STUDIES ON THE REGULATION OF OSMOTIC PRESSURE.

II. The Effect of Increasing Concentrations of Albumin on the Conductivity of a Sodium Chloride Solution.

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INTRODUCTION.

It has been shown[1] that the addition of gelatin in increasing concentrations to a 0.6 per cent sodium chloride solution affects the conductivity in two ways, depending on the hydrogen ion concentration. At pH 3.3 the conductivity increases with each added increment of gelatin, whereas at pH 5.1 and 7.4 the conductivity decreases as the percentage of gelatin increases. It was suggested that the addition of gelatin to a solution of sodium chloride has two opposite effects: (1) to increase the conductivity by the addition of ionized gelatin, and (2) to decrease the conductivity by the mechanical interference of the undissociated gelatin molecules. The relative value of these two influences seemed to depend on the degree of ionization of the gelatin, which in turn is dependent upon the hydrogen ion concentration. The experimental results indicated that at pH 3.3 the first effect obtained, while at pH 7.4 and 5.1 the second effect was predominant.

This paper presents similar experiments with another protein; *viz.*, egg albumin. A preliminary determination of the conductivities of pure egg albumin solutions varying in concentrations from 0.8 to 8.7 per cent was carried out as in the case of gelatin.

[1] Palmer, W. W., Atchley, D. W., and Loeb, R. F., *J. Gen. Physiol.*, 1920–21, iii, 801.

EXPERIMENTAL.

The crystalline egg albumin used in these experiments was prepared according to the method described by Hopkins,[2] and recrystallized twice. It was dialyzed until practically free from inorganic salts. The percentage of albumin was determined by drying to constant weight. The hydrogen ion concentration was determined by a gas chain and the conductivity by a Kohlrausch bridge at 25°. Duplicate observations were made in every case. The albumin was brought to the various hydrogen ion concentrations by the addition of NaOH or HCl.

The first experiment (Table I) was performed with pure albumin solutions varying from 1.1 to 8.3 per cent. The conductivity of these

TABLE I.

Conductivity of Pure Albumin Solutions.

Albumin.	Conductivity $\times 10^{-4}$ at pH 3.1.	Albumin.	Conductivity $\times 10^{-4}$ at pH 5.3.	Albumin.	Conductivity $\times 10^{-7}$ at pH 7.3.
per cent		*per cent*		*per cent*	
1.6	9.2	1.1	0.9	1.4	2.1
3.2	14.8	2.2	1.5	2.3	2.8
4.8	19.6	3.7	2.3	3.3	4.1
6.4	23.7	4.7	2.8	6.4	7.8
8.0	27.5	7.4	3.8		
		8.3	4.2		

solutions was determined at pH 3.1, 5.3, and 7.3. The results are plotted in Fig. 1, with the concentrations of albumin as abscissæ and the specific conductivities $\times 10^{-4}$ as ordinates. The curves are reduced to the same scale and plotted at equal intervals above each other. The increase of conductivity with each increment of albumin apparently follows a straight line curve in each instance. The quantitative relations at the various hydrogen ion concentrations are similar to those found in the gelatin solutions.

In a second experiment (Table II) gradually increasing amounts of albumin were added to a 0.6 per cent NaCl solution. Observations

[2] Hopkins, F. G., *J. Physiol.*, 1899–1900, xxv, 306.

