further. The estimated error in a splitting measurement is about ±0.02 gauss or less.

Temperature dependences of splittings have been reported for anion radicals such as that of toluene,[7] but here an explanation involving the change in mixing of the two nearly degenerate electronic levels seems appropriate. Solvent dependences of splittings in unsubstituted aromatic ions[8] have been found, but these seem, in part at least, to be of a compensating nature corresponding to varying distributions of spin density in the π-system. The case of benzene is simpler in that all positions have attached hydrogens, and a change in the over-all spread corresponds clearly to a change in Q. If the systems containing benzene are like those with higher aromatics,[9] then the Q value for the free ion is represented by some value obtained by extrapolating the curve of Fig. 1 to lower temperatures. A larger value of the total splitting would fit in better with the Q values obtained from other radicals.

The other known systems which measure Q directly are the cyclooctatetraene anion radical and the cyclo-C_5H_5 and cyclo-C_7H_7 radicals. Values for these radicals are given in Table I. Allyl and cyclohexadienyl radi-

TABLE I

TOTAL SPREAD OF THE E.S.R. SPECTRA OF VARIOUS CYCLIC RADICALS

Radical	Total splitting, gauss	Phase	Ref.
C_5H_5	28.0	Solid	a
	29.9	Solid	b
	30.00 ± 0.05	Liquid	c
$C_6H_6^-$	22.95	Liquid	d
C_7H_7	27	Solid	e
	27	Solid	f
	25.6	Liquid?	g
	27.4 ± 0.14	Liquid	h
	27.67 ± 0.05	Liquid	c
$C_8H_8^-$	25.67 ± 0.07	Liquid	i

[a] S. Ohnishi and I. Nitta, J. Chem. Phys., **39**, 2848 (1963). [b] P. J. Zandstra, ibid., **40**, 612 (1964). [c] This work. Radicals were produced by irradiation of hydrocarbons or hydrocarbon mixtures in steady-state experiments similar to those previously described.[6] Temperatures were in the range −50 to −90°. Slight (~1%) solvent dependences have been noted. [d] This work. This value is at about −130°. [e] D. E. Wood and H. M. McConnell, J. Chem. Phys., **37**, 1150 (1962). [f] S. Arai, S. Shida, K. Yamazaki, and Z. Kuri, ibid., **37**, 1885 (1962). [g] J. dos Santos-Veiga, Mol. Phys., **5**, 639 (1962); see text. [h] A. Carrington and I. C. P. Smith, Mol. Phys., **7**, 98 (1963-1964). [i] T. J. Katz and H. L. Strauss, J. Chem. Phys., **32**, 1873 (1960).

cals also can be used to measure Q since all positions have attached hydrogens, but here it must be assumed that Q is the same for all positions, including those of negative spin density. The values derived in this way for these two systems, −24.7 and −25.7 gauss, respectively,[6] are nevertheless in better agreement with those for cyclic systems than is the value for benzene negative ion, especially if no account is taken of the temperature dependence.
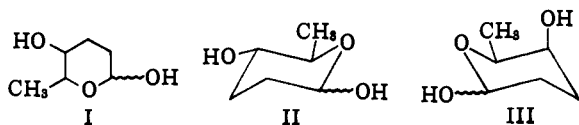
It should be noted that there are included in Table I splittings determined in this laboratory for cyclo-C_5H_5 and cyclo-C_7H_7 radicals. The value for cyclo-C_5H_5

(7) T. R. Tuttle, J. Am. Chem. Soc., **84**, 1492 (1962).

(8) See, for example, the results on biphenyl anion radical: H. Nishiguchi, Y. Nakai, K. Nakamura, K. Ishizu, Y. Deguchi, and H. Takaki, J. Chem. Phys., **40**, 241 (1964).

(9) There is usually increased dissociation of the ion pair at lower temperatures because of the increased dielectric constant of the solvent: A. C. Aten, J. Dieleman, and B. J. Hoijtink, Discussions Faraday Soc., **29**, 182 (1960).

reported here is the first one determined in the liquid phase. Our value for the total splitting of cyclo-C_7H_7 in hydrocarbon solvents is in excellent agreement with that found by Carrington and Smith for water solvent in a flow experiment.

