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The Effect of Ambient Light on Liquid Crystal Tapes†

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Abstract—Previous data indicated that the color/temperature response of cholesteric liquid crystals is severely impaired by exposure to white light. A study was undertaken to determine the protective effects of different packaging materials on cholesteric liquid crystal tapes. The data indicated that light has a deleterious effect on the stability of liquid crystal tapes. It was also shown that degradation of the tape was due mainly to ultraviolet light and that packaging materials such as opaque papers and black polyethylene provide protection against the effect of light.

1. Introduction

Liquid crystals are materials which exhibit a double melting point phenomenon when heated. During the mesophase, they exhibit unique light-scattering properties.[1] At temperatures below the mesophase, the liquid crystal structure becomes crystalline. At temperatures above the mesophase, cholesteric liquid crystals form an isotropic liquid. The cholesteric liquid crystal structure is generally described as having optical activity and negative optical rotation and a helicoid structure. When illuminated with white light, they are capable of scattering the light to yield iridescent colors which vary in hue with temperature changes.[2] The unique properties of cholesteric liquid crystals such as anisotropy, birefringence, optical rotation and reflection are all dependent on a precariously balanced arrangement of the molecules.[3] The behavior of ternary systems such as those used in the present work is even more unpredictable because of the complexity of the materials and the minute impurities contained in them.

† Presented at the Fourth International Liquid Crystal Conference, August 21–25, 1972.

The present study was undertaken to determine, under closely controlled conditions, the actual thermochromic effects produced by exposure of liquid crystal tapes to ambient mixed-light.

2. Materials and Methods

Samples of liquid crystal tapes, prepared as described in an earlier communication,[4] were affixed to glass panels and samples from the the same batches of tape stored in amber glass jars were tested for changes in thermochromic response after exposure at room temperature (21 °C) for various lengths of time to a mixture of fluorescent, white and natural light. Changes in thermochromic response were measured by a modification of the spectrophotometer of the type described by Fergason.[2]

The efficacy of white and Manila envelope paper stocks and of clear and black polythylene (2 mm thickness) as light-protective media was tested on a single batch of liquid crystal tape which had an initial color/temperature response between 30 and 35 °C. The test samples were covered with the protective material during exposure. Samples stored in amber glass bottles were used for comparison.

3. Results

Figure 1 illustrates the effect of exposure to light on two early formulations of liquid crystal tapes (No. 706–01 and No. 706–23) with an initial color/temperature response between 30 and 35 °C. Tape samples stored in amber bottles showed a degradation in color response of approximately − 0.5 °C over a period of 70 weeks. Tapes exposed to mixed light exhibited color/temperature drops of − 8.0 to − 9.0 °C after 52 weeks, and − 12.0 °C after 70 weeks exposure. The degradation rate was approximately − 0.15 °C/week.

Figure 2 illustrates the results obtained with tapes (prepared by refined manufacturing techniques) which had an initial color/temperature response between 35 and 38 °C. Samples stored in amber bottles exhibited a degradation of approximately − 0.5 °C in approximately 52 weeks. The exposed tapes exhibited a degradation of − 3.0 °C for the same period.

