of concentrated hydrochloric acid was added, and the product crystallized; 31 g. (66%), m.p. 242–243°.

Compound 139 was obtained in a similar manner.

p-**Bromoglycolanilide** (Compound 46).—A solution of 10.0 g. (0.066 mole) of glycolanilide (compound 26) in 125 ml. of water was maintained at 70° while treated under vigorous stirring with bromine water until a slight excess of bromine remained. The excess bromine was removed with sodium bisulfite and the product separated: 14.3 g. (94%), m.p. 169–171°.

Compound 126 was prepared in a similar manner.

N-β-Phenethyl-*dl*-pantoamide was prepared by the method of Shive and Snell,[23] in 82% yield, m.p. 92–93° (ethyl acetate–hexane).

N-Benzyl-*dl*-pantoamide was prepared in the same manner in 74% yield, m.p. 79–81° (ethyl acetate–hexane).

Anal. Calcd. for $C_{13}H_{19}NO_3$: C, 65.8; H, 8.1. Found: C, 66.2; H, 7.9.

N-Isobutyl-γ-hydroxybutyramide.—A solution of 20 g. (0.232 mole) of γ-butyrolactone and 20 g. (0.273 mole) of isobutylamine was heated slowly to 95–100° and maintained at that temperature for 3 hours. Volatiles were removed at 100° (0.2 mm.). The yield of residue was 36.5 g. (100%) and the *p*H of an aqueous solution was about 5. There were indications that the material decomposes on distillation and the analysis was run on the residue.

Anal. Calcd. for $C_8H_{17}NO_2$: C, 60.4; H, 10.8; N, 8.8. Found: C, 60.2; H, 10.9; N, 8.7.

N-Isobutyl-γ-hydroxyvaleramide was prepared as above using γ-valerolactone.

(23) W. Shive and E. E. Snell, *J. Biol. Chem.*, **160**, 287 (1945); m.p. 90–91°.

Anal. Calcd. for $C_9H_{19}NO_2$: C, 62.4; H, 11.1; N, 8.1. Found: C, 62.7; H, 11.4; N, 7.9.

Carbonate Esters of α-Hydroxyamides (General Procedure).—To a solution of 0.1 mole of the α-hydroxyamide in 10 ml. of pyridine and 60 ml. of acetonitrile, 0.11 mole of the alkyl (or haloalkyl) chloroformate was added slowly with continued stirring, and cooling (below 15°). After storage at 20° for 2 hours, the reaction mixture was transferred to an open dish and the volatiles evaporated. The solid residue was triturated with dilute hydrochloric acid, then water, filtered, dried and recrystallized.

Under these reaction conditions the attempted preparation of carbonate esters of the α-hydroxy-isobutyramides failed and the reactant amide was recovered.

N,N-Tetramethylenecarbamate of *p*-Bromoglycolanilide (Compound 49).—To 1.0 g. (0.003 mole) of compound 48 in 10 ml. of acetone was added 1.0 ml. of pyrrolidine and the slowly darkening solution stored at 20° for 20 hours. The acetone was removed, the residue was dissolved in benzene and washed with dilute hydrochloric acid, then water. The benzene solution was filtered (charcoal), the benzene removed, and the residue, granulated under hexane, gave 0.75 g. of product which was recrystallized.

Acknowledgment.—The authors are indebted to Dr. G. Ungar and his staff for the pharmacological results herein reported, to E. Roskin, J. Hinchen and F. Testa for technical assistance and to M. Blitz and his associates for the ultraviolet absorption data.

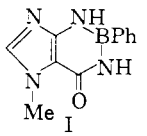
YONKERS 1, N. Y.

COMMUNICATIONS TO THE EDITOR

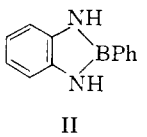
A BORON-CONTAINING PURINE ANALOG

Sir:

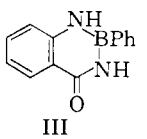
The preparation of boron compounds which might be of use in the treatment of cancer is of current interest.[1] An obvious class of such compounds would be purine analogs containing boron in the ring. We wish to report the first preparation of such a compound (I).