It should be pointed out that the line widths found in our experiments for both cyclo-C_5H_5 (<0.5 gauss) and cyclo-C_7H_7 (0.2 gauss) are similar to or only slightly larger than those (cyclo-C_7H_7) for more usual hydrocarbon radicals[6] without orbital degeneracy. This fact leads to the suggestion that, in the experiment of Santos-Veiga who used sodium-potassium alloy to reduce tropylium bromide, the large line width of 2.88 gauss for cyclo-C_7H_7 radical arose because the radicals were produced on the metal surface and were not truly in solution.

The values given in Table I vary more than might be hoped. The cyclo-C_5H_5 and cyclo-C_7H_7 pair show splittings which differ in the manner predicted by considerations of the changes in hybridization,[10] but both of these values are larger than values derived from neutral radicals such as allyl and cyclohexadienyl with closer to 120° geometry. Unless the splitting for benzene negative ion could be extrapolated to much higher values, no similar behavior of the $C_6H_6^-$ and $C_8H_8^-$ pair would occur. The dependence of splitting upon excess charge density[11] is not strong enough to invert this pair. In defense of the neglect of the Jahn-Teller effect in comparing Q values can be stated the fact that the sum of the splittings at the 2, 3, 5, and 6 positions plus twice that at the 4 position of benzene-1-d anion equals 1.000 ± 0.001 times the total spread of the spectrum of the unsubstituted species.[12]

In conclusion, it can be said that, although some possibility of a larger value for the total splitting of the spectrum of a free benzene negative ion has been established, there is no indication of how much larger the true value may be. With a firm liquid-phase value for the total splitting of the spectrum of cyclo-C_5H_5 radical, it becomes increasingly clear that no treatment presented so far can explain in detail the differences between the Q values derived from these different radicals.

(10) I. Bernal, P. H. Rieger, and G. K. Fraenkel, J. Chem. Phys., **37**, 1489 (1962).

(11) J. P. Colpa and J. R. Bolton, Mol. Phys., **6**, 273 (1963).

(12) R. G. Lawler, J. R. Bolton, G. K. Fraenkel, and T. H. Brown, J. Am. Chem. Soc., **86**, 520 (1964).

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Stereochemical Identification and Synthesis of Amicetose and the Stereochemical Identification of Rhodinose and the Sugar from Streptolydigin

Sir:

The 2,3,6-trideoxyaldohexose I has been shown to be a component of the antibiotics amicetin,[1] rhodomycin,[2] and streptolydigin.[3] In the work reported here amicetose, the component of amicetin, was shown to be 2,3,6-

(1) C. L. Stevens, K. Nagarajan, and T. H. Haskell, J. Org. Chem., **27**, 2991 (1962).

(2) H. Brockmann and T. Waehneldt, Naturwiss., **50**, 43 (1963).

(3) K. L. Rinehart, Jr., and D. B. Borders, J. Am. Chem. Soc., **85**, 4037 (1963).

trideoxy-D-erythro-aldohexose (II); rhodinose, the component from rhodomycin, was shown to be 2,3,6-trideoxy-L-threo-aldohexose (III); and the component from streptolydigin was shown to be rhodinose. The investigation involved synthesis of the optically active natural amicetose and the enantiomorph of rhodinose.

Amicetose was synthesized from ethyl 2,3-dideoxy-α-D-erythro-hexopyranoside (IV) which could be made conveniently in four steps from triacetylglucal.[4] The 6-hydroxy group of IV was selectively tosylated, using 1.1 moles of tosyl chloride in pyridine, after which the 4-hydroxy group was acetylated to give a 47% yield of ethyl 4-O-acetyl-2,3-dideoxy-6-O-(p-tolylsulfonyl)-α-D-erythro-hexopyranoside (V), b.p. 85–90° (bath temperature) (0.001 mm.); n^{25}D 1.5010; $[\alpha]^{22}$D +94.6° (c 1.0, CHCl₃). Anal. Calcd. for $C_{17}H_{24}O_7S$: C, 54.82; H, 6.50; S, 8.61. Found: C, 54.69; H, 6.58; S, 8.32. The 6-tosyl group of V was displaced with sodium iodide in acetone to give 89% of ethyl 4-O-acetyl-2,3,6-trideoxy-6-iodo-α-D-erythro-hexopyranoside (VI), b.p. 32–35° (bath temperature) (0.001 mm.); m.p. 27–27.5°; n^{25}D 1.4999 (supercooled liquid); $[\alpha]^{21}$D +73.3° (c 1.1, CHCl₃). Anal. Calcd. for $C_{10}H_{17}IO_4$: C, 36.61; H, 5.22; I, 38.68. Found: C, 36.59; H, 5.13; I, 38.89.