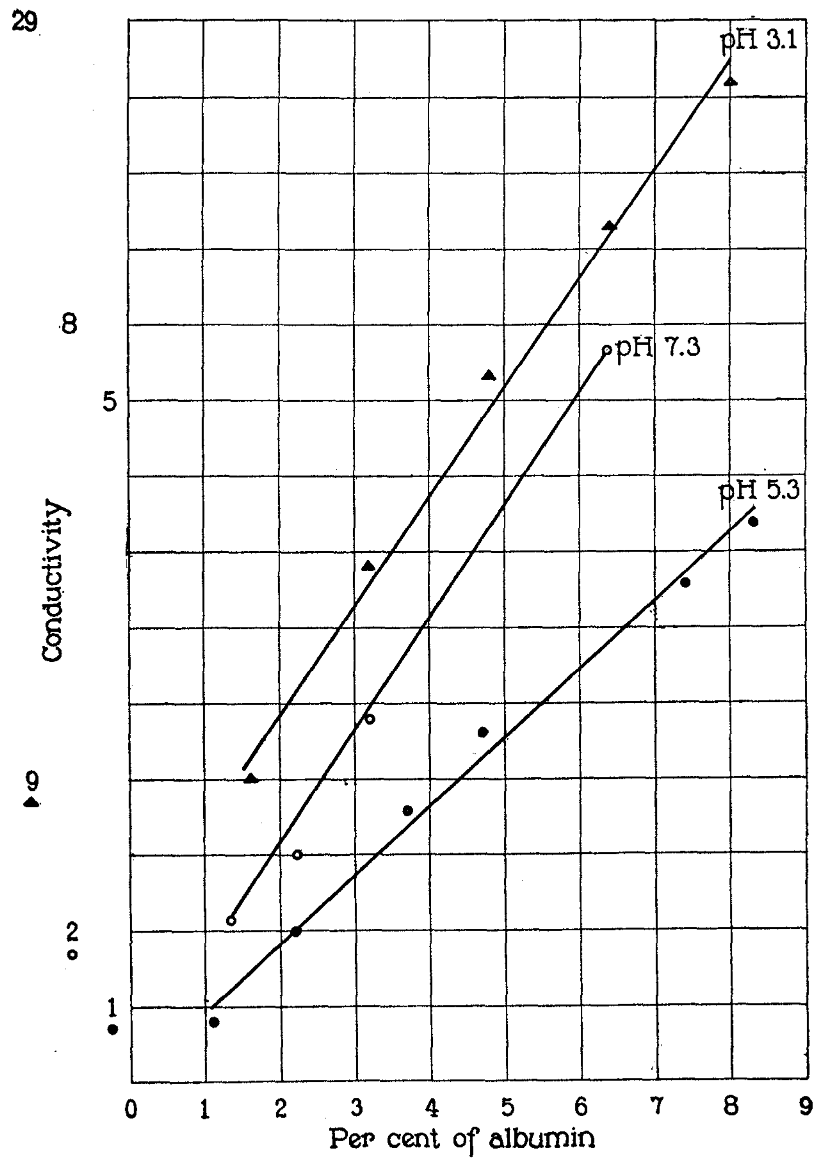

FIG. 1. Conductivities of pure albumin solutions. The abscissæ represent varying concentrations of albumin in per cent, and the ordinates represent specific conductivities $\times 10^{-4}$. The increase in conductivity with increasing concentration of albumin is shown; the increase is greatest at pH 3.1, and least near the isoelectric point (5.3). At pH 3.1, the conductivity increases from 9.2 in 1.6 per cent albumin to 27.5 in 8 per cent albumin. At pH 5.3 the conductivity increases from 0.9 to 4.2 with increase in albumin from 1.1 to 8.3 per cent. At pH 7.3 it increases from 2.1 to 7.8 with an increase in albumin from 1.4 to 6.4 per cent.

TABLE II.

Conductivity of 0.6 Per Cent NaCl Solution with Increasing Albumin.

Albumin.	Conductivity × 10^{-4} at pH 3.5.	Albumin.	Conductivity × 10^{-4} at pH 5.0.	Albumin.	Conductivity × 10^{-4} at pH 7.3.
per cent		*per cent*		*per cent*	
1.1	111.5	0.8	107.9	1.8	110.6
2.9	114.0	1.9	106.4	3.6	108.9
4.8	115.2	3.9	103.8	5.4	107.0
6.6	117.1	5.8	101.2	7.9	105.2
8.3	119.0	8.7	97.0		

