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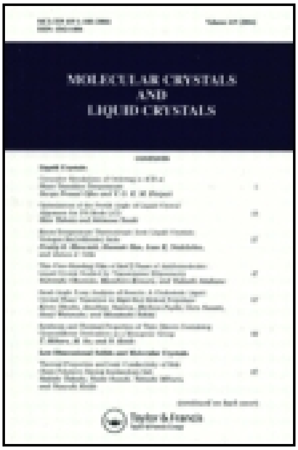

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Color Gamut of Liquid Crystal Polysiloxanest

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Color Gamut of Liquid Crystal Polysiloxanes†

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Polysiloxanes with suitable side-chains form a cholesteric liquid crystal phase that can be applied to a substrate to produce a durable coating which exhibits strong colours below the glass transition temperature. The peak reflectance is almost 0.5 and a nearly 1.0 peak reflectance can be obtained using a half-wave retardation plate coated on both sides with the material and viewed from one direction against a black background. Values below 0.5 and between 0.5 and 1.0 have been also obtained using suitable solvents and alignment techniques. Many desired spectral reflectance distributions can be then obtained because of the additive color properties of such cholesteric coatings. As a result it is possible to produce a larger colour gamut than with real surface colours such as pigments and dyes. Employing commercially available material experimental work was carried out demonstrating a greatly expanded colour gamut on the chromaticity diagram. Also it is possible to modify the spectral reflectance distribution of coloured substrates by coating them with a material having a reflectance peak at the desired band of wavelength.

INTRODUCTION

Cholesteric liquid crystals exhibit remarkable colour properties[1] such as enlarged colour gamut, additive colour properties,[2] dependence of the colour on the angle of viewing and illumination and in some cases also on temperature. Attempts have been made to make them suitable as a coating medium using encapsulation techniques[3] or dispersement in a suitable matrix.[4] However these processes reduce the saturation of the colours and thus the colour gamut. Polysiloxanes

†Paper presented at the 10th International Liquid Crystal Conference, York, 15th–21st July 1984.

with suitable side-chains[5,6,7] form a cholesteric liquid crystal phase above ambient temperatures. On cooling below the glass transition temperature they retain the molecular directional order and thus the brilliancy of the colours. They form a tough coating at ambient temperatures that adhere well to many types of substrate. These polymer liquid crystals therefore show great promise as important new coating materials, of interest in the fine and decorative arts, signage and printing industries, and many other commercial areas.

DESCRIPTION AND EXPERIMENTAL RESULTS

The purpose of this investigation is to show that a greater colour gamut can be obtained with LC polysiloxanes than with other real surface colours using pigments or dyes, and to show that their additive colour properties can be used to modify the colours of the substrates.

