fraction indicates a unit cell of 8 molecules, mol. wt. 136. When heated or held under a reduced pressure of 0.05 mm. IX does not lose water and revert to I. Di- and polymeric derivatives are formed. In alcohols one hydroxyl group of IX is replaced with OR. The adjacent ketone no longer can remain hydrated, probably for steric reasons, and VIII is formed. IX and *o*-phenylenediamine give 3,3 4,4-THFD quinoxaline, m.p. 155°, found for $C_{10}H_8N_2O$: C, 69.88; H, 4.61; N, 16.07. With two equivalents of HIO_4 or H_2O_2 and Na_2CO_3 IX yields diglycolic acid.

3,4-Dione analogs of I with carbon or sulfur in place of oxygen in the ring exist largely in enolized form.[3] The mechanism by which I is stabilized in the dione structure is not evident; its disclosure will require further searching investigation. In ultraviolet the λ_{max} of the single C=O band of THFD at 520 mμ closely coincides with the 518 mμ band of its 2,2-5,5-tetramethyl analog.[4]

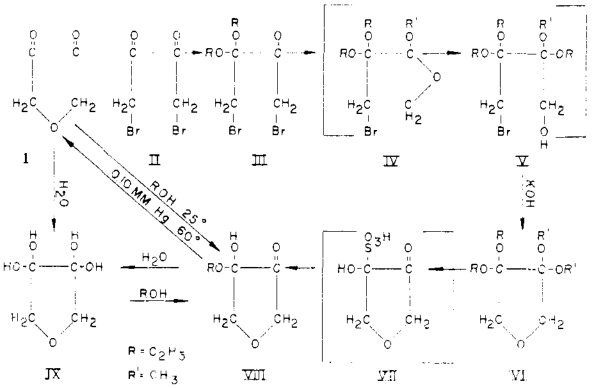

Fig. 2.

The n.m.r., expressed in terms of shielding numbers,[5] was determined in deuteriochloroform on a 60 megacycle Varian Associates instrument with benzene as an external reference. Only a single sharp resonance was observed at 5.51 τ. This indicates that the four protons are equivalent. The position of the resonance is in accord with expectation and the absence of a peak in the olefinic region is strong evidence against any appreciable enolization.

Grateful acknowledgment is given to Dr. N. Trenner and B. Arison of Merck and Co. for n.m.r. data, to Dr. R. Jacobson of Princeton University for X-ray studies, to Dr. H. Stange of F. M. C., Princeton, N. J., for infrared spectrograms, and especially to Prof. E. C. Taylor of Princeton University for assistance both practical and theoretical.

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(3) E. W. Fager, THIS JOURNAL, **67**, 2217 (1945); W. Dieckmann, *Chem. Ber.*, **35**, 3201 (1902).

(4) C. Sandris and G. Ourisson, *Bull. soc. chim. France*, 958 (1956); 350 (1958).

(5) G. V. D. Tiers, *J. Phys. Chem.*, **62**, 1151 (1958).

TETRAHYDRO-3,4-FURANDIONE. II. DIOXOLANE AND DIOXANE DERIVATIVES

Sir:

Synthesis of tetrahydro-3,4-furandione[1] (THFD) has revealed a high degree of stabilization of the heterocycle in the dione form with little or no enolization. The molecule rapidly adds water or alcohol and tends to exist with one or both ketone groups doubly substituted as a tetrol IVb, hydroxydioxane V, hydroxydioxolane VI and VII, or a hemiketal IX.

A small per cent. of water with 0.10 *N* sulfuric acid in acetic acid hydrolyzes one ketal group of THF-3,3-4,4-tetramethoxydiketal[1] I to yield the monoketone-monoketal of THF II, λ_{max} 325 mμ $\epsilon = 40$, C=O band in infrared 1780 cm.$^{-1}$. Water and methanol add to the ketone 78 and 8%, respectively, as indicated by the value of ε. The hydrate or hemiketal III cannot be isolated.

