

coupling constants we calculate that $\rho_{Zn}/\rho_{Ca} = 0.5$. The reason for this difference in spin density is not yet understood, but a number of factors are involved, for example, different s orbitals and the state of solvation, or hydrolysis of the metal ions might be significant.

The transfer of spin density from the flavin radical to the metal ion may be of importance in the action of metalloflavoproteins. A detailed report will be published elsewhere⁶. The work has been supported by a research grant from the National Institute of Arthritis and Metabolic Diseases, U.S. Public Health Service, and by grants from the Swedish Natural Science Research Council and the Swedish Medical Research Council.

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Ions of Low Mass Number in Hydrocarbon Flames

Cooper, Littlewood and Wilson¹ refer to the similarity of their apparatus and one due to one of us, and proceed to report the observation of ions not previously seen from flames. In fact, we use a similar apparatus, but we should like to emphasize one difference, and to show how this may lead to the result observed.

The main difficulty of the experiment is how to take a sample of ions from the flame at atmospheric pressure and perform mass analysis without distortion of the spectrum. It is not possible to deduce from the note by Cooper, Littlewood and Wilson the mean gas pressure in the first low pressure chamber, but they indicate a path length of some 10 cm, with potential differences of 1,000–2,000 V applied in this region. In our experiments, path lengths about 5 cm and pressures of 10^{-3} torr are used, and potential differences do not exceed 100 V. Over the range 10–100 V, only the efficiency of ion collection is affected by voltage change.

We should like to make the following points:

(1) We have recently performed some experiments on a similar apparatus² in which the acceleration of positive ions in the first chamber was increased from 80 V to values as high as 1,000 V. We find that numerous significant changes occur in spectra of ions from the reaction zone of a flame, particularly in the range 200–500 V, compared with our normal operating conditions. There is a striking increase in all ion currents, and new ion peaks are found at mass/charge ratios of 2, (H_2^+); 3, (H_3^+); 12, (C^+); 13, (CH^+); and 14, (CH_2^+); 15 was the lowest mass/charge ratio observed under normal conditions. A ratio of H_3^+/H_2O^+ of up to 10^{-5} was reached. The relative abundances of many other peaks at higher mass/charge ratio were very significantly altered. We feel that the ion spectrum observed under these conditions does not represent the true ion population in the flame.

(2) The proton affinity of water is reasonably well established³ at 169 kcal/mole, which leads, through a statistical mechanical estimate of the equilibrium constant of the relation $H^+ + H_2O = H_3O^+$ to a ratio of about 2×10^{-12} for H^+/H_3O^+ at equilibrium in a flame at 2,000° K. Similarly, a value⁴ of 70 kcal/mole for the proton affinity of

H_2 leads to an estimated ratio for H_3^+/H^+ of 10 for an equilibrium at flame temperature.

(3) The ions H^+ , H_2^+ and H_3^+ have often been seen in conditions of electrical discharges in a hydrogenous atmosphere (for example, ref. 4).

(4) The production of doubly charged ions, as tentatively suggested in ref. 1, requires energies far beyond those of combustion reactions.

If the authors of the note¹ have good reasons and evidence for ignoring the possibility that erroneous ion currents are being produced by Townsend-type discharges inside the first chamber, and that high energy reactions between ions and molecules of the type $H_3O^+ + M \rightarrow H^+ + H_2O + M$ are entirely absent, the publication of these might allay our suspicions that the results presented are largely irrelevant to the investigation of ions in flames.

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Doebner's Reaction with 6-Methyl-2-amino Pyridine

DOEBNER'S reaction has been known since 1887 (ref. 1); it consists of the synthesis of quinoline-4-carboxylic acids, the starting materials being an aromatic amine, an aldehyde and pyruvic acid. It was thought that the reaction with 2-amino pyridine would lead to the formation of 1,8-naphthyridine-4-carboxylic acids², but this was later found to be incorrect. The work of Allen *et al.* has established that 2-amino pyridine, benzaldehyde and pyruvic acid form a condensation product without cyclization to 1,8-naphthyridine-4-carboxylic acid³. The product was identified as γ -pyridyl-amino- γ -phenyl- α -oxo-butyric acid. The result of the present investigation of Doebner's reaction using 6-methyl-2-amino pyridine agrees with that of Allen *et al.* It was found that 6-methyl-2-amino pyridine reacts with an aldehyde and pyruvic acids according to the scheme proposed by Allen *et al.*³. In one representative experiment, 5.4 g (0.05 mole) of 6-methyl-2-amino pyridine was dissolved in 75 ml. of ethyl alcohol in a round bottom flask with three necks equipped with a condenser, a mechanical stirrer and a separatory funnel. The mixture was warmed until all the pyridine went into solution. 7.6 g (0.05 mole) of vanillin was then added and heating was continued. The solution became yellow immediately. At the same time, 4.4 g (0.05 mole) of freshly distilled pyruvic acid was added dropwise through the separatory funnel over a period of 15 min. The mixture was further refluxed for 10 min.

The difficulty of the synthesis lies in the isolation of the product. Allen's method of separation calls for pouring the reaction mixture into a large amount of water with vigorous shaking, but it failed to give the product. The best way to obtain the product was by transferring the reaction mixture into a beaker and allowing it to stand at room temperature until all the alcohol evaporated and a tarry product remained. The latter was left for about 3 weeks until it hardened. A minimum amount of alcohol was added to dissolve all the hardened residue and the solution frozen for crystallization.

After complete crystallization, the yellow solid, γ -(6-methyl-2-pyridyl-amino)- γ -(3-methoxy-4-hydroxy-phenyl)- α -oxo-butyric acid, was filtered off, washed with alcohol and crystallized from hot water. The yellow crystals melt at 152–154° C (dec.).