If the "real D" in Simpson's sense[3] is the determining factor, then this real D bears no obvious relation to the macroscopic solvent D.

The results on at least these two dyes thus do not support Brooker's contention that the factor determining the displacement of the spectrum is the stabilization of the dipolar resonance forms Ib and IIb. There are more obvious correlations with other solvent properties than the dielectric constant. Firstly, the order of the spectra in Fig. 1 is qualitatively the same as the order of the sizes of the solvent molecules. Secondly, the spectra in Fig. 1 seem to divide themselves into two groups—(a) the spectra in pyridine, chloroform, acetone and nitrobenzene, and (b) those in ethanol, formamide and water. Group (b) are just those solvents whose molecules contain hydrogen atoms with the hydrogen bonding property, suggesting that hydrogen bond formation may play a part in the spectral displacement. These various effects are the subject of current study in this laboratory, and will be reported shortly.[4]

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RECEIVED SEPTEMBER 27, 1952

THE IDENTIFICATION OF CYTIDYLIC ACIDS *a* AND *b*[1]

Sir:

The identification of the isomeric cytidylic acids *a* and *b*[2] with known cytidine-2′- or 3′-phosphates has received a considerable amount of attention[3,4,5] but thus far these efforts have been unsuccessful. It is certain, however, that the isomerism is positional,[4] *i.e.*, that the 2 and 3 positions of the D-ribose portion are involved. In this preliminary communication we report the results of measurements which allow a decision to be made based on the distances between the 4-amino and phosphate groups.

Cytidylic acids *a* and *b* were isolated according to the procedure of Loring, Bortner, Levy and Hammell.[6] The samples were recrystallized alternately as their ammonium salts and free acids to constancy with respect to ultraviolet spectral characteristics, optical rotation values, density measurements and *p*H titration curves. For the *a* isomer the 250/260, 280/260 and 290/260 values were 0.47, 1.80 and 1.21; for the *b* isomer, 0.43, 2.01 and 1.43, respectively.[2,6] Specific rotation, $[\alpha]_D$, for *a* was $-3°$; for *b*, $+50°$, $c = 1$, aqueous sodium hydroxide, *p*H 10.[6]

We have carried out high-precision density measurements on aqueous solutions (*ca.* 0.15–0.5%) of the isomers.[7] Measurements were made on two different samples of each isomer; the samples used represented the final and penultimate samples from the recrystallization procedure. To provide a check on the determinations, appropriate dilutions of each of the four samples were made in such a way that equal concentrations of the various solutions could be compared. This crisscross technique thus provided a check both for the weighings and the different fractions. The *b* isomer was found to have a greater density at all concentrations. For example, in 0.3% solutions *b* had a density greater by 18 parts per million. Since it has been firmly established[8] that as the distance between the charged groups of a zwitterion is increased the density of its aqueous solutions increases (because of increased electrostriction) we conclude that the *b* isomer exhibits the greater separation of charge.

We have also determined the apparent dissociation constants of the 4-ammonium group from *p*H titration curves obtained with the aid of a Cambridge *p*H meter.[9] The pK'_a of the *a* isomer was found to be 4.36; for the *b*, 4.28.[10] Since the pK'_a will be lower for the isomer with the greater separation of charge[11] these data also show that the *b* isomer exhibits the greater separation of charge.

The detailed structure of cytidine has been presented by Furberg[12] on the basis of X-ray crystallographic analysis. One of the essential features of the structure is that the glycosidic bond (C_1–N_1) lies in the plane of the pyrimidine ring and is symmetrically disposed with respect to the 2 and 6 carbon atoms of the pyrimidine ring. Thus, regardless of the angle of rotation of the sugar ring about the pyrimidine ring the 3 position of the D-ribose will always be further from the 4-amino group than the 2 position. We conclude, therefore, that the cytidylic acid isomer showing the greater separation of charge (*i.e.*, the *b* isomer) is cytidine-3′-phosphate.

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[1] This investigation was supported by grants from the National Cancer Institute, National Institute of Health, United States Public Health Service, and from the Atomic Energy Commission, Contract No. At(30-1)-910. The author wishes to acknowledge the continued interest of Dr. George Bosworth Brown.