Hydrolysis of the ketal groups of THF-3,3-4,4-tetraethoxydiketal[1] IVa with sulfur dioxide in water and removal of the SO_3H group with lead carbonate affords the dioxane derivative V, slightly soluble in acetone, and the bisdioxolane VI, crystallized from ethyl acetate. Dehydration of V to give VII and hydration of VII to give V are essentially quantitative reactions. Dioxane and dioxolane rings of V, VI, and VII are broken with primary alcohols and water. For VII ε in ethanol is almost twice the value of ε in ethyl acetate.

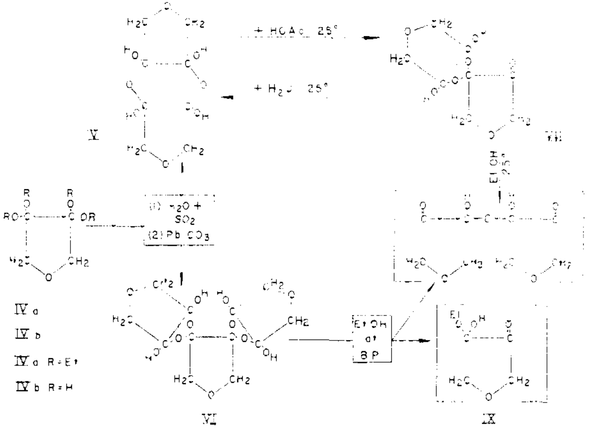

Fig. 1.

V, VI, and VII decompose when heated. The melting points 125°, 205°, and 160° respectively are not sharp. V, found for $C_8H_{12}O_8$: C, 40.60; H, 5.15; strong OH band 3250 cm.$^{-1}$ in infrared; VI, found for $C_{12}H_{16}O_{11}$: C, 42.84; H, 5.15; strong OH band 3333 cm.$^{-1}$ in infrared. VII, found for $C_8H_{10}O_7$: C, 44.04; H, 4.73; C=O band 1777 cm.$^{-1}$ in infrared; ultraviolet λ_{max} 332 mμ, $\epsilon = 31$. VII in acetone with acetic anhydride and sulfuric acid forms a diacetate, m.p. 156–158°, found for $C_{12}H_{14}O_9$: C, 47.61, H, 4.64; infrared C=O band 1785 cm.$^{-1}$. The diacetate of VII does not make a quinoxaline with *o*-phenylenediamine. IVb, V, VI and VII form the same quinoxaline derivative in theoretical yield.[1]

The dioxolane structure of VII, its λ_{max} in ultraviolet, and the value of ε agree with the corre-

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(1) E. C. Kendall and Z. G. Hajos, THIS JOURNAL, **82**, 3219 (1960).

sponding data previously published for 2,2-5,5-tetramethyl-THFD.[2] With the latter compounds the ϵ of the tetraalkyldioxolane, analogous to VII, indicates alcoholysis of the dioxolane ring in methanol.

Grateful acknowledgment is given to Dr. H. Stange of F.M.C., Princeton, N. J., for infrared spectrograms and to Prof. E. C. Taylor of Princeton University for assistance both practical and theoretical.

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(2) C. Sandris and G. Ourisson, *Bull. Soc. Chim. France*, 338 (1958).

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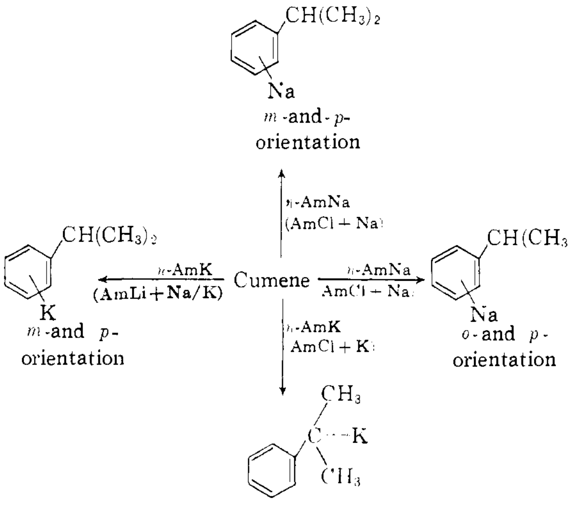
FACTORS GOVERNING ORIENTATION IN HETEROGENEOUS METALATION REACTIONS

Sir:

Compelling evidence has been advanced that *homogeneous* metalation reactions involve a nucleophilic attack by the anion of the metalating agent on hydrogen.[1] This view never has been generally accepted for heterogeneous metalations, particularly those involving organoalkali compounds,[2] although similarities between the two systems have been pointed out recently.[3,4]

Typical of the controversies which have prevailed in the area of heterogeneous metalations are the results which have been reported for the metalation of cumene by alkylalkali reagents. One laboratory[5,6] reports that n-amylsodium metalates cumene predominantly *para* and some *ortho* to the isopropyl group, while another[3] claims nearly a 1:1 *meta/para* ratio. Very little side chain metalation was observed with n-amylsodium by either Laboratory. n-Amylpotassium is reported to give almost exclusive side chain metalation, when the potassium reagent is prepared from n-amyl chloride and potassium,[7] but only 13% side chain product when it is prepared from n-amyllithium and a sodium–potassium alloy.[3]

An attempt[7] was made recently to explain these puzzling discrepancies on the basis that each Laboratory had prepared their organoalkali reagents by different methods. It was reasoned[7] that different modes of preparation would cause variations in the surfaces of these insoluble reagents and hence the metalations (which in all likelihood are surface reactions) might take different courses.



We are hereby reporting (see Table I) that n-amylsodium, prepared *either* from n-amyl chloride or di-n-amylmercury, metalates cumene almost entirely in the ring. Practically identical isomer distributions result in each case. Clearly the metal enters the ring in such fashion as to be as far removed from the isopropyl group as possible, which is contrary to findings in earlier reports.[5,6] We can only conclude that the *meta* isomer was not recognized as a major product by these earlier workers. Table I also discloses that when n-amylpotassium was prepared from both the chloride and di-n-amylmercury (entries 3 and 4) almost exclusive *alpha* metalation resulted. While the isomer ratios in the two cases were not identical they were extremely close. Further, if the metalation of cumene by n-amylpotassium in heptane was allowed to proceed for 20 hours, almost exclusive *alpha* metalation occurred (entry 5). If the reaction was interrupted at the end of 3 hours (entry 6), however, considerable quantities of *meta* and *para* isomer were found. *Clearly the latter two isomers disappear with time.* This is graphically illustrated by the results shown in Table II, wherein highly purified p-chlorocumene was treated with potassium in both excess

TABLE I

METALATION OF CUMENE BY n-AMYLSODIUM AND n-AMYLPOTASSIUM

	n-Amyl-	Prepn.	Solvent	% Isomer distribution[c,d,e] Alpha	Meta	Para
1	Na	*a*	Cumene	2.6	55.6	41.8
2	Na	*b*	Cumene	1.2	56.0	42.8
3	K	*a*	Cumene	88.0	4.5	7.5
4	K	*b*	Cumene	91.6	..	8.4
5	K	*a*	Heptane[f]	100		
6	K	*a*	Heptane[f,g]	42.0	39.0	19.0

[a] n-AmCl + metal. [b] n-Am_2Hg + metal. [c] All reactions were stirred at high speed at room temperature. [d] All analyses were of the methyl esters obtained by treating the carbonation products with excess diazomethane. Vapor phase chromatography was used in every case. [e] The reaction time was 20 hr. in every case except for entry 6. [f] Contained a two-mole excess of cumene. [g] The reaction time was 3 hr.

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(1) G. E. Hall, R. Piccolini and J. D. Roberts, THIS JOURNAL, **77**, 4540 (1955).

(2) A. A. Morton, *ibid.*, **69**, 969 (1947); see also A. A. Morton, *Chem. Revs.*, **35**, 1 (1944); A. A. Morton, C. E. Claff, Jr., and F. W. Collins, *J. Org. Chem.*, **20**, 428 (1955).

(3) D. Bryce-Smith, *J. Chem. Soc.*, 1079 (1954).

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(5) A. A. Morton, J. T. Massengale and M. L. Brown, THIS JOURNAL, **67**, 1620 (1945).

(6) A. A. Morton and C. E. Claff, Jr., Abstracts of the 119th Meeting of the American Chemical Society, Boston, Mass., 1951, p. 11-M.

(7) A. A. Morton and E. J. Lanpher, *J. Org. Chem.*, **23**, 1636 (1958).