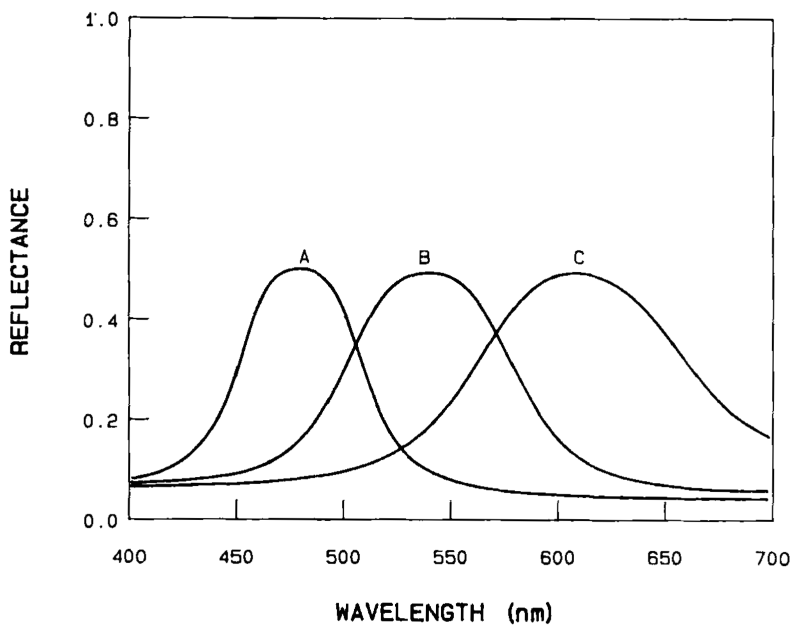

FIGURE 1 Spectral reflectance curves A, B and C of polysiloxane liquid crystals centered at the wavelengths of about $\lambda_A = 480nm$, $\lambda_B = 540nm$ and $\lambda_C = 610nm$ repectively. Note that the peak reflectance does not exceed the value of 0.5.

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The peak reflectance of cholesteric liquid crystals cannot exceed the value of 0.5. This is because only the component of the incident light that has the same handedness of circular polarisation as the handedness of the cholesteric helix is reflected and the component of opposite handedness is transmitted. However it is possible to obtain a peak reflectance of 1.0 by coating both sides of a half-wave retardation plastic sheet with cholesteric liquid crystals. The half-wave retardation sheet converts the transmitted component of opposite handedness to become the same as that of the cholesteric helix. This component is then also reflected and is added to the first reflected component.[8,9]

A black substrate was coated with LC polysiloxanes. Three samples were prepared with the centre peak reflectance at 480nm, 540nm and 610nm respectively. The spectral reflectance was measured with a Zeiss DMC25 spectrophotometer in the 8° incident-diffuse collection (specular reflection excluded) mode. The results are shown in Figure 1.

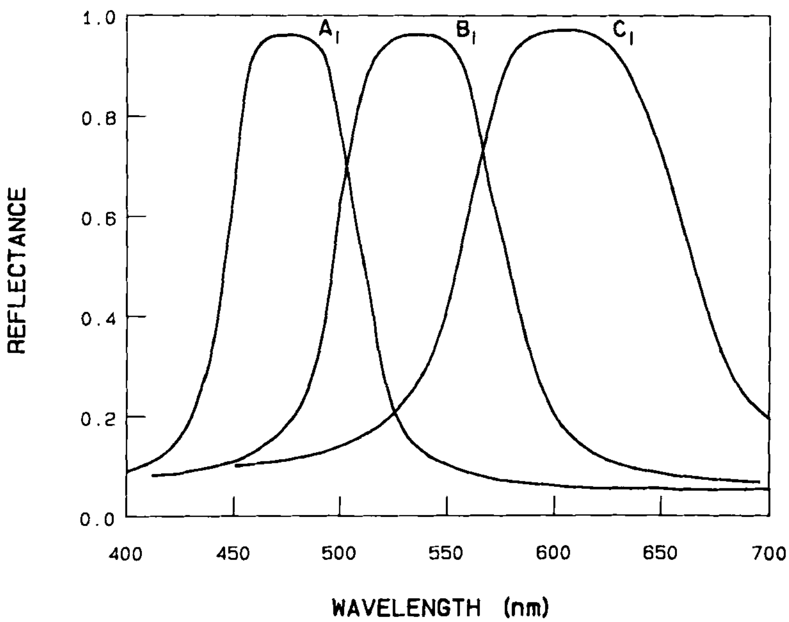

FIGURE 2 Spectral reflectance A_1, B_1 and C_1 of polysiloxane liquid crystals centered at about the same wavelengths as in Figure 1. Note that the peak reflectance approaches the value of 1.0. This is achieved by coating both sides of a $\lambda/2$ retardation sheet with this material and viewing it against a black background.