[2] C. E. Carter and W. E. Cohn, *Federation Proc.*, **8**, 190 (1949); W. E. Cohn, THIS JOURNAL, **72**, 2811 (1950).

[3] D. M. Brown and A. R. Todd, *J. Chem. Soc.*, 52 (1952).

[4] H. S. Loring, M. L. Hammell, L. W. Levy and H. W. Bortner, *J. Biol. Chem.*, **196**, 821 (1952).

[5] R. Markham and J. D. Smith, *Nature*, **168**, 406 (1951).

[6] H. S. Loring, H. W. Bortner, L. W. Levy and M. L. Hammell, *J. Biol. Chem.*, **196**, 807 (1952).

[7] The falling drop method used gave results reproducible to within 1 to 2 parts per million.

[8] See, for example, Cohn and Edsall, "Proteins, Amino Acids and Peptides," Reinhold Publishing Corp., New York, N. Y., 1943, p. 155.

[9] The reproducibility of this instrument was 0.006 *p*H unit.

[10] The pK'_a of the secondary phosphoryl dissociation for the cytidylic acids was 6.17 for the *a* and 6.00 for the *b*. Loring, *et al.*,[6] report 6.2 and 6.0, respectively. In the zwitterionic form (at *ca.* *p*H 4) the secondary phosphoryl dissociation is negligible and pK'_a values for these potential hydrogen ions are not pertinent to the question of separation of charge.

[11] A. Neuberger, *Proc. Roy. Soc.* (*London*), **A158**, 68 (1937).

[12] S. Furberg, *Acta Chem. Scand.*, **4**, 751 (1950).

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RECEIVED OCTOBER 8, 1952

THIOUREA ADDUCTS OF *n*-PARAFFINS

Sir:

In applying the reasonably well-defined principles of urea and thiourea adduction to the development of a systematic, analytical fractionation of petrolatums and other high boiling petroleum stocks, it was found by analysis that certain thiourea adducts contained considerable amounts of n-paraffins. Because the literature, recently reviewed by Kobe and Domask,[1] strongly infers that n-paraffin–thiourea adduct formation should not occur, a series of experiments was performed to investigate this contradiction. The results of the study show that n-paraffins containing fourteen or more carbon atoms can adduct with thiourea and consequently, for the separation of hydrocarbons which boil above the gasoline range, serious limitations are imposed on the previously supposed complementary selectivity of urea and thiourea.

Eight essentially pure n-paraffins were studied: n-decane, n-tetradecane, n-hexadecane, n-tricosane, n-pentacosane, n-octacosane and n-dotriacontane. Additional data were obtained with various fractions from a purified, commercial paraffin wax. Several different test methods were investigated. The most reliable procedure followed was to stir crystalline thiourea, moistened with methyl ethyl ketone, with a solution of the paraffin sample in benzene. In every case, care was taken to ensure the presence of a sufficient volume of benzene to prevent crystallization of the paraffin. The solids were filtered, washed, heated with water, and the adducted hydrocarbon recovered and identified.

From the results of the tests, certain conclusions are apparent. A n-paraffin containing twelve or less carbon atoms does not form an adduct with thiourea at 0° or above. n-Tetradecane (n-$C_{14}H_{30}$) forms an adduct at 0° but not at 25°. Paraffins containing sixteen or more carbon atoms can form thiourea adducts at either temperature. Obviously, modification of various conditions and techniques could shift the minimum chain length somewhat in either direction. The ease of formation and the "stability" of the adducts become greater as the molecular weight of the paraffin increases. However, even the higher molecular weight paraffins tested gave very poor yields of adduct at 45° due to the great change of adduct "stability" with temperature. Washing the adducts with one to three volumes of cold (5 to 10°) hydrocarbon solvents does not cause significant decomposition. It is advisable to allow adduct formation to proceed for about one hour in qualitative work. Quantitative recovery can be obtained only by successive treatments, each of about forty-eight hours duration, using in excess of 25 g. of thiourea per gram of n-paraffin.

At our request, certain of the above generalizations have been confirmed independently by another laboratory.[2] Professor Schiessler also determined that if the n-paraffin chain were coiled into a multiturn helix containing five methylene groups per turn, its dimensions would fall within the limits predicted for a molecule which will adduct with thiourea.[3]

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RECEIVED OCTOBER 6, 1952

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(1) K. A. Kobe and W. G. Domask, *Petroleum Refiner*, **31**, no. 3, 106–113; no. 5, 151–157; no. 7, 125–129 (1952).

