solution. Ether was used to extract the resultant mixture. The combined extracts were dried and the solvent evaporated. There remained 150 of diol, m.p. 93.6–94.4°, after two recrystallizations from ligroin. A mixed m.p. with a sample of the diol from the performic acid reaction product was 93.8–94.6°. The infrared spectra of the two samples were superimposable; the high resolution 3 μ hydrogen bonding spectra showed identical positions and intensities of absorption, 3619, 3590 and 3562 cm.$^{-1}$.

Performic Acid Oxidation of 1-Phenylcyclopentene.— Potassium bisulfate dehydration of 1-phenylcyclopentanol

gave 1-phenylcyclopentene, b.p. 109–113° (15 mm.). n^{20}D 1.5732. The compound solidified in an ice-bath and melted at room temperature (lit.[49] m.p. 22–23°). Performic acid oxidation of this olefin was conducted in the usual manner. The infrared spectrum of the crude product was devoid of carbonate bands; hence, the reaction was not pursued further. This olefin is very prone to ketone formation and cleavage under these conditions.[13c,26]

(49) G. Baddeley, J. Chadwick and H. T. Taylor, *J. Chem. Soc.*, 451 (1956).

[Contribution from the Department of Chemistry, the University of San Francisco, San Francisco 17, Calif., Varian Associates, Palo Alto, Calif.]

Synthesis of Two New Quercitol (Deoxyinositol) Stereoisomers. Nuclear Magnetic Resonance and Optical Rotatory Configurational Proofs[1,2]

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Two new optically active diastereomeric quercitols (cyclohexanepentols), m.p. 258° and 248°, were obtained by addition of hydrogen bromide to (+)-1,2-anhydro-*allo*-inositol, and subsequent hydrogenolysis. Analysis of the nuclear magnetic resonance spectra of the 248° diastereomer and its bromoquercitol precursor, together with chemical evidence, indicated that the 248° diastereomer has the configuration (123/45); the 258° diastereomer then necessarily has the configuration (125/34). Optical rotation calculations by the methods of Whiffen and Brewster permitted assignment of absolute configurations XIII and XV to the 258° and 248° isomers, respectively. Rotatory dispersion measurements gave, as expected, only plain dispersion curves. The configurational assignments finally were confirmed by chemical correlations, based on formation of the 248°, but not the 258°, diastereomer on direct hydrogenation of the diastereomeric (+)-1,2-anhydro-*neo*-inositol.

The generic name *quercitol* has been proposed for the deoxyinositols (cyclohexanepentols). Ten diastereomers, six active and four *meso*, would be predicted for the quercitols (see Table I and Chart I). Six of these ten had been reported when our present work was started.[5] Two (*proto* and *vibo*) were from botanical sources, and four (*scyllo*, *epi*, *neo*, *cis*) had been prepared by synthesis only. Two additional synthetic diastereomers, *gala* and *talo*, are described in the present article. Since completion of the experiments now reported, the last remaining active diastereomer (*allo*),[6,7,7a] and the

(1) Presented at the I.U.P.A.C. Symposium on the Chemistry of Natural Products, in August, 1960, at Sydney, Australia. Taken in part from the M.S. Thesis of Stanley S. Furuta, Graduate School, University of San Francisco, 1961.

(2) Paper XI on cyclitol chemistry by G. E. McCasland and co-workers; for preceding paper see *J. Am. Chem. Soc.*, **79**, 160 (1957).

(3) To whom any reprint requests or other communications should be sent: Department of Chemistry, University of San Francisco, San Francisco 17, Calif.

(4) Varian Associates.

(5) For reviews of previous work on the quercitols, see: (a) S. J. Angyal and L. Anderson in Vol. 14, "Advances in Carbohydrate Chemistry," Academic Press, Inc., New York, N. Y., 1959; (b) R. L. Lohmar, Jr., "The Carbohydrates," by W. Pigman (Editor), Academic Press, Inc., New York, N. Y., 1957, pp. 268–296.

(6) We have recently prepared the racemic *allo* diastereomer (m.p. 262°) and its pentaacetate, m.p. 94°; this work will be described in a separate publication.

(7) After completing the synthetic part of our present work, we learned from M. Nakajima (June, 1960) that by reduction of epoxides or bromoquercitols he has prepared the pentaacetates of *rac-gala-*, *talo-* and *allo-*quercitols, and of *meso-muco-*quercitol. He has also made the racemic form of free *talo-*quercitol. Professor Nakajima (by addition of aqueous hydrogen bromide to epoxides) reportedly also has prepared six new *meso* or racemic diastereomers of bromoquercitol, one or two of which may correspond to our optically active bromoquercitols. We are indebted to Professor Nakajima for helpful consultation by correspondence, and in personal discussions at Melbourne, Australia, in August, 1960.

(7a) Note added in proof.—The work of M. Nakajima (with N. Kurihara) has now been published; see *Chem. Ber.*, **94**, 515 (1961).

Table I

The Quercitols or Deoxyinositols

Formula, configuration, prefix	M.p., °C., and spec. rotations Quercitol	Pentaacetate
meso-Diastereomers		
VII, (12345), *cis*	235–240 d.	163
VIII, (1245/3), *muco*[a]	. . . . .	168
V, (135/24), *scyllo*	235	190
VI, (15/234), *neo*	239 d.	182
Active or racemic diastereomers		
XV, (123/45), *talo*	248, +61°	183, +28°
IV, (1234/5), *allo*[a,b]	DL 262	DL 94
III, (1235/4), *epi*	194, −5° (DL 208)	125, .. (DL 143)
II, (124/35), *vibo*	181, −50° (DL 163)	125, −22° (DL 114)
XIII, (125/34), *gala*	258, −48°	117, −24°
I, (134/25), *proto*	237, +26°	. .[c]

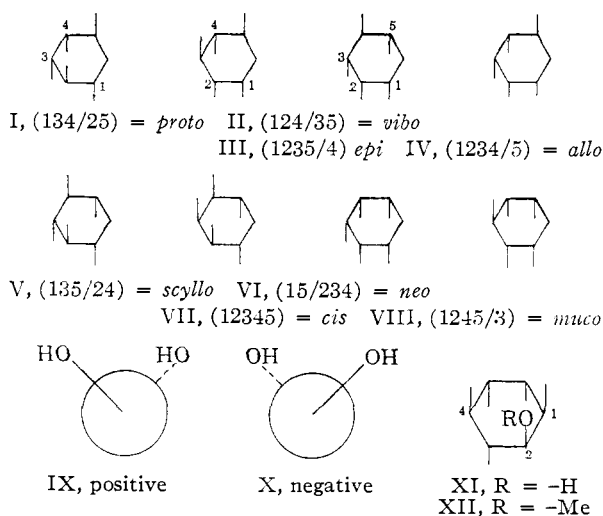[a] M. Nakajima, personal communication, July, 1960. [b] S. Furuta and G. E. McCasland, unpublished work. [c] Pentaacetate was amorphous; pentabenzoate, m.p. 155°.

last remaining *meso* diastereomer (*muco*),[7] have been synthesized.

Methods which have been used for quercitol synthesis[5] include: reduction (hydrogenation) of inososes, inosose oximes or deoxyinososes; hydrogenolysis of bromoquercitols; hydrogenation of a quinonetetrol; and reduction of anhydro-inositols.[7] The reduction of anhydro-inositols (see below) now appears to be the most convenient and general route.

His quercitols were made from bromoquercitols, not directly from epoxides. Nakajima's products included the racemic form (m.p. 190-191° *dec.*, pentaacetate 158–159°) of our active (125/346) bromoquercitol. He also made the racemic form (m.p. 214° *dec.*) of our active (123/456) bromoquercitol.