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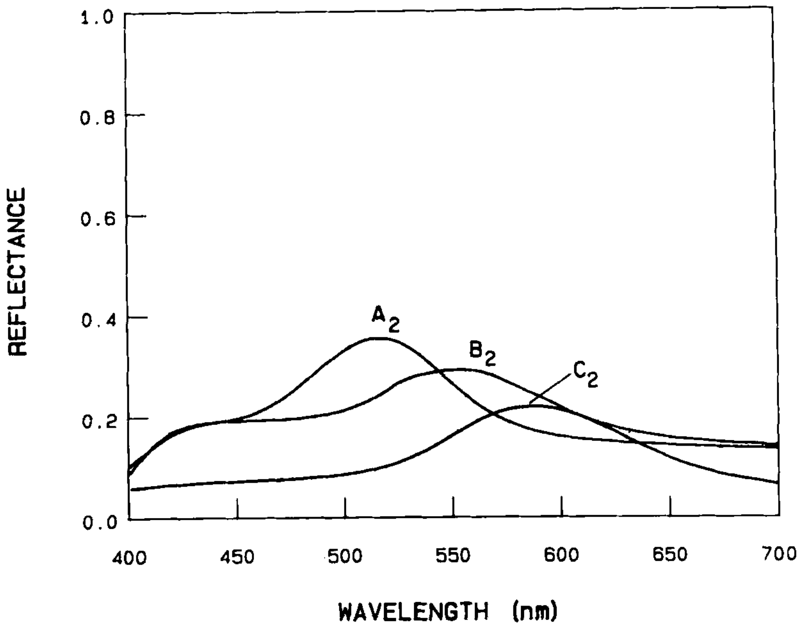

FIGURE 3 Spectral reflectance curves A_2, B_2 and C_2 of polysiloxane liquid crystals having peak reflectance values less than 0.5. This can be achieved by using suitable solvents or deliberately misaligning the molecules of the LC layer.

Commercially available retardation sheets were coated on both sides with LC polysiloxanes and one side was then painted black. Three samples were again prepared having the center peak reflectance at the same wavelength as in Figure 1. The results are shown in Figure 2. Figure 3 shows the spectral reflectance curves prepared as in Figure 1 but the LC polysiloxane material was diluted with a suitable solvent. Depending on the amount of the solvent it is possible to reduce the peak reflectance from its value of 0.5 or 1.0 without changing significantly the shape of the curve.

This effect can also be achieved by reducing the alignment of the molecules either by chemical treatment of the substrate or by mechanical means. The above methods can be used as a means of reducing the luminous reflectance of the colour.

Returning to the curves shown in Figure 2, their CIE 1931 tristimulus values and luminous reflectance[10] were calculated. The former determine the location on the CIE 1931 chromaticity diagram; the latter were found to be 0.18 and about 0.60 and 0.60 for the curves A_1, B_1 and C_1 respectively. The location of B_1 and C_1 were plotted on the chromaticity diagram shown in Figure 4 and were compared

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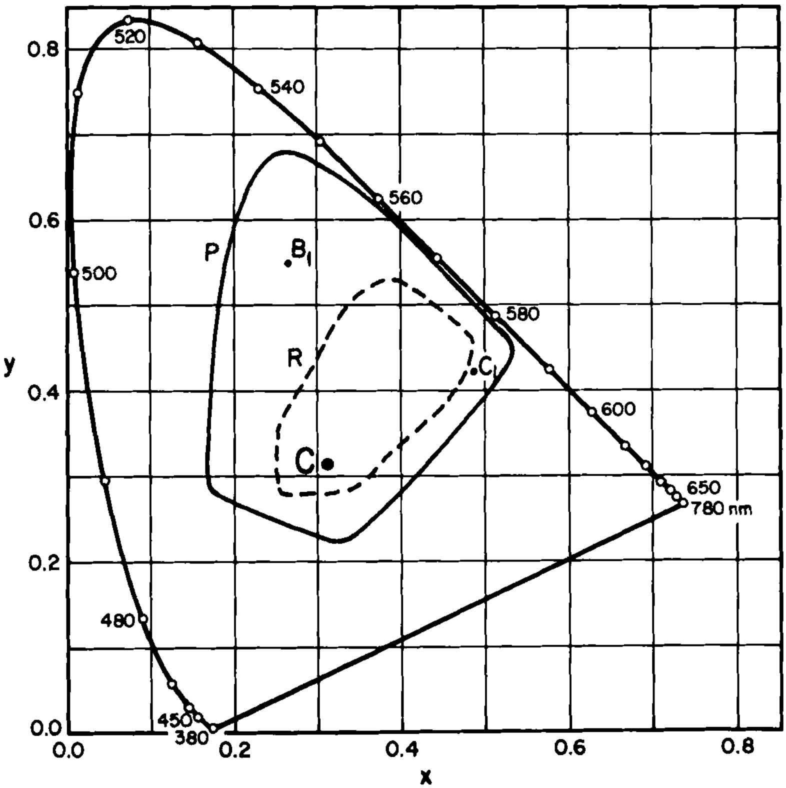

