Chapter - IV

DIELECTRIC PERMITIVITY

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4.1 Introduction

The most commonly measured small signal electrical properties is the dielectric permitivity (ε), also often referred as the dielectric constant. This happens due to that the electric field, the centers of positive and negative charges of each atom or molecule, are displaced from their equlibrium positions. This produces the electric dipoles and the dielectric material is then said to be polarized. The dielectric permitivity is a function of temperature as well of the oscillation frequency of the applied electric field.

The dielectric constant of ferroelectric material will obey the Curie-Weiss law, valid above the curie transition temperature.

$$\varepsilon = \frac{C}{T-T_o} \qquad (4.1)$$

where ε = dielectric constant,

T = temperature

C = Curie-Wiess constant

T_o = Paraelectric transition temperature.

In second order phase transition T_o is practically the same as the transition temperature or curie-point T_c. While

in case of first-order phase transition T_o is lower than the curie-temperature T_c. The spontaneous polarization is decreases with increase in temperature and it reduces effectively to zero at curie temperature, hence gives rise to a maximum dielectric constant.

Rupprecht (1) et al and Diamond (2) have atempted to give an explicit relationship between dielectric constant and externally applied field. Stern and Lurio (3) determined the change in dielectric constant with applied field. Mathias and Remeika (4) Shirame et al (5) Wijesendange (6), Triebwasser (7), Triebwasser and Halpern (8) reported the dielectric constant of $KNbO_3$ as a function of temperature. Yanovskhii (9) investigated the influence of impurities on dielectric properties of potassium niobate. Godefory et al (10) found that the dielectric constent increases with Nb doped in barium titanate. Wu (11) et al reported the dielectric constant of potassium niobates with Fe^{+3}, Mn^{+3} and Ce^{+3}. Bouillet and Godefroy (12) determined the dielectric and optical properties of perovskies compound by shell model method.

In the present study we have experimentally determined the dielectric constant of potassium niobate and of the system $K(Ni_x\ Fe_y\ Nb_z)O_3$ at several temperatures for different values of x and y.

4.2 Experimental

The dielectric constant of a ferroelectric is obtained readily by the formula.

$$\epsilon = \frac{cd}{\epsilon_0 A} \qquad (4.2)$$

where c = capacitance of the sample,

d = thickness of the sample,

A = area of the sample,

ϵ_0 = permitivity of free space = 8.85×10^{-12} F/m,

and ϵ = dielectric constant of the sample.

The value of capacitance is measured by employing a L C. resonant circuit. The experimental set-up used for measurement of dielectric constant at various temperature is shown in Fig.4.1. It consists of an electrically heated furnace, a temperature controller arrangement and a capacitance bridge circuit arrangement. The capacitances of the materials were determined at different temperatures, by keeping the pellet holder inside the furnace. The dielectric constants were calculated from capacitence measurement data at two different frequencies 1 KHz and 100 Hz. Several samples exhibited good dielectric constant behaviour at 1 KHz.

The variation of the dielectric constant with temperature for potassium niobate is shown in Fig.4.2, while

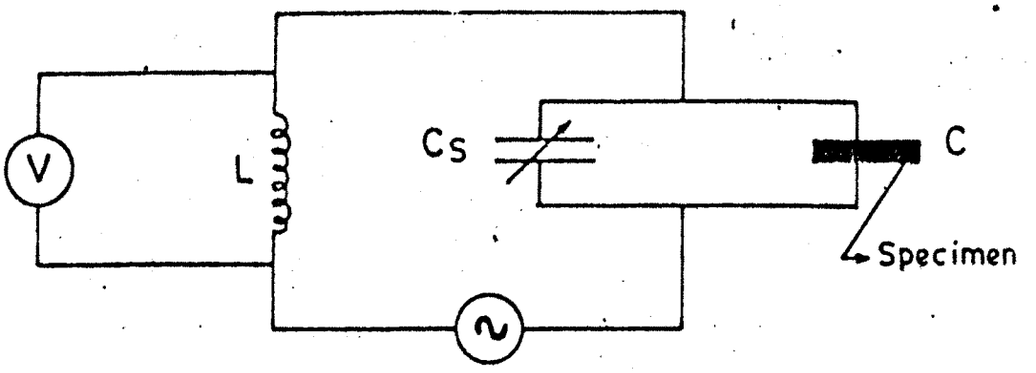

Fig.4·1— SCHEMATIC DIAGRAM OF APPARATUS FOR THE MEASUREMENT OF DIELECTRIC CONSTANT.

the Fig.4.3 to 4.6 show the variation of dielectric constant with temperature for the systems $K(Ni_{0.02}\ Fe_{0.02}\ Nb_{.96})O_3$, $K(Ni_{0.05}\ Fe_{0.05}\ Nb_{0.90})O_3$, $K(Ni_{0.1}\ Fe_{0.1}\ Nb_{0.80})O_3$ and $K(Ni_{0.15}\ Fe_{0.15}\ Nb_{0.70})O_3$ respectively.

