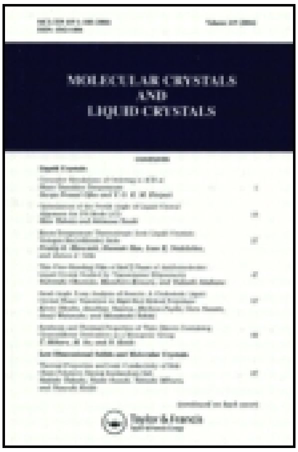

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NONLINEAR OPTICAL PROPERTIES OF SOME FATTY ACIDS-CHOLESTEROL MIXTURES

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Abstract It is shown that fatty acids such as the arrachidic and the lauric acids and their mixtures with cholesterol exhibit nonlinear optical properties. The effects of a 20 mW He-Ne laser (λ = 6328 Å) on such mixtures exhibiting smectogenic mesomorphism were examined and the optical activity dependence on the cholesterol percentage was determined.

Keywords: fatty acids, nonlinear effects, cholesterol, arrachichic acid, optical activity

INTRODUCTION

In the last years, several optical devices using different liquid crystal configurations have been proposed. An increasing interest in the use of liquid crystals as nonlinear optical media was developed[1].

Liquid crystals are highly nonlinear, the optical field-induced molecular reorientation being significant due to the strong molecular correlations.

This is the reason why we considered that the study of nonlinear effects, at low optical power limit in liquid crystals is very useful, having many applications.

In this paper we investigate the effects of a 20 mW He-Ne laser (λ = 6328 Å) on some fatty acids-cholesterol mixtures.

MATERIALS

As liquid crystals we used arrachidic acid, lauric acid and mixtures of these fatty acids with cholesterol.

As microscopical investigations under polarized light have shown, the arrachidic acid exhibits an enanthiotropic smectic mesomorphism within 70-73°C and the lauric acid a smectic mesomorphism within 44.3-51.3°C.

Mixtures of these fatty acids and cholesterol in different percentages were obtained and their physical properties were determined. It was proved[2] that by adding cholesterol to these fatty acids the mesomorphic range is widened (Figure 1); this was also evidenced by the corresponding texture changes.

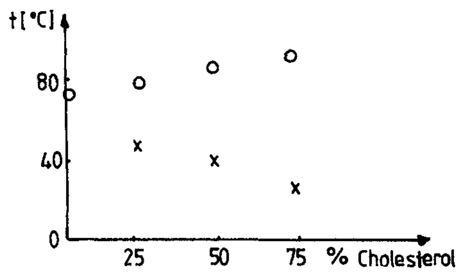

FIGURE 1 Transition temperatures of arrachidic acid cholesterol mixtures as function on cholesterol percentage : × solid-liquid crystal, o liquid crystal-isotropic liquid transition temperatures.

EXPERIMENTAL RESULTS

The liquid crystal cell, 20 μm thick, was placed between parallel and crossed polarizers respectively and irradiated with a He-Ne laser (λ = 6328 Å) . The output powers $P_{\parallel}$ and $P_{\perp}$ were determined as functions of the incident optical laser power P.

As it is shown in Figure 2a and Figure 2b , at very low optical incident power, a linear dependence of the output power on the incident power was obtained. When the incident power was increased over 12 mW, the slope of the plot changed.