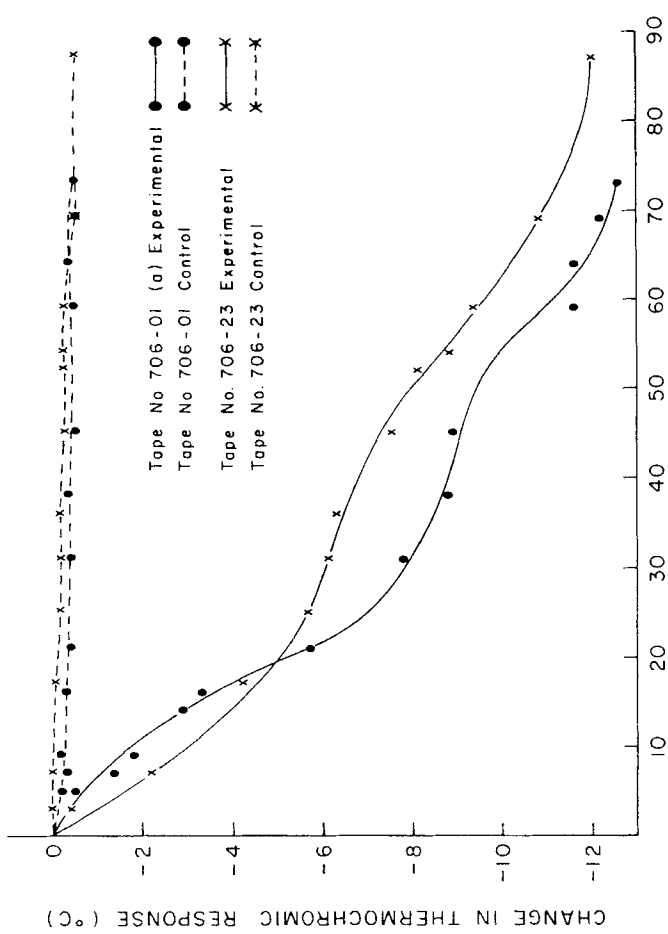

Figure 1. The effect of exposure to light on the thermochromic response of liquid crystal tapes.

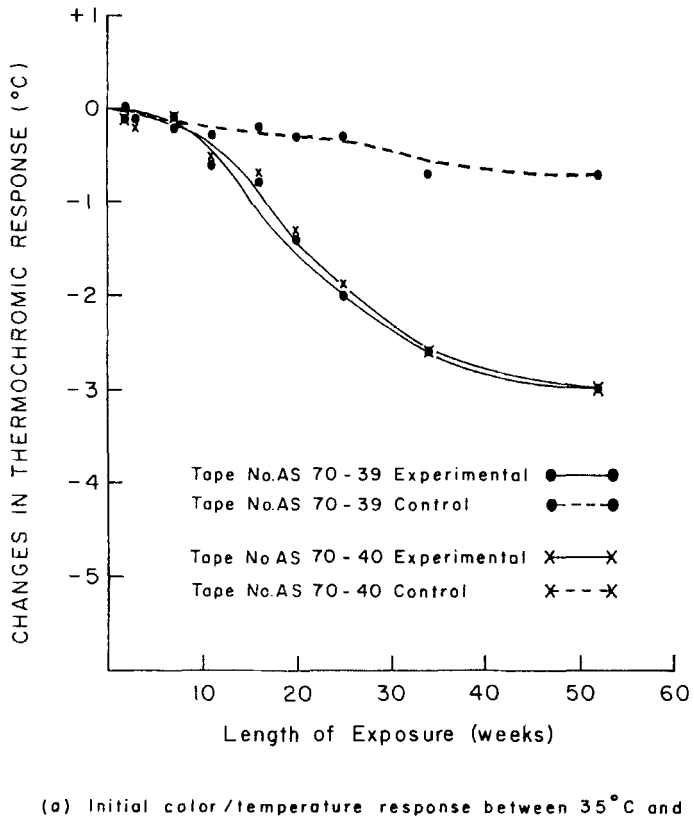

Figure 2. The effect of exposure to light on the thermochromic response of liquid crystal tapes.

Figure 3 shows the effect of four light protective media on samples of a single batch of liquid crystal tape which had an initial color/temperature response between 30 and 35 °C. The tape stored in amber glass bottles exhibited a degradation of −0.5 °C in 70 weeks. Tapes protected by manila paper stock and black polyethylene