I



II



III

The possibility of preparing stable compounds of this type was indicated by recent syntheses of heterocyclic boron compounds, in particular (II), which seemed to show aromatic properties.[2] In an extension of this work we first prepared the quinazolone analog (III) from *o*-aminobenzamide, either with phenylboron dichloride in benzene (20% yield), or by heating with dibutyl phenylboronate and removing butanol (63% yield). (III) crystallized from benzene in small plates, m.p. 210–211°. *Anal.* Calcd. for $C_{13}H_{11}N_2OB$: C, 70.27; H, 4.95; N, 12.61; B, 5.0; mol. wt., 222. Found: C, 70.22; H, 4.86; N, 12.68; B, 5.1; mol. wt., 213. Solutions of (III) in ethanol showed an ultraviolet spectrum with peaks at 260 mμ (log ε, 3.84) and 314 mμ (log ε, 3.4). The infrared spectrum of the solid showed the presence of a CO group, but not OH, supporting the lactam formulation (III). The alcoholic solution of (III) was not stable; after a few hours the ultraviolet spectrum became identical with that of a mixture of *o*-aminobenzamide and phenylboronic anhydride.

Analogous condensation of 4-amino-1-methyl-5-imidazolecarboxamide[3] with dibutyl phenylboronate gave a solid (62% yield) which appeared to be the purine analog (I). It crystallized with difficulty from ethanol and sublimed without melting at *ca.* 300°. *Anal.* Calcd. for $C_{11}H_{11}N_4OB$: C, 58.41; H, 4.87; N, 24.78; B, 4.9. Found: C, 58.40; H, 4.78; N, 24.66; B, 4.9. Owing to the insolubility of the compound its molecular weight could not be determined. For the same reason the ultraviolet spectrum could be studied only in alcohol, where under all conditions it was identical with that of an equimolecular mixture of the imidazolecarboxamide and phenylboronic anhydride. The structure of (I) is established by its method of preparation, analogy with (III), analysis, and infrared spectrum (different from that of a mixture of the imidazolecarboxamide and phenylboronic anhydride, notably in the loss of the NH_2 and BO bands).

The solvolysis of (I) is reversible. On mixing concentrated alcoholic solutions of the imidazole carboxamide and phenylboronic anhydride (effectively diethyl phenylboronate), (I) crystallized in 97% yield. This novel synthesis was extended to (II) (35% yield) and (III) (82% yield).

(1) E. Nyilas and A. H. Soloway, THIS JOURNAL, **81**, 2681 (1959).

(2) M. J. S. Dewar, V. P. Kubba and R. Pettit, *J. Chem. Soc.*, 3076 (1958).

(3) J. Sarasin and W. E. Wegmann, *Helv. Chim. Acta*, **7**, 713 (1924).

Work on these and related compounds is continuing. We wish to thank British Petroleum for a Fellowship (to P.M.M.) and D.S.I.R. for a studentship (to S.S.C.).

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RECEIVED OCTOBER 21, 1959

PHOTOSENSITIZED OXYGENATION OF MONO-OLEFINS

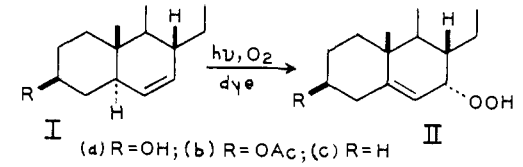
Sir:

Oxidations of olefins with molecular oxygen conducted photochemically in the presence of a sensitizing dye are proving most useful in synthetic work.[1] With mono-olefins Schenck, *et al.*, have established that the initial products are hydroperoxides and that the double bond always undergoes an allylic shift during the process.[1] We have studied the geometric requirements of photosensitized oxidations and have found that the reaction (a) is stereospecific, (b) is markedly subject to steric hindrance, (c) may have specific conformational (*i.e.*, stereoelectronic) requirements.

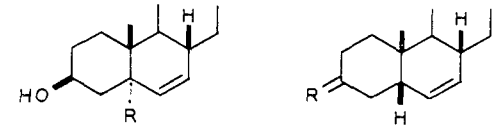
Photochemical oxygenation of various Δ^6-cholestenes (Ia,b,c,) in pyridine in the presence of hematoporphyrin gave the corresponding Δ^5-cholestene-7α-hydroperoxides (II), but no isolable amounts of the 7β-epimers.[2] For characterization the hydroperoxides were reduced without purification to the known allylic alcohols, which were identified as such and by conversion to known benzoates. As a typical result: Ia gave Δ^5-cholestene-3β,7α-diol (*ca.* 60% isolated), some $\Delta^{3,5}$-cholestadien-7-one (*ca.* 5–10%), and some starting material (*ca.* 5–10%). In one case (IIb) the hydroperoxide was isolated separately and purified. Similar oxygenation of cholesterol-7α-*d* gave us 3β-hydroxy-5α-hydroperoxy-Δ^6-cholestene[1] (IIIa) that retained only 8.5% of the original deuterium, whereas cholesterol-7β-*d* gave IIIa that retained 95% of the original deuterium.[3] We conclude that in hydroperoxide formation the new C–O bond bears a *cis* relationship to the C–H bond that suffers cleavage.