Chart I

Configurations of the Diastereomeric Quercitols
See also formulas XIII and XV

I, (134/25) = proto   II, (124/35) = vibo

III, (1235/4) epi   IV, (1234/5) = allo

V, (135/24) = scyllo   VI, (15/234) = neo

VII, (12345) = cis   VIII, (1245/3) = muco

IX, positive   X, negative   XI, R = –H
    XII, R = –Me

Synthesis of New Quercitols.

By addition of hydrogen bromide to the epoxide[8a] XIV, followed by hydrogenolysis to remove bromine, we obtained

XIII, (125/34) = gala   XIV   XV, (123/45) = talo
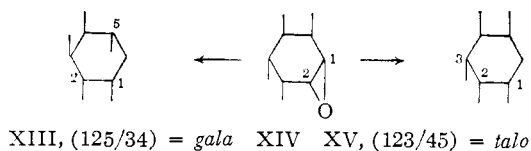
two new diastereomers of quercitol; direct hydrogenation of the epoxide to quercitols should give similar results (see below).

One of the new diastereomers melted at 258° and was levorotatory in water; the other melted at 248° and was dextrorotatory. The pentaacetates[9] were prepared, and melted, respectively, at 117° and 183°.

From the known mechanism of epoxide additions,[10] it was apparent that the two new quercitol diastereomers must have the (125/34) or gala configuration XIII and the (123/45) or talo configuration XV (regarding nomenclature, see below). However, there appeared at first to be no reliable basis for deciding which compound corresponded to which configuration. Experimentally, a 3:1 mixture of bromo-quercitol isomers was obtained, and separated before hydrogenolysis. The major bromoquercitol product (m.p. 203°) on hydrogenolysis gave the quercitol of m.p. 258°; the minor product, m.p. 229°, gave the quercitol of m.p. 248°.

One of the most promising, though still relatively unexplored, methods for assigning diastereomeric

(8) (a) S. J. Angyal and N. Matheson, J. Am. Chem. Soc., 77, 4343 (1955); (b) S. J. Angyal and P. Gilham, J. Chem. Soc.. 3697 (1957); (c) S. J. Angyal and C. Macdonald, ibid., 686 (1952); (d) S. J. Angyal, personal communication, April, 1960.

(9) In 1957, S. J. Angyal and D. McHugh (J. Chem. Soc., 3691) by hydrogenation of quinonetetrol reportedly obtained a few milligrams of a quercitol pentaacetate, correct analysis, m.p. 115–117°. Deacetylation gave a product which decomposed at 230–240° without melting, presumably the free quercitol. This meso or racemic product cannot yet be correlated with any of the ten diastereomers now known.

(10) (a) F. Newth, Quart. Revs., 13, 30 (1959); (b) R. Parker and N. Isaacs, Chem. Revs., 59, 737 (1959).

configurations is nuclear magnetic resonance. This method was now applied, and did lead to successful assignments of configuration to our new compounds. The n.m.r. results were later confirmed by optical rotatory and chemical correlation methods (see below).

N.m.r. Assignments of Configurations.—The high resolution n.m.r. spectra of the two diastereomeric compounds of m.p. 258 and 248° are shown in Figs. 1-a and 1-b, while that of the 229° bromoquercitol appears in Fig. 1-c. The compounds were studied in dilute D_2O solution at 60 mc. (14,092 gauss). Exchange of the hydroxyl protons with the solvent resulted in a strong HDO line which was employed as an arbitrary reference point for the measurement of other peak positions in c.p.s.

Rather striking differences exist in the spectra of Figs. 1-a and 1-b, clearly showing the non-identity of the 258 and 248° quercitols. While these spectra can be interpreted in terms of the molecular configurations and conformations, this detailed analysis will be reserved for a later paper. The most direct and unequivocal demonstration of the configuration of one of these compounds, the 248° quercitol, comes from the interpretation of the spectrum of the corresponding 229° bromoquercitol. This compond gives a complex series of peaks lying between 14 and 51 c.p.s. (at 60 mc.) from the HDO peak. Although the assignment of these peaks is not immediately obvious, a systematic analysis can be developed which is in good accord with the observed spacings and intensities.

An examination of Figs. 1-b and 1-c discloses a striking similarity between the multiplet near 58 c.p.s. in the 248° quercitol and the one at 50 c.p.s. in the bromoquercitol. These multiplets must arise from two of the three protons on C-2, C-3 and C-4 (see Chart II), since the spectrum of the protons on C-1, C-5 and C-6 would change radically with replacement of one of the protons on C-6 by bromine. Therefore, the remaining signals in the bromoquercitol spectrum must arise from the protons on C-1, C-5, C-6 and one of the protons on C-2, C-3 or C-4.

It is well known that two protons whose spins are coupled together with a coupling constant which is comparable in magnitude to the chemical shift between them give a characteristic n.m.r. spectral pattern consisting of four lines. Such nuclei are usually designated as an AB system.[11a] Coupling to additional neighboring nuclei can lead to further splitting of those lines, the complexity depending upon the values of the various possible coupling constants. Such behavior might be expected in a six-membered ring compound in which one proton is located on each carbon atom.

Figure 2 shows the spectrum of the six ring protons in the 229° bromoquercitol, together with the integral of the spectrum. Three doublets whose positions and intensities are suggestive of an AB coupling scheme are labeled a, a' and b', while a fourth doublet is presumed hidden by the strong high-field multiplet and is designated b.

(11) (a) J. Pople, W. Schneider and H. Bernstein, "High Resolution Nuclear Magnetic Resonance," McGraw-Hill Book Co., Inc., New York, N. Y.. 1959, pp. 119–123; (b) p. 193; also see Chap. 14
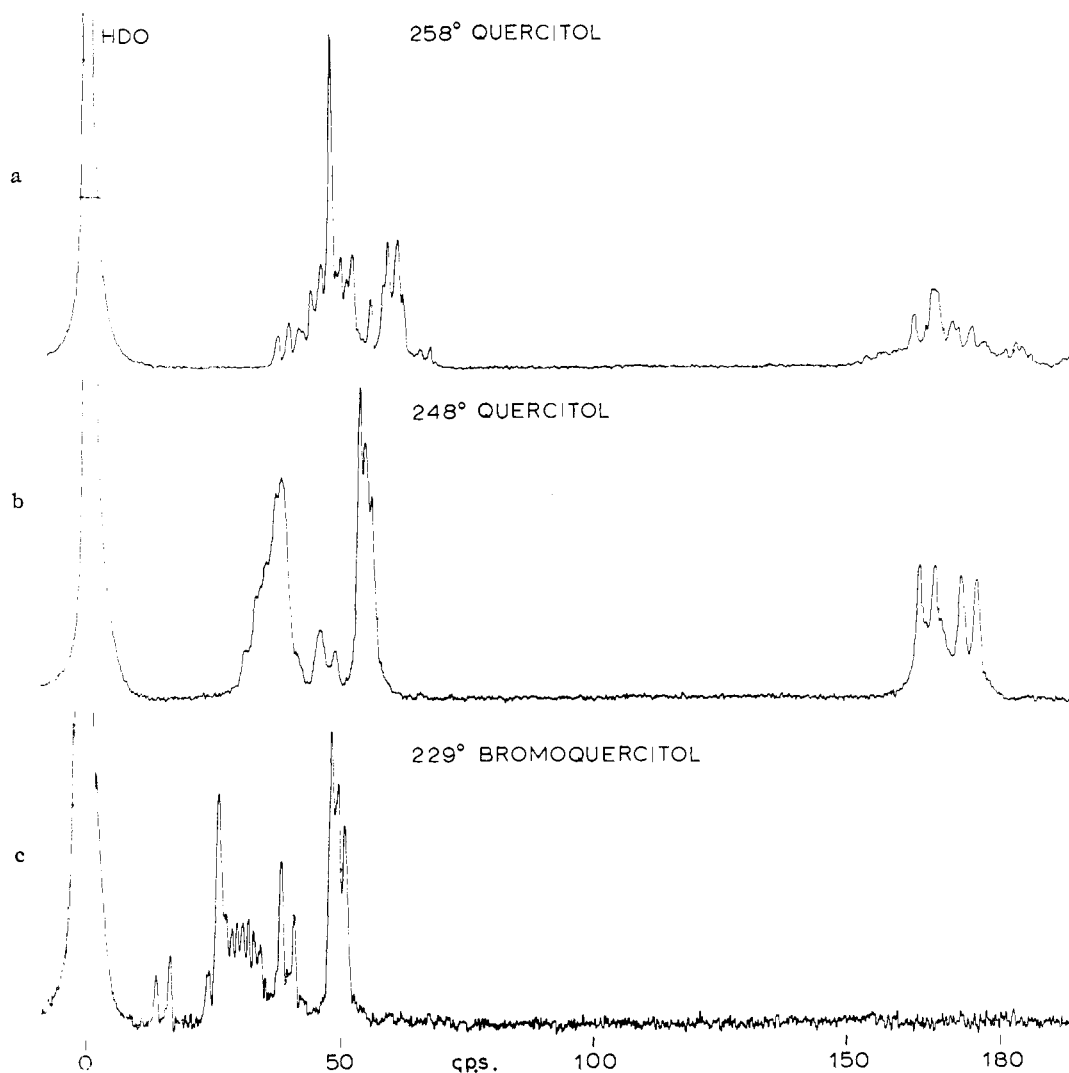
Fig. 1.—Sixty megacycle n.m.r. spectra of two quercitols and one bromoquercitol; H increases left to right.