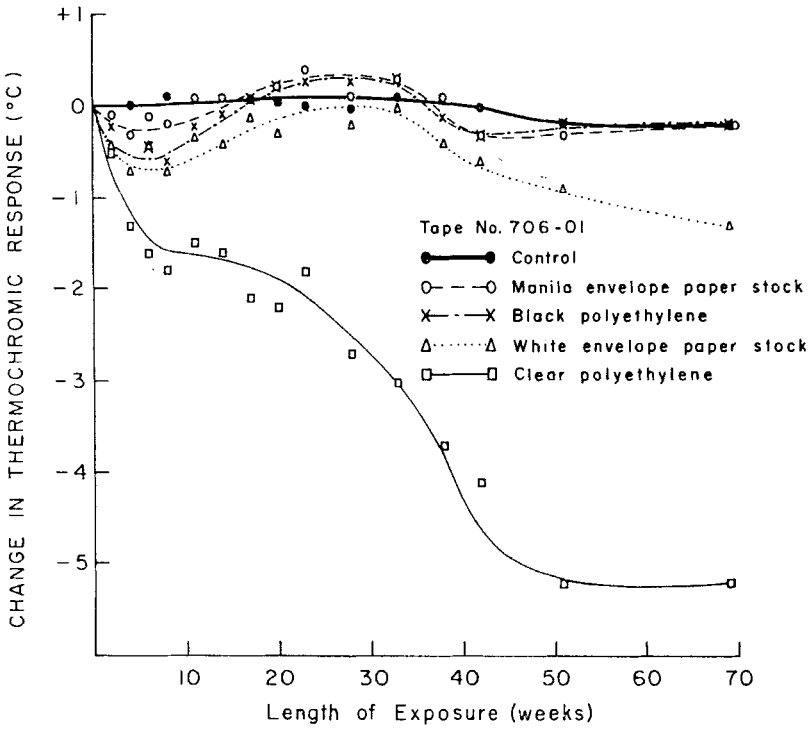

Figure 3. The effect of protective media on the thermochromic response of liquid crystal tapes.

exhibited a color/temperature degradation similar to the degradation of those stored in amber glass. Samples protected by white paper stock exhibited a degradation of the color/temperature response of −1.3 °C. Those protected by clear polyethylene exhibited a degradation of the color/temperature response of −5.2 °C in 70 weeks.

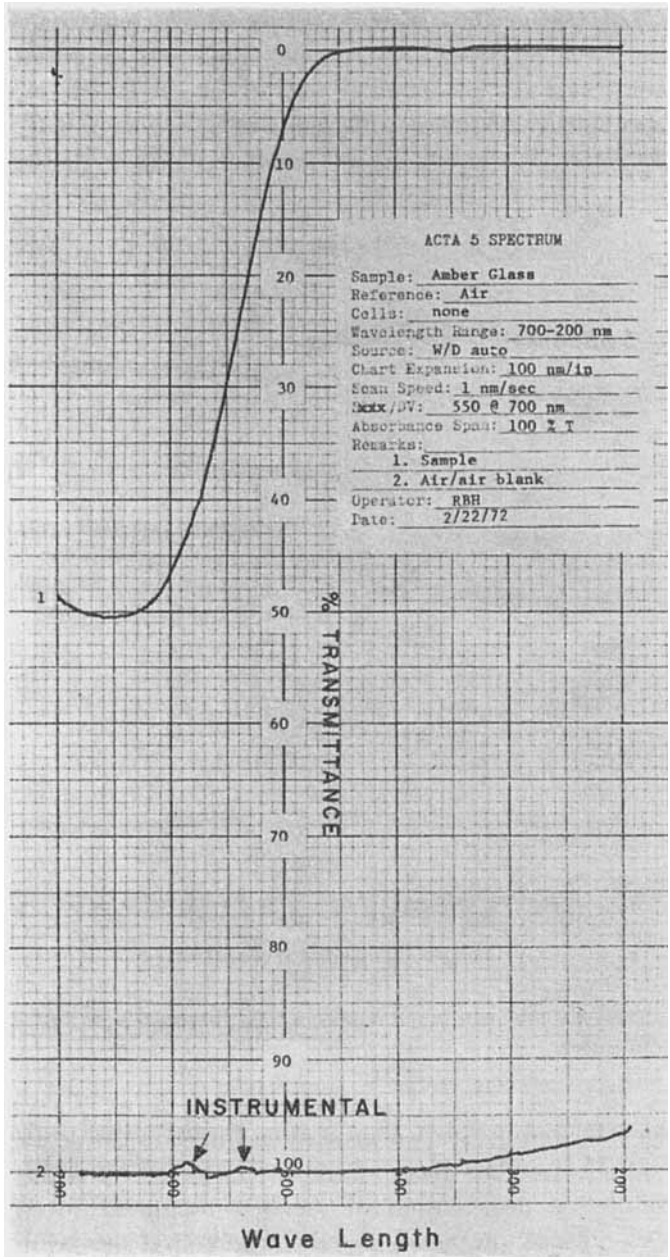

Figure 4. Light transmission of amber glass.

