Ionic Friction.

By P. N. Evans.

The velocity of a moving body is proportional to the impelling force and inversely proportional to the resistance offered by the surroundings. In the case of dissolved particles moving through a solution the resistance is of the nature of friction.

The movement of ions through solutions may be observed in the diffusion of dissolved electrolytes from positions of higher to those of lower concentrations, and also in the migrations of the ions during the electrolysis of solutions. The impelling force in the first case is the osmotic pressure; in the second, electric tension. The resistance in both cases is the friction against the other particles—mostly those of the solvent. That this resistance or friction is enormous is seen in the force necessary to overcome it—three hundred and two million kilograms will move a gram of hydrogen ions in water with a velocity of one centimeter per second.

It has been observed that the addition of a non-electrolyte to a solution of an electrolyte increases the resistance to the passage of the electric current. This might be due to either or both of two causes—the number of ions or carriers of the current might be diminished by the non-electrolyte's causing a partial deionization of the electrolyte, or the resistance of the solution to the migration of the ions—the ionic friction—might be increased. The second of these two hypotheses has been shown to be the correct one when only moderate quantities of the non-electrolyte are added, though the first also becomes appreciable with larger quantities.

The lines of reasoning and experiment leading to this conclusion have been of two kinds. First, the degree of ionization of the electrolyte in pure water and in water containing the non-electrolyte was determined in the usual way, based on the conductivity at some definite concentration compared with that at infinite dilution and found to be the same when moderate quantities of the non-electrolyte were present. Second, the increase in the resistance to the passage of the electric current and to the movement of ions by diffusion due to osmotic pressure has been found to be approximately proportional to the increase in internal friction measured by the rate of flow through a capillary, indicating friction as the immediate cause.

The purpose of the investigation here reported was to attack the problem by a method not hitherto used apparently in this connection. The freezing point method was employed, and the solutions examined were those of hydrochloric acid and sucrose. The freezing points determined were those of water, of twice-normal and twentieth-normal water solutions of hydrochloric acid, of water solutions of sucrose containing 1, 5, 10, 25 and 35 grams in 100 cubic centimeters, and of water solutions of hydrochloric acid and sucrose of corresponding concentrations. The ordinary Beckmann apparatus was used.

It was found that the lowerings of the freezing point produced by known weights of acid and sugar mixed in a given quantity of water was equal to the sum of the lowerings produced by the same weights of acid and sugar each dissolved separately in the same quantity of water. This result harmonizes with those found by the other methods mentioned above in showing no effect of the sugar on the degree of ionization of the acid, and leading to the conclusion that the increase in resistance to the current observed in corresponding solutions of hydrochloric acid on addition of sugar, was due wholly to an increase in the friction between the ions and the solutions.

The author desires to express his appreciation of the experimental work done by Mr. H. E. Bachtenkircher, B.S., at that time a student in Purdue University.

Lafayette, Indiana, December, 1903.