

RESEARCH LABORATORIES
CHAS. PFIZER AND CO., INC.
BROOKLYN 6, N. Y.

F. A. HOCHSTEIN
C. R. STEPHENS
L. H. CONOVER
P. P. REGNA
R. PASTERNAK
K. J. BRUNINGS

CONVERSE LABORATORY
HARVARD UNIVERSITY
CAMBRIDGE, MASS.

R. B. WOODWARD

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THE EXCHANGE OF VANADIUM(II) AND VANADIUM(III) IONS IN PERCHLORIC AND SULFURIC ACID SOLUTIONS

Sir:

The successful rate measurement¹ of the rapid electron-transfer exchange reaction between iron(II) and iron(III) ions in perchloric acid solutions with the aid of a separation based on formation of a stable complex between α, α' -dipyridyl (dipy) and iron(II) ions has led us to examine exchange in the similar vanadium(II)-vanadium(III) system with this same separating reagent and also with a cation-exchange-resin separation. Vanadium(II) and vanadium(III) ions in 1 *f* perchloric acid appear to exist predominantly as the hydrated V^{++} and V^{+++} ions, respectively. The hydrolysis constant² of the latter is such that only *ca.* 0.1% of the vanadium(III) should be in hydrolyzed forms, principally as hydrated VOH^{++} ion. Consequently, this system appears satisfactory for examination with respect to a possible electron-transfer exchange reaction.

Solutions of vanadium(II) perchlorate (or sulfate) and labeled vanadium(III) perchlorate (or sulfate) were mixed in the appropriate acid, aliquots removed at definite time intervals, the two oxidation states separated, and the specific activities of both fractions determined by counting the solutions in a reproducible geometry with a dipping Geiger-Mueller tube and determining total vanadium by oxidation to the +5 state, followed by reduction to the +4 state with sulfite ion and titration of the vanadium(IV) with standardized potassium permanganate. The chloride-ion concentration was less than 1×10^{-5} *f* in most of the runs; in one run it was as high as 0.02 *f*. Because vanadium(II) and vanadium(III) in aqueous solution are both easily oxidized by air, all experiments were carried out in a reaction vessel under nitrogen freed from oxygen by passage through a chromium(II) chloride solution, and all preparations and transfers were handled similarly. Oxidation of the vanadium species during an exchange run was found to be entirely negligible. All but two runs were made at 2° in the absence of light.

The vanadium(II) solutions were made in some cases by electrolytic reduction of vanadium(V) oxide suspended in perchloric (or sulfuric) acid and in others by reduction of vanadium(IV) perchlorate

(or sulfate) solutions at 0.5° with a Jones reductor; a stoichiometric concentration of zinc ions was present during the exchange runs in the latter case. The vanadium(III) solutions were prepared by mixing equivalent amounts of standardized vanadium(IV) and vanadium(II) stock solutions, which react rapidly and completely to produce vanadium(III). The tracer used was 16-day V^{48} produced on the U.C.L.A. cyclotron by $Ti(p, xn)$ reactions and radiochemically purified; the purity was checked by half-life measurements.

Separation with dipy was achieved by running the exchange mixture into dipy in 50% ethanol, forming the green tris(dipy)vanadium(II) ion, then precipitating the vanadium(III), which apparently remains uncomplexed, by addition of ammonium hydroxide or ammonium fluoride solutions. Separation with a cation-exchange resin (250-500-mesh Ion-X) was effected by eluting the vanadium(II) from the resin column with 2 *f* perchloric acid. Vanadium(III) was subsequently eluted with 5 *f* perchloric acid. Both separation methods were quantitative.

