TABLE I

SYMMETRICAL N,N,N',N'-TETRAALKYLPIPERAZINIUM DI-ALKYLSULFATES
$[(R)(R')N(CH_2CH_2)_2N(R)(R')]^{++}2R'SO_4^-$

R	R'	Formula	M.P., °C.[a]	C Calc'd	C Found	H Calc'd	H Found	N Calc'd	N Found
n-Decyl	Methyl	$C_{28}H_{62}N_2O_8S_2$	179–180	54.31	54.10	10.09	9.68	4.52	4.85
n-Decyl	Ethyl	$C_{32}H_{70}N_2O_8S_2$	165–166	56.93	57.11	10.45	10.49	4.15	4.10
n-Dodecyl	Methyl	$C_{32}H_{70}N_2O_8S_2$	275 dec.	56.93	57.16	10.45	10.39	4.15	4.08
n-Dodecyl	Ethyl	$C_{36}H_{78}N_2O_8S_2$	250 dec.	59.13	58.92	10.75	10.90	3.84	3.87
n-Tetradecyl[b]	Methyl	$C_{36}H_{78}N_2O_8S_2$	265 dec.	59.13	58.14	10.75	10.40	3.84	3.76
n-Tetradecyl	Ethyl	$C_{40}H_{86}N_2O_8S_2$	236 dec.	61.02	61.75	11.01	11.23	3.55	3.44
n-Hexadecyl	Methyl	$C_{40}H_{86}N_2O_8S_2$	260 dec.	61.02	61.02	11.01	11.10	3.55	3.52
n-Hexadecyl	Ethyl	$C_{44}H_{94}N_2O_8S_2$	250 dec.	62.66	63.20	11.23	11.19	3.32	3.29
n-Octadecyl	Methyl	$C_{44}H_{94}N_2O_8S_2$	258 dec.	62.66	63.16	11.23	10.91	3.32	3.20
n-Octadecyl	Ethyl	$C_{48}H_{102}N_2O_8S_2$	242 dec.	64.09	64.81	11.43	11.56	3.11	3.05

[a] Melting points are uncorrected. [b] Reference 1.

Anal. Calc'd for $C_{40}H_{82}N_2$: C, 81.20; H, 13.98; N, 4.73. Found: C, 80.89; H, 14.02; N, 4.77.

N,N,N',N'-Tetralkylpiperazinium di-alkylsulfates were prepared by dissolving 0.02 mole of the dialkylpiperazine in a sufficient volume of boiling ethyl acetate, adding 0.042 mole of the redistilled dialkyl sulfate and refluxing for 3 hr. The reaction mixture was chilled filtered, and the product recrystallized from ethyl acetate. In the case of N,N'-di-*n*-octadecylpiperazine, ethyl isovalerate was used as the reaction solvent. The yields obtained varied from 35 to 45%.

The dialkyl sulfates are white waxy solids, insoluble in ether and are only slightly soluble in cold alcohol and ethyl acetate. They are only slightly soluble in hot mineral oil.

LAFAYETTE COLLEGE
EASTON, PA.

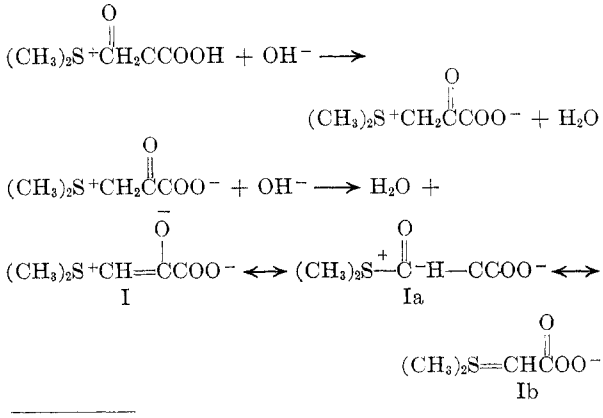
ST. JOHN'S UNIVERSITY
BROOKLYN, N. Y.

The Conjugative Effect of the Dimethylsulfonio Group in an Aliphatic System

N. F. BLAU AND C. G. STUCKWISCH

Received Aug. 20, 1956

In connection with the preparation of sulfonium compounds as possible lipotropic agents,[1] we observed that dimethylsulfoniopyruvic acid bromide



(1) N. F. Blau, J. W. Johnson, and C. G. Stuckwisch, *J. Am. Chem. Soc.*, **76**, 5106 (1954).

