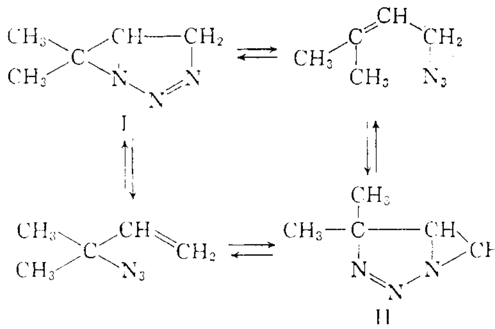
cyanates.[6,7] Both rearrangements show very low solvent sensitivity[6,7] and similar ΔS^* values. For isomerization of allyl thiocyanate in toluene, a ΔS^* of -9 e.u. has been reported,[7] while the ΔS^* values average -10 e.u. and -11 e.u. for isomerization of α,α-dimethylallyl and γ,γ-dimethylallyl azides, respectively, in pentane, ether and 70% acetone. With respect to sensitivity to methyl substitution, azide isomerization is even less sensitive than is the thiocyanate rearrangement.[6]

The known ability[8,9] of aryl and alkyl azides to add to olefins and acetylenes makes it conceivable that the allylic azide isomerization process partakes partly of the character of an intramolecular addition. In the extreme, one could visualize possible intermediates[10] such as I and II.



---

[6] A. Iliceto, A. Fava and U. Mazzucato, *Tetrahedron Letters*, **11**, 27 (1960).

[7] P. A. S. Smith and D. W. Emerson, THIS JOURNAL, **82**, 3076 (1960).

[8] K. Alder, *Ann.*, **486**, 211 (1931); **501**, 1 (1933).

[9] (a) J. H. Boyer and F. C. Canter, *Chem. Reviews*, **54**, 1 (1954); (b) F. Moulin, *Helv. Chim. Acta*, **35**, 167 (1952); (c) W. Kirmse and L. Horner, *Ann.*, **614**, 1 (1958).

[10] See E. A. Chandross and G. Smolinsky, *Tetrahedron Letters*, **13**, 19 (1960), for an analogous formulation of the isomerization of triphenylcyclopropenyl azide to a triazine.

DEPARTMENT OF CHEMISTRY
UNIVERSITY OF CALIFORNIA
LOS ANGELES 24, CALIFORNIA

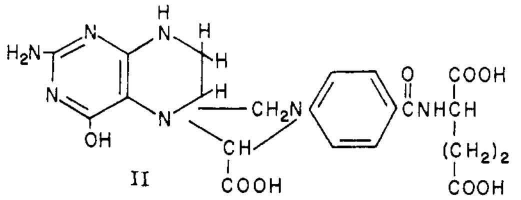
A. GAGNEUX
S. WINSTEIN
W. G. YOUNG

RECEIVED OCTOBER 15, 1960

A NOVEL REACTION BETWEEN GLYOXYLATE AND TETRAHYDROFOLATE[1]

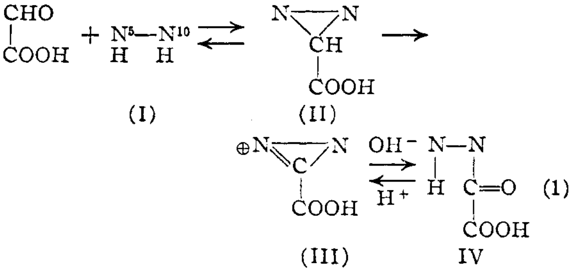
Sir:

When an excess (*ca.* 100-fold) of glyoxylate is mixed with tetrahydrofolate (I) at *p*H 4, the glyoxylate analog (II) of N^5,N^{10}-methylene tetrahydrofolate is formed within 1 min. At this *p*H



II

(I) displays two absorption maxima[2] at 272 and 292 mμ, while (II) has a single absorption band at 297 mμ. Similar spectral changes have been observed[3,4] when formaldehyde and (I) react to form N^5,N^{10}-methylene tetrahydrofolate. Upon further standing in the presence of excess glyoxylate, (II) is oxidized slowly (20–30 minutes) to a compound (III) having an absorption spectrum (λ_{max} at 358 mμ) comparable to that of N^5,N^{10}-methenyl tetrahydrofolate.[5,6] (III), in turn, is stable below *p*H 6, but at *p*H 8 it is hydrolyzed to the N^{10}-oxalyl analog (IV) (λ_{max} at 260, shoulder at 300 mμ) of N^{10}-formyl tetrahydrofolate[5,6]; this reaction is reversible since acidification of (IV) reconverts it quantitatively to (III). The progressive transformations of I to IV, described above, are outlined schematically in equation (1)



where the N^5- and N^{10}-positions of tetrahydrofolate are represented by the symbol HN^5—NH^{10}.

