

THE VISCOSITY OF AQUEOUS SOLUTIONS  
OF SODIUM MONOFUOROPHOSPHATE

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**ABSTRACT.**—The viscosity of aqueous solutions of sodium monofluorophosphate,  $\text{NaPO}_3\text{F}$ , has been determined at 25° C over a concentration range up to 1.6 molar. The concentration dependence of the fluidity,  $\phi$ , can be expressed by the equation  $\phi = 1 - 0.01568\sqrt{c} - 0.4160c$  up to a concentration of 0.5 molar.

We have determined the viscosity of aqueous solutions of sodium monofluorophosphate,  $\text{NaPO}_3\text{F}$ , at 25° C over the concentration range 0.014 to 1.6 moles per liter. Viscosity measurements were made in quadruplicate in modified Ostwald viscometers. Solutions were prepared from crystalline sodium monofluorophosphate of 97.0% purity.

TABLE 1.—Relative Viscosity as a Function of Molar Concentration for Aqueous Solutions of Sodium Monofluorophosphate at 25° C.

| $c$ , moles/l. | $\eta$ |
|----------------|--------|
| 0.0140         | 1.0024 |
| 0.0207         | 1.0041 |
| 0.0336         | 1.0141 |
| 0.0433         | 1.0167 |
| 0.0511         | 1.0210 |
| 0.0552         | 1.0270 |
| 0.0640         | 1.0317 |
| 0.0799         | 1.0397 |
| 0.0872         | 1.0395 |
| 0.0948         | 1.0445 |
| 0.1129         | 1.0580 |
| 0.1957         | 1.0563 |
| 0.2928         | 1.1009 |
| 0.3775         | 1.2009 |
| 0.4075         | 1.2163 |
| 0.5098         | 1.3452 |
| 0.7207         | 1.4177 |
| 0.8433         | 1.5229 |
| 1.0655         | 1.7495 |
| 1.2296         | 1.8657 |
| 1.3443         | 1.9754 |
| 1.6371         | 2.9051 |

Our data are presented in Table 1 where  $c$  represents the concentration of sodium monofluorophosphate in moles per liter and  $\eta$  is the relative viscosity of the solutions. Relative viscosity is the ratio of the viscosity of the solution to that of the pure solvent.

The data was evaluated according to the methods of Gruneisen (Harned and Owen, 1950) and Jones and Dole (1929). Gruneisen observed that in regions of high dilution viscosity is not a linear function of concentration. Plotting relative viscosity versus concentration, he observed that the curves for many electrolytes exhibit negative curvature as concentration is reduced. This behaviour for electrolytes appears to be general and has been termed (Jones and Tolley, 1933) the Gruneisen effect. Our data for sodium monofluorophosphate exhibits this general behaviour.

Jones and Dole (1929) observed that the equation

$$\phi = 1 + A\sqrt{c} + Bc \quad (1)$$

accurately represents the fluidities,  $\phi$ , of many solutions to reasonably high concentrations. Fluidity is defined as the reciprocal of the relative viscosity. The data were plotted as  $(\phi - 1)/\sqrt{c}$  versus  $\sqrt{c}$  as a consequence of Equation 1 being rearranged to

$$(\phi - 1)/\sqrt{c} = A + B\sqrt{c} \quad (2)$$

which is the equation of a straight line. The resulting plot yielded negative values of  $A$  and  $B$ . This behaviour is generally observed for electrolytes which increase the viscosity of the medium. Our data were linear up to a concentration of 0.5 moles per liter. A least-squares analysis of the data yields the equation

$$\phi = 1 - 0.01568\sqrt{c} - 0.4160c \quad (3)$$

for aqueous solutions of sodium monofluorophosphate at 25° C up to a concentration of 0.5 moles per liter.

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