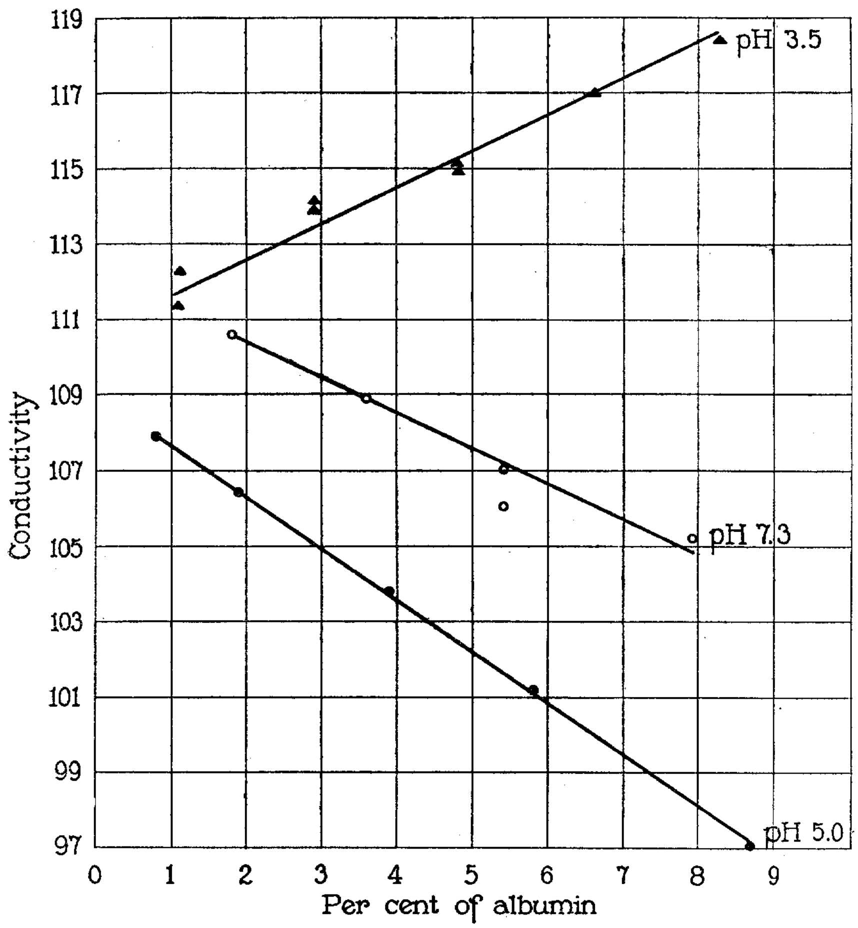

FIG. 2. Changes in specific conductivity (× 10^{-4}) of 0.6 per cent NaCl solutions, with increasing concentration of albumin at various hydrogen ion concentrations. At pH 3.5, conductivity *increases* with increase in albumin per cent. At pH 5.0 and 7.3, conductivity *decreases* with increasing concentration of albumin. This decrease is greater at pH 5.0 than at pH 7.3.

were made at pH 3.5, 5.0, and 7.3. In Fig. 2 the results are plotted on a common scale, conductivities as ordinates and concentrations of albumin as abscissæ. As in the case of pure gelatin solutions, the three curves appear to be straight lines. At pH 3.5 the conductivity increases with the concentration of gelatin, and at pH 5.0 it decreases markedly with increasing amounts of gelatin. At about the reaction of blood, pH 7.3, there is a definite, but less striking, decrease of the conductivity as the percentage of albumin increases.

DISCUSSION.

The results charted in Fig. 2 indicate that egg albumin influences the conductivity of a solution of sodium chloride in about the same manner as does gelatin. Considerable support is thereby given to the idea that the factor determining the influence of protein on the conductivity of a NaCl solution is the degree of ionization which is dependent on the pH of the solution. At the reaction of blood, egg albumin is so little ionized that it decreases the conductivity of the salt solution to which it is added.

CONCLUSION.

Egg albumin, like gelatin, influences the conductivity of a 0.6 per cent NaCl solution in two ways: (*a*) At an hydrogen ion concentration of about pH 3.0, increasing concentrations increase the conductivity. (*b*) Near the isoelectric point of albumin and at the pH of the blood, increasing concentrations of albumin decrease the conductivity of the NaCl solution.