DIELECTRIC CONSTANTS OF IRRADIATED AND CARBONATED POLYMERS

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ABSTRACT

Using the LC resonance circuit, changes in dielectric constants of irradiated and carbonated polymers as a function of carbon concentration are investigated. Both low and high density polymers are used. Results predict a quadratic increase in the dielectric constant of specimen as the percentage concentration of carbon is increased. This may be due to the formation of some polar groups which not only get polarized due to relative displacement of electrons and protons, but also have an inherent significant dipole lengths. Results also show that irradiation cases increase in the dielectric constant of both pure and carbonated polymers and that for a given composition, the dielectric constant increases with frequency. Irradiation effect is more pronounced for high density polymers than for low density polymers, and tends to disappear as carbon concentration increases.

1. INTRODUCTION

The dielectric constant of carbonated polymers is investigated using both low and high density polyethylene, polystyrene and polypropylene obtained from some companies in Port-Harcourt and Lagos. These carbonated polymers are exposed to three different electromagnetic rays namely x-rays, ultraviolet rays and infra-red rays to study the effect of changes in the percentage concentration of carbon on the dielectric constant of the specimens.

2. THEORY

In series resonance circuit, at resonance the tuned signal generator frequency is in phase with the natural oscillation of the LC system. The energy (amplitude) superimposition is observed on CRO. Under these conditions,

$$f = \frac{1}{2\pi\sqrt{LC}} \qquad (1)$$

where L = inductance of the inductors

C = capacitance of capacitor

f = frequency

$$\therefore c = \frac{1}{4\pi^2 L f^2} \qquad (2)$$

Hence knowing L and f,C can be calculated. The dielectric constant can then be found using the relation

$$\frac{C_P}{C_a} = \frac{f_a^2}{f_p^2} = \epsilon \qquad (3)$$

where ϵ = dielectric constant of polymer

f_a = resonance frequency of circuit with air as dielectric

f_p = resonance frequency of circuit with polymer sample as dielectric.

C_p , C_a are capacitance of capacitor with polymer and air as dielectric respectively.

2 EXPERIMENTAL DETAILS:

The crystalline polymers are first purified by thorough washing with cold distilled water to remove all the dust particles and then dried. Carbon black extracted from dry cells is mixed with polymer in a definite proportion by weight. Each mixture is then heated in a beaker using an electric heater. As the heating progresses, the content is vigorously stirred to ensure homogeneity of the mixture.

The specimen is finally cooled air until it solidifies.
Samples of definite geometry are cut from bulk. These samples, with varying degrees of carbon concentration, are then exposed to infra-red rays from carbon arc lamp; ultraviolet rays from Hg discharge lamp and finally to x-rays. The exposure time is kept at approximately 20 minutes.
Figure 1 shows the experimental arrangement for the measurement of dielectric constants. Thin copper foil cut to the same geometry as the samples is used as the plates of the capacitor. These plates are glued on to wooden discs and supported with mechanism to vary the distance between them. The series resonance circuit is used. Resonance frequency is obtained using the oscilloscope. The dielectric constant of the various samples are calculated using equation (3).

3 RESULTS AND CONCLUSION

Figure 2 shows variation of dielectric constant of low density polyethylene with percentage carbon concentration for unirradiated and irradiated samples.
Figure 3 shows results for high density polyethylene. Figures 4 and 5 show similar results for low and high density ro1ystyrene respectively.
These results predict a quadratic increase in the dielectric constant of the specimen with the percentage by weight concentration of carbon black to polymer. This is in line with the assumed effect of fillers on polymers [1]. The fillers tend to increase the conductivity of the samples. The net effect is an increase in dielectric constant.
Results also show increase in the dielectric constant for pure as well as for carbonated polymers when exposed to electromagnetic radiations. This effect increases as radiation intensity increases and is more noticeable in high density polymers than in low density ones. More interesting is the fact that these effects tend to be washed away at high carbon concentration.
This is due to the fact that the radiation tends to get absorbed, and at this stage, the high density polymer might have lost much of its crystallinity leaving mostly of amorphous bulk which, because of its structure respond little to further branching
Results obtained on polypropylene are similar to those of polyethylene and polystyrene.