The correctness of the assignment can be demonstrated in two ways, both of which involve the use of the integral curve. First, the total integral can be divided into six equal parts, each corresponding to one proton. When this is done, it can be seen that the area of the high-field multiplet is *larger* than the area corresponding to *two* protons by an amount b which is just equal to the area of the doublet a. Therefore, it can be presumed that a similar doublet is located at b as required by the AB coupling scheme. Second, the areas of the signals must satisfy the condition that b'/a must be equal to the ratio of the distance between a and b to the distance between a' and b'. This test checks within the accuracy of the area measurements.

The spacing between centers of the doublets a and a', or b' and b is a measure of J_{AB}, the spin coupling constant between the nuclei, and is found to be 10 c.p.s. It is now well established that a coupling constant of this magnitude between protons of the saturated six-membered ring can arise only from two *adjacent axial protons*.[11b,12] The

(12) It is important to note that the *axial* ring protons mentioned

fact that the lines of the AB multiplet are doublets, with a spacing of 2 c.p.s., shows that each axial proton has an *equatorial neighbor*. This follows from the observation[11b] that axial–equatorial spin couplings are characteristically 2–3.5 c.p.s. Therefore, the spectrum conclusively demonstrates the sequence equatorial–axial–axial–equatorial for four consecutive protons including those on C-1, C-5 and C-6. Of the four configurational and conformational possibilities shown in Chart II, only the bromoquercitol formula XVIII meets this requirement and, consequently, the quercitol diastereomer of m.p. 248° must be the *talo* diastereomer.

With the conformation of the compound settled, it is now possible to complete and check the assignments. The two nuclei which give the AB multiplet must be the axial protons on C-1 and C-6. Since a doublet very similar to b' appears also in the 248° quercitol spectrum (Fig. 1-b), it is extremely probable that the signals at b' and b arise from the proton on C-1 which is common to both

in the n.m.r. discussion and shown in Chart II are attached to carbon atoms which bear *equatorial* functional (hydroxy or bromo) groups, and *vice versa*.
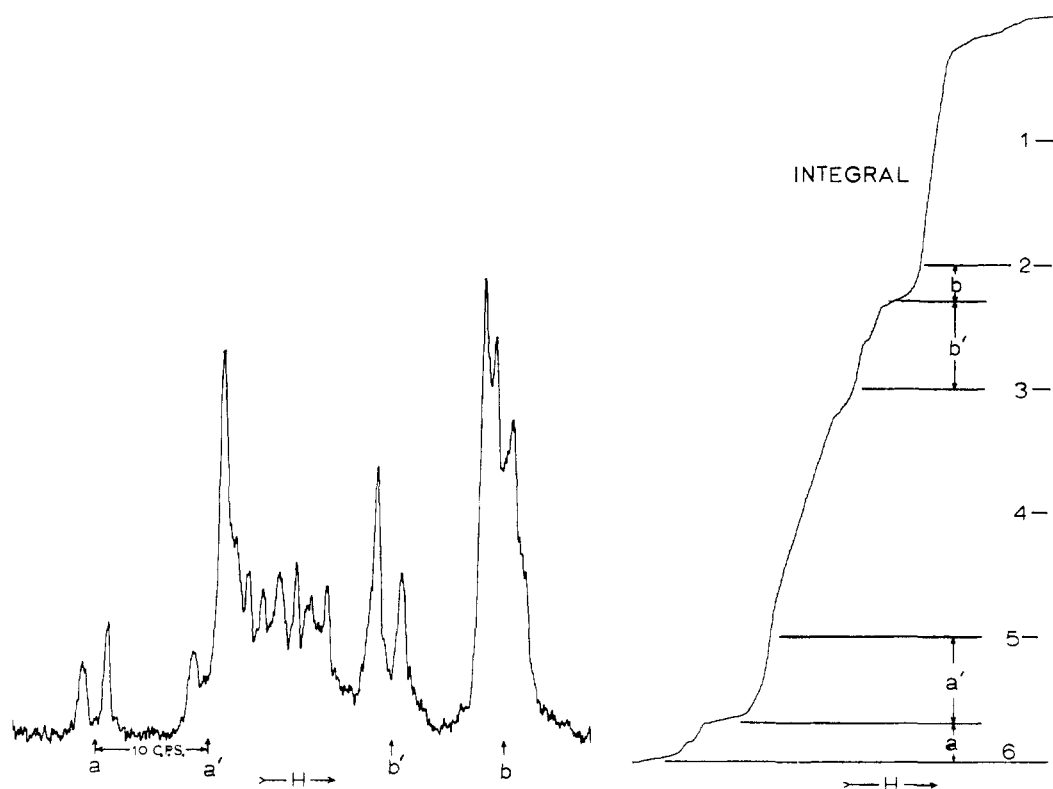
Fig. 2.—Expanded 60 megacycle n.m.r. spectrum and integral for bromoquercitol of m.p. 229°.

molecules, while the signals at a and a' must then arise from the proton on C-6.

The spin-coupling between each axial proton and its equatorial neighbor is comparable in magnitude to the difference in chemical shift between axial and equatorial protons. The perturbation of the

CHART II.—FAVORED AND UNFAVORED (BROMO) QUERCITOL CONFORMATIONS, SHOWING RING PROTONS SIGNIFICANT IN N.M.R. SPECTRA: quercitols, R = H; bromoquercitols, R = Br
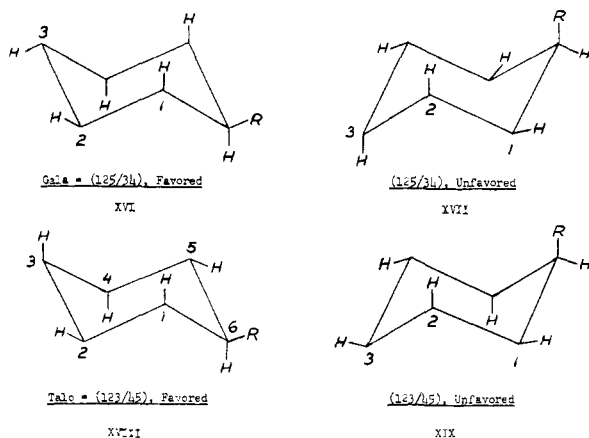
intensities of the doublets a, a' and b', which places the stronger line of each doublet closer to the center of the complete AB pattern, indicates that the signals from the equatorial protons on C-2 and C-5 will be found between the two strong central doublets of the AB pattern. Consequently, the

complex of lines between a' and b' are assigned to the two equatorial protons (formula XVIII). This leaves only the two axial protons on C-3 and C-4 to account for the strong multiplet near 50 c.p.s.