The conversion of (I) → (II) is identical with the synthesis of N^5,N^{10}-methylene tetrahydrofolate from (I) and formaldehyde with respect to: changes in absorption spectrum, *p*H optimum at 4, rate of reaction, inhibition by 2-mercaptoethanol, and requirement for excess aldehyde to force the equilibrium in favor of the adduct.[2–4] (II) is decomposed to (I) by the addition of hydroxylamine at *p*H 4, but not at alkaline *p*H values.[3] At *p*H 9.5, (II) is stabilized both with respect to its oxidative conversion to (III) and its spontaneous decomposition to (I) and the free aldehyde. By allowing the initial reaction (I) → (II) to occur at *p*H 4, and then adjusting the *p*H to 9.5, (II) may be purified by adsorption chromatography on columns of powdered Whatman No. 1 paper using 0.1 *M* bicarbonate buffer, *p*H 9.5: ethanol (60:40), containing 10^{-2} *M* mercaptoethanol, as the eluent.[3]

At *p*H 4 the spontaneous oxidation of (II) to (III), in the presence of excess aldehyde to repress the dissociation of (II), is of considerable interest since N^5,N^{10}-methylene tetrahydrofolate is *not* oxidized to N^5,N^{10}-methenyl tetrahydrofolate under similar conditions. The relatively facile oxidation of (II) probably is referable to the effect of the carboxyl group in enhancing the removal of the hydride ion[7] from the bridge carbon. As measured by a platinum microelectrode,[8] oxygen is consumed in the conversion of (II) → (III).

---

[1] Paper XII in the series "Folic Acid Coenzymes and One-carbon Metabolism." For paper XI, see C. K. Mathews and F. M. Huennekens, *J. Biol. Chem.*, in press. This work was supported by grants from the U. S. Public Health Service (CY-3310) and the Life Insurance Medical Research Fund.

[2] M. J. Osborn, Ph.D. Thesis, University of Washington, 1958.

[3] M. J. Osborn, P. T. Talbert and F. M. Huennekens, THIS JOURNAL, **82**, 4921 (1960).

[4] R. L. Blakley, *Nature*, **182**, 1719 (1958); *Biochem. J.*, **74**, 71 (1960).

[5] M. May, T. J. Bardos, F. L. Barger, M. Lansford, J. M. Ravel, G. L. Sutherland and W. Shive, THIS JOURNAL, **73**, 3067 (1951).

[6] L. D. Kay, M. J. Osborn, Y. Hatefi and F. M. Huennekens, *J. Biol. Chem.*, **235**, 195 (1960).

[7] F. M. Huennekens, H. R. Whiteley and M. J. Osborn, *J. Cell. Comp. Physiol.*, **54**, Supplement 1, 109 (1959).

[8] The authors are indebted to Dr. Bruce Mackler for making available an oxygen microelectrode, designed and built in the laboratory of Dr. B. Chance.

The rate of reaction decreases and increases, respectively, when nitrogen and oxygen are bubbled into a solution of (II).

Following the prolonged interaction of glyoxylate and (I) at *p*H 4, the product (III) has been purified by precipitation with ethanol and chromatography on columns of powdered Whatman No. 1 paper using 1.0 *M* formic acid containing 0.1 *M* mercaptoethanol as the eluent. (III) is easily reduced to (II) by treatment with sodium borohydride under conditions in which N^5,N^{10}-methenyl tetrahydrofolate is also reduced to the N^5,N^{10}-methylene derivative.[2,3] Hydrolysis of (III) at *p*H 12 liberated a stoichiometric amount of oxalate, which was isolated as the calcium salt, identified by paper chromatography ($R_f = 0.33$), in phenol: water: 98% formic acid (75:25:1), and quantitatively titrated with permanganate.

The rate of conversion of (III) to (IV) at *p*H 8 is markedly dependent upon the nature of the buffer (phosphate > Tris > maleate); the same order of reactivity in these buffers has been observed previously for the opening of N^5,N^{10}-methenyl tetrahydrofolate to N^{10}-formyl tetrahydrofolate,[9,10] as shown in equation (2).

$$(N^5,N^{10}\text{-methenyl tetrahydrofolate})^+ + H_2O \rightleftharpoons N^{10}\text{-formyl tetrahydrofolate} + H^+ \quad (2)$$

---

(9) S. C. Hartman and J. M. Buchanan, *J. Biol. Chem.*, **234**, 1812 (1959).

(10) H. Tabor and L. Wyngaarden, *ibid.*, **234**, 1830 (1959).

(11) Recipient of the Eli Lilly and Co. Predoctoral Award in the Department of Biochemistry, University of Washington, 1959–1960.

