ultraviolet range. It was also noted by Lerner[36] and Ferand[37] that proteins and polypeptides containing these amino acids have ultraviolet absorption in the 270–280 mμ range. The spectral properties of mucus may thus be taken to support the identification of two of the amino acid constituents, namely, phenylalanine and tyrosine.[38] The latter, it can be demonstrated, accounts very well for the observed spectral shifts with change in hydrogen ion on the basis of the familiar bathochromic displacement on conversion of phenols to phenolic anions. This type of behavior is strongly reminiscent of polyelectrolytes in general as characterized in the investigations of Katchalsky and Miller on synthetic polyelectrolytes such as polyvinylpyridine[39] and Butler, Conway and Janers[40] on natural polyelectrolytes of the nature of desoxyribonucleic acid.

Spectral Anomalies.—In several instances an anomalous spectrum was observed for a mucus sample. Instead of an absorption maximum at 272 mμ, a strong band appeared at 250 mμ, *p*H 7. This behavior could be found in both the freshly extracted as well as by the thoroughly dialyzed anomaly. It was suspected that some contamination had occurred which was not removable by dialysis.[41] Figure 9, Plot A illustrates that a substantial shift in λ_{max} from 250 to 268 mμ takes place in going from *p*H 7 to 5. The literature[42] reveals similar observations have been made in the instance of histidine samples contaminated by ferric ions. These experiments were repeated with pure histidine with and without added ferric chloride all shown in Fig. 9, plot B. It may be contended on this basis that a trace of ferric ion bound to the histidine constituent of the mucoprotein moiety of mucus was responsible for the spectral anomaly.

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(39) A. Katchalsky and I. R. Miller, *J. Polymer Sci.*, **13**, 57 (1954).
(40) J. A. V. Butler, B. E. Conway and D. W. F. Janers, *Trans. Faraday Soc.*, **50**, 612 (1954).
(41) Subsequently, on reviewing the history of the anomalous samples, it was realized that contamination by traces of iron was indeed possible.
(42) F. Ellinger, *Biochem. Z.*, **215**, 279 (1929); **248**, 436 (1932).

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[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, WASHINGTON UNIVERSITY]

The Condensation of Nitromethane with D-Erythrose, D-Arabinose, D-Mannose and D-*glycero*-D-*gala*-Heptose in Aqueous Alkali

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The reaction of nitromethane with aldose sugars in aqueous alkali has been studied in the sequence of condensations necessary to convert D-erythrose to D-*erythro*-L-*manno*-octose by the nitromethane synthesis. In each instance, the less soluble of the pair of epimeric nitroalcohols produced was isolated without difficulty. In the reactions with D-mannose and D-*glycero*-D-*gala*-heptose, the deoxynitroalditols crystallized directly from the aqueous, alkaline reaction mixtures.

The condensation of nitromethane with aldose sugars usually has been carried out with sodium methoxide in absolute methanol, from which system the sodium salts of the deoxynitroalditols normally precipitate as the condensation reaction progresses.[1] In a previous communication[2] we reported the condensation of nitromethane with D-arabinose in aqueous sodium hydroxide solution to give, after hydrolysis of the intermediate 1-deoxy-1-nitro-D-mannitol, a 22% yield of D-mannose as the phenylhydrazone. The aqueous reaction conditions now have been extended to D-erythrose, D-mannose and D-*glycero*-D-*gala*-heptose to obtain, respectively, 1-deoxy-1-nitro-D-arabitol, 1-deoxy-1-nitro-D-*glycero*-D-*gala*-heptitol and 1-deoxy-1-nitro-D-*erythro*-L-*manno*-octitol.

In a single experiment with D-erythrose, nitromethane and aqueous sodium hydroxide, 1-deoxy-1-nitro-D-arabitol was isolated in only 7% yield. In view of the results obtained with aldoses of greater chain length, it is believed that the isolation by crystallization of the deoxynitropentitol was inhibited in this instance by the presence of a considerable amount of unchanged D-erythrose. D-Arabinose in aqueous, alkaline nitromethane, under the best of a variety of reaction conditions, provided crude 1-deoxy-1-nitro-D-mannitol in 17% yield, and the unchanged starting sugar was recovered in 40% crude yield. Of most interest in the present work were the condensations of D-mannose and D-*glycero*-D-*gala*-heptose with nitromethane. Here, the 1-deoxy-1-nitro-D-*glycero*-D-*gala*-heptitol and 1-deoxy-1-nitro-D-*erythro*-L-*manno*-octitol crystallized directly from the aqueous, alkaline reaction mixtures in 11 and 25% yield, respectively, and further amounts of the deoxynitroalditols were obtained from the filtrates.

