# RELATION BETWEEN CONDUCTIVITY AND VISCOSITY OF SOLUTIONS

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The Walden–Pisarzhevskii equation, giving the relation between the equivalent conductivity $\lambda$ and solution viscosity $\eta$:

$$\eta\lambda = \text{const}, \tag{1}$$

is valid only for certain electrolytes having large ions, predominantly in nonaqueous solutions.

Correlating equivalent conductivities of dilute aqueous solutions with the viscosity of water at various temperatures, Johnston [1] replaced Eq. (1) by the more accurate relation:

$$\eta_0\lambda_0^n = \text{const}, \tag{2}$$

where $\lambda_0$ is the limiting conductivity of the solution, $\eta_0$ is the viscosity of water, and n is a constant.

An equation of this form is valid both for molten melts and glasses [2, 3] and for aquesous electrolyte solutions [4]; i.e., it is a more general relation, applicable to a wide range of conductors of the second kind.

For aqueous solutions of LiCl, LiBr, LiI, $LiNO_3$, LiOH, and NaOH, investigated by us [5, 6] in the temperature range from −70 to +90° at concentrations limited by solubilities of the salts at the given temperatures, the relation between conductivity and viscosity is also represented by an equation analogous to Eq. (2):

$$\eta\lambda^n = c, \quad \ln\eta = \ln c - n\ln\lambda, \tag{3}$$

where c and n are constants which are independent of temperature.

Equations derived theoretically by Frenkel' [7]:

$$\eta = Ae^{E_\eta/RT}, \quad \lambda = Be^{-E_\lambda/RT}, \tag{4}$$

can be used for calculating the activation energy of viscous flow $E_\eta$ and the activation energy of electrical conduction $E_\lambda$:

$$E_\eta = 2.3R\frac{d\lg\eta}{d(1/T)}, \quad E_\lambda = -2.3R\frac{d\lg\lambda}{d(1/T)}. \tag{5}$$

For the solutions studied by us, as for melts and glasses [2, 3, 7], the ratio $E_\eta/E_\lambda$ proved to be a constant quantity for a solution of a given composition, and equal to n in Eq. (3), i.e.,

$$E_\eta/E_\lambda = n, \tag{6}$$

where $n > 1$.

Equation (3), expressing the relation between viscosity and conductivity, would be a formal corollary of Eqs. (4)–(6) if A, B, $E_\eta$, and $E_\lambda$ were independent of temperature. In reality, these quantities usually vary somewhat with temperature.

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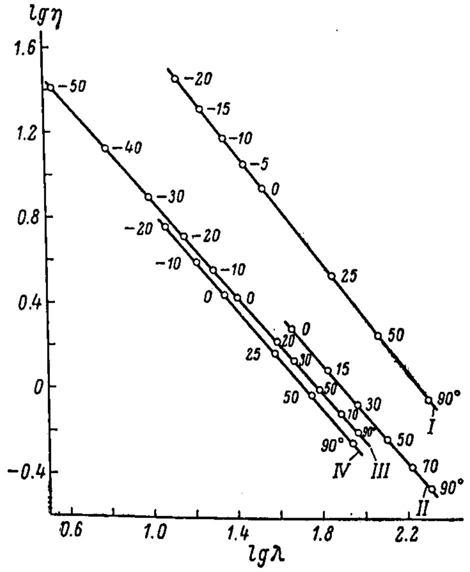


Fig. 1. Relation between the logarithm of the dynamic viscosity $\eta$ (cP) and the logarithm of the equivalent conductivity $\lambda$ ($\Omega^{-1} \cdot cm^2/g$-eq) of aqueous electrolyte solutions at various temperatures. Electrolyte and its concentration (m): I) NaOH and 5.72; II) LiBr and 0.614; III) LiI and 6.67; IV) $LiNO_3$ and 4.84. The numbers at the points are the temperatures (°C).

Despite this, Eq. (3) is valid over a wide range of temperatures, and the fact that n is constant is indicative of a deep-rooted connection between the mechanisms of viscous flow and electrical conduction not only in melts but also in solutions.

As an example, Fig. 1 gives a plot of log $\eta$ vs log $\lambda$ for certain electrolyte solutions in the range from −50 to +90°. The linear relation between log $\eta$ and log $\lambda$ over the entire temperature range makes it possible to calculate one of these quantities from the other at temperatures at which experimental measurement is difficult.

## CONCLUSIONS

The relation between viscosity and conductivity of LiCl, LiBr, LiI, $LiNO_3$, LiOH, and NaOH solutions, as in the case of melts, is represented by the equation $\eta\lambda^n$ = c, where the constant n is always greater than unity and equal to the ratio $E_\eta/E_\lambda$. This equation is valid over a wide range of temperatures.

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