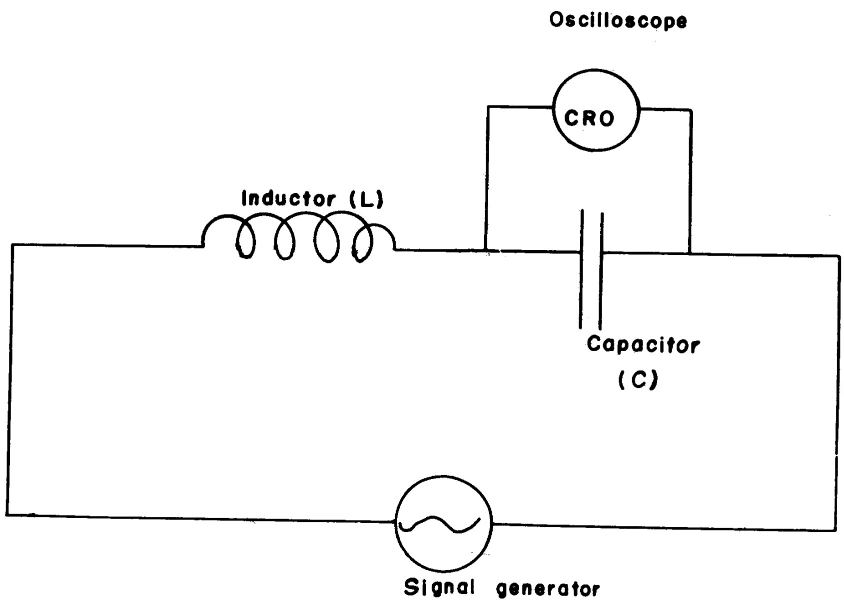

FIG.1. Experimental arrangement for the measurement of dielectric constants