behaves as a diprotic acid. Indeed, the two end-points are readily determined with methyl orange and phenolphthalein, respectively. The corresponding methyl and ethyl esters behave as monoprotic acids, pK_a, 5.5. The potentiometric titration curves for acid and ester are shown in Fig. 1. It seemed unlikely that the unusually high acidity is due solely to the inductive effect of the electron-withdrawing dimethylsulfonio group, but rather to the resonance stabilization of the conjugate base (I) in which the dimethylsulfonio group is conjugated with the keto group by expanding its sulfur valence shell to ten

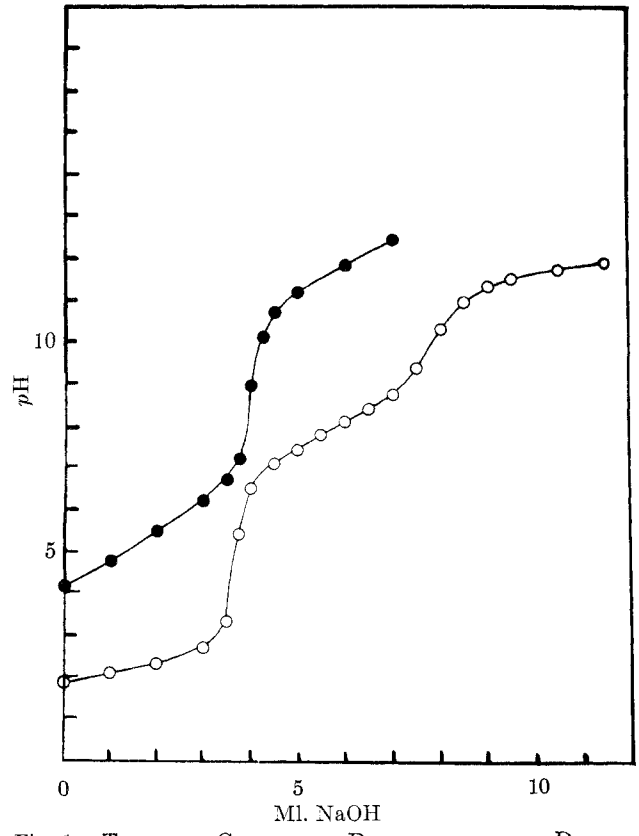


Fig. 1.—TITRATION CURVES FOR DIMETHYLSULFONIO DERIVATIVES OF PYRUVIC ACID. DOTS, ESTER; CIRCLES, ACID.

electrons. Structure (Ib), having no separation of charge, might be expected to contribute significantly to the resonance stability and thus favor the acidity of the methylene group.

For purposes of comparison we prepared the corresponding trimethylammonio derivative of pyruvic acid which cannot conjugate by expansion of the nitrogen valence shell. This derivative behaves as a monoprotic acid. Bordwell and Boutan[2] have reported a similar conjugative effect in *p*-dimethylsulfonio phenols.

Bromopyruvic acid and its methyl and ethyl esters react rapidly with dimethyl sulfide to give excellent yields of the corresponding dimethylsulfonio compounds. The reactions with the esters are best carried out without a solvent or a solvent in which the product is insoluble. Polar solvents such as alcohols are conducive to the formation of trimethylsulfonium bromide and alkyl methylmercaptopyruvates.[3]

Ethyl chloropyruvate reacts more slowly with dimethyl sulfide than the corresponding bromo compound and the reaction products are difficult to purify. Since chloropyruvic acid is difficult to prepare, dimethylsulfoniopyruvic acid chloride was obtained from the corresponding bromide.

EXPERIMENTAL

Bromopyruvic Acid. Triply distilled pyruvic acid[4] was brominated essentially in accordance with the procedure of Wegman and Dahn.[5] The crystalline mass was dissolved in the minimum volume of ether and diluted with petroleum ether to incipient turbidity. After several crystallizations pearly, white crystals were obtained, melting at 77–79°.[6] Bromopyruvic acid does not deteriorate when stored under petroleum ether in a refrigerator.

Dimethylsulfoniopyruvic acid bromide. To an ice cold solution of 8.35 g. (0.05 mole) bromopyruvic acid in 15 ml. of nitromethane was added 3.2 g. of dimethyl sulfide. On vigorous shaking a solid mass was formed. After standing overnight at room temperature the solid product was broken upon a sintered-glass filter and washed well with ether until it was reduced to a colorless powder. This was dissolved in a minimum volume of methanol and reprecipitated with ether, yielding 11.0 g. (95%) of crystals, m.p. 131–133°.

Anal. Calc'd for $C_5H_9BrO_3S$: Br, 34.92; neut. equiv., 114.5. Found: Br, 34.77; neut. equiv., 115.3.

Methyl bromopyruvate. Methyl pyruvate[7] was brominated according to the procedure of Archer and Pratt[8] for ethyl pyruvate. The compound was obtained in a 62–65% yield, b.p. 82–84° (10 mm.), n_D^{25} 1.4770, d_{20}^{25} 1.656, MRD: calculated 31.10, found, 30.96.

