The n.m.r. spectrum of partially deuterated methyl *meso*-α,α'-dimethylglutarate obtained by acid hydrolysis of the deuterated anhydride and succeeding esterification by diazomethane is shown in Figure 1. Absence of *dl*-isomer signals in the spectrum indicates that the configurations around the respective asymmetric carbons are not altered by these treatments. The intensity ratio of the lower- to the higher-field methylene proton multiplet, κ, of the deuterated *meso* ester and κ of the deuterated *meso* acid are equal to $1/\kappa$ of the deuterated anhydride. The higher-field multiplet of the deuterated *meso* ester is, therefore, ascribed to the methylene proton oriented *trans* to the carboxyl groups for the hypothetical planar zigzag conformation of the Me–C–C–C–Me chain, and the lower-field multiplet to the other methylene proton.

Since methyl meso-α,α'-dimethylglutarate is a good model compound of isotactic polymethyl acrylate, and the centers of the methine and methylene proton multiplets of the glutarate appear at nearly the same positions as those of the polymer (at τ 7.7, 8.10, and 8.46 for a methyl formate solution), respectively, we may conclude that the higher-field multiplet of the polymer is due to the methylene proton oriented *trans* to the carboxyl group for the hypothetical planar zigzag skeletal conformation and the lower-field multiplet to the other methylene proton.[3] This result shows that *trans* opening of the double bond occurs in the anionic polymerization of methyl acrylate initiated by lithium aluminum hydride in toluene, in contrast to *cis* opening reported on cationic polymerization of β-chlorovinyl alkyl ethers[4] and polymerization of propylene[5,6] and ethylene[7] by the Ziegler catalyst.

The deuterated and nondeuterated anhydrides were prepared by the following procedures. Ethyl α,α'-dimethylglutaconate-α-d_1 was prepared according to Thole and Thorpe's method[8] except that EtOD was used in place of EtOH in the step removing the ethoxycarbonyl group from ethyl α-ethoxycarbonyl-α,α'-dimethylglutaconate, and the deuterated glutaconate was acid hydrolyzed. Heavy hydrogen was added at 40° to the deuterated acid dissolved in heavy water using platinum black as catalyst. A mixture of deuterated α,α'-dimethylglutaric acids of *meso* and *dl* modifications thus obtained (*meso*/*dl* ratio = 0.5) was dissolved in acetyl chloride at room temperature. After the volatile fraction was almost all evacuated at room temperature, the solution was cooled to 10°. Deuterated *meso*-α,α'-dimethylglutaric anhydride deposited from the solution was recrystallized by an equivolume mixture of ethyl acetate and ligroin. The unresolved structures of the methylene proton multiplets of the deuterated anhydride show that the anhydride contains, besides α,α',β-d_3 components, various isomers different in deuterium substitution, as expected for catalytic addition of heavy hydrogen.

(3) In a recent communication (*J. Am. Chem. Soc.*, **86**, 4481 (1964)), Schuerch, *et al.*, gave a "very probable" assignment of the methylene proton resonances of polyisopropyl acrylate. The assignment is the same as that obtained here. However the reason for their assignment is not clear.

(4) G. Natta, M. Peraldo, M. Farina, and G. Bressan, *Makromol. Chem.*, **55**, 139 (1962).

(5) T. Miyazawa and Y. Ideguchi, *J. Polymer Sci.*, **B1**, 389 (1963).

(6) H. Tadokoro, M. Ukita, M. Kobayashi, and S. Murahashi, *ibid.*, **B1**, 405 (1963).

(7) M. Tasumi, T. Shimanouchi, H. Tanaka, and S. Ikeda, *ibid.*, **A2**, 1607 (1964).

(8) F. B Thole and J. F. Thorpe, *J. Chem. Soc.*, **99**, 2187 (1911).

Ethyl α,α'-dimethylglutaconate was prepared by the method of Thole and Thorpe.[8] A mixture of *meso*- and *dl*-α,α'-dimethylglutaric acids was obtained by hydrogenation of the glutaconate at 20° using palladium–carbon catalyst and succeeding hydrolysis. *meso*-α,α'-Dimethylglutaric anhydride was obtained from the mixture by the method of Auwers and Thorpe.[9]

(9) K. Auwers and J. F. Thorpe, *Ann.*, **285**, 310 (1895).