DEPARTMENT OF BIOCHEMISTRY P. P. K. HO
UNIVERSITY OF WASHINGTON K. G. SCRIMGEOUR[11]
SEATTLE, WASHINGTON F. M. HUENNEKENS

RECEIVED OCTOBER 10, 1960

MAGNETIC PHASES OF THE PEROVSKITE TYPE

Sir:

Previous publications from this laboratory have reported the preparation of face-centered cubic phases[1,2] of composition $A_2^{II}(B^{III}B^{V})O_6$ and $A_2^{II}(B^{II}B^{VI})O_6$ which have a structural relationship to the perovskite structure. The bivalent elements A^{II} are large alkaline earth ions in 12-fold coördination with oxygen while the B ions are in octahedral coördination with oxygen. The B ions may be randomly arranged when the combination is trivalent and pentavalent but assume an ordered arrangement when it is bivalent and hexavalent. In the ordered arrangement, each oxygen is shared between a B^{II} and a B^{VI} cation and in the ideal cubic perovskite structure the angle B–O–B is 180°. Such an arrangement of cations is ideal for superexchange between paramagnetic cations. The pairs of B cations which were used previously to obtain ordered perovskite structures have in every case contained only diamagnetic hexavalent or pentavalent ions.

We have prepared recently a series of compounds of this type containing the paramagnetic ion hexavalent rhenium. Examples of these are $Ba_2(M^{II}Re^{VI})O_6$ where M = Mn, Fe, Co. Strontium also may be used in place of barium.

Preliminary examination of the physical properties of these substances suggests that they are ferrimagnetic in the case of the compounds containing manganese and iron. The following approximate values are given for the curie temperatures: $Ba_2(Fe\ Re)O_6$ (40°C), $Ba_2(Mn\ Re)O_6$ (−137°), $Sr_2(Fe\ Re)O_6$ (128°). The cobalt compound gave no magnetic response over the temperature range employed. It appears likely that it is antiferromagnetic.

The preparation and characterization of these phases will be described in detail in the near future.

The authors are grateful to Dr. T. J. Swoboda for making the magnetic measurements on these samples.

DEPARTMENT OF CHEMISTRY ROLAND WARD
THE UNIVERSITY OF CONNECTICUT
STORRS, CONNECTICUT JOHN LONGO

RECEIVED SEPTEMBER 23, 1960

---

(1) F. Galasso, Lewis Katz and Roland Ward, THIS JOURNAL, **81**, 820 (1959).

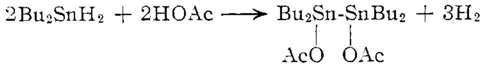
(2) E. J. Fresia, Lewis Katz and Roland Ward, *ibid.*, **81**, 4783 (1959).

1,2-DIACYLOXYDITINS[1]

Sir:

We wish to record the preparation of a new class of organotin compounds, 1,2-diacyloxyditins.

Di-*n*-butyltin dihydride[2] (I) (one mole) was found to react with one mole of acetic acid in ether at room temperature according to equation (1) to produce 1,1,2,2-tetra-*n*-butyl-1,2-diacetoxyditin



$$2Bu_2SnH_2 + 2HOAc \longrightarrow \underset{AcO}{Bu_2Sn}\text{-}\underset{OAc}{SnBu_2} + 3H_2 \quad (1)$$

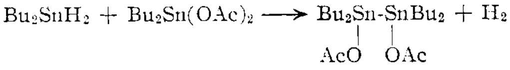
I II

(II) (65% yield), m.p. −7 to −4°, $n^{26}D$ 1.5060. *Anal.* Calcd. for $C_{20}H_{42}O_4Sn_2$: C, 41.06; H, 7.24; Sn, 40.49. Found: C, 40.81; H, 7.41; Sn, 40.88, 40.80. It reacted with one mole of bromine, giving a product, probably acetoxybromodi-*n*-butyltin (62%), m.p. 67.0–68.5°. *Anal.* Calcd. for $C_{10}H_{21}O_2SnBr$: C, 32.29; H, 5.69; Sn, 31.92; Br, 21.99. Found: C, 32.52; H, 5.71; Sn, 32.21, 31.98; Br, 21.62.

When two moles of acetic acid were used for each mole of hydride the main product was di-*n*-butyltin diacetate formed according to equation (2). With other carboxylic acids also the composition of the reaction product mixture depended on the acid/hydride ratio. Ditins were obtained using various carboxylic acids in the yields indicated for analytically pure product: benzoic (65%), *o*-chlorobenzoic (60%), and *p*-chlorobenzoic (16%).

$$Bu_2SnH_2 + 2HOAc \longrightarrow Bu_2Sn(OAc)_2 + 2H_2 \quad (2)$$

Alternatively, equimolar quantities of I and di-*n*-butyltin diacetate reacted according to equation (3). Gas evolution was 45% complete in



$$Bu_2SnH_2 + Bu_2Sn(OAc)_2 \longrightarrow \underset{AcO}{Bu_2Sn}\text{-}\underset{OAc}{SnBu_2} + H_2 \quad (3)$$

---

(1) Support of this work by the Office of Ordnance Research, U. S. Army is gratefully acknowledged. Our thanks are also due to Metal and Thermit Corporation for monetary support and gifts of chemicals.

(2) G. J. M. Van Der Kerk, J. G. Noltes and J. G. A. Luijten, *J. Appl. Chem.*, **7**, 366 (1957).