The conformation found for the 229° bromoquercitol proves that the configuration of the 248° quercitol corresponds to 123/45. Furthermore, the strikingly different spectrum of the 258° quercitol shows that it must be the other possible product with the 125/34 configuration.

Optical Rotatory Proof of Configuration.—Another approach for assigning configurations to our two new quercitols was found in the semi-empirical method for prediction of molecular rotations recently discovered by Whiffen[13] and later developed by Brewster.[14] It happens that the contiguously substituted cyclohexanes with two to six hydroxy groups are ideally suited for this Whiffen proof of configuration.

By successive evaluation of the rotatory contributions at each carbon–carbon ring bond, and summation for the entire molecule, one arrives at the parameter $-3F$ for the D(125/34) absolute configuration XIII, and $+2F$ for the D(123/45) configuration XV, provided each configuration has its functional groups (not ring protons)[12] in the favored diaxial triequatorial conformation XVI or XVIII. Here "F" is defined as $O|O - 2O|H + H|H$ and has the empirical value of $+45°$ (molecular rotation at sodium D line, water as solvent).

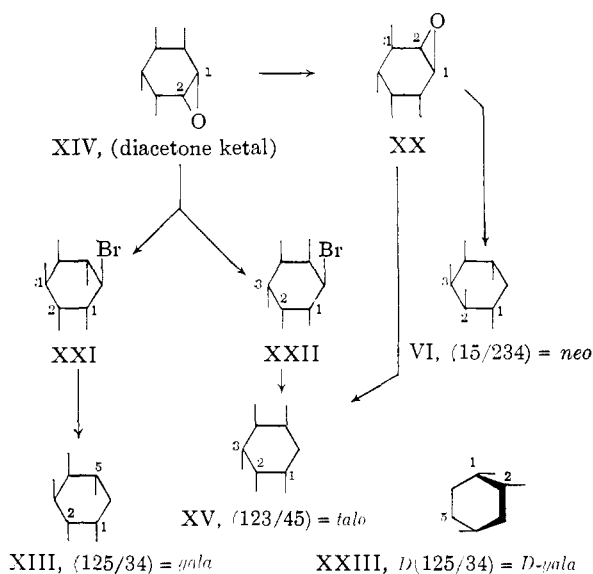(13) (a) D. H. Whiffen, Chemistry & Industry, 964 (1956); (b) personal communication, March, 1960.

(14) (a) J. H. Brewster, J. Am. Chem. Soc., 81, 5475, 5483, 5493 (1959); (b) personal communication, April, 1960.

The empirical value for F is an average from experimental data on numerous similar compounds.

On this basis the predicted molecular rotations for the quercitols XIII and XV would be $-135°$ and $+90°$, respectively. Since the two favored (2A, 3E) conformations[12] here assumed possess nearly equal numbers of axial and equatorial groups, there may be small contributions by the unfavored (3A, 2E) conformations, for which the predicted molecular rotations would be $+3F = +135°$ for XVII and $-F = -45°$ for XIX. It was suggested[13b] that rough corrections to allow for minor contributions by the unfavored conformations would change the predicted values from $-135°$ and $+90°$ to about $-100°$ and $+80°$—this would correspond to unfavored populations of $10 \pm 3\%$.

Experimentally, our quercitols of m.p. 258° and 248° had molecular rotations of $-80°$ and $+101°$, respectively. Despite the lack of exact agreement it was clear (on either the corrected or uncorrected basis), that our levorotatory quercitol very probably has the D(125/34) configuration XIII, and the dextrorotatory quercitol the D(123/45) configuration XV. The parent bromoquercitols would then have the corresponding configurations XXI and XXII (Chart III).

<div align="center">

CHART III

Synthesis of Two New Quercitols and Chemical Proof of Configurations

</div>

XIV, (diacetone ketal)   XX

XXI   XXII   VI, (15/234) = neo

XV, (123/45) = talo

XIII, (125/34) = gala   XXIII, D(125/34) = D-gala

In the course of these calculations it was noted that for contiguously substituted polyhydroxycyclohexanes, a shortcut version of the Whiffen calculations apparently can be used. Namely, each –CHOH–CHOH– moiety in the molecule is successively examined, looking down its carbon–carbon bond, and assigned the value $+F = +45°$ if the *nearer* hydroxy group is to the left (IX), or $-F = -45°$ if the nearer hydroxy group is to the right (X). This treatment works at least for the optically active contiguous diols, triols, tetrols, pentols and hexols. Summation of the rotatory contributions for each specified configuration and assumed conformation gives the approximate

molecular rotation for the corresponding compound (sodium D line, water as solvent).

Similar calculations, using Brewster's method,[14a] for the bromoquercitols of configuration (125/346) and (123/456) led to predicted molecular rotations of $-135°$ and $-210°$, as compared with found values of $-109°$ and $-332°$, respectively.

Optical Rotatory Dispersion Studies.—Optical rotatory dispersion measurements were obtained on both diastereomeric bromoquercitols, quercitols and quercitol pentaacetates. As expected, these six compounds gave only plain dispersion curves,[15] which could not be interpreted to permit configurational assignments. The *gala*-quercitol showed an interesting reversal of sign of rotation when the solvent was changed from water to dioxane; and its pentaacetate, when the solvent was changed from chloroform to dioxane. The reasons for these reversals are not entirely clear; further work is in progress. Rotatory dispersion measurements were also made on the starting materials (quebrachitol and (−)-inositol) and six intermediates. The resulting data will be published elsewhere. We are now preparing chromophoric derivatives of various cyclitols, which should give Cotton effect curves more readily susceptible to configurational interpretation.

Chemical Proof of Configurations.—These configurational assignments based on physical measurements have now been fully confirmed by the more traditional but laborious approach of chemical correlations. The epoxytetrol XX, isomeric with that used above for the reaction with hydrogen bromide, was converted *directly* by hydrogenation into a mixture of two quercitol diastereomers XV and VI (see Chart III). It will be apparent that the D(123/45) quercitol XV should be obtained from *both* the epoxides XIV and XX, while the D(125/34) quercitol XIII should be obtained only from the epoxide XIV. Experimentally, the predominant product from hydrogenation of epoxide XX proved to be identical with the above-mentioned quercitol isomer of m.p. 248°. Identity was established by comparisons of m.p., mixed m.p., and rotation for the quercitols and their pentaacetates, and also by infrared spectra (on quercitols only). The remaining product from the hydrogenation of the epoxide XX, formed in rather small amount, was the previously known *neo*-quercitol[16] VI, a *meso* diastereomer.

Since non-identical but diastereomeric samples may give almost identical infrared spectra, we also compared our two preparations of the m.p. 248° quercitol by nuclear magnetic resonance spectra, which showed no difference between them. N.m.r. rarely has been employed for proving identity of samples. Because of its great sensitivity to configurational changes, n.m.r. should be superior to all other methods in checking the identity of samples which might be diastereomeric.

Synthesis of Bromoquercitols.—Twenty diastereomers (12 active, 8 *meso*) are predicted for 6-bromo-1,2,3,4,5-cyclohexanepentol (bromodeoxy-

(15) C. Djerassi, "Optical Rotatory Dispersion," McGraw–Hill Book Co., Inc., New York, N. Y., 1960, pp. 12, 203.