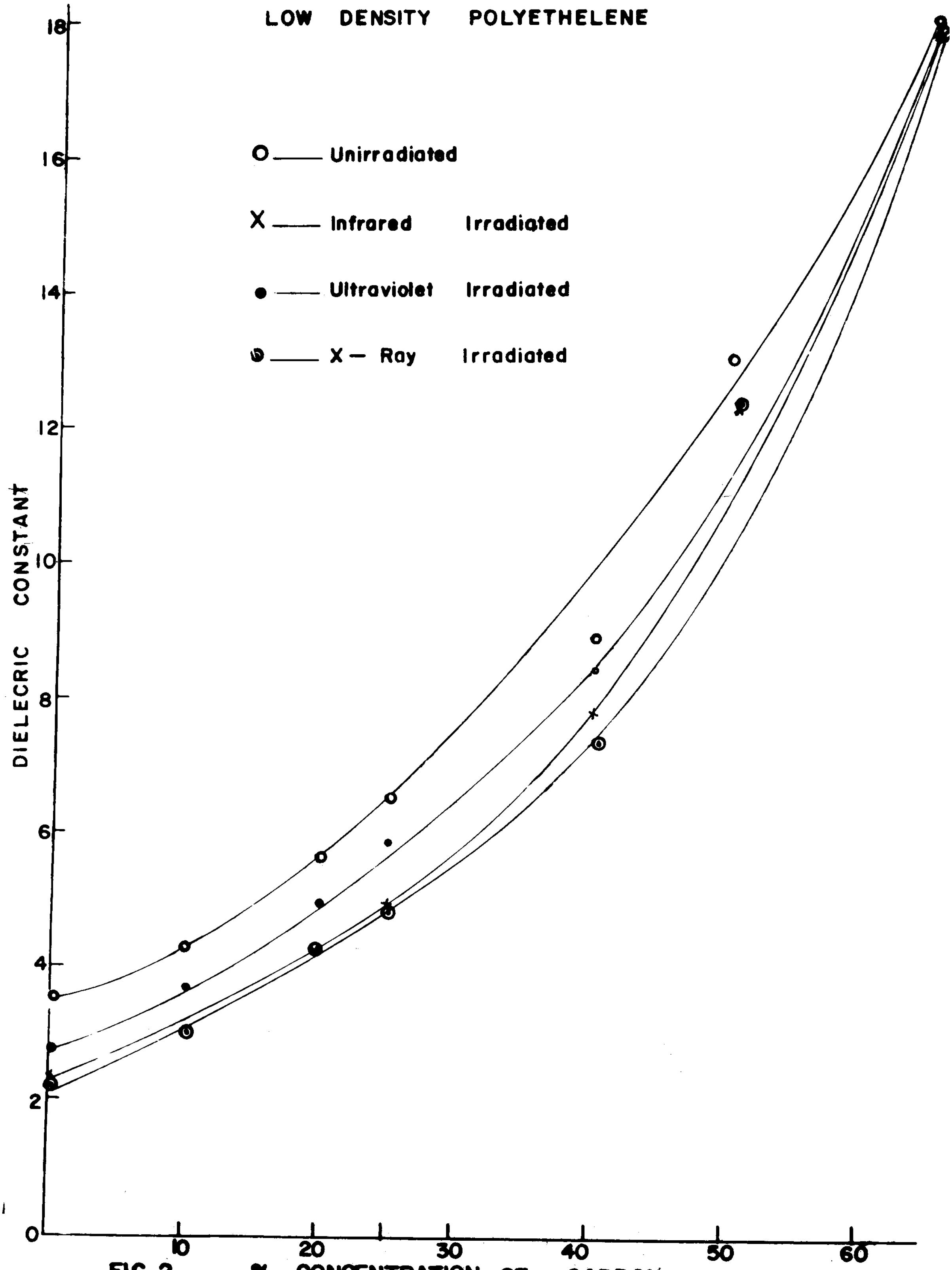

FIG. 2. % CONCENTRATION OF CARBON

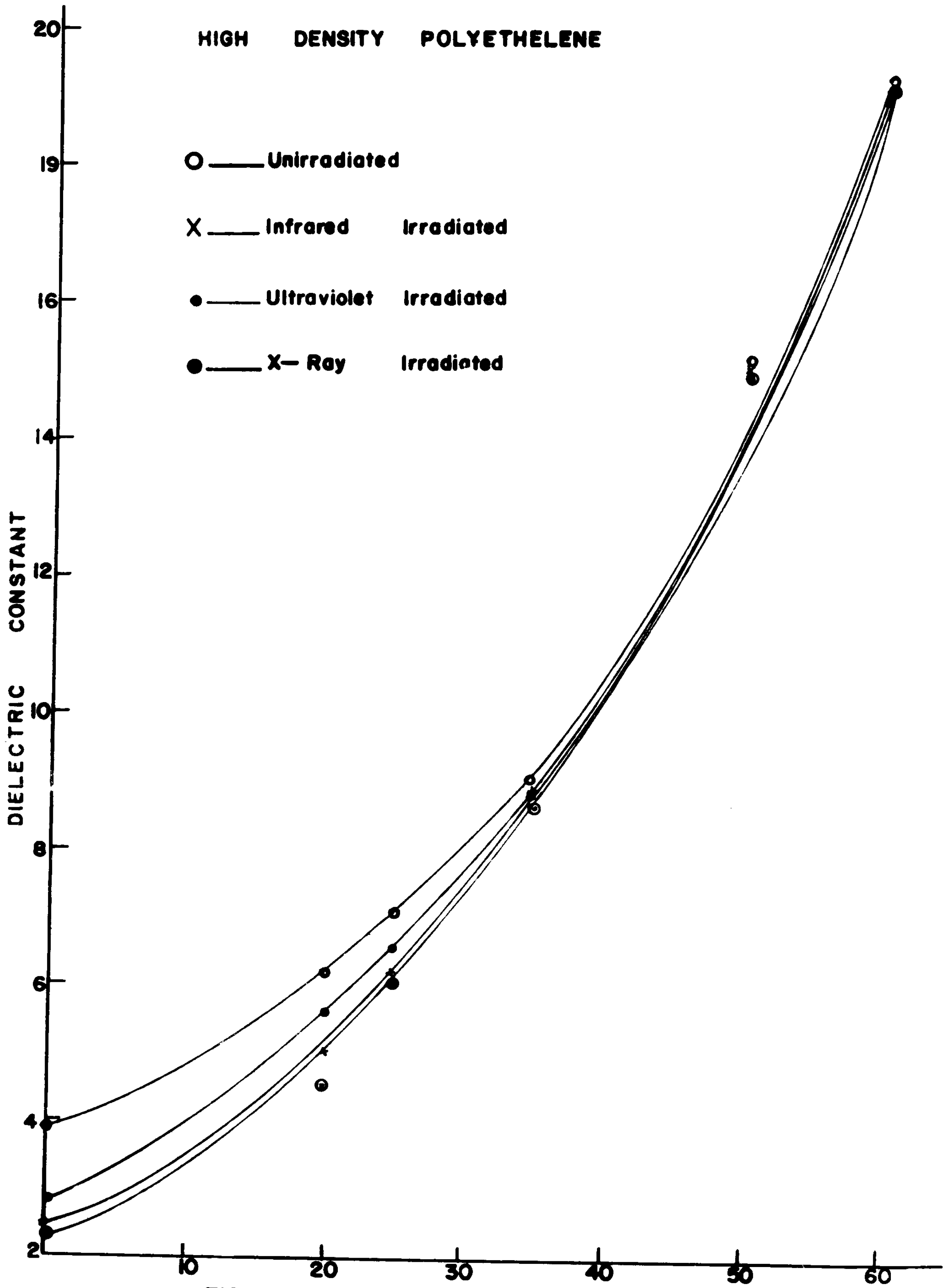

