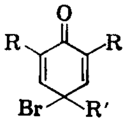
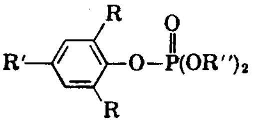
The Reactions of 4-Bromocyclohexadienones with Esters of Phosphorous Acids

Sir:

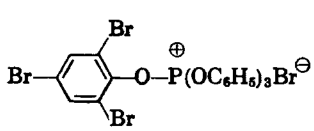
The reactions of quinones[1] and α-halocarbonyl compounds[2] with esters of phosphorous acid have recently attracted appreciable interest. We now wish to report that certain features of these two types of reactions have been combined to afford a novel synthetic route to the biologically active dialkyl aryl phosphates.

Dialkyl phosphonates react with 2,4,6-tribromo, 4-methyl-cyclohexadienone (Ia) in a manner similar to other reducing agents,[3] giving 2,6-dibromo, 4-methylphenol in high yield.





Ia. R = Br; R′ = CH_3 II a. R = Br; R′ = CH_3; R″ = Me
b. R = Cl; R′ = CH_3 b. R = Cl; R′ = CH_3; R″ = Et
c. R = R′ = Br c. R = R′ = Br; R″ = Et
d. R = Br; R′ = CH_3; R″ = Et



III

Trialkyl phosphites, however, react with Ia–c in benzene solution to give the dialkyl aryl phosphates IIa–d in quantitative yields. The reactions at room temperatures are apparently instantaneous, as judged by the disappearance of the yellow cyclohexadienone colors. Evaporation of the solvent leaves IIa–d in essentially pure states, as determined by comparisons of their vapor phase chromatograms with those of distilled products.

The structure of IId was confirmed by comparison of its infrared spectrum with that of a sample prepared by condensation of dry sodium 2,6-dibromo, 4-methyl phenoxide with *O,O*-diethylphosphorochloridate.

In contrast to the very rapid reactions of the 4-bromocyclohexadienones, neither 4-phenylamino, 2,6-dibromo, 4-methylcyclohexadienone nor 2,4,6-trimethyl, 6-acetoxy cyclohexadienone would react with trimethyl phosphite even on prolonged refluxing in benzene.

Triphenyl phosphite reacts with Ic to give the tetraäryloxy phosphonium salt III as a white, intensely hygroscopic solid which reacts rapidly with water or alcohols to give 2,4,6-tribromophenol and triphenyl phosphate.

Theoretical elementary analyses were obtained for all new compounds.

CHEMISTRY RESEARCH DEPT.
AGRICULTURAL DIVISION
AMERICAN CYANAMID CO.
STAMFORD, CONN.

BERNARD MILLER[4]

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(1) (a) F. Ramirez and S. Dershowitz, *J. Am. Chem. Soc.*, **78**, 5614 (1956). (b) F. Ramirez and S. Dershowitz, *J. Org. Chem.*, **22**, 857 (1957). (c) F. Ramirez and S. Dershowitz, **22**, 1282 (1957). (d) F. Ramirez, E. Chen, and S. Dershowitz, *J. Am. Chem. Soc.*, **81**, 4338 (1959). (e) B. A. Arbuzov, N. A. Polezhaeva, and V. S. Vinogradova, *Izvest. Akad. Nauk S.S.S.R. Otdel. Khim. Nauk.*, No. 7, 1219 (1960).

(2) See B. A. Arbuzov, V. S. Vinogradova, and M. A. Zvereva, *Izvest. Akad. Nauk S.S.S.R. Otdel Khim. Nauk.*, No. 10, 1772 (1960), for leading references.

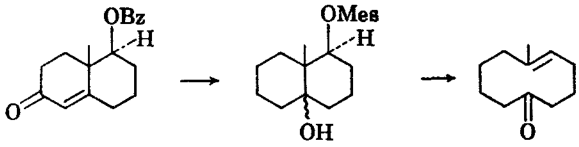
(3) K. Fries and G. Oehmke, *Ann.*, **462**, 1 (1928).

(4) Present Address: American Cyanamid Company, Agricultural Research Center, Princeton, N. J.

