TABLE II

EFFECT OF FOREIGN GASES ON PHOTOISOMERIZATION OF *m*-XYLENE[a]

Added gas	None	N_2	O_2	O_2	C_2H_4
Pressure, mm.		100	100	9	2.4
Isomer	Yield, %				
p-	4.10	2.81	0.83	2.16	4.12
o-	1.09	0.81	0.29	0.63	1.14
m- (recovered)	85.5	91.6	84.8	85.4	86.9

[a] Irradiated for 30 min. under condition *b* of Table I.

effect of oxygen at 9 mm. pressure argues against the participation of methyl radicals.[7] The fact that isomerization is independent of the intensity supports the conclusion that it does not occur by radical recombination and also rules out reactions between excited molecules.

The results of Table II do not permit an unambiguous choice between singlet and triplet as the excited state leading to isomerization, since little is known about the lifetimes of these states in xylene vapor. The inhibition by oxygen, however, appears to be more consistent with a singlet state. It cannot be due simply to collisional deactivation, since the effect of nitrogen at the same pressure is much smaller. The magnitude of the effect with oxygen at 9 mm. is comparable to that observed[8] for quenching of fluorescence in benzene vapor, and oxygen is known[9] to quench the fluorescence of xylene in solution. A much larger inhibition would be expected if a triplet were involved unless it has a lifetime much shorter than that of benzene triplet[8] or is quenched less efficiently by O_2 than the triplets of other aromatic hydrocarbons.[10]

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RECEIVED APRIL 13, 1964

The Nature of Vitamin B_{12s}

Sir:

The power of vitamin B_{12s}[1] (hydridocobalamin) as a reductant and the analogy which can be drawn between it and $HCo^{III}(CN)_5^{-3}$ have led to the supposition that this compound may contain a cobalt–hydrogen bond.[2,3] We report herein experiments which cast considerable doubt on this supposition, and which are consistent with the postulation of the cobalt atom itself as the electron acceptor in the reduction of vitamin B_{12} to vitamin B_{12s}. The experimental method consisted in forming B_{12s} in a deuterium-rich medium and testing for incorporation of deuterium as deuteride in the product by examination of the hydrogen produced upon acidification of the product.

Vitamin B_{12s} was produced by reduction of cyanocobalamin (Sigma Chemical Co.) by zinc dust in 10 ml. portions of 99.5% D_2O, after equilibrating the starting material with D_2O. As the electrolyte in this reduction, warm 0.02 *M* NaOD served equally as well as the 10% NH_4Cl previously used.[2] The amount of cyanocobalamin taken in these experiments was necessarily small in comparison to the amount of water used. Because the usual isotope effect would favor the production of hydridocobalamin over deuteridocobalamin in this situation, the zinc was left in contact with the starting solutions for at least 24 hr. Thus, the cyclic formation of B_{12s} and its oxidation by water,[4] the side reaction of zinc with water over the long period, and the small ratio of protium to deuterium in the water should have favored formation of deuteridocobalamin, if B_{12s} were indeed a hydride.

TABLE I

DECOMPOSITION OF VITAMIN B_{12s}

Expt.	Cor. wt. of B_{12} taken, mg.	Reduction medium	Vol. of H_2 evolved, STP	$[H_2]/[HD]$
I	49.0	0.02 *M* NaOD	0.34	140
II	49.0	1% ND_4Cl[a]	0.55	>60
III	49.0	1% ND_4Cl	0.44	30

[a] Five milliliters of 0.48 *M* NaOD added immediately before filtration.

After the zinc reduction the solution of B_{12s} was drawn through a sintered glass filter disk into a bulb where it was evaporated to dryness under vacuum. In experiment II (Table I) the solution was made alkaline with 5 ml. of deaerated 0.48 *M* NaOD before filtering to ensure the stability of the B_{12s} during evaporation. In experiment III this precaution was omitted, and by freezing the solution immediately after transfer and subliming D_2O from the frozen mixture, decomposition of B_{12s} at the pH of ND_4Cl was avoided. The solids left in all experiments had the same color as the B_{12s} solutions.

Pure 0.5 *M* HCl in H_2O, deaerated by saturation with CO_2, was then added to the solid, whereupon the mixture immediately assumed the brown color of vitamin B_{12r}, and gas was evolved. The gas was freed of condensable material by passage through liquid nitrogen traps and was collected in a gas buret. It was semiquantitatively analyzed by mass spectrometry and found to contain hydrogen with no significant amount of deuterium, as shown in Table I. We attribute the HD formed in these experiments, which represents at most only a few per cent of the reducing power of the B_{12s} on the basis of the amount of hydrogen it yielded, to traces of water of hydration retained in the solid. These results indicate no incorporation of hydrogen as hydride into the vitamin B_{12s} molecule when the latter is formed by reduction with zinc in aqueous solution.

The formulation of vitamin B_{12s} as a compound of cobalt(I) is consistent with the results of these experiments and with its known reactions with electrophilic reagents.[2,5] If, as has been suggested,[6] vitamin B_{12s} consists of an equilibrium mixture of the two forms, $Co^{III}H^-$ and $Co^{I}H^+$, the equilibrium must largely favor the $Co^{I}H^+$ form, which must also react faster than the hydride; otherwise, we should have found HD rather than hydrogen in the reaction

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studied. It remains to be shown whether the postulated hydride form of vitamin B_{12s} has any existence at all, even at low concentration as a component of an equilibrium.