(16) L. Anderson, *et al.*, *Arch. Biochem. Biophys.*, **78**, 520 (1958).

inositol); the same prediction would apply to other cyclohexane derivatives of type $C_6H_6A_5B$. So far as is known, bromoquercitols do not occur in nature. At the time our present research was started, only three of the twelve diastereomers of the "active" group had been prepared,[17-19] each in racemic form only. The two new diastereomers now reported are the first actually obtained in the optically active condition. Of the eight predicted *meso* diastereomers, only one had previously been reported.[17,18] Since completing the work described below, we have prepared two or three additional bromoquercitol diastereomers[7]; these will be described in subsequent publications.

Methods which have been used for bromoquercitol synthesis include: substitution of inositol hexaacetates with hydrogen bromide[17,18]; addition of hypobromous acid to conduritols[19]; and addition of hydrogen bromide to anhydroinositols.[7] The last named route (see below) now seems most convenient and general.

Hydrogen bromide addition to the diisopropylidene epoxide XIV gave us a mixture of two bromoquercitols, m.p. 203° and 229°. Only configurations XXI and XXII needed to be considered for each of these isomers, since epoxide ring opening is known to occur in the "*trans*" manner. Existing mechanistic knowledge does not permit a safe prediction of the predominant product in such a reaction. By actual experiment, diastereomer XXI (m.p. 203°) predominated about three to one when the *diacetone ketal* of XIV reacted with hydrogen bromide in *anhydrous acetic acid*. This suggests that the attack by nucleophilic bromide ion on the protonated epoxide ring occurs more easily at position 2, formula XIV—a position which in molecular models appears less hindered than position 1. We have learned recently from Nakajima[7] that *aqueous* hydrobromic acid is a more convenient reagent for making bromoquercitols from anhydro-inositols. This reagent rapidly hydrolyzes any (acetone) ketal groups which may be present, and for this and other reasons, might give a different isomer ratio in the bromoquercitol product.

The *absolute* bromoquercitol configurations XXI and XXII were deduced from the previously established[20] configuration XI of (−)-inositol, since the preparation from (−)-inositol of the intermediate dextrorotatory diacetone ketal of 1,2-anhydro-alloinositol (XIV) is known not to involve any inversions of configuration at positions 1, 2, 5 or 6 (XI).

Attempts to prepare a crystalline pentaacetate derivative of the bromoquercitol (m.p. 203°) were unsuccessful. Since Kubler[19] had reported a pentaphenylurethan derivative of his bromoquercitol isomer, we tried a reaction of our bromoquercitol m.p. 203° with phenyl isocyanate. A crystal-line product of m.p. 181° was obtained, but turned out to be merely a dimer[21] of phenyl isocyanate.

Nomenclature

Since cyclitol nomenclature is still in a confused state,[5] it is necessary to explain the names here used.

Trivial Prefixes.—According to a proposal[8c,8d] of Angyal, the six previous quercitols[5] are sometimes denoted by the prefixes: *proto, vibo, epi, neo, scyllo* and *cis*. The first two prefixes refer to circumstances of discovery; the last four each refer arbitrarily to *one* of the two related inositols. Dr. Angyal has suggested[8d] that suitable prefixes for the four remaining quercitols would be *gala* for XIII, *talo* for XV, *allo* for IV and *muco* for VIII. These prefixes suggest a relationship to aldohexose configurations, but obviously are not completely definitive without further assumptions. We endorse the prefixes *gala* and *talo*, but ordinarily prefer fractional symbols.

Fractional Notation.—Lespieau and Maquenne[22] long ago proposed a fractional notation for polysubstituted alicyclic stereoisomers. It has been used by numerous subsequent authors, and its special suitability for cyclitols recently was recognized by Cahn, Ingold and Prelog.[23] This notation has the great advantage of being nearly self-explanatory. For example, the symbol (125/34) for the quercitol XIII signifies that in the conventional Haworth type formula the functional groups at positions 1, 2 and 5 are on one side of the plane of the ring, those at 3 and 4 on the other side.

The supplementary symbol "*D*," applied for example to XIII, here signifies that the *lowest*-numbered group is *down* when the perspective formula is so oriented that numbering runs from right to left around the front; or to the *right* in the corresponding vertical formula XXIII. The symbol "*L*" has the opposite significance.

Position numbering in this article follows "Chemical Abstracts" rules, which are based on *structure* without regard to configuration: thus 6, not 1, is assigned to the bromine-substituted and methylene carbons in bromoquercitols and quercitols, respectively. The numbering *direction*, when otherwise ambiguous, is assigned (clockwise or counterclockwise) so as to yield the *longest series of smallest numbers* in the numerator of the configurational fraction: *e.g.*, for formula XIII (125/34) is preferred to (145/23); and for XV, (123/45) is preferred to (12/345).

Experimental

All melting points have been corrected and were measured on a Nalge–Axelrod micro hot-stage. Microanalyses by the Micro-Tech Laboratories, Skokie, Ill. Nuclear magnetic resonance spectra were measured with a Varian model

(17) (a) E. Griffin and J. Nelson, *J. Am. Chem. Soc.*, **37**, 1552 (1915); (b) A. Menzel, *et al., ibid.*, **71**, 1268 (1949); (c) H. Müller, *J. Chem. Soc.*, **91**, 1790 (1907); **101**, 2383 (1912); (d) E. Flynn, Ph.D. Thesis, University of Illinois, 1949.

(18) (a) G. E. McCasland and E. Horswill, *J. Am. Chem. Soc.*, **75**, 4025 (1953); (b) G. E. McCasland and J. Reeves, *ibid.*, **77**, 1812 (1955); (c) M. Wolfrom, *et al., ibid.*, **79**, 160 (1957).

(19) K. Kubler, *Arch. Pharm.*, **246**, 620 (1908).

(20) T. Posternak, *Helv. Chim. Acta*, **19**, 1007 (1930).

(21) "Beilstein," Vol. 24, p. 240, 3rd edition.

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HR-60 high resolution n.m.r. spectrometer. Infrared spectra were measured on a Perkin–Elmer model 137 Infracord recording infrared spectrometer. Optical rotatory dispersion curves were measured on a Rudolph model 260/655/850-614 automatic recording photoelectric spectropolarimeter. In order to save space, only three points of each RD plain dispersion curve are given here. Most of the optical rotations at the sodium D line were measured with a No. 5443 Laurent polarimeter.

D(125/346)-6-Bromoquercitol, M.p. 203°; 3-Bromo-3-deoxy-L-inositol (XXI).—To 5.0 g. of 1,2-anhydro-*allo*-inositol 3,4:5,6-diacetone ketal[8a] was added 20 g. of commercial 30–32% hydrogen bromide in anhydrous acetic acid. The mixture, which became homogeneous in 15 minutes, was stirred for 24 hours at 25° (anhydrous conditions), and the resulting solution vacuum-distilled. To the thick amorphous residue was added 20 ml. of absolute ethanol, and the distillation repeated; the addition and distillation were then repeated again. To the viscous mass was added 100 ml. of M hydrogen chloride in 50% (v./v.) aqueous ethanol, and the mixture boiled under reflux for 3 hours.

The resulting brown solution was evaporated to a thick mass, and the evaporation repeated after adding 25 ml. of absolute ethanol. The residue was taken up in 100 ml. of boiling 2-methyl-1-propanol. The crystals which separated on cooling were collected, washed with solvent (5 ml.) and vacuum-dried at 70°, giving 3.20 g. of mixed isomers, m.p. 175–181° dec. By vacuum-concentration of the filtrate, second, third and fourth crops of crystals were collected, with gradual rise in melting range to 179–187° dec. The four crops were combined, giving 4.97 g. of crude mixed isomers.