Hydrogenation of VI using Raney nickel and in the presence of excess base removed the 6-iodo group and the 4-acetyl group to give 63% yield of ethyl 2,3,6-trideoxy-α-D-erythro-hexopyranoside (VII), b.p. 53–55° (0.2 mm.); n^{25}D 1.4470; $[\alpha]^{21}$D +144° (c 1.0, CHCl₃), +123° (c 1.1, H₂O). Anal. Calcd. for $C_8H_{16}O_3$: C, 59.97; H, 10.07; O, 29.96. Found: C, 60.07; H, 9.88; O, 29.99. Hydrolysis of VII in 2 N hydrochloric acid gave 76% yield of amicetose, 2,3,6-
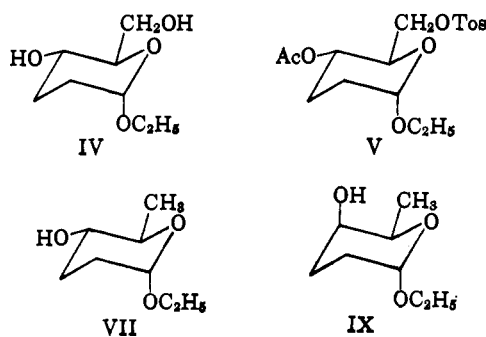
trideoxy-D-erythro-aldohexose, b.p. 70–80° (bath temperature) (0.1 mm.); n^{25}D 1.4680; $[\alpha]^{22}$D +43.6° (c 1.0, acetone); +30.1° (c 1.0, H₂O). Anal. Calcd. for $C_6H_{12}O_3$: C, 54.52; H, 9.15. Found: C, 54.62; H, 9.27. The dinitrophenylhydrazone of the synthetic amicetose was prepared in 59% yield. After recrystallization, the m.p. was 156–156.5°; $[\alpha]^{27}$D −9.2° (c 0.9, pyridine). Anal. Calcd. for $C_{12}H_{16}N_4O_6$: C, 46.14; H, 5.16; N, 17.94. Found: C, 46.34; H, 5.37;

N, 18.15. The dinitrophenylhydrazone from natural amicetose had m.p. 156–157°; $[\alpha]^{25}$D −10.0° (c 0.9, pyridine). A mixture melting point of the two samples was not depressed, the infrared spectra were identical, and the electrophoresis mobilities were identical with each other and different for corresponding derivatives in the threo series.[5]

