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INVESTIGATIONS OF SMECTIC POLYSILOXANES 1 - ELECTRIC FIELD INDUCED TURBULENCE

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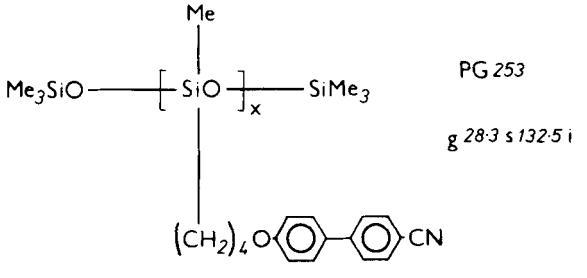
ABSTRACT

Optical and electro-optical properties of a smectic side chain polysiloxane, possessing a cyanobiphenyl mesogenic moiety, are presented as a function of temperature and applied voltages. Field induced turbulent motion is observed at frequencies up to 1KHz.

INTRODUCTION

Since the early work of Roviello and Sirigu[1], thermotropic mesophases have been reported in a variety of polymers with mesogenic moieties and flexible polymethylene spacers in the main chain. More recently, the synthesis of polymers with mesogenic groups fixed by a flexible alkyl chain to the polymer backbone has produced liquid crystalline side chain polymers which show properties similar to those of low molar mass liquid crystals.

Research into the behaviour of liquid crystalline polymers in electric fields has concentrated on nematic polymers and comparisons with low molecular weight nematogens. Krigbaum et al[2-4] investigated electric field induced instabilities in nematic main chain polymers, and Corazza et al[5] observed similar effects in nematic and cholesteric main chain polyesters. Recent work has shown that side-chain nematic polymers show electro-optic effects similar to low molecular weight liquid crystals[6-9]. In this letter we report preliminary work on the effect of electric fields on a smectic side chain homopolysiloxane containing the cyano-biphenyl unit.



PG 253

g 28·3 s 132·5 i

EXPERIMENTAL

The polymer samples were contained between two transparent conducting glass slides etched to give an electrode area of $2mm^2$. No particular treatment was given to the glass substrates other than a thorough de-greasing followed by washing in isopropanol. Because of the high viscosity of the polymers, samples were melted onto one glass plate and the cell assembled using an adhesive spacer, rather than use the conventional capillary filling procedure.

The cell temperature was controlled by a programmable heating stage (LIN-KAM TH600) and the samples were viewed on an Olympus BH-2 polarising microscope, photomicrographs being taken with an Olympus OM-2 camera body and attachment. Thermo-optic analysis (TOA) was carried out using a photodiode attachment and chart recorder.

AC fields were supplied by a sinewave oscillator via a linear amplifier (which also supplied DC fields).

RESULTS

Thermo-optic analysis measures the intensity of light passing through polymer films under crossed polars as a function of temperature. Figure 1 shows a typical trace for the polymer under investigation. Below a temperature of around 130°(T'), the polymer film is opaque and provides low transmission. Above this temperature a rapidly increasing intensity of light is observed which passes through a maximum at $134^{\circ}C$ and then falls rapidly as the isotropic state is attained. Between T' and T_m the polymer is more fluid and highly anisotropic (i.e. in this region rotation of the polariser or analyser changes the level of light transmission). From T_m to T_c the polymer exhibits a

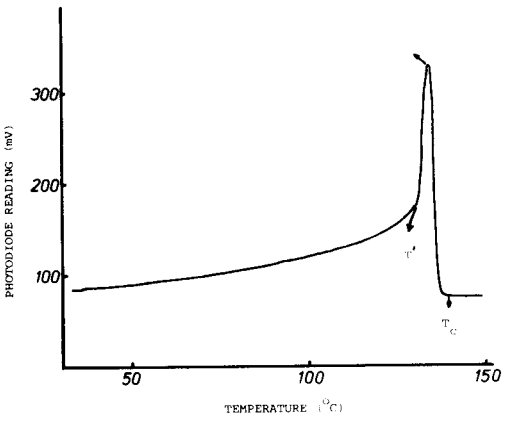


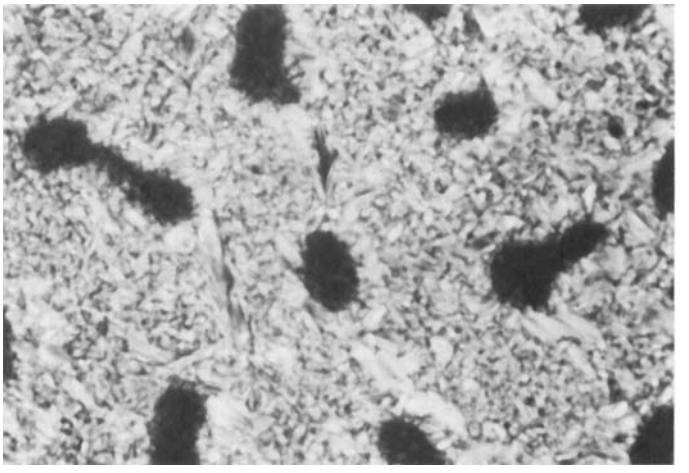
FIGURE 1 Thermo-optic analysis (TOA) curve for PG253.

biphasic region in which anisotropic and isotropic phases coexist. T_m and T_c are respectively defined as the temperatures at which the isotropic phase first appears, and at which the anisotropic phase disappears.