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The Synthesis of Azomycin

Sir:

The antibiotic azomycin was first isolated by Maeda[1] in 1953 from a strain resembling *Nacardia mesenterica*. In 1955, Nakamura[2] established its structure as the hitherto unknown[3] 2-nitroimidazole. Until now, 2-nitroimidazole and its homologs had not been prepared by total synthesis despite the fact that these structurally simple compounds offered a tempting challenge to chemists seeking potentially active chemotherapeutic agents.[4] A possible route to these compounds was suggested by the work of Jones and Robins[5] who, by the action of nitrous acid, were able to convert 8-aminopurines, *via* 8-diazopurines, to 8-nitropurines. Thus a nitro group was introduced into the 2-position of the imidazole moiety in the purine ring system. However, when 2-aminoimidazole was caused to react at room temperature with an excess of sodium nitrite at about pH 6, the diazo compound was not isolated and the desired 2-nitroimidazole which has a characteristic ultraviolet peak at 374 mμ (in 0.1 *N* NaOH) was not formed (Figure 1). If, after standing at room temperature for a short time, this reaction mixture was boiled, spectrophotometry indicated that 2-nitroimidazole had been formed to the extent of 6%, and 1% was indeed isolated. At room temperature, the reaction apparently took a different course because, when heating was delayed for 16 hr., no 2-nitroimidazole was formed. This circumstance may explain the failures of previous investigators[6] who diazotized 2-aminoimidazole. In the presence of cupric sulfate, however, the desired reaction proceeded at room temperature and gave appreciable yields (Figure 1). Thus 15.7 g. of 2-aminoimidazole sulfate,[7] 41 g. of sodium nitrite, and 297 g. of cupric sulfate pentahydrate were dissolved in 18 l. of distilled water[8] and the solution was allowed to stand at room temperature for 16 hr. The pH of the reaction mixture was adjusted to 2.0 with dilute nitric acid, and the solution was extracted with 24 l. of ethyl acetate in a Karr Recipro-

(1) K. Maeda, T. Osato, and H. Umezawa, *J. Antibiotics* (Tokyo), **6A**, 182 (1953).

(2) S. Nakamura, *Pharm. Bull.* (Tokyo), **3**, 379 (1955).

(3) K. Hofmann, "Imidazole and Its Derivatives, The Chemistry of Heterocyclic Compounds," Vol. 6, A. Weissberger, Ed., Interscience Publishers, Inc., New York, N. Y., 1953.

(4) Nitroimidazoles have significant antiprotozoal activity; see, *e.g.*, C. Cosar and L. Julou, *Ann. Inst. Pasteur*, **96**, 238 (1959).

(5) J. W. Jones and R. K. Robins, *J. Am. Chem. Soc.*, **82**, 3373 (1960).

(6) R. G. Fargher and F. L. Pyman, *J. Chem. Soc.*, **115**, 217 (1919).

(7) B. T. Storey, W. W. Sullivan, and C. L. Moyer, *J. Org. Chem.*, **29**, 3118 (1964).

(8) This high dilution favored the yield.

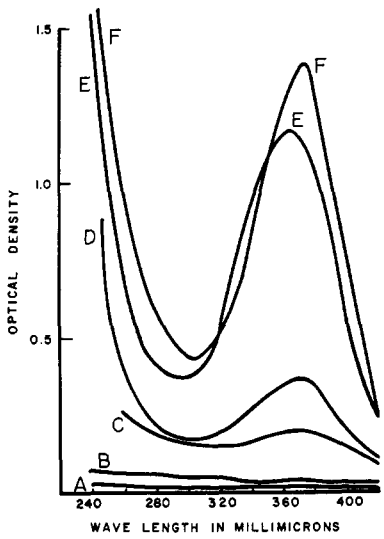

Figure 1. Ultraviolet spectra taken in 0.1 *N* NaOH at a dilution of 1:40 of reaction mixtures consisting of 1 mmole of 2-aminoimidazole sulfate, 5 mmoles of sodium nitrite, and 100 ml. of water: (A) 16 hr. at room temperature and then heated 2 hr. on steam bath; (B) 16 hr. at room temperature; (C) 1 hr. at room temperature and then heated 1 hr. on the steam bath; (D) 1 hr. at room temperature in the presence of 5 mmoles of $CuSO_4$; (E) heated 1 hr. on the steam bath in the presence of 5 mmoles of $CuSO_4$; (F) 16 hr. at room temperature in the presence of 5 mmoles of $CuSO_4$.

cating Plate column.[9] The ethyl acetate extract was evaporated to 200 ml. and cooled to give 5.34 g. (40%) of crude 2-nitroimidazole, $\lambda_{max}^{0.1NNaOH}$ 373 mμ (ε 12,600). This material was purified first by sublimation and then by crystallization from ethanol to give 4.2 g. of pale yellow crystals, m.p. 287–288° dec., $\lambda_{max}^{0.1NNaOH}$ 374 mμ (ε 12,750). *Anal.* Calcd. for $C_3H_3N_3O_2$: C, 31.86; H, 2.67; N, 37.16. Found: C, 32.28; H, 2.60; N, 36.98. It was identified with natural azomycin[2,10–12] by mixture melting point, by ultraviolet and infrared spectra, and by its *in vitro* antibacterial spectrum against 19 microorganisms. 1-Methyl-2-nitroimidazole, m.p. 102–103°, identical with the product obtained by Gallo, *et al.*,[11] by methylation of azomycin, was prepared from the corresponding amino compound by a variation of our method. Modifications of our procedure have been applied successfully to the preparation of other homologs of 2-nitroimidazole and to nitro derivatives of related heterocyclic systems. Details of this work will be reported later.[13]

Acknowledgment. The authors wish to express their appreciation to Dr. Arnold Brossi for helpful suggestions and continued interest.

