THE TRUE VISCOSITY AND THE COLLOIDAL VISCOSITY.

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It is one of the characteristic properties of the lyophile sol that it has remarkably larger viscosity than that of the pure dispersing medium. Most of the organic " resinous " or " gelatinous " substances make viscous lyophile sols when they are brought into solutions. Cane sugar or glycerine, in the other hand, give viscous aqueous solutions though they are crystalline substances. The colloidal solutions are considered to be composed of very large " solute " particles suspended in the medium of solvent, so they may be called heterogeneous. In lyophile sols, moreover, these vulky particles have very porous structure. The viscosity of the lyophile sol is caused by the friction in moving of these vulky porous masses, or in other words friction in mass motion of solute and solvent molecules. But the viscosity of glycerine or cane sugar solution is caused by the friction between molecules of solvent or solute.

Now if we send a small particle—an ion—to travel through the liquid, then it will encounter some resistance. This resistance will be large if there are many obstacles—glycerin or sugar molecules—scattering in the way. And the resistance will be small if there are many channels of clear ways through which the particle can travel without being disturbed. The former case is assigned to the true or molecular viscosity and the latter to the colloidal viscosity. We may, therefore, clearly distinguish the two kinds of viscosities by the measurements of the electrical conductivities of the viscous solutions which contain a definite quantity of an electrolyte.

For the relation between the viscosity (η) and the conductivity, Johnstone[1] proposed the following equation,

$$\lambda=k\left(\frac{1}{\eta}\right)^m,$$

where λ is the equivalent conductivity of the solution, and k and m are constants for one kind of ion.[2] This equation may be applicable for the pure

(1) Johnston, *J. Am. Chem. Soc.*, **31** (1909), 1010.
(2) Washburn, *J. Am. Chem. Soc.*, **33** (1911), 1461 & 1686.
Sachanov, *Z. Elektrochem.*, **19** (1913), 588.

aqueous solutions of salts, but cannot be used in our experiments, viz. alcohol, glycerine or sugar solutions. In the other hand Dumanski[1] has shown that the conductivity of the solution of an inorganic salt in gelatine jelly is only slightly less than those of equally concentrated solution in pure water.

Experimental. The apparatus used is shown in accompanying figure. This apparatus has been made by inserting two platinum electrodes in an Ostwald viscosimeter. So we can measure the viscosity and the conductivity of one liquid at the same time. The concentration of the solution was chosen so as its relative viscosity was 2.5 at 25°. This can easily be attained by repeating the viscosity measurements several times for each solute. In addition to the organic matters all solutions contain 0.1 normal potassium chloride which serves as the conducting material. In each case the conductivity of the solutions of no potassium chloride was determined in order to know the correction value for the conductivity of the electrolytes which existed in the organic matter as impurities, and such a value was subtracted from the conductivity of the solution containing potassium chloride. The results are shown in the following table.

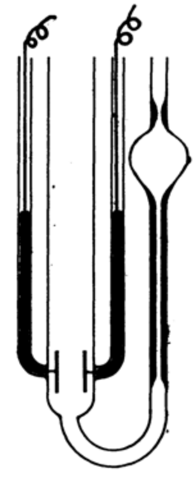

Fig. 1.

Solutes	Density d_4^{25}	Relative viscosity	Specific conductivity
KCl (0.1 N.) only	1.0019	1.005	0.01288
KCl (0.1 N.) and ethyl alcohol (ca. 50% in volume)	0.9278	2.50	0.00441
,, ,, glycerine (ca. 35% in volume)	1.0825	2.50	0.00580
,, ,, mannite (ca. 30% in wt., supersaturated)	1.1030	2.59	0.00621
,, ,, cane sugar (ca. 30% in weight)	1.1160	2.50	0.00654
,, ,, gum arabic (ca. 5.5% in weight)	1.0208	2.50	0.01160
,, ,, soluble starch (ca. 1% in weight)	1.0052	2.43	0.01235
,, ,, gelatine (ca. 3.4% in weight)	1.0113	2.47	0.01286

From the above table we see, in general, that the heavy solute molecules give less effect on conductivity than the light molecules, provided the viscosity being the same. Of course there is a great effect of solvent on dissociation degree of electrolyte, so the conductivity is influenced not only by the viscosity but also by the dissociation degree. Among the colloidal solutions gum arabic give stronger effect than gelatine, consequently the former may have lighter " molecular weight " than the latter,

(1) Dumanski, *Z. physik. Chem.*, **60** (1907), 553.

Summary.

There are two kinds of viscosities, viz. the true viscosity and the colloidal viscosity. They can be distinguished by the conductivity measurements. The true viscosity give strong effect on the conductivity but the colloidal viscosity give slight effect on it.

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