The mixture (4.97 g.) was then crystallized from 15 ml. of 75% (v./v.) aqueous ethanol (decolorizing carbon). The crystals were collected, washed with cold 75% ethanol (3 ml.), and vacuum-dried at 75°, giving the pure D(125/346) isomer as colorless rosettes, 2.11 g., m.p. 201–203° dec., $[\alpha]_D^{14} - 44°$ (water, c 5), $[\alpha]_D^{12} - 45°$ (c 0.5).

Anal. Calcd. for $C_6H_{11}BrO_5$: C, 29.65; H, 4.56; Br, 32.88. Found: C, 29.79; H, 4.62; Br, 33.04.

With the spectropolarimeter, the m.p. 203° bromoquercitol showed a negative plain dispersion curve: RD in dioxane (c 0.3), 31° $[\alpha]_{589} - 11°$, $[\alpha]_{400} - 30°$, $[\alpha]_{280} - 85°$.

A second crop of the 203° isomer was obtained upon vacuum-concentration of the mother liquor (1.3 g., m.p. 179–184°). After washing these crystals (rosettes plus matted needles) for 1 minute with 6 ml. of hot 2-methyl-1-propanol, there was obtained 0.72 g. additional of nearly pure, vacuum-dried bromoquercitol, m.p. 200–202° dec.

A third crop (mostly needles, a few rosettes) was similarly obtained (0.79 g., m.p. 214–219°), and after washing with 2-methyl-1-propanol as before, gave 0.15 g. of pure third crop, m.p. 201–203° dec.

The total yield of the 203° isomer was thus 2.98 g. (59% yield, based on anhydro diketal). The ratio of formation of this isomer to the 229° isomer (see below) was about 3:1.

The homogeneity of the product of m.p. 202–203° was established by *two-dimensional paper chromatography*. A spot of 1 mg. of compound in 0.2 ml. of water was applied to a 200 mm. × 200 mm. sheet of Whatman No. 1 paper, and a descending chromatogram run with 4:1 (v./v.) acetone–water. After drying the paper it was turned 90°, and developed with 4:1:1 butanol–acetic acid–water (also descending). The dried paper was treated with Ballou and Anderson[24] ammoniacal silver nitrate reagent (heat 2–3 minutes). Only a single spot was present, indicating homogeneity of the sample. For a permanent record, the use of Lemieux and Bauer[25] permanganate–periodate spray was found preferable.

D(123/456)-6-Bromoquercitol, M.p. 229°; 1-Bromo-1-deoxy-*neo*-inositol (XXII).—The combined 2-methyl-1-propanol mother liquors and wash-solvent from the m.p. 203° isomer (see above) were vacuum-concentrated to about 3.0 ml. The crystals which separated on standing were collected, washed with solvent (1.0 ml.), and vacuum-dried at 75°, giving 0.48 g. of soft, matted, colorless needles, m.p. 227–229° dec., $[\alpha]_D^{13} - 137°$ (water, c 0.1).

The 2-methyl-1-propanol solvent (about 14 ml.) which had been used for washing the second and third crops of the

(24) C. Ballou and A. Anderson, *J. Am. Chem. Soc.*, **15**, 648 (1953).

(25) R. Lemieux and H. Bauer, *Anal. Chem.*, **26**, 920 (1954).

ethanol crystallization of the 203° isomer (see above) was combined with the third crop ethanolic mother liquor, and the mixture vacuum-concentrated to about 4.0 ml. The crystals which separated on standing were collected, washed with 1 ml. of 2-methyl-1-propanol, and vacuum-dried at 75°, giving 0.59 g. of soft matted needles, m.p. 227–229° dec.

The total yield of the 229° isomer was thus 1.07 g. (21% based on anhydro diketal). The combined yield for both isomers was 80%.

Anal. Calcd. for $C_6H_{11}BrO_5$: C, 29.65; H, 4.56; Br, 32.88. Found: C, 29.62; H, 4.61; Br, 33.33.

The m.p. 229° bromoquercitol is soluble in water to the extent of 0.5 g./ml., as compared with 0.4 g./ml. for the m.p. 203° isomer. Both isomers are soluble in methanol, or in hot ethanol, and nearly insoluble (less than 33 mg./ml.) in acetone, ether or chloroform.

With the spectropolarimeter, the m.p. 229° bromoquercitol showed a negative plain dispersion curve: RD in dioxane (c 0.1), 31° $[\alpha]_{650} - 62°$, $[\alpha]_{400} - 135°$, $[\alpha]_{260} - 461°$.

Attempted Acetylation of the D(125/346)-Bromoquercitol of M.p. 203°.—Attempted preparation of the pentaacetate by heating the bromoquercitol (m.p. 202–203°) with acetyl bromide or acetyl chloride under various conditions gave only sirups or viscous foams, from which no crystalline product could be obtained. Acetylation with acetic anhydride was attempted using various catalysts such as pyridine, sodium acetate, zinc chloride and sulfuric acid. Again, no pure product could be isolated. Column chromatography on adsorbents such as Florisil seemed not to improve the products, nor attempted crystallization with numerous different solvents. An infrared spectrum was taken on the crude acetic anhydride–pyridine product. It showed no hydroxyl peaks, but had strong carbonyl absorption at 1750 and 1225 cm.$^{-1}$.

Reaction of D(125/346)-6-Bromoquercitol with Phenyl Isocyanate.—A mixture of 245 mg. of the finely powdered bromoquercitol (m.p. 202–203°) 1.0 ml. (1.09 g.) of phenyl isocyanate and 1 drop of anhydrous pyridine was boiled under reflux for 1 hour (anhydrous conditions). The crystals which separated on cooling were collected, washed with (b.p. 30–80°) petroleum ether (10 ml.), and vacuum-dried at 75°. The combined filtrates were evaporated to dryness, and the residue washed with petroleum ether (20 ml.).

The combined solid products were recrystallized from absolute ethanol (15 ml.), giving 660 mg. of colorless platelets, m.p. 181–182°.

Analysis indicated that the desired pentaphenylurethan had not been obtained, and that instead the product consisted of 1,3-diphenyl-2,4-diazetidinedione (phenyl isocyanate dimer[21]), reported m.p. 175°. The yield (based on monomeric phenyl isocyanate) was 61%.

Anal. Calcd. for $C_{41}H_{36}BrN_5O_{10}$: C, 58.71; H, 4.30; N, 8.35; Br, 9.55. Calcd. for $C_{14}H_{10}N_2O_2$: C, 70.60; H, 4.23; N, 11.76; Br, 0.00. Found: C, 70.32; H, 4.19; N, 11.87; Br, 0.00.

D(125/34)-Quercitol (M.p. 258°); (−)-*gala*-Quercitol; (−)-2-Deoxy-*allo*-inositol (XIII).—To a solution of 2.68 g. of the above bromoquercitol (m.p. 202–203°) in 50 ml. of water was added 5.0 g. of Amberlite IR-45 anion exchange resin and 10 g. (moist weight) of commercial Raney nickel catalyst. The mixture was hydrogenated at 3 atm. and 25° for 12 hours. The filtrate was vacuum-distilled to dryness, and the residue recrystallized from absolute methanol (10 ml.), giving 0.7 g. of the pure *gala*-quercitol, m.p. 257–258° dec., $[\alpha]_D^{22} - 48.6°$ (water, c 0.5), $[\alpha]_D^{21} - 48.2°$ (water, c 5), molecular rotation −80°. A second crop, 0.5 g., m.p. 255–257°, was obtained: total yield 1.2 g. (67%).

Anal. Calcd. for $C_6H_{12}O_5$: C, 43.90; H, 7.37. Found: C, 43.72; H, 7.32.