The present work, taken with previous observations on the nitromethane–aldose condensation reaction,[1,2] leads us to the following conclusions. In homogeneous alkaline solution, in either methanol or water, the aldoses, nitromethane and the deoxynitroalditols establish an equilibrium. The equilibrium may be displaced in favor of the deoxynitroalditols either by their precipitation as alkali

(1) J. C. Sowden, *Adv. in Carbohydrate Chem.*, **6**, 291 (1951).
(2) J. C. Sowden and R. R. Thompson, THIS JOURNAL, **77**, 3160 (1955).

salts from methanolic solution, or by their direct crystallization from aqueous solution. It seems probable that the aqueous reaction conditions will be particularly applicable for the preparation of those higher-carbon deoxynitroalditols that, like 1-deoxy-1-nitro-D-*glycero*-D-*gala*-heptitol and 1-deoxy-1-nitro-D-*erythro*-L-*manno*-octitol, are sparingly soluble in water.

Experimental

1-Deoxy-1-nitro-D-arabitol.—D-Erythrose (0.7 g.), prepared by the method of Perlin and Brice,[3] was dissolved in 2 equivalents of 2 *N* sodium hydroxide containing 2 equivalents of nitromethane. After 30 minutes at room temperature, the reaction mixture was acidified with 8% hydrochloric acid, deionized, and concentrated at reduced pressure to a sirup (0.8 g.). The latter was dissolved in 2 ml. of absolute ethanol and the solution was seeded with 1-deoxy-1-nitro-D-arabitol to yield 78 mg. of the deoxynitropentitol, m.p. 144–145°.[4]

1-Deoxy-1-nitro-D-mannitol.—Five grams of D-arabinose was dissolved in 2 equivalents of 2 *N* sodium hydroxide containing 2 equivalents of nitromethane. After 25 minutes at room temperature, the reaction mixture was acidified with dilute hydrochloric acid, deionized, and concentrated at reduced pressure to a sirup. Fractional crystallization of the latter from 95% ethanol yielded 1.23 g. (17.5%) of crude 1-deoxy-1-nitro-D-mannitol, m.p. 120–130°; 2.0 g. (40%) of crude D-arabinose, m.p. 145–155°; and a few mg. of 1-deoxy-1-nitro-D-glucitol, m.p. 106–107°. Recrystallization of the crude 1-deoxy-1-nitro-D-mannitol from 95% ethanol yielded the pure deoxynitrohexitol,[5] m.p. 132–133°, $[\alpha]^{24}D$ −6.4° in water, *c* 6.

Wide variations in the reaction conditions with regard to concentration and reaction time did not improve the above yield of 1-deoxy-1-nitro-D-mannitol.

1-Deoxy-1-nitro-D-*glycero*-D-*gala*-heptitol.—A large number of condensations of D-mannose with nitromethane were performed employing from 5 to 10 equivalents of nitromethane, from 0.25 to 2 equivalents of sodium hydroxide (0.08 to 5 *N*), reaction temperatures from 0° to room temperature, and reaction times from 30 minutes to 28 days. The best results were obtained in the following experiment. Five grams of D-mannose was dissolved at room temperature in a mixture containing 1.5 equivalents of 5 *N* sodium hydroxide and 10 equivalents of nitromethane. After 30 minutes, the reaction mixture was cooled to 0° and maintained at this temperature for 15 hours. The mixture then was neutralized with dilute hydrochloric acid and filtered. The product was recrystallized from water, after decolorization, to give 0.73 g. of 1-deoxy-1-nitro-D-*glycero*-D-*gala*-heptitol, m.p. 190–198°. An additional 0.62 g. (total yield, 20%), m.p. 190–198°, was obtained from the combined filtrates by deionization and concentration. Recrystallized from water, the deoxynitroheptitol[6] showed m.p. 197–198° and $[\alpha]^{20}D$ +2.1° in water, *c* 0.9.