Stereospecific Synthesis of 6-Methyl-*trans*-5-cyclodecenone

Sir:

We wish to report the preparation of 6-methyl-*trans*-5-cyclodecenone (III) by a sequence of reactions which exemplifies an effective approach, of wide applicability, to the synthesis of various polyfunctional medium-sized carbocyclic ring systems of interest.[1] The key reaction of the sequence is the facile fragmentation of the 1,3-diol monomesylate II. Concomitantly, the ten-membered ring



I II III

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(1) The simplest systems, the *cis*- and *trans*-5-cyclodecenones and the corresponding alcohols have been synthesized and studied. See H. L. Goering and W. D. Closson, *J. Am. Chem. Soc.*, **83**, 3511 (1961), and ref. 9. See also D. J. Cram and L. K. Gaston, *J. Am. Chem. Soc.*, **82**, 6386 (1960). The more complex systems belong to a subgroup of the sesquiterpenes which continues to grow in number at a rapid rate. For leading references see the following: J. P. deVilliers, *J. Chem. Soc.*, 2049 (1961); J. Hochmannova, V. Herout, and F. Šorn, *Coll. Czech. Chem. Comm.*, **26**, 1826 (1961); M. Suchý, V. Herout, and F. Šorm, *Coll. Czech. Chem. Comm.*, **26**, 1358 (1961); M. Souček, V. Herout, and F. Šorm, *Coll. Czech. Chem. Comm.*, **26**, 803 (1961); D. H. R. Barton, O. C. Böckman, and P. de Mayo, *J. Chem. Soc.*, 2263 (1960); M. Suchý, V. Benešová, V. Herout, and F. Šorm, *Ber*, **93**, 2449 (1960); M. Suchý, V. Herout, and F. Šorm, *Coll. Czech. Chem. Comm.*, **24**, 1542 (1959); S. C. Bhattacharyya, G. R. Kelkar, and A. S. Rao, *Chem. & Ind.*, 1069 (1959); V. Herout and F. Šorm, *Chem. & Ind.*, 1067 (1959); S. Dev, *Tetrahedron*, **9**, 1 (1960); S. Dev, *Chem. & Ind.*, **8**, 171 (1960); M. Holub, V. Herout, M. Horák, and F Šorm, *Coll. Czech. Chem. Comm.*, **24**, 3730 (1959). For a summary of the above, see F. Šorm, *Pure and Applied Chem.*, **2**, 533 (1961).

is formed from its bicylic precursor and the *trans* double bond is introduced stereospecifically.[2]

Treatment of 8β-benzoyloxy-9β-methyl-Δ^4-3-octalone (I)[3] with alkaline hydrogen peroxide yielded 8β-benzoyloxy-9β-methyl-4,10ξ-epoxy-3-decalone (IV), m.p. 158–158.5° (found: C, 71.98; H, 6.66). Addition of hydrazine hydrate to a methanolic solution of IV containing a trace of acetic acid converted[4] IV to 8β-benzoyloxy-9β-methyl-Δ^3-10ξ-octalol (V), m.p. 116–117° (found: C, 75.18; H, 7.74), and subsequent hydrogenation gave 8β-benzoyloxy-9β-methyl-10ξ-decalol (VI), m.p. 119-120° (found: C, 75.31; H, 8.15). Without isolation of intermediate compounds VI was converted to III by successively (a) saponifying, (b) treating the crude decalindiol with one equivalent of methanesulfonyl chloride in pyridine, and (c) warming the crude monomesylate II with a solution of potassium *t*-butoxide in *t*-butanol.[5] The product was distilled at 0.1 mm. from an oil bath at 100° and yielded a colorless liquid which solidified on cooling, m.p. 18–21°. Analysis by gas chromatography[6] showed that a single sharp peak accounted for 97% of the total area corresponding to effluent. The preparation of an oxime, m.p. 132–134° (found: C, 72.92; H, 10.52; N, 7.80), confirmed the presence of the ketonic function observed in the infrared spectrum, $\lambda_{max}^{CCl_4}$ 5.86 μ. The formation of an unsaturated ten-membered ring was demonstrated by hydrogenation with platinum oxide in ethanol–acetic acid: oximation of the product yielded an oxime, m.p. 70–75°, in 25% yield, which, after several crystallizations from hexane, proved to be identical with the oxime prepared from authentic 6-methylcyclodecanone,[7] m.p. 82–83° (found: C, 72.10; H, 11.42). The NMR spectrum[8] of the unsaturated ketone confirmed the presence of the trisubstituted double bond $-CH{=}CCH_3-$ (bands with an area ratio of *ca.* 3:1 centered at 8.31 and 5.05 τ, respectively), the *trans* nature of which was evident from the photodesmotic transition[9] observed in the ultraviolet spectrum[10]; in 2,2,3,3-tetrafluoropropanol,[11] λ_{max} 227 mμ (ε 2750) and in methanol, λ_{max} 221 mμ (ε 3050).

