

On the Dielectric Properties of Polycapramide

By

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1. Introduction

On the dielectric properties of polycapramide Fuchino and Okada^[1] studied at frequencies higher than 400kc/s, and Kawaguchi^[2] at 100kc/s. Nylon which is similar on the structure as polycapramide was studied in detail by Baker and Yager^[3] at frequencies higher than 1 kc/s. The present author examined polycapramide dielectrically at frequencies lower than 1 kc/s, and found that polycapramide is analogous to *n*-higher alcohols.

Moreover it was found that polycapramide placed between two metallic plates of different kinds develops an electromotive force in a similar way as the phenomenon discovered by Takeyama^[4] in *n*-higher alcohols.

2. Experimental procedure

(Material)

A specimen of polycapramide kindly offered by Toyo Rayon Co. was used. Its m. p. is about 210°C and $\beta \rightarrow \alpha$ transition point is about 150°C. For the dielectric measurements discs of the material 4.5 cm in diameter and 2.0 mm or 4.3 mm in thickness were made by moulding and machining. These were covered with aluminum foils on both faces using vacuum grease.

(Dielectric measurements)

Two sorts of circuits were used in the present experiment. In frequencies higher

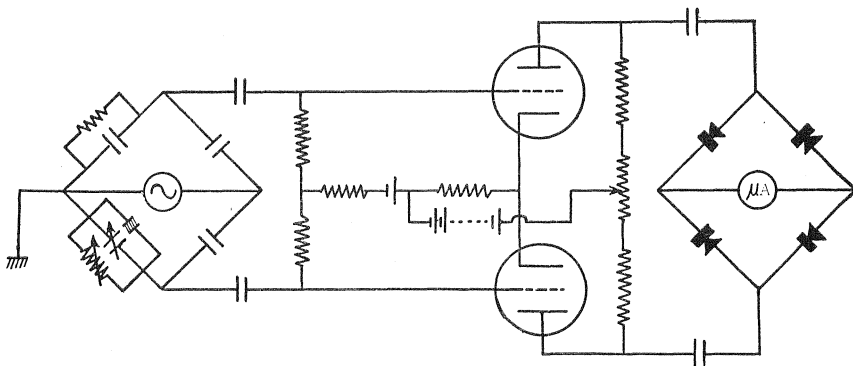


Fig. 1. Circuit for low frequency measurement

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than 500 c/s a bridge was used in the same way as described in the previous paper.^[5] For the lower frequency region we constructed a special circuit as shown in Fig. 1 similar to the type devised by Brown and Ramsay.^[6]

An RC type oscillator was used for frequencies higher than 20 c/s, and a motor-driven sine potentiometer was used for frequencies of 1 c/s and 0.5 c/s.

(Measurement of electromotive force)

The specimen was melted between two metallic plates (distance : 1.4 mm, area : 3 cm²) of different kinds and then solidified, and this was placed in a liquid paraffin bath in which the temperature of the specimen was regulated. The electromotive force was measured by a potentiometer of low sensitivity.

3. Experimental results and discussion

(Lower temperature region)

The frequency dependency of the dielectric constant at 8°C is shown in Fig. 2. The dispersion at extra-low frequencies seems to be analogous to that discovered in

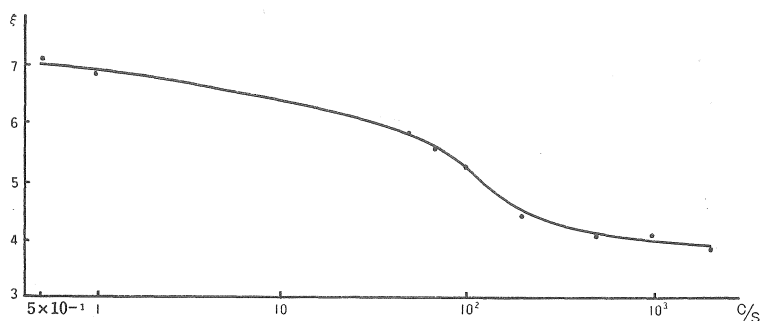


Fig. 2. Frequency dependency of the dielectric constant at 8°C

n-higher alcohols at 20°C by Meakins and Mulley,^[7] who explained the fact by assuming the presence of hydrogen-bonded chains of hydroxyl groups capable of reversing their directions. In polycapramide also the orientation of polar groups forming hydrogen bonding N—H.....O is probably the cause of the dispersion.

(Higher temperature region)

The relation of the real part ϵ' and the negative imaginary part ϵ'' of the complex dielectric constant at 150°C is shown in Fig. 3.

The direct conductance error of ϵ'' , namely the additive contribution to ϵ'' from dc conductance was corrected by the subtraction of the dc conductance G_{dc} from the total conductance $G(\omega)$ at each frequency as in the previous paper.^[8] The dc conductivity of polycapramide was determined by a vacuum tube electrometer.