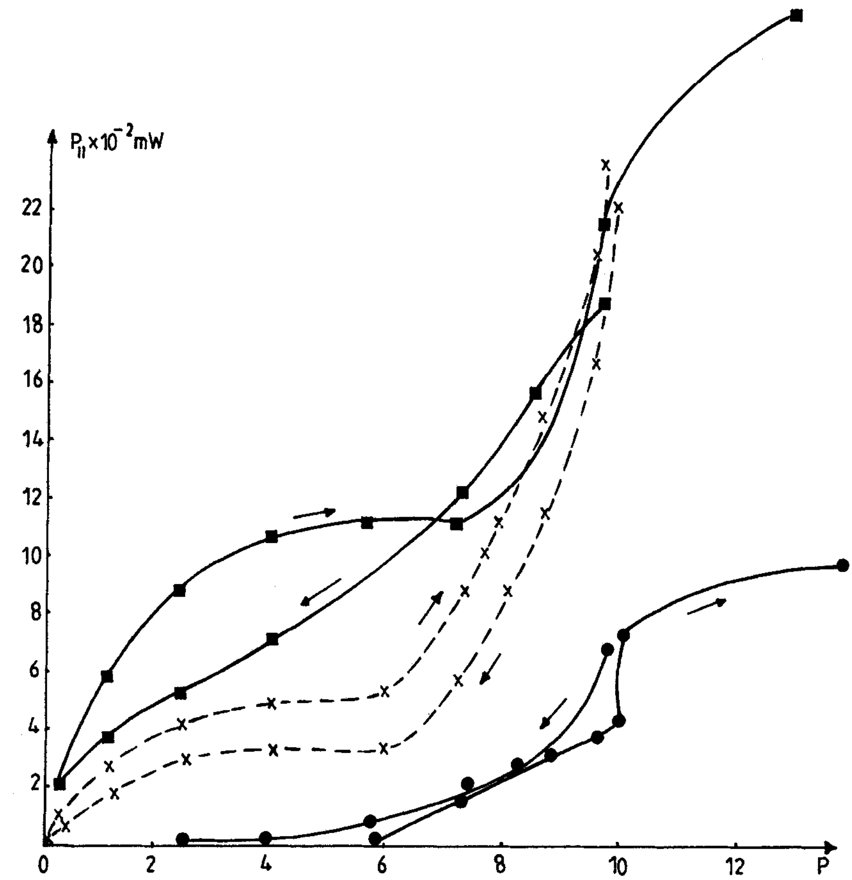

FIGURE 2a The output power $P_{\parallel}$ versus input power P ■ pure arrachidic acid, × arrachidic acid-cholesterol 1+2,• arrachidic acid-cholesterol 2+1 . $P_{\parallel}$ values obtained when increasing or decreasing P are indicated by arrows.

The change of the slope in the $P_{\parallel} = P_{\parallel}$ (P input) or $P_{\perp} = P_{\perp}$ (P input) plots is an indication for the existence of an induced rotatory power, when the incident laser power was strong enough (> 12 mW).

In the case of pure arrachidic acid and its 1+2 and

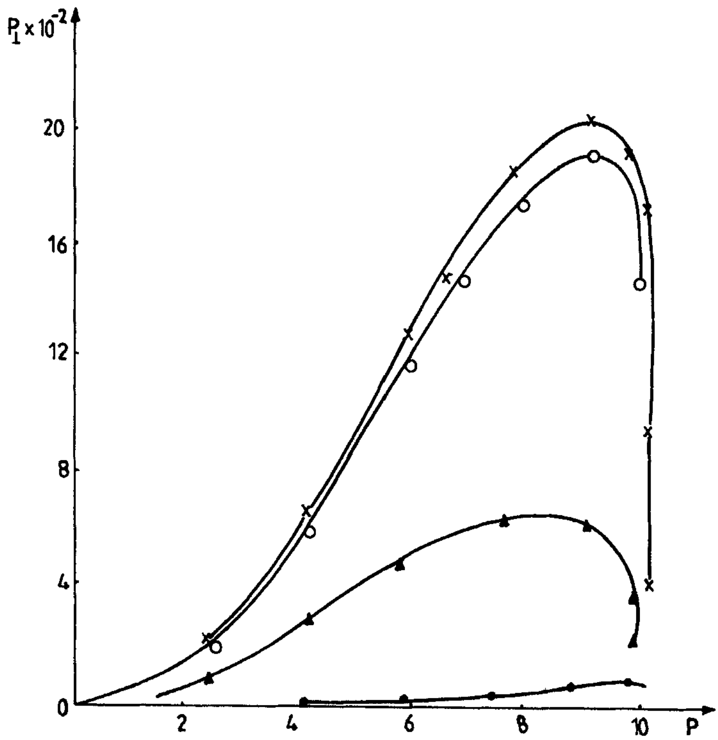

FIGURE 2b The output power $P_\perp$ versus input power P ▲ pure arrachidic acid, • arrachidic acid-cholesterol 2+1 , arrachidic acid-cholesterol 1+2 : × when P was increased , o when P was decreased.

