

ULTRASONIC VELOCITY AND COMPRESSIBILITY INDEX IN ACID-BASE SOLUTIONS

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(Received 1 July 68, revised 11 Sep. 68.)

Ultrasonic velocity, adiabatic compressibility and refractive index have been determined in mixtures of hydrochloric acid and sodium hydroxide solutions at different concentrations. Variation of these parameters with composition of the mixture has been studied and it is shown that the end point of neutralization can be determined using these parameters.

Most of the methods described in literature^{1,2} only determine the concentration of acids and bases of moderate strength. When the concentration of the acid or base is high, difficulty is experienced in locating the exact end point by neutralization methods. As the ultrasonic velocity in an acid is very much different from that in a base, the variation in the ultrasonic velocity with the addition of alkali to an acid can be readily followed to fix the exact neutralization point, whence the concentration of the acid may be calculated if the concentration of alkali is known. The present work reports a study of the neutralization reactions, particularly of acids and bases of high concentrations, using ultrasonic technique. In addition, the applicability of other physical methods like adiabatic compressibility, density and refractive index have been examined in detail.

EXPERIMENTAL DETAILS

The solutions studied were mixtures of aqueous hydrochloric acid—sodium hydroxide at different concentrations. The chemicals used were of Analar quality. Acid and base of the same normality were mixed in fixed ratios by volume and cooled to room temperature of 29°C.

Ultrasonic velocities were determined by Debye-Sears light diffraction method³. The diffraction pattern was produced by projecting a light beam from a sodium vapour lamp through a glass cell containing the liquid. Standing waves were set up by an oscillating quartz crystal fed by a TPTG oscillator in the liquid. A precision Heterodyne frequency meter of Marconi type TF 1067 was used to determine the frequency of the oscillating crystal and the frequency was found to be 2.920 Mc/sec. As the solutions were corrosive and conducting, the crystal was tied externally to one of the side walls of the cell with rubber bands, electrical contact was made through two copper foils kept one on each face of the crystal. The foil between the wall and the crystal had a small opening at the centre to have good acoustic transmission. To ensure good acoustic coupling a drop of coconut oil was added between the crystal and the wall of the cell. The diffraction pattern produced by the ultrasonic waves was photographed and fringe width measurements were made by a comparator. The velocity measurements were accurate within an error of ± 0.1 per cent.

The densities were determined by the specific gravity bottle method by determining the weight correct to 1 mg. The adiabatic compressibility β was calculated using the

relation $\beta = \frac{1}{V^2\rho}$ where V is the velocity and ρ is the density of the solution.

Abbe's Refractometer was used to determine the refractive index.

RESULTS AND DISCUSSION

The variations of ultrasonic velocity, adiabatic compressibility, density and refractive index with composition of the mixture are presented in Fig. 1-4.

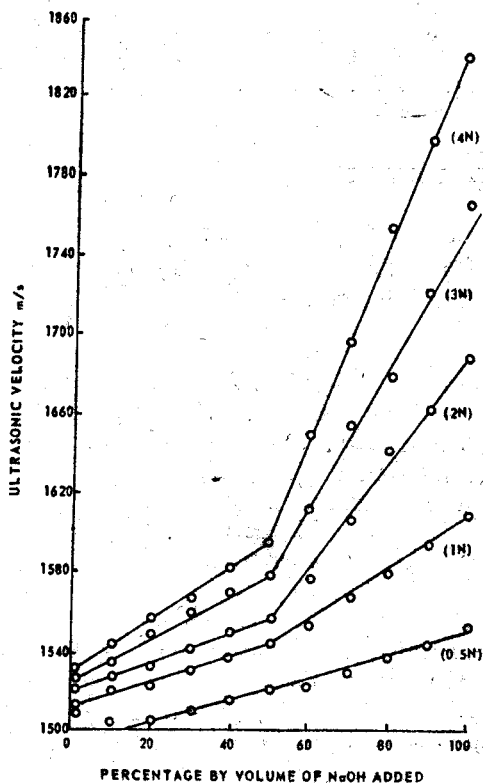


Fig. 1—Variation of ultrasonic velocity with composition of mixtures.