FIG 3. % CONCENTRATION OF CARBON

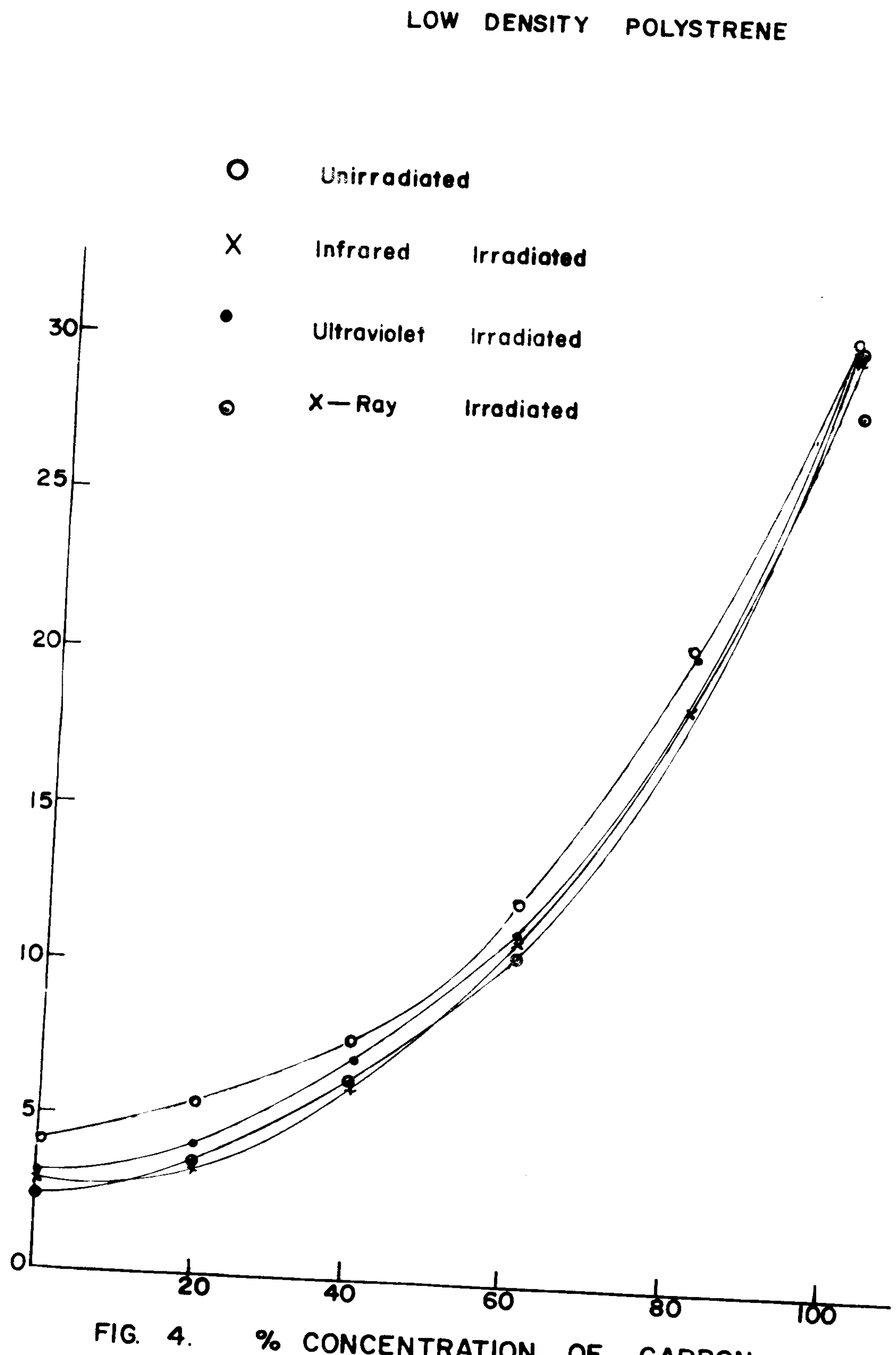

FIG. 4. % CONCENTRATION OF CARBON