(2) R. W. Schiessler, Am. Petroleum Institute Project 42, Pennsylvania State College, State College, Pa., private communication.

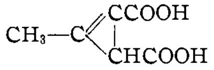
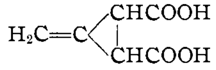
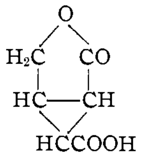
(3) R. W. Schiessler and D. Flitter, THIS JOURNAL, **74**, 1720–1723 (1952).

STRUCTURE OF FEIST'S METHYLCYCLOPROPENEDICARBOXYLIC ACID

Sir:

In 1893, Feist[1a] discovered that the reaction of 3-bromo-5-carboethoxy-4,6-dimethyl-2-pyrone with alkali furnished a dicarboxylic acid $C_6H_6O_4$, to which subsequent investigators[1] have ascribed the structure of 1-methylcyclopropene-2,3-dicarboxylic acid (I). Although my work on this most accessible supposed derivative of cyclopropene is not completed, current interest[1j] suggests publication of the conclusions, which differ from all advanced hitherto.

The Feist acid must be reformulated as 1-methylenecyclopropane-*trans*-2,3-dicarboxylic acid[2] (II). *The acid contains no C-methyl group.*[3] On bromination there are formed a dibromo diacid,[1a] reconverted to the unsaturated acid by zinc[1c] or sodium amalgam,[1e] and a bromo lactone monoacid,[1a] inert to neutral permanganate or hot silver nitrate. The bromo lactone may be reversibly hydrated to a hydroxy diacid, obtained also by hydrolysis of the dibromo acid.[1b] Reduction of the bromo lactone by sodium amalgam[1a] or over palladium gives a lactone monoacid, which may be reversibly hydrolyzed[4] and has a lactone carbonyl band at the same position as the bromo lactone (5.55 μ). *On oxidation with permanganate in bicarbonate the lactone gives trans-cyclopropane-1,2,3-tricarboxylic acid,*[5] m. p. 213.5–217.5°, neutr. equiv. 59.7, trimethyl ester m. p. 55–57°. *The lactone must therefore be 1-hydroxymethylcyclopropane-trans-2,3-dicarboxylic acid lactone* (III), and the bromo lactone and dibromo acid are respectively the 1-bromo derivative of III and 1-bromo-1-bromomethylcyclopropane-*trans*-2,3-dicarboxylic acid.

I

II

III

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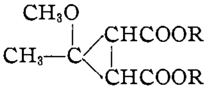
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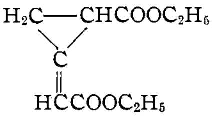

The dimethyl ester[1c] of the Feist acid adds

(1) (a) F. Feist, *Ber.*, **26**, 747 (1893); (b) *Ann.*, **436**, 125 (1924); (c) D. T. Jones, *J. Chem. Soc.*, **87**, 1062 (1905); (d) C. K. Ingold, *ibid.*, **121**, 2676 (1922); (e) F. R. Goss, C. K. Ingold and J. F. Thorpe, *ibid.*, **123**, 327 (1923); (f) *ibid.*, 3342 (1923); (g) *ibid.*, **127**, 460 (1925); (h) F. R. Goss and C. K. Ingold, *ibid.*, **127**, 2776 (1925); (i) G. A. R. Kon and H. R. Nanji, *ibid.*, 2557 (1932); (j) K. B. Wiberg, Abstracts of the 122nd National Meeting of the American Chemical Society, September 14–19, 1952, p. 38M.

(2) The stereochemistry is fixed by resolution.[1b,g]

(3) Determined by Mr. S. M. Nagy, Massachusetts Institute of Technology. The lactone III also possessed no C-methyl, whereas oxidations of citraconic anhydride and IV ($R = CH_3$) gave 0.82 and 0.7 equivalents of acetic acid.

(4) The reported[1a,e] reversion of lactone to unsaturated acid in alkali proved erroneous.

(5) Compare the reported[1b] oxidation of bromo lactone to a triacid $C_6H_5O_6Br$.