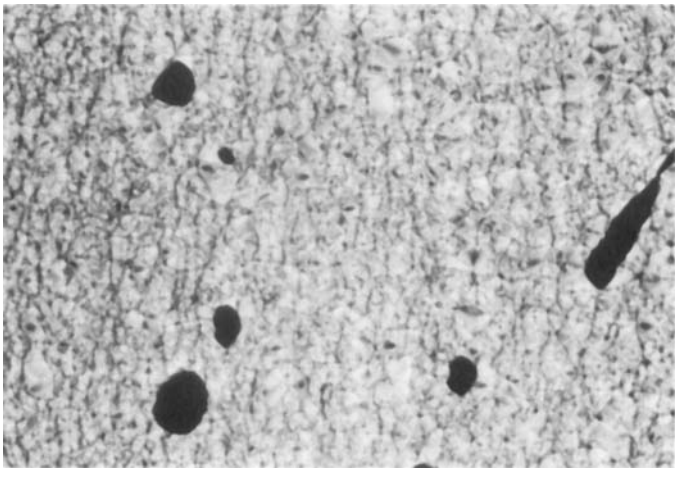
No typical low molecular weight smectic textures were observed during the heating cycle; indeed annealing for 20 hours below T' had no effect on the optical properties of the sample. Above T', however, focal conic textures were obtained after annealing for a few hours. Figure 2 shows two such textures at temperatures just above T' and T_m respectively.

ELECTRIC FIELD EFFECTS (DC, low frequency AC)

The behaviour of polymer PG253 in DC and low frequency AC (<1KHz) electric fields was studied as a function of temperature and voltage between 120 and 140°C. At temperatures above T' (130°C), electric fields of sufficient magnitude induced turbulent motion in the polymer leading to an intense scattering of light, with a consequent reduction in transmission as seen between crossed polars. Figure 3 shows this to good effect, the dark region in Figure 3(b) being the area of the polymer film to which the field is applied. Below T', the response of the polymer to applied

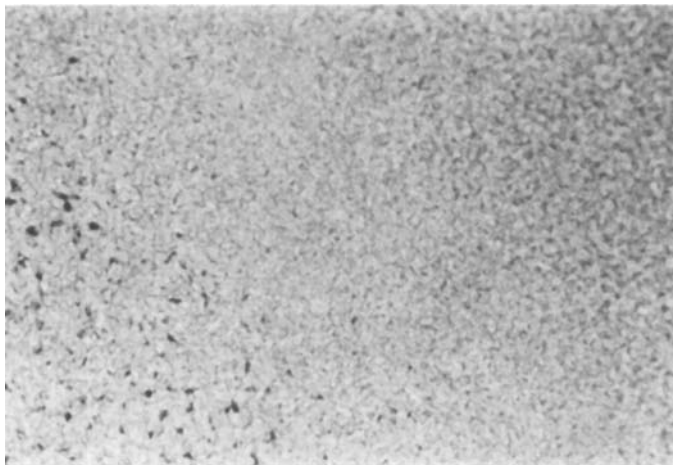


(a)

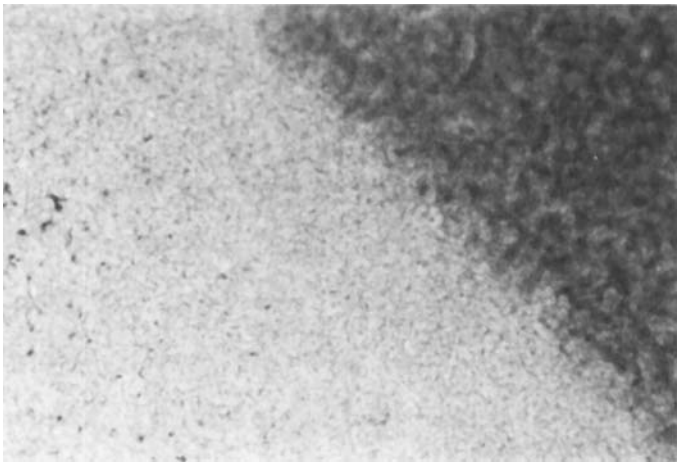


(b)

FIGURE 2 Photomicrographs of PG253 taken at an original magnification of 100X. (a) Texture at 131°C, (b) Texture at 134°C.



(a)



(b)

FIGURE 3 Photomicrographs showing (a) texture prior to, and (b) texture 5 mins after application of 150V r.m.s., 200Hz to the polymer film. Temperature 133.6°C, original magnification 100X.

fields is significantly reduced - application of high voltages (>300V) for 12 hours induced no textural change at 120°C. Above T' the turbulent motion becomes more intense the higher the temperature and voltage, and optical response times vary from minutes to several hundred milliseconds (details will be given in a later publication). This turbulent motion is observed in a frequency range from DC up to 1KHz, for cell spacings around 50μm.

We believe that this is the first time such dynamic scattering effects have been observed in cyanobiphenyl side chain siloxane polymers. Although the initial measurements imply voltages of 100-200V rms, the relaxation times suggest that the materials have some potential for electro-optic polymer devices.

ACKNOWLEDGMENTS

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