TABLE I

V(II)-V(III) EXCHANGE, 1.0-1.2 *f* $HClO_4$, 2°, DARK RUNS

Sepr. method	$[V(ClO_4)_2]$, <i>f</i>	$[V(ClO_4)_3]$, <i>f</i>	Exch. time, min.	% exch.
Dipy	0.072	0.144	1	100 ± 7
Ion exch.	.072	.144	3	99 ± 7
	.072	.144	5	104 ± 7 ^a
	.071	.039	4	120 ± 15 ^a
	.063 ^b	.126 ^b	3	112 ± 7

^a At 25°, in laboratory lighting. ^b Sulfates, in 0.86 *f* H_2SO_4 .

From the average results of duplicate runs given in Table I one sees that the exchange appears to be complete within the one- to five-minute interval required to get the exchange mixture into the dipy reagent or onto the resin column (the over-all time for each separation was five to ten minutes).

In order to check the possibility that the rapid apparent exchange with the dipy separation is a result of exchange between tris-(dipy)-vanadium(II) and vanadium(III) ions during the separation, exchange between these species was investigated at 25° in ordinary laboratory lighting, using the perchlorates with excess dipy present. Separation was brought about by the addition of ammonium hydroxide to precipitate the vanadium(III), followed by centrifugation, all within ten minutes total time. The results are shown in Table II.

TABLE II

TRIS-(DIPY)-V(II)-V(III) EXCHANGE, 0.5 *f* $HClO_4$, 25°

$[V(dipy)_3^{++}]$, <i>f</i>	$[V(ClO_4)_3]$, <i>f</i>	Exch. time, min.	% exch.
0.017	0.034	0.4	44 ± 4
.017	.034	1	15 ± 1
.017	.034	10	43 ± 2
.025 ^a	.050 ^a	2	38 ± 2

^a Exchange mixture 0.75 *f* in $HClO_4$.

The exchange reported in Table II appears to be a zero-time exchange, and is sufficiently incomplete to suggest that the exchange observed with the hydrated ions in the case of the dipy separation is not primarily between tris-(dipy)-vanadium(II) and

(1) R. W. Dodson, *THIS JOURNAL*, **72**, 3315 (1950).

(2) S. C. Furman and J. T. Denison, private communication.

vanadium(III) ions. The possibility of rapid separation-induced exchange brought about when the reaction mixture is added to alcoholic α, α' -dipyridyl is not excluded by these observations. Dodson's work with the iron(II)-iron(III) exchange showed exchange half-times of the order of 15-50 seconds with the reactant species at *ca.* 0.001 *f* each. Reduction of the concentrations of the vanadium reactants may slow the observed rapid exchange rate to a point where kinetic studies could be undertaken, but the techniques used so far have not permitted this because of difficulties with oxidation of both vanadium species in solutions at high dilution by traces of oxygen present.

DEPARTMENT OF CHEMISTRY
UNIVERSITY OF CALIFORNIA
LOS ANGELES 24, CALIFORNIA

WILLIAM R. KING, JR.
CLIFFORD S. GARNER

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SYNTHESIS OF DEGRADATION PRODUCTS OF AUREOMYCIN

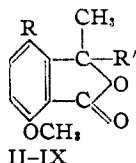
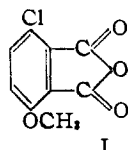
Sir:

The synthesis of several degradation products¹ of Aureomycin by unequivocal methods has been accomplished. In each case these synthetic products were compared with the degradation products by means of m.p., mixed m.p., ultraviolet and infrared absorption spectra, and other properties to prove their identity.

No.	R	R'	M.p., °C.	Theory				Found			
				C	H	OCH ₃	Cl	C	H	OCH ₃	Cl
II	H	—H	73-75	67.4	5.6			66.9	6.0		
III	Cl	—H	113-14	56.5	4.2		16.7	57.0	4.6		16.3
IV	H	—OH	164-65	61.8	5.2	16.0		62.1	5.9	16.4	
V	Cl	—OH	204-206	52.4	3.9		15.5	52.3	3.9		15.4
VI	H	—COOH	168-70	59.5	4.5			59.8	5.2		
VII	Cl	—COOH	199-200	51.5	3.5		13.8	51.7	3.9		13.8
VIII	H	—CH ₂ COOH	207-209.5	57.1	4.8	10.5		57.3	5.2	9.7	
IX	Cl	—CH ₂ COOH CH ₂ COOH CH ₂ COOH	209-210.5	51.1	4.0		10.8	51.4	4.4		10.9