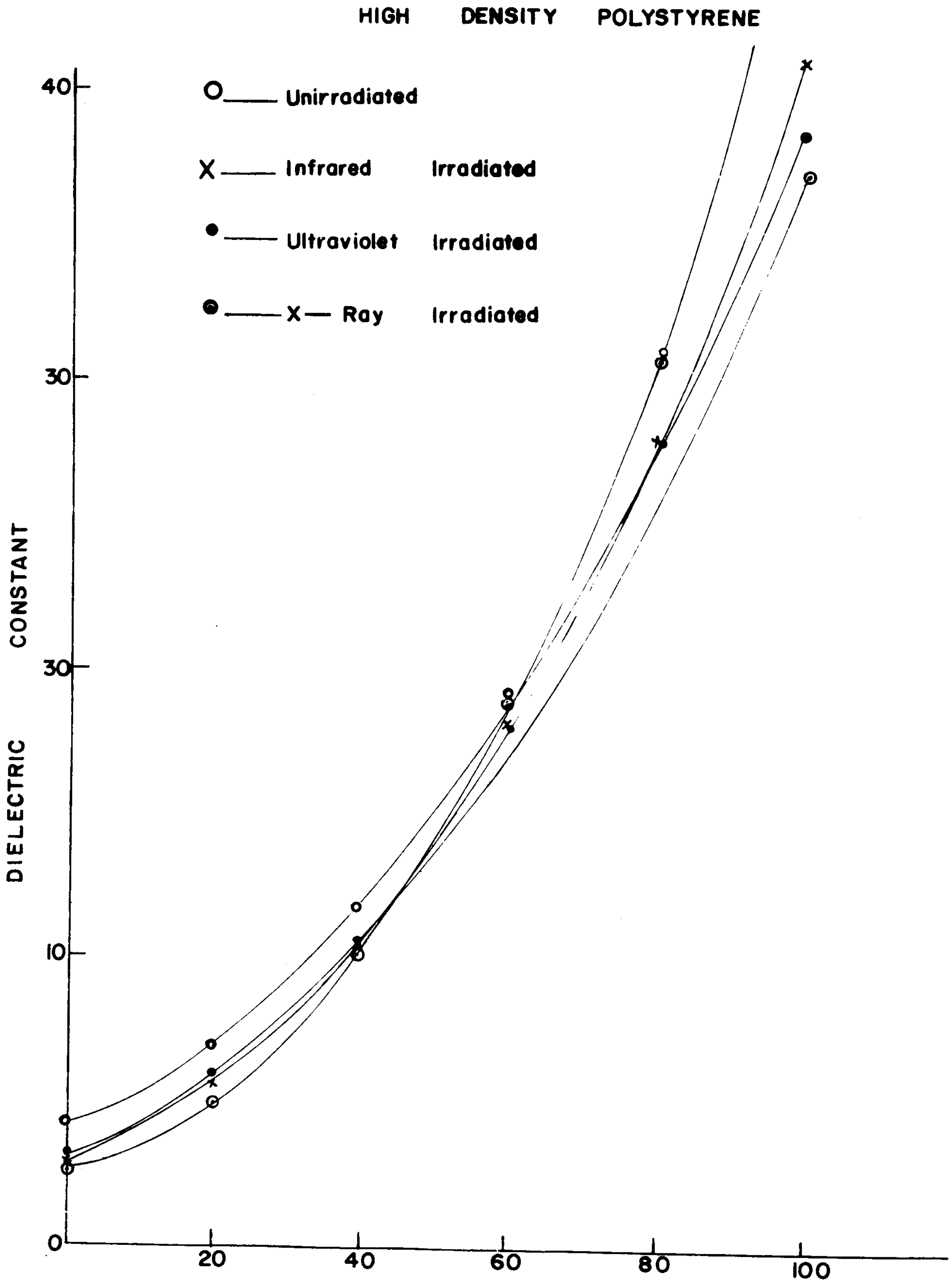

FIG. 5.

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