The combined filtrates from the preparation of the deoxynitroheptitol, on treatment with phenylhydrazine and acetic acid, yielded 3.37 g. (45% recovery) of D-mannose phenylhydrazone, m.p. 188–189° dec.

1-Deoxy-1-nitro-D-*erythro*-L-*manno*-octitol.—One gram of D-*glycero*-D-*gala*-heptose in 5 equivalents of nitromethane and 2 equivalents of 5 *N* sodium hydroxide was allowed to stand at room temperature for 48 hours. Filtration then yielded 0.324 g. of crude 1-deoxy-1-nitro-D-*erythro*-L-*manno*-octitol, m.p. 185–195°. Acidification of the filtrate with dilute hydrochloric acid, followed by deionization and concentration, provided an additional 0.217 g. of the deoxynitroöctitol, m.p. 195–200°, for a total, crude yield of 42%. Recrystallization from water raised the m.p. to 202–203°.[7]

Reaction times of 2 or 3 hours at room temperature, with the same concentrations of reactants as above, gave lower yields (*ca.* 30%) of the deoxynitroöctitol.

(3) A. S. Perlin and C. Brice, *Can. J. Chem.*, **33**, 1216 (1955).
(4) J. C. Sowden, THIS JOURNAL, **72**, 808 (1950).
(5) J. C. Sowden and H. O. L. Fischer, *ibid.*, **69**, 1963 (1947).
(6) J. C. Sowden and R. Schaffer, *ibid.*, **73**, 4662 (1951).
(7) J. V. Karabinos and C. S. Hudson, *ibid.*, **75**, 4324 (1953), record the m.p. of this substance as 191–192°. However, preparations in this Laboratory using either aqueous sodium hydroxide or sodium methoxide in methanol have all shown the higher m.p. On one occasion, after several recrystallizations from water, we obtained material with m.p. 209–210°. The deoxynitroöctitol apparently is polymorphous, since our product of m.p. 202–203° showed the correct analysis and gave D-*erythro*-L-*manno*-octose in normal fashion and yield when subjected to hydrolysis according to the directions of Karabinos and Hudson.

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[CONTRIBUTION FROM THE DEPARTMENTS OF CHEMISTRY AT THE UNIVERSITY OF OTTAWA AND QUEEN'S UNIVERSITY]

The Configurations of the 3-Methoxycyclohexene Oxides. A Novel Application of Proton Magnetic Resonance Spectroscopy to the Determination of Structure and Configuration[1]

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It was found possible to assign the structures and configurations to two of the diastereoisomeric 1,3-dimethoxy-2-acetoxycyclohexanes on the basis of their proton magnetic resonance spectra and thereby assign configurations to the parent diastereoisomeric 3-methoxycyclohexene oxides. The conclusions thus reached were substantiated by a variety of chemical means.

McRae, Moir and co-workers[3] have reported the diastereoisomeric D,L-3-methoxycyclohexene oxides, but did not provide evidence for their configurations. Methanolysis of the so-called α-oxide with sodium methoxide produced essentially only one product which on treatment with hydriodic acid gave $1\alpha,2\beta,3\alpha$-cyclohexanetriol.[4] Thus, the product of methanolysis appeared to be either Ia or IIa. Similar experiments with the so-called β-oxide[3] produced $1\alpha,2\alpha,3\beta$-cyclohexanetriol and it could be concluded that the product of methanolysis was either IIIa or IVa.

(1) Presented in part at the Miami Meeting of the American Chemical Society, April 7–12, 1957.
(2) A portion of this work is to be submitted by R. K. K. as part of a thesis in partial fulfillment of the requirements for the Ph.D. degree at the University of Ottawa.
(3) J. A. McRae, R. Y. Moir, J. W. Haynes and L. G. Ripley, *J. Org. Chem.*, **17**, 1621 (1952).
(4) The system of nomenclature used herein to describe a variety of *meso* and racemic compounds is adopted from the field of steroid chemistry and is similar to that proposed by L. F. Fieser [THIS JOURNAL, **72**, 623 (1950)] for the carbohydrates. The names give no information on absolute configuration since the orientations of the molecules are not specified. The use of the symbol α is given preference over β.