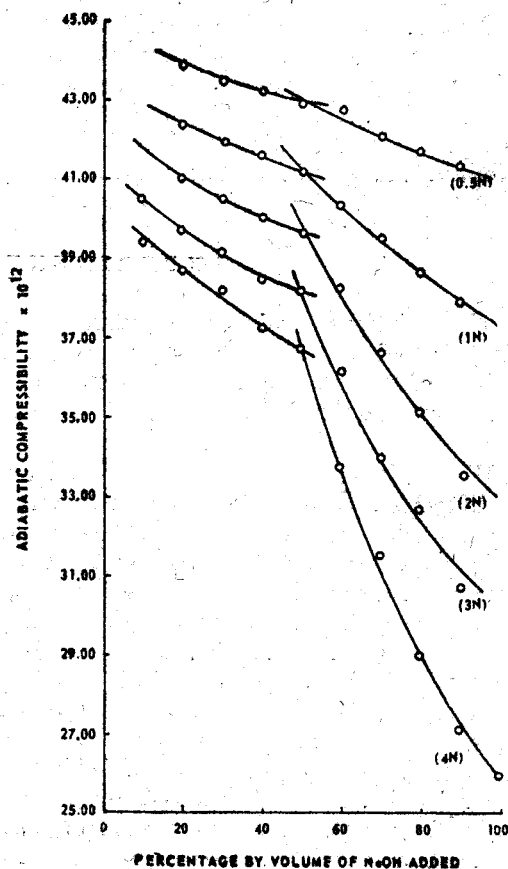


Fig. 2—Variation of adiabatic compressibility with composition of mixtures.

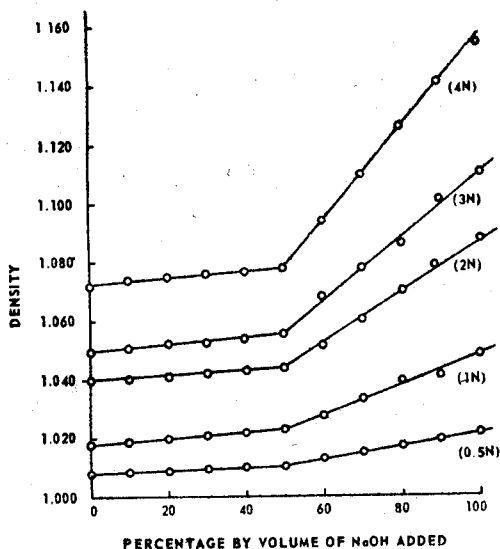


Fig. 3—Variation of density with composition in HCl-NaOH mixtures.

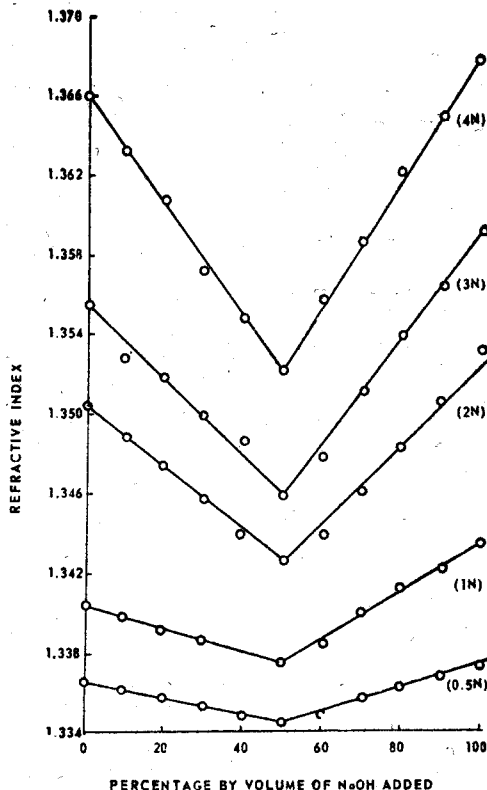


Fig. 4—Variation of refractive index with composition of mixtures.

The ultrasonic velocity uniformly increases with the addition of alkali to an acid solution. However, after the end point it is seen that there is a marked rapid change in velocity accompanying further addition of alkali. Since the variation of ultrasonic velocity with addition of alkali is linear, it is possible to fix the neutralization point by extrapolation to the point of intersection. Thus for 1N HCl (Fig. 1; Curve 1N) the ultrasonic velocity is measured to be 1511 m/sec. The addition of alkali brings about an increase in the velocity to 1543 m/sec at the neutralization point, beyond which the change in velocity is pronounced as is evident from the slope of the curve. Thus by this method the end point can be determined within an experimental error of ± 0.5 to 1 per cent. Below 0.5N the variation in the above mentioned property is not marked.

Adiabatic compressibility decreases with the addition of alkali but the variation is not linear. It consists of two curves (Fig. 2) intersecting at a point. The point of intersection once again corresponds to the end point.

Variation of density with composition in hydrochloric acid-sodium hydroxide mixtures (Fig. 3) is similar to the variation of ultrasonic velocity.

The refractive index decreases as alkali is added to acid. After neutralization it increases with further addition of alkali. The variation is linear. The intersection of the two straight lines corresponds to the end point of neutralization. The refractive index curve (Fig. 4) resembles the conductivity titration curve. Similar results have been obtained for other acids and bases, both strong and weak and the results will be published shortly.

ACKNOWLEDGEMENTS

Thanks are due to Mr. V. Krishnan and Mr. S. Pandiperumal for their help in the present work. One of the authors (N. Raman) thanks the Ministry of Education for the award of a scholarship.

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