Anal. Calc'd for $C_4H_5BrO_3$: Br, 44.2. Found: Br, 44.4.

Ethyl dimethylsulfoniopyruvate bromide. Ethyl bromopyruvate,[8] 19.5 g. (0.1 mole) was added to 6.8 g. (0.11 mole) of dimethyl sulfide and cooled in an ice bath. After standing overnight, at room temperature, the solid cake was washed with acetone and then with ether until the crystals were no longer sticky. The crystals were dissolved in a minimum amount of cold methanol and precipitated with ether. The yield of product, melting at 88–90°, was 24.3 g., 95%.

Anal. Calc'd for $C_7H_{13}BrO_3S$: Br, 31.1; neut. equiv., 257. Found: Br, 31.2; neut. equiv., 261.

Repeated crystallizations of the sulfonio esters from polar solvents cause a gradual rise in melting point with a concomitant increase in the neutral equivalent due to the formation of $(CH_3)_2SBr$.

Methyl dimethylsulfoniopyruvate bromide. This compound was prepared in 85% yield by the procedure described for the analogous ethyl ester. M.p. 102–103°.

Anal. Calc'd for $C_6H_{11}BrO_3S$: Br, 32.9; neut. equiv., 243. Found: Br, 32.0; neut. equiv., 246.

Dimethylsulfoniopyruvic acid chloride. The chloride was prepared from the corresponding bromide by treatment with silver chloride in the usual manner. M.p. 140–141°.

Anal. Calc'd for $C_5H_9ClO_3S$: Cl, 19.23; neut. equiv., 184.5. Found: Cl, 19.28; neut. equiv., 186.

Trimethylammoniopyruvic acid bromide. Bromopyruvic acid, dissolved in methanol, was treated with excess trimethylamine. The precipitate formed on addition of ether was collected on a filter and washed with ethyl ether. The product was dissolved in absolute alcohol and acidified with hydrogen bromide. Addition of acetone precipitated trimethylammonium bromide. The filtrate from this mixture was diluted with ether and refrigerated overnight. The trimethylammoniopyruvic acid bromide which formed was collected on a filter and was recrystallized from an ethyl alcohol-ethyl ether mixture. M.p. 180–181° dec.

Anal. Calc'd for $C_6H_{12}BrNO_3$: Br, 35.4; neut. equiv., 226. Found: Br, 35.2; neut. equiv., 223.

RESEARCH LABORATORIES
VETERAN'S ADMINISTRATION CENTER AND
CHEMICAL LABORATORIES
UNIVERSITY OF WICHITA
WICHITA, KAN.

(2) F. G. Bordwell and Pierre J. Boutan, *J. Am. Chem. Soc.*, **78**, 87 (1956). This paper presents an excellent discussion, with pertinent references, on the conjugative effect of various sulfur groupings.

(3) Einar Biilmann and K. A. Jensen [*Bull. soc. chim. France*, **3**, 2310 (1936)] observed the same result with ethyl 2-bromopropionate and dimethyl sulfide. As in our case, the corresponding acid did not behave in this manner.

(4) V. E. Price and L. Levintow, *Biochemical preparations*, Eric G. Ball, Editor, John Wiley and Sons, Inc., New York, 1952, p. 22. For the instability of pyruvic acid in storage see C. M. Montgomery and J. L. Well, *Science*, **120**, 843 (1954).

(5) J. Wegman and H. Dahn, *Helv. Chim. Acta*, **29**, 415 (1946).

(6) D. B. Sprinson and E. Chargall [*J. Biol. Chem.*, **164**, 424 (1946)] report a melting point of 74°. Wegman and Dahn, ref. (5), give the melting point as 54–55°. Our product was analyzed for bromine, was converted to the 3,5-dinitrophenylhydrazone, m.p. 180°, and was condensed with benzamide to yield 2-phenyloxazole-4-carboxylic acid, m.p. 206–208°.

(7) A. Weissberger and C. J. Kebler, *Org. Syntheses*, Coll. Vol. 2, 610 (1955).

(8) S. Archer and M. G. Prat, *J. Am. Chem. Soc.*, **66**, 1956 (1944).

Base Strength of Monovinylpyridines

ALEXANDER PIETRZYK,[1] RONALD WILEY,[1] AND DARL MCDANIEL

Received July 31, 1956

The base strengths have been determined for the monovinylpyridines and from these the σ values for

(1) Student affiliates of the AMERICAN CHEMICAL SOCIETY, University of Pittsburgh. This work was done as part of a student affiliate project.