.l.c. comparisons with an authentic sample. Numbers in parentheses indicate yields of purified material (chromatography, recrystallization), m.p. 180—182° from ethyl acetate. [b] Yield is given of liquid product which had been dried azeotropically, which gave a negative test for inorganic phosphate (except the first entry), and was characterized spectroscopically. The numbers in parentheses represent, respectively, the yields of crystalline dicyclohexylammonium and mono anilinium salts. Satisfactory microanalytical data were obtained for the latter. [c] N.S. Corby, G. W. Kenner, and A. R. Todd, *J. Chem. Soc.*, 1952, 1234, m.p. 92—94°. [d] Yield of crude crystalline product. The yield of material purified by recrystallization from moist benzene, m.p. 181—183°, was 57% (H. A. C. Montgomery, J. H. Turnbull, and W. Wilson, *J. Chem. Soc.*, 1956, 4603 give m.p. 181°).

There have been many recent reports on methods for the preparation of phosphate monoesters,[4,5] often with particular application to new phosphate protecting groups in nucleotide synthesis.[6] Photochemical techniques[7] have included the irradiation of dibenzyl, 3,5-dimethoxybenzyl, and 3,5-dinitrophenyl phosphates. The *ortho*-nitrobenzyl group has also been used as a light-sensitive phosphate-protecting group.[8]

Preliminary results on the use of the aryl coupling reaction as a deblocking step are listed in the Table. While the isopropyl ester was prepared by condensing the alcohol with dianisyl phosphate using *NN′*-di-*p*-tolylcarbodi-imide, the others were derived by reaction of the appropriate alkyl phosphorodichloridate with sodium *p*-methoxyphenolate.† Ethanol solutions (*ca.* 5—10 M) were irradiated in quartz vessels for *ca.* 5 hours with a 450 W medium-pressure mercury arc lamp. The solutions were then evaporated and separated into neutral and acidic fractions. The neutral product was identified as 4,4′-dimethoxybiphenyl and the monoalkyl phosphates were obtained as syrupy liquids (except for crystalline cholesteryl phosphate) characterized spectroscopically and by the formation of crystalline derivatives.[5,9]

Although the 4-methoxyphenyl group is effective in promoting the photodeblocking of these simple phosphates, further work is planned with groups which absorb at longer wavelength and therefore are more likely to be applicable to the problem of nucleotide synthesis.

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† All new compounds were fully characterized spectroscopically and microanalytically.

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