4.3 Results and Discussion

It is observed from Fig.4.2 to 4.6 that the dielectric constant of pure $KNbO_3$ depends upon the temperature. The maximum dielectric constant of $KNbO_3$ is at curie temperature. This dielectric constant value observed is in good agreement with that reported Shirane et al (5), and Yanovskii (9). From Fig.4.3 to 4.6 the dielectric constant of the system is found to increase with temperature and the peak values of dielectric constants are observed at temperature 460°k, 435°k, 598°k and 548°k for the materials $K(Ni_{0.02}\ Fe_{0.02}\ Nb_{0.96})O_3$ $K(Ni_{0.05}\ Fe_{0.05}\ Nb_{0.90})O_3$ $K(Ni_{0.10}\ Fe_{0.10}\ Nb_{0.80})O_3$ and $K(Ni_{0.15}\ Fe_{0.15}\ Nb_{0.70})O_3$ respectively.

From this observation the following conclusions may be made

(1) The dielectric constant various with temperature and shows peak value at the curie temperature of the respective compositions and is a characteristic of the sample chosen.

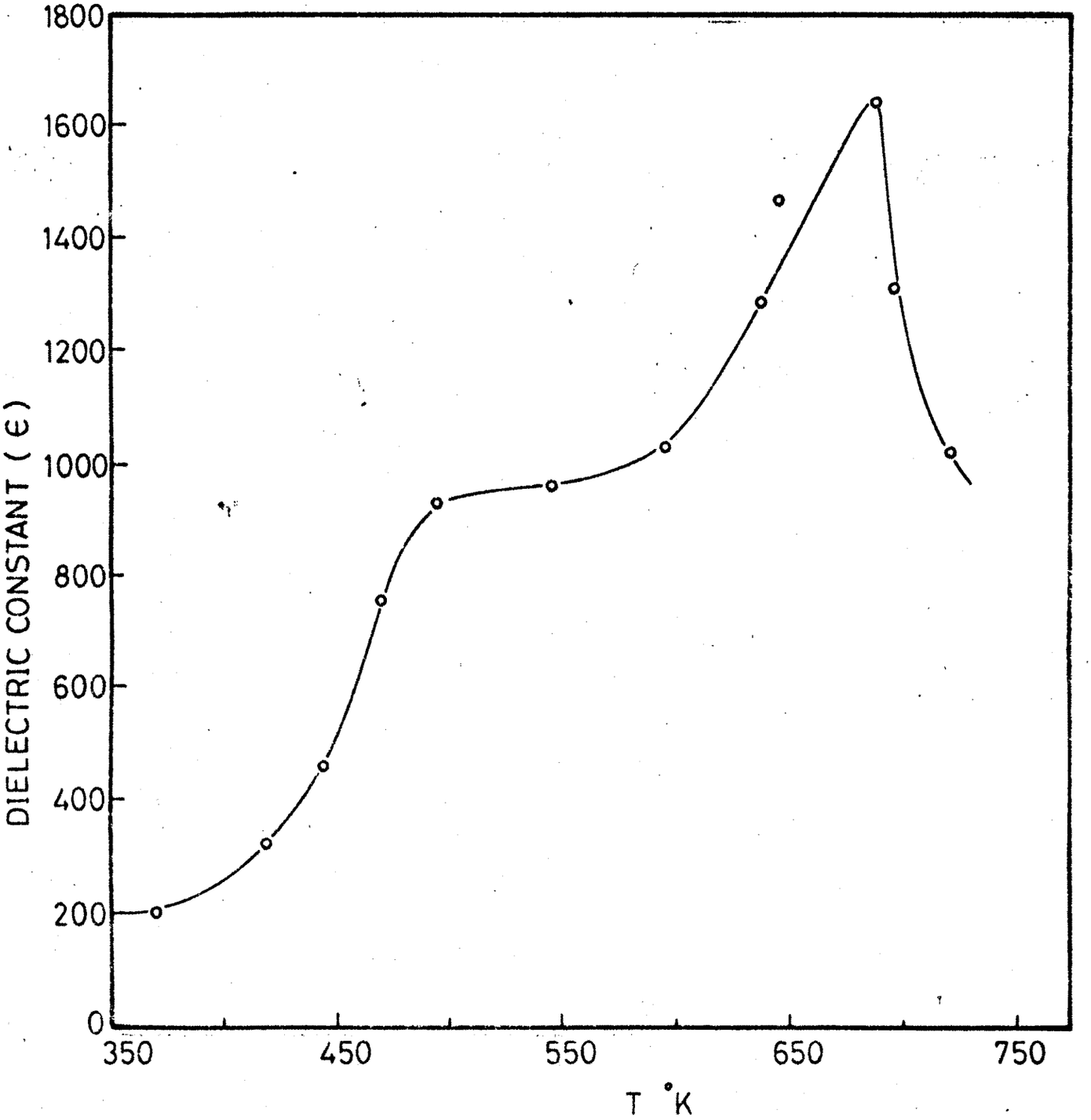

Fig. 4·2 – THE VARIATION OF DIELECTRIC CONSTANT WITH TEMPERATURE IN $KNbO_3$

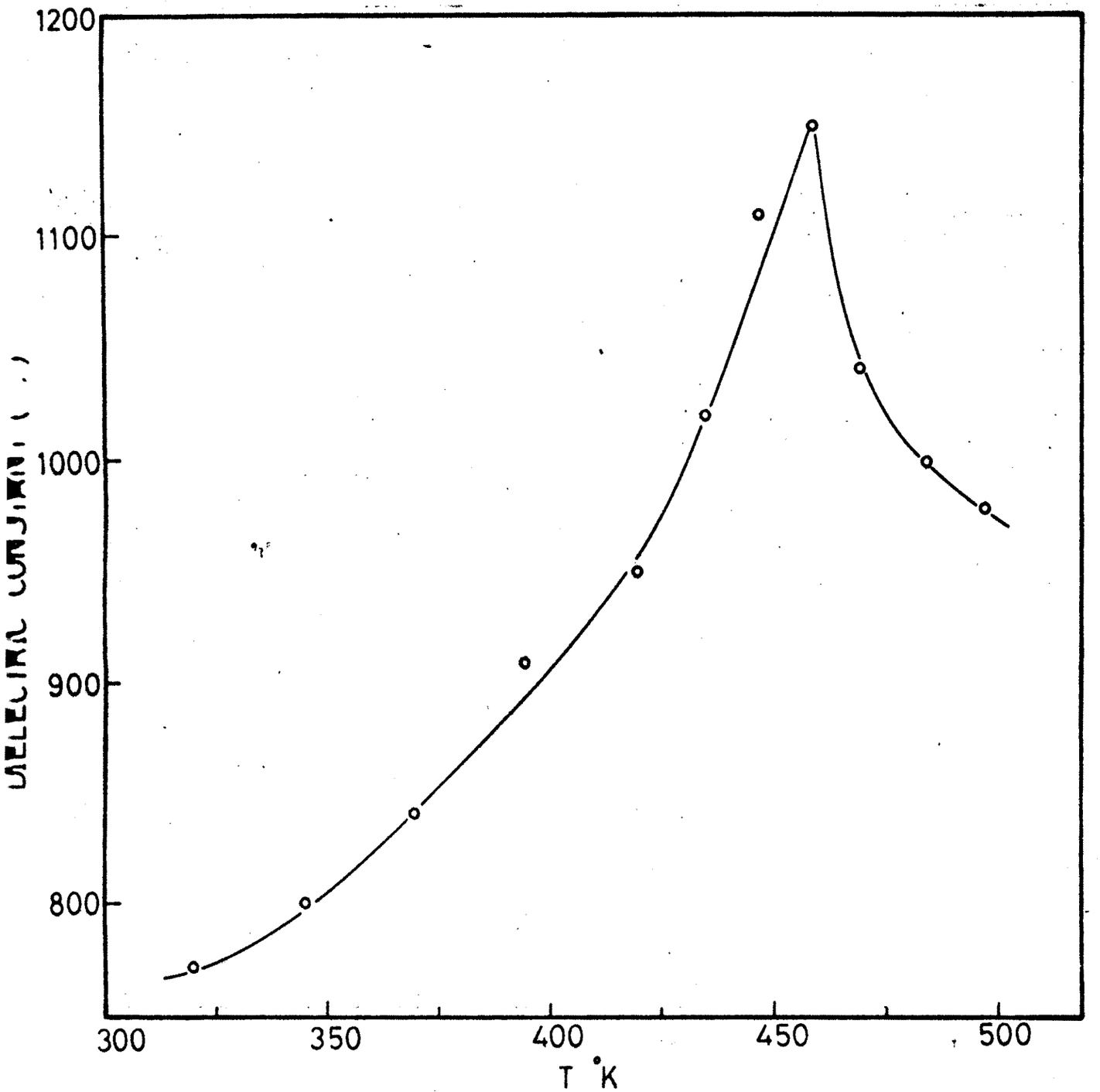

Fig. 4·3 – THE VARIATION OF DIELECTRIC CONSTANT WITH TEMPERATURE IN $K(Ni_{0.02}Fe_{0.02}Nb_{0.96})O_3$

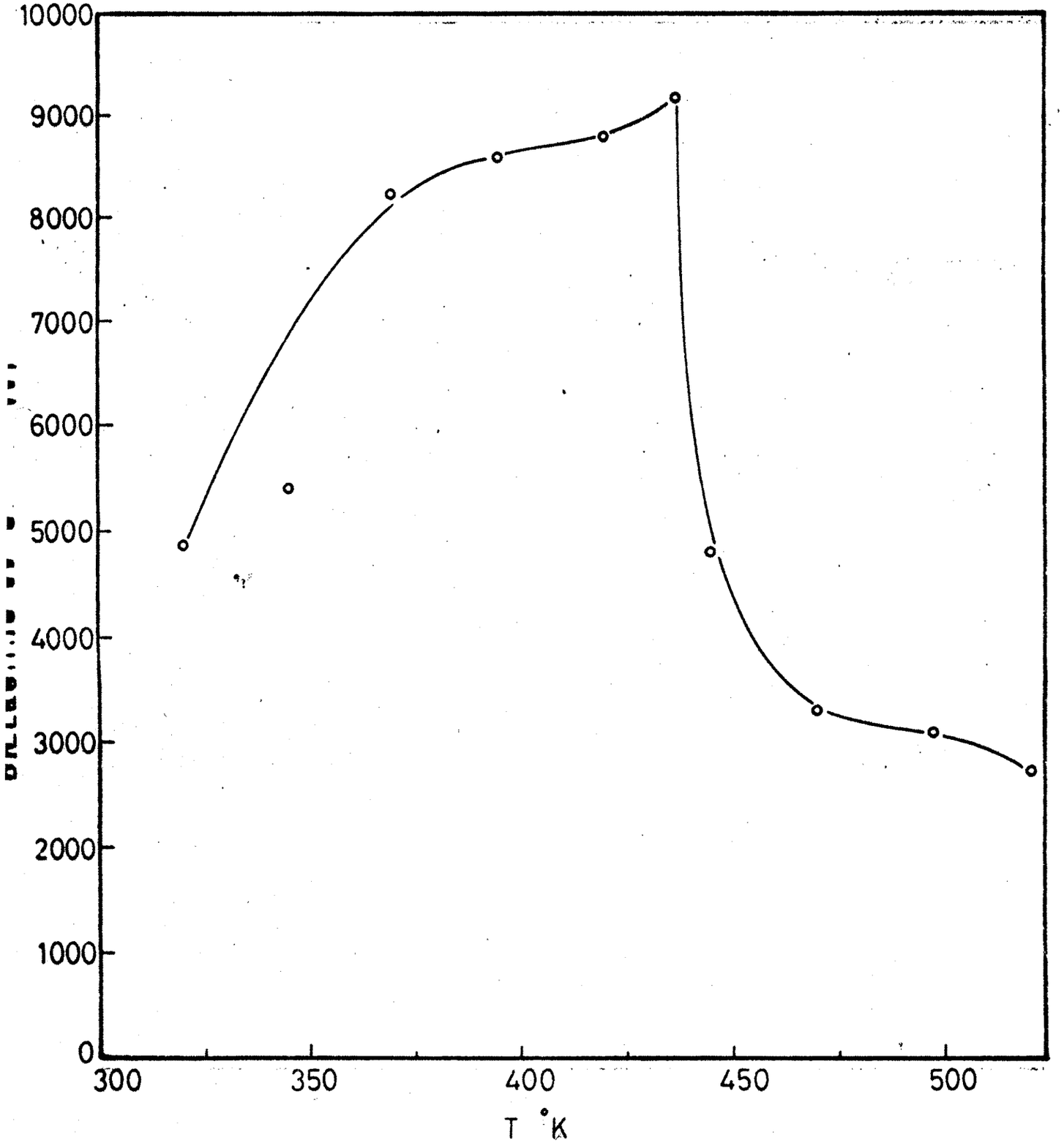

Fig. 4·4 – THE VARIATION OF DIELECTRIC CONSTANT WITH TEMPERATURE IN $K(Ni_{0.05}Fe_{0.05}Nb_{0.90})O_3$.

