XCVII.—*The Viscosity of Solutions.*

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THE work in this paper was carried out more than a year ago, and its publication was delayed in the hope that the measurements might be extended over a larger field. Being now fully occupied with high-temperature viscosity observations, I do not feel that any further delay is advisable, as it is not likely to result in a continuation of the work in the present paper, at any rate, in the immediate future.

The viscosity of aqueous solutions has already been discussed in previous papers (*Zeitsch. physikal. Chem.*, 1904, **48**, 585; *Proc. Faraday Soc.*, 1904, 664). When dilute solutions are studied, the viscosity is usually a linear function of the concentration of the solute. A number of colloidal aqueous solutions and some alcoholic solutions have now been examined, and it is found that they behave very similarly to aqueous solutions. It would have been of considerable interest to obtain viscosity measurements on colloidal solutions of metals and metallic sulphides, but an attempt to prepare such solutions in sufficient concentration to give viscosity measurements was not successful. Measurements of viscosity were, however, carried out with solutions of tungstic acid, hæmoglobin, gelatin, and albumen.

Measurements on alcoholic solutions here given are also in confirmation of the statement made in a previous paper (*loc. cit.*), that the viscosity of equimolecular solutions of substances forming a homologous series is to some extent an additive property.

EXPERIMENTAL.

Colloidal Solutions.—The tungstic acid used was prepared by dialysing a mixture of sodium tungstate and hydrochloric acid. The other substances were purchased in as pure a state as they could be obtained. The viscosity of gelatin solutions has already been investigated by Schroeder (*Zeitsch. physikal. Chem.*, 1903, **45**, 75), who noticed that the viscosity of such solutions depends greatly on their previous history. I have found that this property is not confined only to gelatin solutions, but appears to belong to other colloidal solutions, although in no case have I noticed the viscosity of solutions to vary in the extraordinary manner that gelatin solutions do, simply by allowing them to stand.

The following results were obtained at 25°, using the Ostwald form of U-tube with a glass capillary. The viscosity of water at 25° is taken as unity:

Substance.	Percentage.	Viscosity.	Substance.	Percentage.	Viscosity.
Albumen	0·25	1·019	Hæmoglobin	0·45	1·021
,,	0·85	1·066	,,	0·9	1·042
,,	1·70	1·140	Gelatin	0·0082	1·012
Tungstic acid	2·8	1·028	,,	0·0165	1·029
,, ,,	4·4	1·044	,,	0·033	1·096

The divergence from the linear formula is noticeable only in the case of gelatin. The Arrhenius formula $\mu = A^x$, where μ is the viscosity, x the concentration, and A a constant, is also unable to represent the case of gelatin solutions. Even among crystalloids, however, there are abnormal cases of this kind, as, for example, sucrose (Rudorf, *Zeitsch. physikal. Chem.*, 1903, **43**, 257).

Alcoholic Solutions.—The temperature of experiment was again 25°, and the viscosity of alcohol is taken as unity at this temperature.

Solutions in Ethyl Alcohol.

Substance.	Concentration.	Viscosity.	Substance.	Concentration.	Viscosity.
Butyramide	*N*/8	1·029	Methylcarbamide	*N*/8	1·028
,,	*N*/4	1·061	,,	*N*/4	1·050
,,	*N*/2	1·113	,,	*N*/2	1·099
,,	*N*	1·205	,,	*N*	1·212

The linear formula is applicable in both these cases.

A comparison of a number of amides at normal concentration gave the following results:

Acetamide	1·122	Valeramide	1·246
Propionamide	1·156	*n*-Hexamide	1·275
Butyramide	1·205		

The increment in the successive numbers is not constant, so that the property is not of a strictly additive character. The viscosity of the corresponding normal aqueous solutions (taking the value for alcohol again as unity) is as follows:

Acetamide	0·926	Butyramide	1·080
Propionamide	1·000	Valeramide *	1·149

* By extrapolation from more dilute solutions.

It will be noticed that the viscosity constants of the aqueous solutions increase more rapidly with substances of increasing molecular weight than those of the alcoholic solutions.

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