The effect of steric blocking is exemplified with 3β,5α-dihydroxy-Δ^6-cholestene (IIIb), which we find is largely unchanged even on prolonged photosensitized oxygenation.

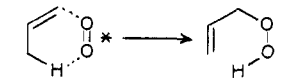
The operation of a conformational factor is suggested by studies with Δ^6-coprosten-3-one (VI) and Δ^6-coprostene (VII), where the β-hydrogen at C-5 is *quasi*-equatorial on the (non-flexible) B ring. Peracid epoxidation of $\Delta^{4,6}$-cholestadien-3-one gave Δ^4-cholesten-3-one-6,7-epoxide (IV), hydrogenated at −27° (Pd/C) to coprostan-3-one-6,7-epoxide (V). Treatment with HBr, then acetylation and the action of zinc gave VI, which provided VII on Wolff–Kishner reduction. For characterization VI and VII were hydrogenated



I (a) R=OH; (b) R=OAc; (c) R=H II



III (a) R=OOH (b) R=OH VI R=O VII R=H2



to coprostan-3-one and to coprostane, respectively. Both VI and VII proved inert to photosensitized oxygenation even on prolonged treatment.

Our findings suggest a cyclic mechanism (concerted or not) for the olefin–oxygen combination, after the system has been suitably energized. The reaction is of special interest as a possible pathway for biological oxidations, particularly in plants, and may even represent a pathway for non-photochemical processes where the reactants can be activated enzymatically.

Constants[4] for the new compounds mentioned are: IIb m.p. 142–142.5°; α−137°; λ(chf) 3540, 3300 cm.$^{-1}$. IV m.p. 138.5–139°; α−59° λ 1684, 1621, 870 cm.$^{-1}$; λ (EtOH) 241 mμ (ϵ 12,010). V, m.p. 122–123°; α−46°; λ 1724, 892 cm.$^{-1}$. VI, m.p. 109–110°; α−52°; λ 1727; 1656 cm.$^{-1}$. VII, m.p. 44–45°; α−7°; λ 1647 cm.$^{-1}$.

(1) See G. O. Schenck, *Angew. Chem.*, **69**, 579 (1957), for a review and leading references.

(2) Mother liquors also were thoroughly investigated.

(3) The deuterated cholesterols were kindly provided by Dr. E. J. Corey.

(4) Optical rotations in chloroform; infrared spectra in CS_2. All compounds gave satisfactory C and H analyses.

(5) This work was supported by the National Science Foundation and by the Alfred P. Sloan Foundation.

(6) Alfred P. Sloan Foundation Fellow.

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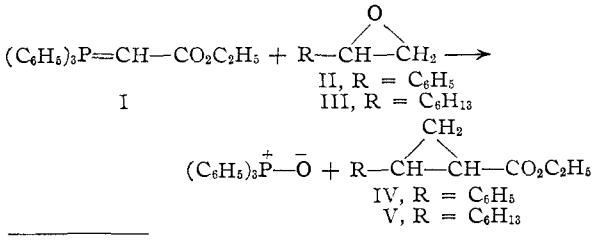
RECEIVED OCTOBER 7, 1959

FORMATION OF CYCLOPROPANES FROM PHOSPHORANES AND EPOXIDES[1]

Sir:

The phosphorane (I) reacts with styrene oxide (II) at 190–200° to yield triphenylphosphine oxide (90%) and ethyl *trans*-2-phenylcyclopropane carboxylate (IV) (21%), b.p. 100–103° at 0.5 mm. (reported[2] 103–105° at 0.5–0.7 mm.). The ultraviolet absorption spectrum of IV agreed with that in the literature.[3] Alkaline hydrolysis afforded the *trans*-acid, m.p. 90–91° (reported[3] 92–93°). The



(1) Supported by the National Science Foundation.

(2) A. Burger and W. L. Yost, THIS JOURNAL, **70**, 2198 (1948).

(3) E. N. Trachtenberg and G. Odian, *ibid.*, **80**, 4015 (1958).