The graph in Fig. 3 is a circular arc with its center a little below the ϵ' axis. At lower frequencies experimental errors became larger and below a limiting frequency

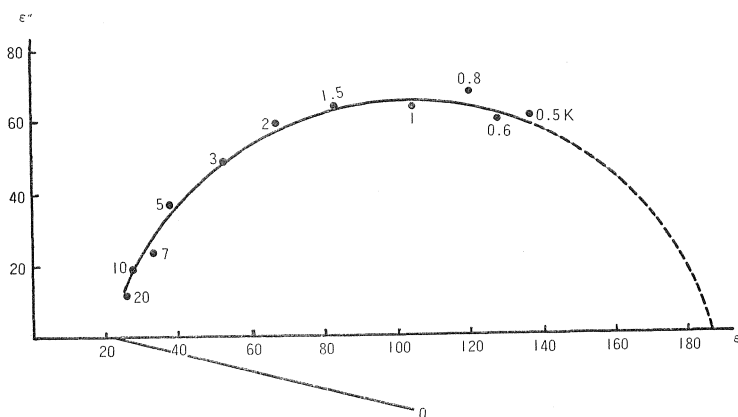


Fig. 3. Complex dielectric constant of polycapramide at 150°C

(about 0.5 kc/s) neither ϵ' nor ϵ'' could not be measured. The value G_{dc} for the case of Fig. 3 amounted to 5% of the total conductance at 20 kc/s and to 30% at 0.5kc/s.

It was supposed from the previous studies^{[1][2]} that a different kind of dispersion will happen at frequencies higher than 20 kc/s, but this was not confirmed by measurement.

The above-mentioned phenomenon exhibited by polycapramide in the higher temperature region seems to be analogous to that found by the present author^[8] in *n*-higher alcohols. The anomalous dielectric properties of polycapramide and *n*-higher alcohols may be similarly explained.

(Electromotive force)

The electromotive force developed by using Au and Pt plates as two electrodes is shown in Fig. 4 as an example. As to the polarity Au is positive and Pt is negative.

The value of the electromotive force was not necessarily the same in every case, but was generally independent of the temperature. The dotted curve in Fig. 4 shows the temperature dependency of the electric conductivity measured by a galvanometer by using nickel electrodes. As the electromotive force was measured by a potentiometer it could not be measured when the electric conductivity of the specimen was poor. But it appeared that even at temperatures lower than 100°C electromotive force was developed. The polarities of the electromotive force developed by using several metals are

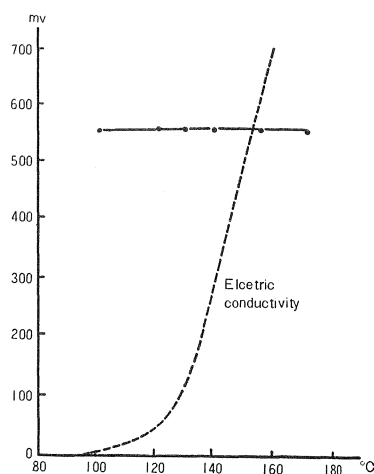


Fig. 4. Temperature dependency of the electromotive force developed in polycapramide by Au and Pt plates, and of the electric conductivity

shown below.

+	Au	Au	Pt	Ag	Ni
-	Pt	Ni	Ni	Ni	Zn

From this we found that the polarities were the same as when water was placed between the electrodes instead of polycapramide. For comparison we measured the electromotive force developed by using cetyl alcohol from the Eastman Kodak Co. (m.p. 48.7°C), and found that the polarity was the same as in the case of polycapramide. For example the temperature dependency of the electromotive force developed by using Pt and Ni as two electrodes is shown in Fig. 5. The fluctuation of the electromotive force was conspicuous in our experiment.

Though the measurement at the temperatures above the m.p. was difficult on account of the poor conductivity, electromotive force of the same order of magnitude as in the solid was also detected when the specimen was in the liquid state.

Now we suppose that electromotive force is developed by polycapramide and cetyl alcohol for a same reason. In Takeyama's experiment^[4] using Pt and Au as electrodes Pt was positive and Au negative and he concluded that the metal with a larger work function showed positive polarity. But in our experiment using Pt and Au, Au was positive and in that using Ag and Ni, Ag was positive though Ag has a smaller work function.

After all, the origin of the electromotive force seemed to be due to the difference of the ionization tendencies of the two metals with respect to the trace of water inevitably contained in the specimen rather than to the difference of the work functions. The fact that the electromotive force developed by impure specimens was larger than that by pure specimens seem to support the supposition.

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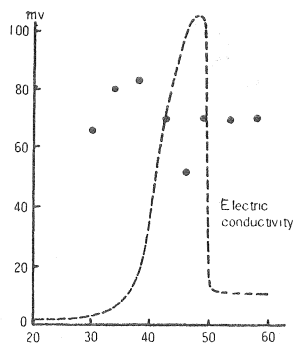


Fig. 5. Temperature dependency of the electromotive force developed in cetyl alcohol by Pt and Ni plates

References

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