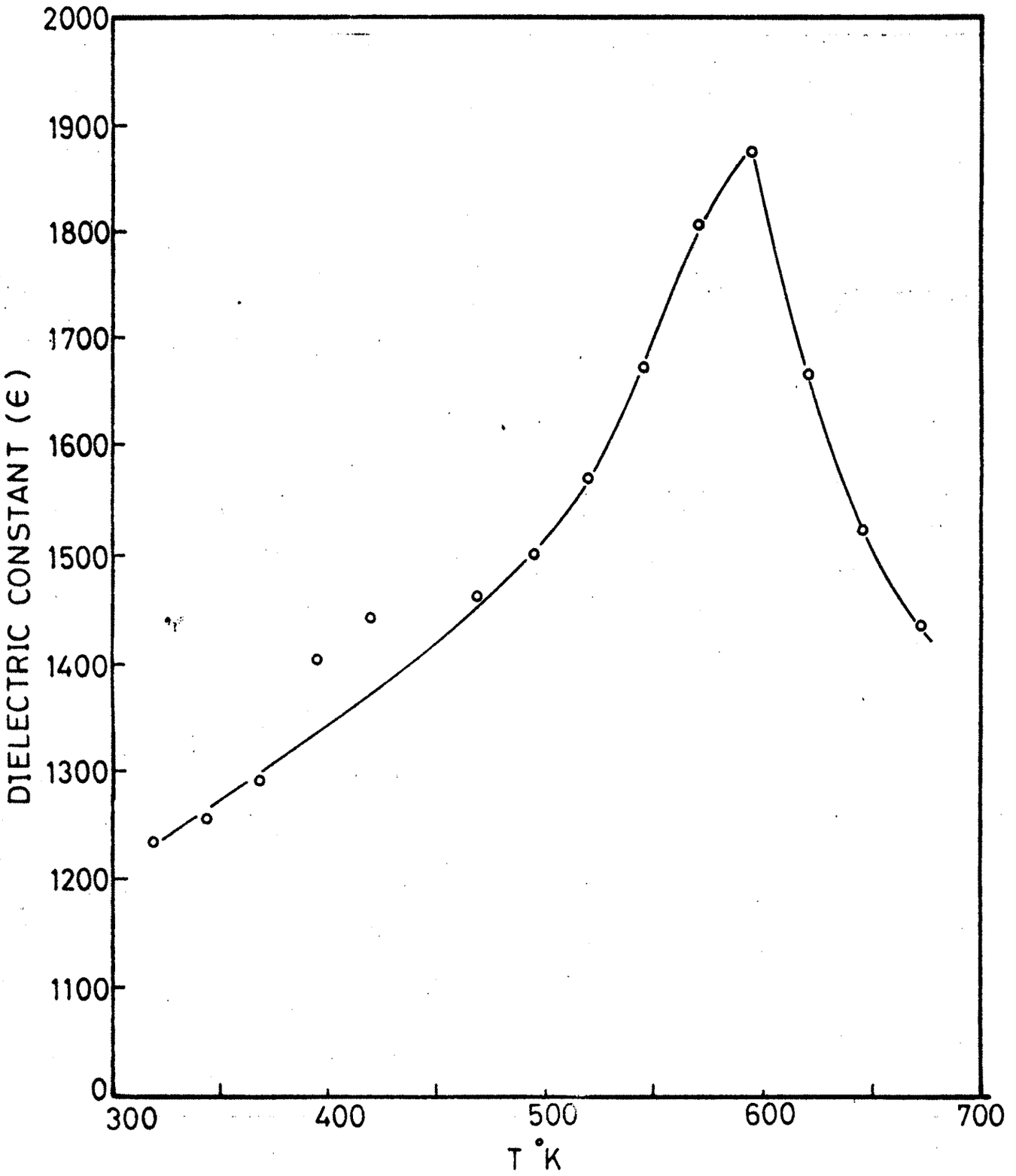

Fig. 4·5 - THE VARIATION OF DIELECTRIC CONSTANT WITH TEMPERATURE IN $K(Ni_{0.10}\ Fe_{0.10}\ Nb_{0.80})O_3$

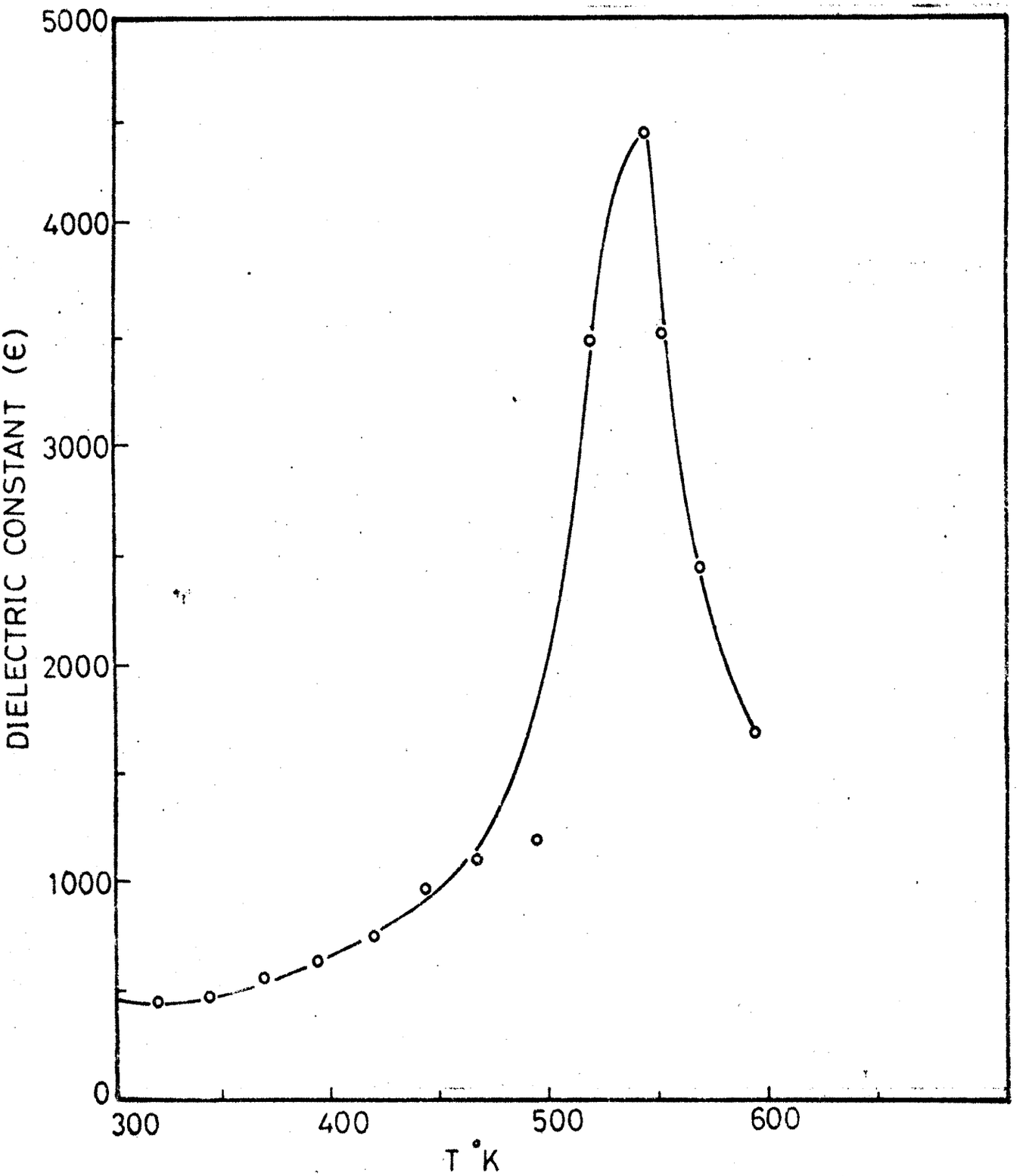

Fig. 4·6 – THE VARIATION OF DIELECTRIC CONSTANT WITH TEMPERATURE IN K $(Ni_{0.15}Fe_{0.15}Nb_{0.70})O_3$.

(2) The value of dielectric constant at the respective curie temperatures of system $K(Ni_x\ Fe_y\ Nb_z)O_3$ exhibits an increase with the increase in the concentration of the dopant impurities.

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