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DEPARTMENT OF CHEMISTRY P. S. WHARTON
UNIVERSITY OF WISCONSIN
MADISON 6, WIS.

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(2) For a review of fragmentation reactions see C. A. Grob, *I.U.P.A.C. Kékulé Symposium*, Butterworths, London, 1959, p. 114. The fragmentation of 1,3-diol monotosylates is described by R. B. Clayton, H. B. Henbest, and M. Smith, *J. Chem. Soc.*, 1982 (1957), and implies a stereospecific relation of product to reactant. The observed formation of III (*trans* double bond) implies the stereochemistry of I as drawn, in agreement with that reasonably assumed on the basis of reduction of the corresponding 3,8-dione with lithium aluminum hydride and sodium borohydride. See ref. 3 and C. B. C. Boyce and J. S. Whitehurst, *J. Chem. Soc.*, 2680 (1960). It is interesting to consider the possibility that fragmentation is of significance in the biogenesis of medium-sized ring sesquiterpenes. At least, this is an attractive speculation to add to two others which are widely held: that medium-sized ring sesquiterpenes (1) arise by direct cyclization of a farnesol-type precursor, and (2) are of significance in general sesquiterpene biogenesis. See L. Ruzicka, *Proc. Chem. Soc.*, 341 (1959) and *Experientia*, **9**, 357 (1953); J. B. Hendrickson, *Tetrahedron*, **7**, 82 (1959); D. H. R. Barton and P. de Mayo, *Quart. Rev.*, **11**, 189 (1957).

(3) F. Sondheimer and D. Elad, *J. Am. Chem. Soc.*, **79**, 5542 (1957).

(4) This is a further example of a new synthetic method described by P. S. Wharton and D. H. Bohlen, *J. Org. Chem.*, **26**, 3615 (1961).

(5) The fragmentation of II to III could also be effected under solvolytic conditions in aqueous pyridine containing acetic acid.

(6) A four-foot column of 0.5% polyethylene glycol (average m. wt. 4000) on 60–80 mesh glass beads was used in conjunction with an ionization detector.

(7) V. Prelog and W. Küng, *Helv. Chim. Acta*, **39**, 1394 (1956).

(8) The spectrum of a solution *ca.* 10% in carbon tetrachloride containing tetramethylsilane was recorded on a Varian 60 mc. spectrometer.

(9) E. M. Kosower, W. D. Closson, H. L. Goering, and J. C. Gross, *J. Am. Chem. Soc.*, **83**, 2013 (1961).

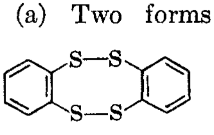
(10) The ultraviolet spectra were recorded on a Cary spectrophotometer, Model 14M, using 1 mm. cells.

(11) We are grateful to Dr. Kosower for supplying this spectroscopic-grade reagent.

Organic Disulfides and Related Substances. V. The Eight-Membered Ring System Bis(*o*-phenylene) Tetrasulfide[1,2]

Sir:

Bis(*o*-phenylene) tetrasulfide (I) is of interest for several reasons: (a) Two forms are possible,



I

a rigid *anti* form (I_A) with the benzene rings on opposite sides of the plane of the sulfur atoms and a *syn* form (I_{S_1}) with the rings on the same side; I_{S_1} may exist in a conformation (I_{S_2}) with mutually perpendicular benzene rings. The stereoisomerism of I is interesting *per se*, but particularly in its probable connection with orbital dispositions about the sulfur atoms. (b) Both the isosterism of sulfur with carbon-carbon double bonds and the electron swarm about the sulfur atoms imply interesting properties. (c) Ring-ring interactions are possible in I_{S_1}.

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(1) Dibenzo[c,g][1,2,5,6]tetrathiocin.

(2) Research supported by the Office of Ordnance Research, U. S. Army. Taken mainly from the Ph.D. dissertation of W.D.S., Vanderbilt University, 1960. Paper IV, L. Field, T. C. Owen, R. R. Crenshaw, and A. W. Bryan, *J. Am. Chem. Soc.*, *in press*.