on Magnesol–Celite under such developmental conditions that monosaccharide derivatives were removed from the column. β-D-Glucose pentaacetate was identified in the effluent and β-D-maltose octaacetate in the bottom zone (identifications by melting point, mixed melting point and rotation). The next higher zone was twice rechromatographed in the same manner and the eluent which crystallized from ethanol was identified as β-D-isomaltose octaacetate (m. p. 144–145°, unchanged on admixture with an authentic specimen; $[\alpha]^{25}\text{D} +96°$, $c$ 2.0, chloroform); yield 50 mg.

Repetition of the previously described procedure[4] with the substitution of corn amylose for animal glycogen, failed to yield any β-D-isomaltose octaacetate by chromatography.

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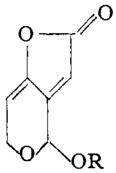
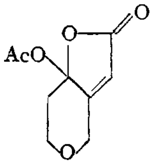
## THE SYNTHESIS OF PATULIN

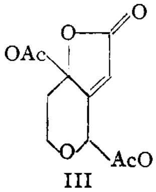
*Sir:*

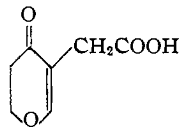
We have reported elsewhere[1,2] the considerations which led us to propose the structure (I, R = H) for patulin. The evidence now available[1,2,3,4] in favor of that expression may be regarded as conclusive. A partial synthesis of the antibiotic has already been achieved.[4] We now wish to record the total synthesis of patulin.


I


II

The lactol acetate (II)[1] in carbon tetrachloride in the presence of a trace of benzoyl peroxide rapidly consumed one mole of N-bromosuccinimide. When the crude bromination product was taken up in acetic acid and treated with silver acetate, the diacetate (III) m. p. 142–143° (Calcd. for $C_{11}H_{12}O_7$: C, 51.56; H, 4.69. Found: C, 51.91; H, 4.80), was formed. The structure of the diacetate was confirmed through its conversion, by hydrogenation over reduced platinum oxide in pure dioxane followed by hydrolysis with warm hydrochloric acid, to **desoxypatulinic acid (IV)**.[4]


III


IV

Treatment of the pure diacetate (III) for a short time with warm acetic anhydride–acetic acid–sulfuric acid[1] gave a complex mixture of substances from which patulin acetate (I, R = Ac) was readily isolated in 1–2% yield by taking advantage of the fact that in ethereal solution it traveled more rapidly through a column of Brockmann alumina than its congeners. The pure synthetic acetate melted at 114–116°, alone or in admixture with the acetate (m. p. 115–116.5°) from natural patulin. The ultraviolet ($\lambda_{\text{max.}}$ 277 m$\mu$) and infrared spectra of the synthetic and natural samples were identical. The ready hydrolysis of patulin acetate to patulin is well known.[5]

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[1] Woodward and Singh, THIS JOURNAL, **71**, 758 (1949).

[2] Woodward and Singh, *Experientia*, in press.

[3] Dauben and Weisenborn, THIS JOURNAL, **71**, 3853 (1949).

[4] Woodward and Singh, *Nature*, in press.

[5] *Cf.* Bergel, Morrison, Moss and Rinderknecht, *J. Chem. Soc.*, 418 (1944).

## ON THE MECHANISM OF OXIDATION OF INDOLE COMPOUNDS[1,2]

*Sir:*

Perbenzoic acid cleaves indole compounds[3] in the same way as ozone,[4] or, in some cases, peracetic acid.[5] It was possible to isolate as an intermediate in these reactions derivatives of β-hydroxyindolenines in the case of some natural products in which internal addition to the reactive C=N bond blocked further oxidation.[6]

In accordance with this view 11-hydroxytetrahydrocarbazolenine (I)[7] reacted smoothly with perbenzoic acid to yield the 9-membered cyclic lactam II (magnificent, slightly yellow prisms from ethyl acetate, m. p. 157°. *Anal.* Calcd. for $C_{12}H_{13}O_2N$: C, 70.94; H, 6.40; N, 6.9. Found: C, 71.05; H, 6.76; N, 6.8). II was also obtained from 11-hydroperoxytetrahydrocarbazolenine[8] (III) by a rearrangement that was almost quantitative under neutral or slightly acidic conditions. The change in the latter case seems to be analogous to some peroxide rearrangements involving intermediate cationoid oxygen.[9,10] The kinetic evaluation of this interesting rearrangement is in progress. Under the action of cold 2 *N* aqueous alkali on II, the initially yellow solution (salt of the enol of II) became slightly warm and then decolorized.

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[1] This investigation was supported by a grant-in-aid from Research Corporation, New York.

[2] Directed Oxidations in the Indole Series. IV.

[3] Witkop and Fiedler, *Ann.*, **558**, 91 (1947).

[4] Witkop, *ibid.*, **556**, 103 (1944).

[5] Witkop, *ibid.*, **558**, 98 (1947).

[6] Witkop, in preparation.

[7] Patrick and Witkop, THIS JOURNAL, **72**, 633 (1950).

[8] *Cf.* Beer, McGrath, Robertson and Woodier, *Nature*, **164**, 362 (1949).

[9] Criegee, *Ann.*, **560**, 127 (1948).

[10] Leffler, *Chem. Reviews*, **45**, 385 (1949).