Rotational Mechanical Moments of Electrolite Solutions in a Rotating High-Frequency Electric Field.

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Summary. In the present paper measurements are reported from which it results that electrolite solutions placed in a rotating high-frequency (r = 100 MHz) electric field show remarkable rotational moments, although in this frequency range the theory of the torque depending on the conductivity does not foresee any effect. The measurements have been made against the dilution (defining the dilution as the inverse of the concentration and expressing it in dm³/g eq). While the conductivity $\lambda$ of such solutions, already for dilutions of the order of $10^2 \Omega^{-1} \text{cm}^{-1} \cdot (\text{g eq})^{-1}$, acquires a value which practically does not change with the dilution, the torque due to the presence of dipoles, still tends to increase even when the dilution has reached values of the order of $10^5 \Omega^{-1} \text{cm}^{-1} \cdot (\text{g eq})^{-1}$. Furthermore it has been shown that the torque is proportional to the square of the electric field. The dependence of this moment on the frequency is characteristic of each solution.

In previous works (1,2) it has been shown that, apart from a rotational mechanical moment $M_\mu$ (Born effect) which depends on the fact that there exists a phase displacement between the axis of the dipoles and the direction of the rotating field, a moment $M_c$ appears in a liquid placed in a rotating electric field; this moment is in relation with the electrical conductivity of the liquid itself. However these moments $M_\mu$ and $M_c$ show a different behaviour at the variation of the frequency.

It may be said, e.g., that for low frequencies (50, 180, 100 Hz) (3) only the mechanical moment $M_e$, which depends on the conductivity, appears. Such moment is inversely proportional to the conductivity itself (Lampa's formula) (4), while, for frequencies of the order of $3 \cdot 10^5$ Hz and higher the effect which appears is that depending only on the presence of the dipoles; that is, the moment $M_B$ (Born formula) (5) results experimentally in agreement with the theory itself. Moreover the determination of the coefficient of proportionality between the mechanical moment $M_e$ and $E^2$ the square of the field intensity allows to determine, in a completely different manner the coefficients $\eta$ of the liquid's viscosity, once the electrical moment $m$ of the liquid molecules under consideration is known, whose value may obtained from the study of the polarization in relation to temperature.

According to Debye's theory, one obtains at first, in an electrolite solution a condensation of the dipoles around the ions, a phenomenon which causes characteristic behaviours, and furthermore, on the basis of the fundamental concepts of this theory, every ion is surrounded by an ionic cloud. The presence of this ionic cloud causes a variation of the conductivity with relation to the dilution, different from the one which could be expected on the basis of the classical theory, and on the appearance of a variation of the conductivity in relation to frequency. We wanted to find out whether these peculiarities, which are foreseen in electrolitic solutions, on the basis of Debye's theory, could influence the rotational effect of the dipoles which, as is known, show themselves by means of the appearance of a mechanical moment in a rotating electric field.

The condensation of the dipoles around the ions, in the last analysis causes a decrease of the dipole's mobility. And again, since they are placed radially around the centre of the ion, it causes decrease of the polarizability of the medium, which apparently has as consequence a decrease in the value of the mechanical moment. On the other hand, the formation of the ionic cloud, on the basis of Debye's theory, brings essentially to a mobility decrease of the system of dipoles, which, in the last analysis, equals a viscosity increase in the sense in which the dipoles are less free to orientate themselves. On the basis of this effect the mechanical moment should then increase.

The decrease depending on the first cause tends to lessen with the dilution and the increase due to the second cause also tends to decrease with the dilution.

Therefore, according to the entity and to the prevalence of one effect over the other a variation of the torque is to be foreseen. For this reason we

(4) A. LAMPA: Wien Ber., 115 (2a), 1659 (1936).