Brockmann and Waehneldt[2] have reported the rotation of rhodinose in the course of their initial characterization of the sugar. This datum clearly placed rhodinose in the threo series, which conclusion was confirmed by the synthesis of the enantiomorph of rhodinose. The starting material for this synthesis was VII. Treatment of VII with methanesulfonyl chloride in pyridine gave an 84% yield of ethyl 2,3,6-trideoxy-4-O-(methylsulfonyl)-α-D-erythro-hexopyranoside (VIII), b.p. 90–95° (bath temperature) (0.1 mm.); n^{25}D 1.4531; $[\alpha]^{22}$D +137° (c 1.0, CHCl₃); reported[6] $[\alpha]$D +100° (c 1.0, CHCl₃). Displacement of the 4-methanesulfonate group with sodium benzoate in refluxing dimethylformamide, followed by base hydrolysis of the benzoate, afforded 35% of ethyl 2,3,6-trideoxy-α-D-threo-hexopyranoside (IX), b.p. 30–35° (bath temperature) (0.1 mm.); n^{25}D 1.4469, $[\alpha]^{26}$D +82.7° (c 1.3, H₂O). Examination of the material by vapor phase chromatography showed that IX was present to the extent of 87% and contained two minor impurities. Collection of the major component gave the pure IX, n^{25}D 1.4474; $[\alpha]^{25}$D +88.5° (c 0.7, H₂O), reported[6] $[\alpha]$D +98° (c 0.8, H₂O). Anal. Calcd. for $C_8H_{16}O_3$: C, 59.97; H, 10.07. Found: C, 59.74; H, 10.17. Hydrolysis of IX in 2 N hydrochloric acid gave 77% yield of 2,3,6-trideoxy-D-threo-aldohexose X, b.p. 60–65° (bath temperature) (0.1 mm.); n^{25}D 1.4689; $[\alpha]^{26}$D −0.2° (c 0.9, H₂O), +10.2° (c 1.1, acetone). Anal. Calcd. for $C_6H_{12}O_3$: C, 54.52; H, 9.15. Found: C, 54.84; H, 9.21. The sugar reduced Fehling's solution and traveled as a single component in thin-layer chromatography, silica gel G, $R_{digitoxose}$ 1.16 in chloroform–acetone (1:7). Brockmann and Waehneldt report[2] for rhodinose $[\alpha]^{20}$D −11° (in acetone) and $R_{digitoxose}$ (calculated from the R_f values) 1.16 in thin-layer chromatography. The dinitrophenylhydrazone derivative of X (D-threo) was prepared in 39% yield. After recrystallization, the m.p. was 121–122°, $[\alpha]^{25}$D +13.7° (c 0.9, pyridine). Anal. Calcd. for $C_{12}H_{16}N_4O_6$: C, 46.14; H, 5.16; N, 17.94. Found: C, 45.94; H, 5.10; N, 17.97.

Streptolydigin[7] was hydrolyzed in the presence of dinitrophenylhydrazine reagent and, after chromatography, a phenylhydrazone (L-threo) was isolated, m.p. 121–122°; $[\alpha]^{25}$D −14.9 (c 0.5, pyridine). The infrared spectra of the D-threo and L-threo derivatives were identical with each other but different in the 8.5 to 9.5 μ fingerprint region from the D- or DL-erythro derivatives. The D- and L-threo derivatives had the same mobilities in paper electrophoresis using a solvent system which differentiated erythro and threo isomers.[8] Further evidence that the two compounds were enantiomorphs resulted from mixture melting point de-

(4) S. Laland, W. G. Overend, and M. Stacey, J. Chem. Soc., 738 (1950); M. Bergmann, Ann., 443, 223 (1925).

(5) C. L. Stevens, B. Cross, and T. Toda, J. Org. Chem., 28, 1283 (1963).

(6) A. B. Foster, R. Harrison, J. Lehmann, and J. M. Webber, J. Chem. Soc., 4471 (1963).

(7) We wish to thank Dr. F. Kagan and the Upjohn Company for a sample of the antibiotic.

(8) The paper electrophoresis was conducted in 0.083 M borax at a pH of 9.2 and a constant voltage of 300 v.

terminations. Identical amounts (0.32 mg.) of the D and L isomers were mixed. The melting point of the mixture was 104–105° which was in good agreement with the melting of the synthetic DL-*threo* derivative,[5] m.p. 104–105°. The mixture melting point of the mechanically prepared DL-*threo* derivative with the synthetic DL-*threo* compound was not depressed, m.p. 104–105°.

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BOOK REVIEWS

Friedel-Crafts and Related Reactions. Volume I. Edited by GEORGE A. OLAH, Research Scientist, Dow Chemical of Canada, Limited, Sarnia, Ontario. Interscience Publishers, John Wiley and Sons, Inc., 605 Third Ave., New York 16, N. Y. 1963. 1031 pp. 16 × 24 cm. Price, $29.50.

Volume I presents the general aspects of "Friedel-Crafts and Related Reactions" and lays the groundwork for three subsequent volumes: II, "Alkylation and Related Reactions"; III, "Acylation and Related Reactions"; and IV, "Miscellaneous Reactions."

Long needed has been an authoritative source book of this type to bring into comprehensive and coordinated review the extensive subject matter relating to Friedel-Crafts chemistry, *i.e.*, "electrophilic organic reactions catalyzed by electron deficient compounds."