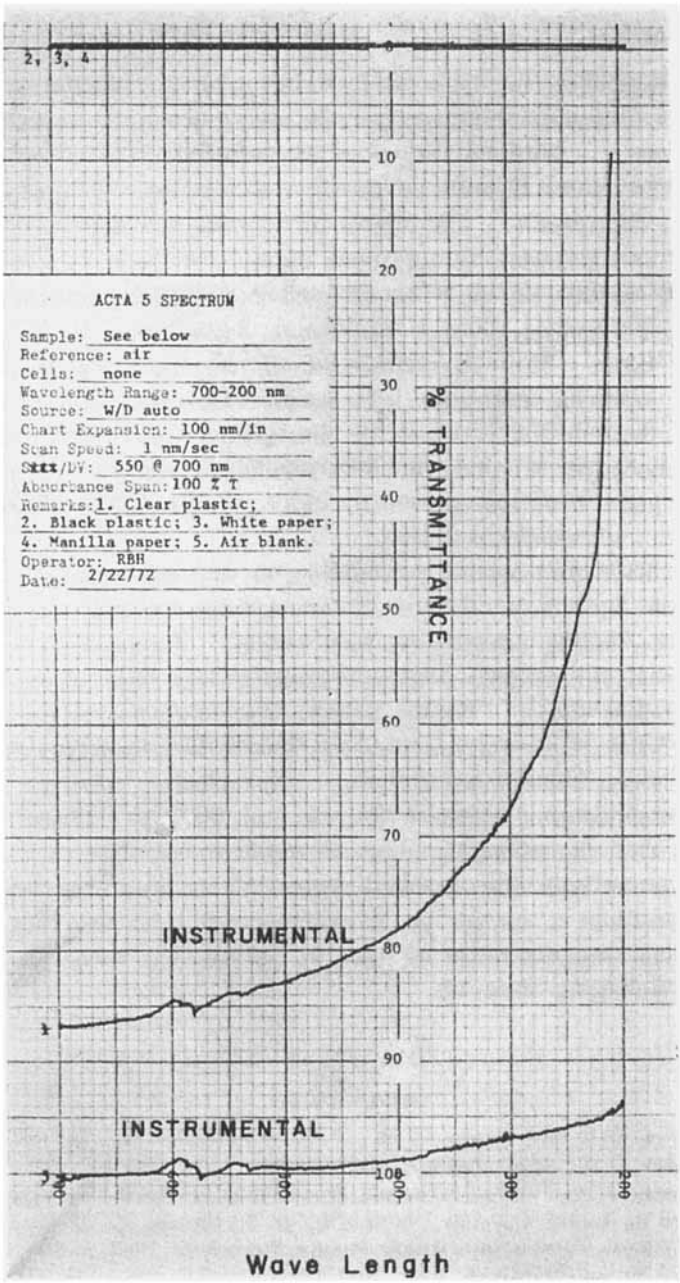

Figure 5. Light transmission of various packaging materials.

4. Discussion

The data show the degree of degradation of the color/temperature response of liquid crystal tapes which takes place under experimental conditions. A minimal degree of degradation occurred when the tapes were stored in amber glass whereas unprotected tapes showed marked degradation. The degree of degradation was significantly less in tapes prepared by improved manufacturing techniques.

In the studies on the protective effect of various materials, only clear polyethylene allowed significant degradation of the liquid crystal tapes. Minimal degradation of the tapes occurred when opaque covering materials were used. However, the protection against degradation provided by non-opaque amber glass suggests that opacity *per se* is not the chief requisite for protection of liquid crystal tapes from degradation by light. Amber glass is known to screen out ultraviolet radiation.

Since little information is available on the degradative effect of ultraviolet light on liquid crystal systems,[5] the spectral transmission of the packaging components was studied. Figure 4 shows that commercial amber glass does not transmit any light with a wave length below 450 nm. Figure 5 shows that materials such as black plastic, white paper and manila paper do not allow any light penetration between 200 nm and 700 nm. Clear plastic, however, allows 80% transmittance between 200 nm and 400 nm. These results indicate that the packaging materials which do not allow penetration of ultraviolet light offer excellent protection for liquid crystal tapes. If any stability in the thermochromic response is to be achieved, an ultraviolet absorber must be used in conjunction with ultraviolet barrier packaging material.

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