The first of these products is 6-chloro-3-methoxyphthalic anhydride (I) which definitely places the position of the methoxyl and chloro groups in relation to the other 2 substituents on the benzene ring. This compound was prepared from 3-methoxy-6-chloroanthranilic acid² by replacement of the amino group by a cyano group through a Sandmeyer reaction and hydrolysis to the phthalic acid derivative, m.p. 187-188°. *Anal.* Calcd. for C₈H₆O₄Cl: C, 50.8; H, 2.4; Cl, 16.7. Found: C, 51.5; H, 2.7; Cl, 16.7.

The remaining compounds are phthalides of the following general formula in which R = chlorine



and R' = groups as shown in Table I. These phthalides can be degraded to phthalic or benzoic acid derivatives to prove the position of the chlorine atom as indicated in the previous paper.¹

4-Chloro-7-methoxy-3-methylphthalide (III) was prepared from 2-amino-3-methoxyacetophenone³ by reducing the ketone to the alcohol and replacing the amino by a cyano group. On hydrolysis, II was formed which was chlorinated to III with chlorine in acetic acid or with sodium hypochlorite and hydrochloric acid.

4-Chloro-3-hydroxy-7-methoxy-3-methylphthalide (V) was prepared by replacement of the amino by cyano in 2-amino-3-methoxyacetophenone, hydrolysis to IV and chlorination to V. Both IV and V probably exist in equilibrium with the corresponding *o*-carboxyacetophenone structure and both will form "normal" esters with diazomethane and "pseudo" esters with acid-methanol or acid chloride-methanol procedures.

4-Chloro-7-methoxy-3-methyl-3-phthalidecarboxylic acid (VII) was prepared by adding hydrogen cyanide to 2-cyano-3-methoxyacetophenone, hydrolysis of the product to VI and chlorination to VII. The compound was resolved by crystallizing the brucine salt from water; $[\alpha]^{25}_D + 25^\circ$ (1.2% in ethanol).

3-(4-Chloro-7-methoxy-3-methylphthalidyl)-succinic acid (IX) was prepared by treating IV with

phosphorus pentachloride to form the "pseudo" acid chloride which reacted with sodio diethyl carbethoxysuccinate. Hydrolysis and decarboxylation yielded VIII which was chlorinated to IX. Two racemates resulted and the higher melting one, m.p. 228-229° with gas, was resolved by crystallizing the brucine salt from ethanol; m.p. 209-210.5° with gas; $[\alpha]^{25}_D - 20.4^\circ$ (5% in alcohol).

(3) J. C. E. Simpson, *et al.*, *J. Chem. Soc.*, 646 (1945).

CONTRIBUTION FROM THE
LEDERLE LABORATORIES DIVISION
AMERICAN CYANAMID COMPANY
PEARL RIVER, NEW YORK

S. KUSHNER
JAMES H. BOOTHE
JOHN MORTON II
JOSEPH PETISI
J. H. WILLIAMS

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DEGRADATION OF AUREOMYCIN

Sir:

In a preliminary report¹ certain of the physical and chemical properties of aureomycin were out-

(1) R. W. Broschard, A. C. Dornbush, S. Gordon, B. L. Hutchings, A. R. Kohler, G. Krupka, S. Kushner, D. V. Lefemine and C. Pidsacks, *Science*, **109**, 199 (1949).

(1) B. L. Hutchings, *et al.*, *THIS JOURNAL*, **74**, 3710 (1952).

(2) B. R. Baker, *et al.*, *J. Org. Chem.*, **17**, 160 (1952).