2+1 cholesterol mixtures, a hysteresis was noticed : different $P_{\parallel}$ respectively $P_\perp$ values were obtained when the laser power was increased or decreased.

The same effect occured when pure lauric acid or its mixtures were examined ; however, different values for the output power were obtained (when the input power was increased or decreased). A nonlinear lens effect was evidenced in lauric acid and its cholesterol mixtures[3].

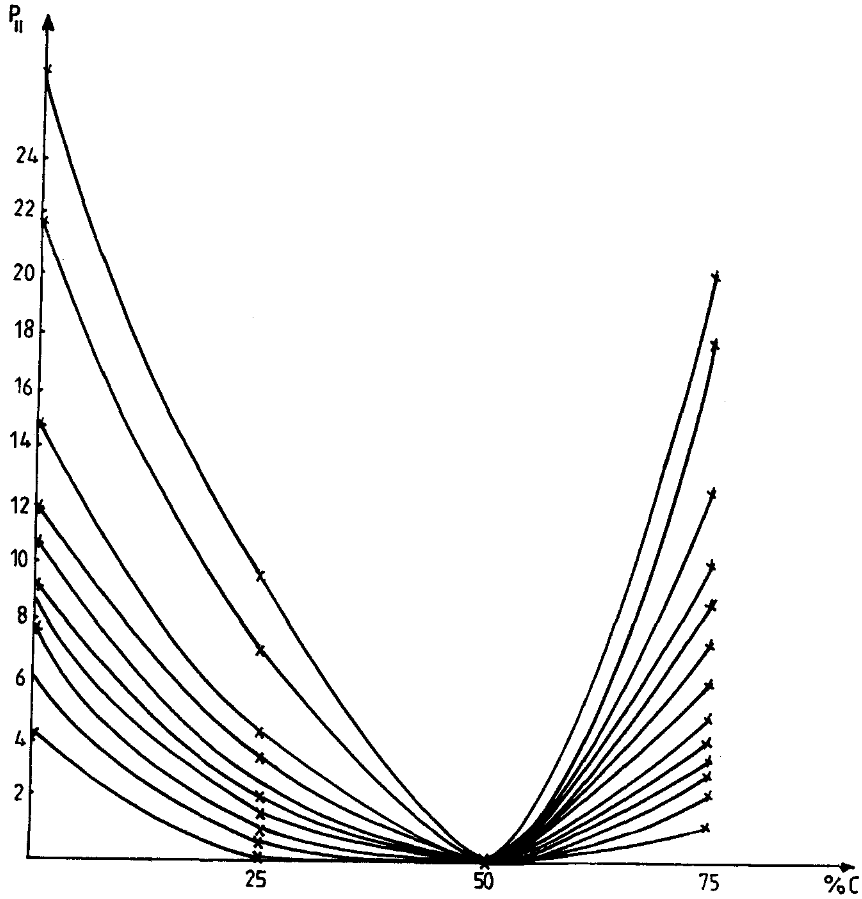

FIGURE 3a The output power $P_{\perp}$ versus cholesterol percentage in arrachidic acid-cholesterol mixtures.

Dielectrics generally behave in this way, most of them exhibiting ferroelectric properties ; as it was experimentylly proved, some liquid crystals display such properties[4].

We may conclude that the investigated fatty acids and their mixtures with cholesterol display an "optical nonlinear activity". This is dependent on the cholesterol percentage, as it is shown in Figure 3a and Figure 3b.