With the spectropolarimeter, *gala*-quercitol *in water* showed a negative plain dispersion curve, RD (c 0.3), 31°; $[\alpha]_{650} - 28°$, $[\alpha]_{400} - 95°$, $[\alpha]_{250} - 352°$. In *dioxane* it showed a remarkable reversal of sign to a positive plain dispersion curve, RD (c 0.2), 31°; $[\alpha]_{650}$ 0, $[\alpha]_{450} + 93°$, $[\alpha]_{260} + 348°$.

D(123/45)-Quercitol (M.p. 248°); (+)-*talo*-Quercitol; (+)-1-Deoxy-*allo*-inositol (XV).—To a solution of 75 mg. of the bromoquercitol (m.p. 228–229°) in 25 ml. of water was added 150 mg. of Amberlite IR-45 anion exchange resin and 750 mg. (moist weight) of commercial Raney nickel

catalyst. The mixture was hydrogenated at 3 atm. and 25° for 15 hours. The solids were removed by filtration, and washed twice with water (5 ml., 5 ml.). To remove traces of nickel ion, the combined filtrate was stirred with 300 mg. of Amberlite IR-120 (H⁺) cation exchange resin until a negative dimethylglyoxime test was obtained (90 minutes). After filtration, the filtrate was stirred with 500 mg. of Amberlite IR-45 until neutral.

The combined filtrates were evaporated to dryness, and the residue recrystallized from 3.0 ml. of absolute ethanol, giving 39 mg. (77%) of vacuum-dried (75°) quercitol, m.p. 245–247° dec. The product was again recrystallized in the same manner, giving 31 mg. of pure product, m.p. 246–248°, $[\alpha]^{21}D$ + 62° (water, c 0.5), molecular rotation +101°. A mixed m.p. with the other isomer (m.p. 257–258°) was depressed to 230–236°.

Anal. Calcd. for $C_6H_{12}O_5$: C, 43.90; H, 7.37. Found: C, 43.83; H, 7.22.

With the spectropolarimeter, (+)-*talo*-quercitol showed a *positive plain dispersion curve;* RD in water (c 0.47), 23°: $[\alpha]_{700}$ + 47.7°, $[\alpha]_{400}$ + 149°, $[\alpha]_{245}$ + 412°.

(−)-*gala*-Quercitol Pentaacetate, D(125/34) Stereoisomer of M.p. 118° (XIII).—A mixture of 164 mg. of the quercitol (m.p. 257–258°), 1.0 ml. of acetic anhydride and 130 mg. of fused sodium acetate was boiled under reflux for 2 hours (anhydrous conditions). The sirupy residue resulting on vacuum-distillation was washed twice with warm water (2.0 ml., 2.0 ml.) by decantation. The sirup then was taken up in chloroform (7 ml.). The solution after drying was vacuum-distilled to dryness, and the still sirupy residue was taken up in hot absolute ethanol (1.5 to 2.0 ml.). On cooling, no crystals were obtained.

After removal of ethanol by evaporation, the residue was taken up in 2.0 ml. of dry benzene and the solution passed through a 6 mm. × 75 mm. column of Woelm neutral aluminum oxide (Activity Grade No. 1), with the aid of 50 ml. of additional benzene.

The total benzene eluent was evaporated, and the still sirupy residue taken up in boiling absolute 2-propanol (1.5 ml.). The crystals which now appeared on cooling were collected, washed with solvent (0.5 ml.), and vacuum-dried at 75°, giving 170 mg. of the pure quercitol product, m.p 117–118°, $[\alpha]^{27}D$ − 24° (chloroform, c 0.5).

Anal. Calcd. for $C_{16}H_{22}O_{10}$: C, 51.33; H, 5.92. Found: C, 51.45; H, 5.73.

Including a second crop (m.p. 116–118°) the total yield was 265 mg. (71%). In later runs, a satisfactory product was obtained without use of chromatography.

With the spectropolarimeter, the *gala*-pentaacetate in dioxane showed an almost zero specific rotation from 650 down to 350 mμ, but the specific rotation then gradually increased, to +135° at 260 mμ, giving the compound a *positive* plain dispersion curve in this solvent.

(+)-*talo*-Quercitol Pentaacetate, D(123/45) Stereoisomer of M.p. 183° (XV).—A mixture of 50 mg. of the quercitol (m.p. 246–248°) with 1.5 ml. of acetic anhydride and 40 mg. of fused sodium acetate was boiled under reflux for 2 hours (anhydrous conditions). The sirupy residue obtained on vacuum-distillation was washed by decantation with 5.0 ml. of water, and distributed between 20 ml. of chloroform and 20 ml. of water. The separated aqueous layer was again washed with chloroform (10 ml.). The combined chloroform solution was washed with 5% sodium bicarbonate solution (20 ml.), separated, and dried. The dry solution on evaporation gave a crystalline residue, which was recrystallized from 5.0 ml. of anhydrous 2-propanol. The collected crystals were washed with 1 ml. of solvent, and vacuum-dried at 75°, giving 75 mg. of the pure quercitol pentaacetate, m.p. 182–183°, $[\alpha]^{27}D$ +28° (chloroform, c 1). Including a second crop (m.p. 181.5–183°), the total yield was 114 mg. (83%).

Anal. Calcd. for $C_{16}H_{22}O_{10}$: C, 51.33; H, 5.92. Found: C, 51.65; H, 6.05.

With the spectropolarimeter, the *talo*-pentaacetate showed a positive plain dispersion curve; RD in dioxane (c 0.1), 31°; $[\alpha]_{650}$ + 17°, $[\alpha]_{450}$ +23°, $[\alpha]_{260}$ +110°.

1,2-Anhydro-*neo*-inositol (XX).—The above 3,4:5,6-diacetone ketal of 1,2-anhydro-*allo*-inositol was deacetonated as previously reported,[8b] giving a 75% yield of 1,2-anhydro-*allo*-inositol, m.p. 205–206° (reported 200° *dec.*), $[\alpha]^{14}D$ + 156° (water, c 0.5) (reported[8b] +153°). This product was isomerized with barium hydroxide as pre-

viously described[8b] giving a 26% yield (based on "*allo*" isomer) of 1,2-anhydro-*neo*-inositol, m.p. 153–154° (reported 154°), $[\alpha]^{14}D$ +112° (water, c 1) (reported[8b] +113°).

(+)-*talo*-Quercitol and *neo*-Quercitol: Preparation from 1,2-Anhydro-*neo*-inositol.—A solution of 1.0 g. of the above "*neo*" epoxide (m.p. 153–154°) in 25 ml. of warm water was cooled, and 2 g. (moist weight) of commercial Raney nickel catalyst was added. The mixture was hydrogenated at three atmospheres and 25° for 12 hours. The mixture was filtered, and the residue washed (water, 3.0 ml.). The combined filtrate was vacuum-distilled to dryness, and the colorless residue taken up in boiling absolute ethanol (10 ml.). The crystals which separated on cooling were collected, washed (absolute ethanol, 2 ml.), and dried *in vacuo* at 70° for 6 hours. The crude *talo*-quercitol fraction weighed 0.72 g. (71%), m.p. 220–235° dec. The mother liquor was reserved for isolation of *neo*-quercitol (see below).

The crystals were recrystallized seven times from 4:1 v./v. isopropyl alcohol–water, using progressively smaller solvent volumes (8.0 to 2.0 ml.). The melting range was constant at 246–248° dec. for the last three crystallizations.