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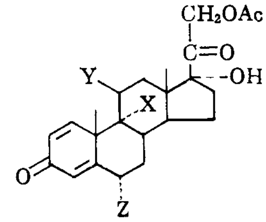
A Novel Steroid Aromatization Reaction

Sir:

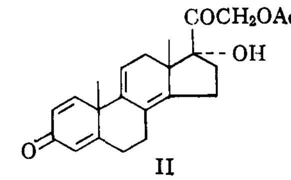
Apart from total synthetic methods,[1] ring AB aromatic steroids have been prepared by (a) palladium–carbon-catalyzed dehydrogenation of a ring A[2,3] or B[3] aromatic precursor, (b) acid elimination of an allylic hydroxyl group in a ring A aromatic compound with subsequent rearrangement of double bonds,[4] and (c) pyrolysis of a $\Delta^{1,4,6}$-triene followed by selenium dioxide dehydrogenation.[5] We now wish to report the partial synthesis of ring AB aromatic steroids from nonaromatic intermediates by a new ionic method[6] with elimination of the C-19 methyl group. This method, moreover, provides a means of preparing ring AB aromatic steroids with a variety of C-17 substituents, such as the dihydroxyacetone moiety.

When 21-acetoxy-9α,11β-dichloro-17α-hydroxypregna-1,4-diene-3,20-dione (Ia)[7] was refluxed in dimethylformamide for 0.5 hr., or in pyridine for at least 6 hr., two major products resulted, each in 20–25% yield. One product was assigned the structure 21-acetoxy-17α-hydroxypregna-1,4,8(14),9(11)-tetraene-3,20-dione (II),[8] m.p. 249–252°; λ_{max}^{MeOH} 241 mμ (ϵ 18,900); n.m.r. ($SiMe_4$): 5.72 p.p.m. (C-11 vinyl H); maleic anhydride adduct, m.p. 230–237°. The other product was assigned the structure 21-acetoxy-3,17α-dihydroxy-19-norpregna-1,3,5(10),6,8-pentaen-20-one (IIIa), λ_{max}^{MeOH} 230, 270, 280, 292, 327, and 341 mμ (ϵ 66,000, 4780, 5520, 3980, 2280, and 2650, respectively). The n.m.r. spectrum of the corresponding 3,17-diacetate IIIb showed signals for methyl groups at 0.58 p.p.m. (C-18 methyl) and at 2.22 and 2.39 p.p.m. (acetate methyl).

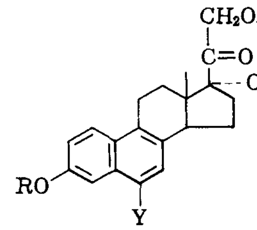
Similarly, 21-acetoxy-9α,11β-dichloro-6α-fluoro-17α-hydroxypregna-1,4-diene-3,20-dione (Ib)[9] in di-



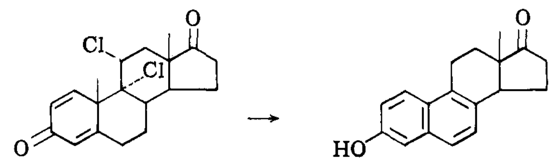
Ia, X = Y = Cl; Z = H
Ib, X = Y = Cl; Z = F
Ic, X = Y = Cl; Z = CH_3
Id, X = Br; Y = OH; Z = H



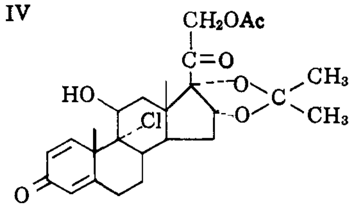
II



IIIa, R = Y = H
IIIb, R = Ac; Y = H
IIIc, R = Ac; Y = F
IIId, R = Ac; Y = CH_3



IV V



VI

methylformamide was refluxed for 0.5 hr., and the crude product was acetylated to give 3,21-diacetoxy-6-fluoro-17α-hydroxy-19-norpregna-1,3,5(10),6,8-pentaen-20-one (IIIc). In addition, 21-acetoxy-9α,11β-dichloro-17α-hydroxy-6α-methylpregna-1,4-diene-3,20-dione (Ic)[11] was converted into 3,21-diacetoxy-17α-hydroxy-6-methyl-19-norpregna-1,3,5(10),6,8-pentaen-20-one (IIId), characterized as the 3,17α,21-triol IIIe.

Definitive proof of the aromatic system generated by this rearrangement was provided by treatment of 9α,11β-dichloroandrosta-1,4-diene-3,17-dione (IV)[7] in refluxing dimethylformamide which gave equilenin (V).[12]

A further investigation revealed that 21-acetoxy-9α-bromo-11β,17α-dihydroxypregna-1,4-diene-3,20-dione (Id)[13] with dimethylformamide gave IIIa. Also, 21-acetoxy-9α-chloro-11β-hydroxy-16α,17α-isopropylidenedioxypregna-1.4-diene-3,20-dione (VI) yielded the corresponding 19-norpregna-1,3,5(10),6,8-pentaene.

The fate of the C-19 methyl group was established by gas chromatographic analysis which showed that methyl chloride was evolved during the aromatization of the 9α,11β-dichloro-1,4-diene Ia. Methyl bromide was obtained from the bromohydrin Id. These ob-

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(8) Satisfactory analytical data were obtained for all new compounds prepared. The assigned structures were also supported by infrared spectral data and, in the case of the tetraene II, by mass spectrometric analysis.

(9) Compound Ib was prepared by N-chlorosuccinimide–lithium chloride–acetic acid treatment[7] of 21-acetoxy-6α-fluoro-17α-hydroxypregna-1,4,9(11)-triene-3,20-dione.[10]

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(12) We wish to thank Dr. T. F. Gallagher for providing us with an authentic sample of equilenin for infrared spectral comparison.

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