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(11) G. G. Gallo, C. R. Pasqualucci, P. Radaelli, and G. C. Lancini, *J. Org. Chem.*, **29**, 862 (1964).
(12) We gratefully acknowledge the gift of a sample of natural azomycin which we obtained from Lepetit S.p.A., Milan, Italy.
(13) After the present investigation was essentially completed, the formation of 2-nitroinosine (as a by-product in yields up to 5%) by treatment of guanosine with nitrous acid was described [R. Shapiro, *J. Am. Chem. Soc.*, **86**, 2948 (1964)].

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A Pyrolytic Synthesis of Ylides. Isolation of Trimethylphosphinetrimethylsilylmethylene

Sir:

The usual routes to ylides are reactions of onium salts with strong bases such as lithium alkyls in suitable solvents. It has now been found that the novel, distillable ylide, trimethylphosphinetrimethylsilylmethylene (I) can be prepared by a solid state pyrolytic route which appears to involve a five-coordinate silicon transition state.

$$(CH_3)_3\ddot{S}i\ddot{C}H\overset{+}{P}(CH_3)_3 \longleftrightarrow (CH_3)_3\bar{S}i{=}CH\overset{+}{P}(CH_3)_3 \longleftrightarrow (CH_3)_3SiCH{=}P(CH_3)_3$$

I

Heating trimethylsilylmethyltrimethylphosphonium chloride (II), $(CH_3)_3SiCH_2P(CH_3)_3Cl$, under vacuum produces I and trimethylsilyl chloride as the volatile products and leaves a residue of tetramethylphosphonium chloride. These observations can be rationalized by a mechanism in which the chloride ion attacks the silicon site leading to rearrangement and decomposition into trimethylsilyl chloride and trimethylphosphinemethylene (III), and the latter product then abstracts a proton from II to form tetramethylphosphonium chloride and ylide I. The presence of finite amounts of intermediate trimethylphosphinemethylene was confirmed by a pyrolysis in the presence of acetone vapor which produced small yields of isobutylene.[1]

Trimethylphosphinetrimethylsilymethylene (I) is a colorless liquid boiling at 70–75° (14 mm.), freezing at −36°. Its ^1H n.m.r. spectrum at 60 Mc. has three resonances, a low-field doublet (chemical shift of −1.20 p.p.m. from external tetramethylsilane, A_{PCH} = 13 c.p.s.) a singlet (0.27 p.p.m.), and a high-field doublet (1.03 p.p.m., A_{PCH} = 8 c.p.s.). The integrated intensities of the peaks were in the ratio of 9:9:1, respectively, in excellent agreement with an assignment of the low-field doublet to CH_3P protons, the singlet to CH_3Si protons, and the high-field doublet to the methylenic proton. The high-field position of the methylenic proton can be explained by the decreased electronegativity of the methylenic carbon atom owing to its partial negative charge and by an enhanced paramagnetic contribution of the neighbor-anisotropy effect.[2] The infrared spectrum of I as a liquid shows the following absorptions in $cm.^{-1}$: 2950 (s), 2900 (m), 1430 (m, sharp), 1305 (w, sharp), 1285 (m), 1250 (w), 1235 (m), 1150 (s), 1000 (s), 930 (s), 825–875 (s), 750 (m, doublet), 710 (w), 675 (w), and 635 (w).

The chemical reactivity of I is intermediate between that of III and highly stable ylides containing carbonyl groups conjugated with the methylenic carbon. Some of the latter type may be obtained from water solution.[3]

(1) Isobutylene is the expected product of a Wittig reaction of acetone with III: see S. Trippett and D. M. Walker, *Chem. Ind.* (London), 933 (1960).
(2) J. A. Pople, W. G. Schneider, and H. J. Bernstein, "High-Resolution Nuclear Magnetic Resonance," McGraw-Hill Book Co., New York, N. Y., 1959, p. 176.
(3) J. A. Ford, Jr., and C. V. Wilson, *J. Org. Chem.* **26**, 1433 (1961); F. Ramirez and S. Dershowitz, *ibid.*, **22**, 41 (1957).