Adiabatic Compressibility of Aqueous Solution. III. Egg Albumin

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R. J. Urick[1] has pointed out empirically that the adiabatic compressibility of a suspensoid could be computed from the compressibilities of dispersed phase and dispersion medium. His treatment was based on the assumption that the compression of the suspension is the arithmetic sum of compressions of components. The extension of this idea to the hydrophilic colloids has been tried by the present author in a preliminary study on a starch sol[2].

In this paper the ultrasonic velocity in the aqueous solution of egg albumin was measured and the numerical value of the compressibility of the albumin molecule in the aqueous solution at its isoelectric point was estimated approximately. Along this line of the investigation, Jacobson[3] has determined the compressibilities of oxyhemoglobin, hemocyanin and serum albumin molecules.

The ultrasonic velocity was measured with an ultrasonic interferometer, the detailed description of which and the experimental procedures have been reported previously[4]. The frequency of the ultrasonics was 1090 KC and the measurement was made at 20.0°C.

The egg albumin used was prepared from the white of a fresh hen's egg by the usual procedure, using ammonium sulphate as a salting out agent. After recrystallizing several times, the electrolytes' impurities were removed by dialysis with redistilled water until no trace of ammonia was detected by the Nessler reagent. The concentration of the egg albumin in the solution was determined by the density measurement. The relation between density and concentration used here was obtained from the partial specific volume, numerical values of which had been given as 0.749 cc./g. by T. Svedberg et al.[5]

The experimental results of the measurements of the ultrasonic velocities and other related quantities are listed in Table I. The physical meaning of the notations here used was given in the previous paper[6].

The numerical value of K/x, the specific compression of the albumin solution at an infinite dilution, was calculated from the present data by using the method of least squares and is found to be -0.16.

To get the numerical value of the com-

TABLE I

No.	D_S/D_O	x	c/c_O	κ/κ_O	K
1	1.0034	0.0134	1.0022	0.9922	−0.0022
2	1.0005	0.0019	1.0003	0.9989	−0.0003
3	1.0062	0.0247	1.0041	0.9857	−0.0041
4	1.0045	0.0179	1.0031	0.9893	−0.0027
5	1.0030	0.0117	1.0019	0.9933	−0.0020
6	1.0025	0.0100	1.0019	0.9937	−0.0012
7	1.0032	0.0125	1.0024	0.9922	−0.0015
8	1.0027	0.0107	1.0017	0.9939	−0.0019
9	1.0026	0.0104	1.0016	0.9942	−0.0019
10	1.0005	0.0020	1.0003	0.9988	−0.0003

pressibility of the albumin molecule itself, we should estimate the effect of hydration on the compressibility of the solution. The necessary equation has already been given in the previous paper[6]. However, we have not obtained sufficient data for these terms, because we could not measure the hydration effect and compressibility separately. In the present investigation, the data of amino acid solutions were used for this purpose. As was shown in the previous paper[4], the hydration effect of amino acids is nearly independent of their species, and their numerical values are almost constant. The molar value, K_m $(=M\cdot K_h/x$, M being molecular weight) is about $6\cdot10$ on an average. In the albumin molecule, the radicals which give the dominant effects upon the compressibility of the solution by the hydration effect may be its ionized radicals only, and the effects of non-ionic groups could be neglected as in the case of amino acid solution. Further we assume here that the hydration effect of polar groups which are ionized perfectly in the solution at its isoelectric point is not greatly different from the effect of free amino acids in the solution. Of course this assumption should be subjected to further discussion. The number of pairs of ionized radicals in an albumin molecule at its isoelectric point could be determined from the data of potensiometric titration. The value adopted here is 9.10^{-4} gram equivalent per gram[7]. Using these data, the effect of hydration, K_h/x for albumin molecule is estimated as 0.05, about thirty per cent of K/x. That means that the deviation due to the above assumption produces not so much difference from the right value, if we expect just semi-quantitative discussion. The actual volume occupied by albumin molecule in the aqueous solution, which is necessary for the present purposes, was calculated as well from the specific volume obtained by Svedverg[5]. The value is $v_m=0.749\ x$ per one cc. solution.

The molecular compressibility of albumin molecule in the aqueous solution at its isoelectric point is then found to be 13.10^{-12} cgs. The values of oxyhemoglobin, hemocyanin and serum albumin were recalculated from Jacobson's data[3] by using the same procedure are 11, 17 and 11 cgs. respectively. These values are in the order of the compressibilities of organic molecular crystals and they are of reasonable magnitudes, considering that protein molecules have some special structures, not like artificial polymermolecules which stretch in the solution. The extension of the present survey is thought to deserve further investigation.

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1) R. J. Urick, *J. Applied Phys.*, 18, 983 (1947).
2) Y. Miyahara and H. Shiio, *J. Chem. Soc. Japan (Pure Chem. Sect.)*, 73, 1 (1953).
3) B. Jacobson, *Arkiv För Kemi*, 2, 177 (1950).
4) Y. Miyahara, *Bull. Chem. Soc. Japan*, 26, 390 (1953).
5) T. Svedberg and J.B. Nichols, *J. Am. Chem. Soc.*, 48. 3081 (1926).
6) Y. Miyahara, *Bull. Chem Soc. Japan*, 25, 326 (1952).
7) E. J. Cohn and J. T. Edsall, "Protein, Amino Acids and Peptides", (1943), p. 498.