Although the product of many contributing authors, this is much more than a disjointed compilation of chapters haphazardly assembled by the editor. As an architect visualizes his final structure, so has Dr. Olah carefully designed this compendium, with a harmonious blending of many parts. The net effect is best described by C. K. Ingold in the Introduction: "The arrangement of chapters is logical and the place of each in the complete account is so obvious and natural that one notices very little the discontinuities of style and approach that so often spoil the reading of multi-author books." The authoritative nature of this work comes not only from the quality of the contributing authors—each an expert in his own field—but also from the stature of the editor and his own contributions. Of the 13 chapters in Volume I, five are authored or coauthored by Dr. Olah.

In his opening chapter, he provides an excellent historical background, starting with biographical sketches of Messrs. Friedel and Crafts. This is followed with a penetrating review of their initial discovery, including clear reproductions of key entries in Friedel's laboratory notebook. In the second chapter, Dr. Olah sets forth the definition and scope of the material to be covered in Vol. I and in later volumes. With its 657 references, this chapter in itself is a significant contribution to the field. The clarity of expression and the underlying logic for setting up the limitations and the scope to be covered bring a remarkable degree of order to what had become a tangled network of fact and theory.

Presented in logical sequence thereafter are background chapters on the nature of Friedel-Crafts catalysts, leading off with a general review of proton acids and Lewis acids. This is followed by a comprehensive outline of active Lewis catalysts from Groups I through VIII, with a thorough treatment of the role of cocatalysts, solvents, and reaction variables. The unique role of boron compounds is recognized in a separate chapter covering coordination compounds of the boron halides, which is followed by a review of coordination compounds of aluminum and gallium halides.

A chapter on intermediate complexes deals with the species involved in the reaction itself. Further mechanistic insights are provided by discussions of spectroscopic investigations and application of isotopic techniques. The three final chapters cover reaction and selectivity, thermodynamic considerations, and stereochemical aspects.

This work will be of value both to students and to experts in the field. Although it provides a comprehensive review of a rapidly expanding area of research, it is far more than an encyclopedic source of knowledge. In providing a critical evaluation of conflicting data and diverse theoretical interpretations, it achieves a cohesive view of an extremely complex field.

As it comes off the press, it is as up-to-date as a major work can be. The wisdom and courage of the editor are evident in his monumental undertaking of planning the work as a whole and proceeding with all volumes simultaneously. As the first volume was published, Vol. II and III were being printed, with Vol. IV soon to follow. These volumes will serve as a sound and solid foundation on which to build in future efforts to bring up-to-date the story of Friedel-Crafts and related reactions.

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Molecular Biochemistry. By EDWARD M. KOSOWER, Department of Chemistry, State University of New York, Long Island Center, Stony Brook, N. Y. McGraw-Hill Book Company, Inc., 330 West 42nd St., New York 36, N. Y. 1962. xii + 304 pp. 16 × 23.5 cm. Price, $12.50.

The mechanisms of chemical reactions have been and are today of major concern to organic chemists and biochemists. Although the biochemist deals mainly with enzymatic reactions either *in vitro* or *in vivo*, these reactions obey the same laws as do chemical reactions which do not require enzymes. Enzymes may lower the energy of activation of chemical reactions and introduce special steric and entropy factors, but they still can be rationalized by a consideration of the electronic structure of molecules. There exist many text books dealing with mechanisms of reactions, but biochemists have done relatively little in this field. Possibly the biochemists felt that such texts were not urgently needed since the concepts available in existing texts could be applied to enzymatic reactions. However, the need for such a text was visualized by Dr. Kosower and prompted him to write "Molecular Biochemistry." He has defined molecular biochemistry as the study of the detailed mechanisms of the chemical transformations in biology as they are described by biochemists, and has attempted to use the physical-organic approach to explain these chemical transformations.

Dr. Kosower has organized his book into three major parts: the first, a survey of metabolic reactions; the second, a discussion of reaction mechanisms; and the third, a brief treatment of the concept of "active site" of enzymes. Very little use is made of molecular orbital theory in this book.

Biological processes dealing with glycolysis, the Krebs tricarboxylic acid cycle, biological oxidation and oxidative phosphorylation, photosynthesis, the urea cycle, transamination, biosynthesis of purines and pyrimidines, and the biosynthesis of fatty acids and cholesterol are covered in the first part of the book. The second part covers reaction mechanisms of carboxylation,