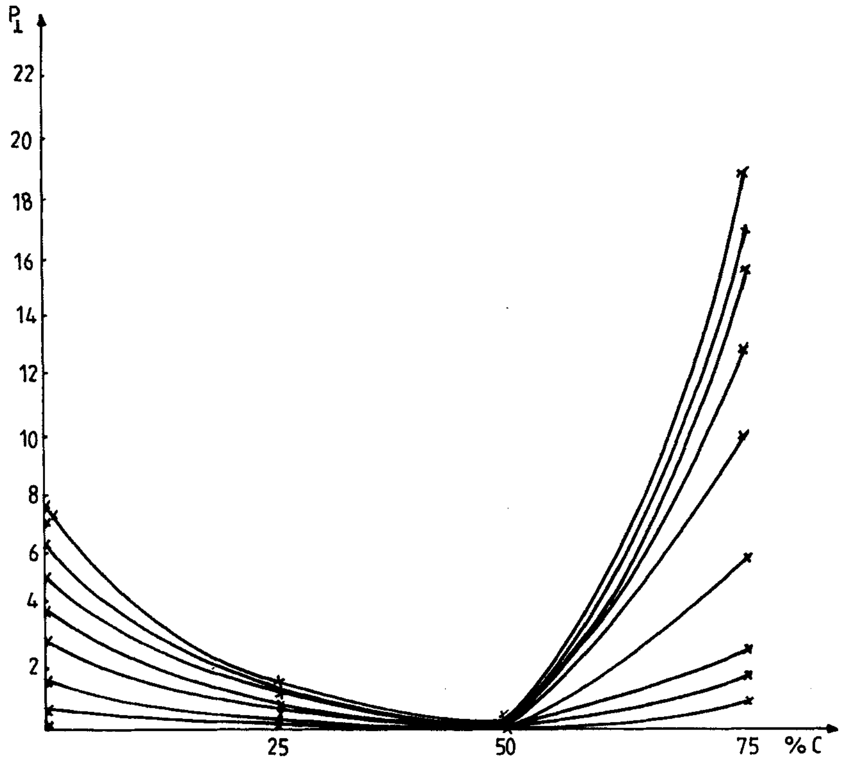

FIGURE 3b The output power $P_\perp$ versus cholesterol percentage in arrachidic acid-cholesterol mixtures.

When cholesterol is added to arrachidic acid, $P_\parallel$ and $P_\perp$ are first decreased ; they reach a minimum value near the percentage 50:50% (by weight) and then $P_\parallel$ and $P_\perp$ increase when the cholesterol percentage is increased.

It is worth mentioning that when some electrical measurements are performed, such as capacitance (Figure 4) or space charge (Figure 5), the cholesterol percentage is essential in confering particular properties to these mixtures.

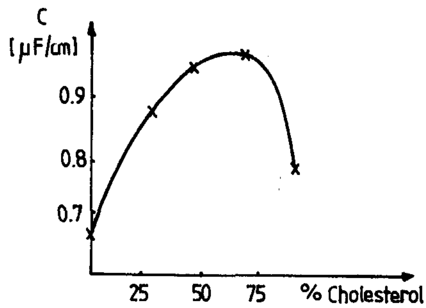

FIGURE 4 Electrical capacitance versus cholesterol percentage in arrachidic acid-cholesterol mixtures.

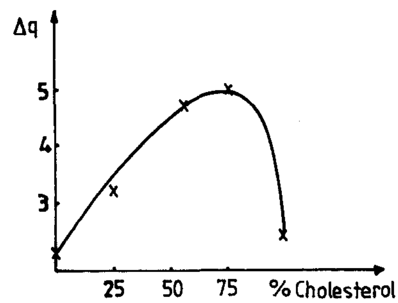

FIGURE 5 Space charge accumulated in arrachidic acid-cholesterol mixtures versus cholesterol percentage.

This shows that by adding cholesterol to some fatty acids a space charge is induced and the dielectric constant of the mixture is increased, reaching a maximum in the vicinity of the 50:50% cholesterol percentage ; consequently, the refractive index will be changed. It may be suggested that the immaginary part of the dielectric constant, responsible for the absorption, will be also affected by the cholesterol percentage. Therefore, when the mixture is irradiated with a He-Ne laser, the output power will be decreased as a result of these nonlinear induced effects.

These results are in agreement with other reports on liquid crystals as well as with the results we obtained when other fatty acids-cholesterol mixtures were examined.

CONCLUSIONS

The saturated fatty acid - the arrachidic acid - and its mixtures with cholesterol in different percentages are nonlinear optical media. The nonlinear optical activity is a function on the cholesterol percentage and its lower values are connected to the maximum value for the capacitance or for the space charge accumulated within the sample.

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