The 160 mg. of nearly pure *talo* isomer from the seventh recrystallization was chromatographed on a 10 × 100 mm. column of Whatman No. 1 powdered cellulose with 4:1 v./v. acetone–water. To facilitate location of the solvent front, one drop of 0.4% methyl orange indicator (R_f 1.0) was added to the solution. Seven 10-ml. fractions of effluent were collected. The combined second and third fractions were vacuum-distilled to dryness, and the residue recrystallized from boiling absolute ethanol (3 ml.), giving 100 mg. of pure *talo*-quercitol, m.p. 247–248° dec., $[\alpha]^{18}D$ + 63° (water, c 0.5). A mixed m.p. with (+)-*talo*-quercitol (m.p. 248°, dec.) prepared (see above) by debromination of the m.p. 229° bromoquercitol showed no depression, and infrared and nuclear magnetic resonance spectra of the two samples were identical.

To confirm further the identity of the two preparations of (+)-*talo*-quercitol, a 15-mg. sample derived from the "*neo*" epoxide was acetylated in the manner described above. The pentaacetate so obtained (yield 22 mg., 54%) melted at 182–183°, and a mixed m.p. with the product from the bromoquercitol was not depressed. The rotation $[\alpha]^{27}D$ + 28° (chloroform, c 1) was in agreement with the above value, and the infrared spectra of the two preparations were identical.

In order to detect *neo*-quercitol, a sample of the crude product from hydrogenation of the epoxide was chromatographed on Whatman No. 1 paper with 4:1 v./v. acetone–water, using D-glucose as a reference substance. The spots were detected with permanganate–periodate spray.[25]

The slower-moving and larger spot had an R_f value of 0.36 and corresponded to the new quercitol isomer of m.p. 248°. The second and smaller spot had an R_f value of 0.39 (reported[16] for *neo*-quercitol, R_f 0.40). Chromatography was repeated with eight 35 × 15 cm. paper sheets, and the *neo*-quercitol zones eluted with water. On evaporation there was obtained a small residue, m.p. 233–237° dec. This was recrystallized from methanol (0.2 ml.), giving 1 mg. of colorless crystals, m.p. 236–238° dec. This material in all probability was *neo*-quercitol (reported[16] m.p. 238–239° dec.), but since several other quercitol isomers have nearly the same m.p., the identification cannot be regarded as entirely certain.

Infrared Spectra.—The infrared spectrum was determined on every new compound prepared. The bromoquercitols showed the expected O–H and C–O secondary-alcoholic stretching absorption at 3400 and 1150 cm.⁻¹, respectively. Debromination produced relatively small spectral changes: C–O stretching maxima now were found at 1030 and 1060 cm.⁻¹, and methylene C–H bending at 1450 cm.⁻¹.

Acetylation of the quercitols caused complete disappearance of the strong O–H stretching absorption at 3400 cm.⁻¹. Acetate ester C=O stretch now showed a strong maximum at 1750 cm.⁻¹; methyl C–H bending was observed at 1360; and an ester C–O stretching maximum was noted at 1230 cm.⁻¹. The secondary alcoholic C–O stretching maxima at 1030 and 1060 remained relatively unchanged on esterification. Amorphous bromoquercitol pentaacetate (acetic anhydride–pyridine method) gave a spectrum quite similar to the quercitol pentaacetates.

Although the above-mentioned changes in structure were readily detected spectroscopically, the two different quercitol (or quercitol pentaacetate) diastereomers gave spectra which

were very closely similar. It was concluded that the identity or non-identity of quercitol *diastereomers* cannot be established reliably by routine infrared measurements with instruments of limited resolving power. This is in contrast to the n.m.r. measurements, which gave spectra that differed markedly for the two diastereomers.

Isomerization of Alkyl Tropilidenes[1]

BY KENNETH CONROW[1a]

The monomethyltropilidenes are involved in reversible hydride exchange equilibria with tropylium and methyltropylium ions in acetonitrile solvent. The composition of the equilibrium mixture of the methyltropilidene isomers and the equilibrium constant for hydride exchange between the equilibrium mixture of methyltropilidenes and tropylium ion have been measured. From these results, it follows that the methyltropylium ion is 3.7 ± 0.4 kcal./mole more stable than the unsubstituted tropylium ion. Crude measures of the rate of hydride transfer from 7-methyltropilidene to tropylium ion ($k_2 \sim 1.8 \times 10^{-3}$) and to methyltropylium ion ($k_2 \sim 3 \times 10^{-4}$) also were obtained. No evidence was observed for isomerization in solution by mechanisms other than that of hydride exchange.

The reaction mixtures involved in the study of electrophilic fragmentation of 7-(functionally substituted alkyl)-tropilidenes[2] invariably contain an electrophile, a 7-alkyltropilidene and tropylium ion. The possibility that the electrophile or the tropylium ion might isomerize the 7-alkyltropilidene to 1-, 2- or 3-alkyltropilidenes (which cannot fragment except by isomerization back to the 7-isomer) in a reaction competitive with the fragmentation reaction prompted a study of the isomerization of 7-alkyltropilidenes. To avoid the complication which would arise from a competing fragmentation reaction, simple 7-methyl- and 7-ethyltropilidenes were selected for this study.

Attention first was turned to seeking a way to identify the various alkyltropilidenes when and if isolated in a pure state. Since pyrolysis of tropilidene itself gives rise to toluene[3] it was expected that alkyltropilidenes would give α-, o-, m- and p-alkyltoluenes. On the basis of Woods'[3] suggested mechanism, 7-alkyltropilidene would give α-alkyltoluene, 1-alkyltropilidene would give α- and o-, 2-alkyltropilidene would give o- and m- and so on. However, it was found that pyrolysis of 7-ethyltropilidene at 400° gave a mixture of 1-, 2-, 3- and 7-ethyltropilidene with little, if any, ring contraction to toluene derivatives. Since isomerization of ethyltropilidene occurs at this temperature prior to ring contraction, any mixture of alkylbenzenes which might be obtained at higher temperature will be that derived from some isomeric mixture of ethyltropilidenes regardless of which isomer was utilized in the pyrolysis. This result eliminates the possibility of using pyrolysis as a means of identification of structure.

The production of tropylium ion by various mild oxidizing agents[4] suggests that any oxidation to substituted benzaldehydes or benzoic acids ob-

served with stronger oxidizing agents[5] would proceed through tropylium ion as an intermediate. In this event, all of the isomeric alkyltropilidenes would proceed through a common intermediate and no information about isomerization in the alkyltropilidene could be gained by such an oxidative process.

Processes based on the Diels–Alder reaction[6] or direct correlation with the Buchner acids of known[6] structure remained to be considered as means of structure proof of the isomeric alkyltropilidenes, but fortunately a communication[7] appeared at this time describing the preparation of 1-, 2- and 3-methyltropilidenes by solvolysis of 1- and 2-methyl-1,4-dihydrobenzyl tosylates and the isomerization of the 2-isomer to the 1- and 3-isomers. Assignment of structure to the 1-isomer was substantiated by its proton magnetic resonance spectrum; assignment of structure to the 2- and 3-isomers was based on mechanistic considerations. These workers also determined the relative retention times of the 2-, 3- and 1-methyltropilidenes to be 0.50, 0.57 and 0.67, respectively, relative to o-xylene as 1.00 on a γ-methyl-γ-nitropimelonitrile column at 70°.[8] The 7-methyl isomer (see below) has a retention time of 0.42 on this scale so that the means of separation and identification of the isomers was readily available.

The isomer that arises from the action of methylmagnesium iodide on tropylium perchlorate was taken to be 7-methyltropilidene, by analogy with the course of the reaction with phenyllithium[9] and from mechanistic considerations. Further indication of the correctness of this assignment was gained from the identity of 7-ethyltropilidene prepared by two different routes: by the reduction of the tosylate of 2-tropylethanol[2] and by the action of ethylmagnesium bromide on tropylium perchlorate. In this connection, advantage was taken of the

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