FIGURE 4 Chromaticity loci of various colours at the luminous reflectance Y = 0.6 on the basis of the CIE 1931 standard observer and illuminant C. (P) Optimum colours (from MacAdam 1935). (R) The gamut of real surface colours (from Pointer 1980). (C) Illuminant C. (B_1) and (C_1) are the colours shown by the spectral reflectance curves B_1 and C_1 in Figure 2. Note that the colours B_1 and C_1 are outside the locus R thus showing that the colour gamut of polysiloxane liquid crystals is greater than that of real surface colours.

with the loci of optimal colours P and the limits of real surface colours[11] R for the luminous reflectance Y = 0.6. The optimal colours have a rectangular shaped spectral reflectance than can never be obtained in practice and represent the theoretical limits. The limit of real surface colours represent the colours having maximum saturation that have been achieved in practice with present day pigments and dyes. The luminous reflectance is related to the integral of the product of the spectral response of the coloured surface, the source, and the human eye. It is seen that the point B_1 and C_1 are located outside the limits of real surface colours thus confirming that the colour gamut

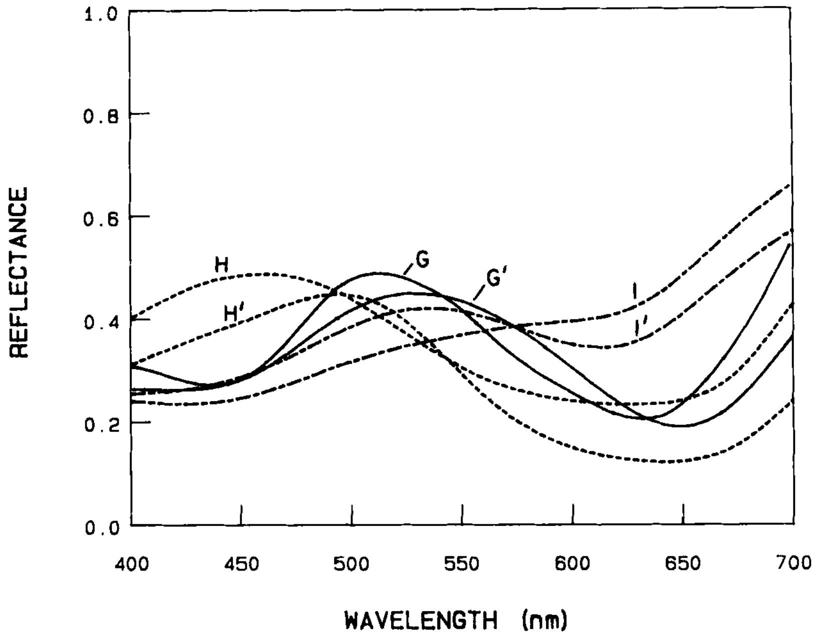

FIGURE 5 Spectral reflectance curves of a green, blue and grey substrate given by the curves G, H and I. These substrates were coated by LC polysiloxanes centered at about 540nm, 480nm and 480nm respectively and their spectral reflectance is shown by the curves G′, H′ and I′. Note the shift of the peaks in the curves G′ and H′ and the introduction of the new peak in the curve I′.

of LC polysiloxanes can be greater than that of real surface colours presently in use.

Cholesteric liquid crystal coatings absorb little light and therefore their spectral reflectance is added to the spectral reflectance of the substrates. These additive properties can be utilised to modify the spectral reflectance of the latter. Green, blue and grey coloured cardboard substrates were coated with LC polysiloxanes centered at 540nm, 480nm, and 480nm respectively. The corresponding spectral reflectance curves before and after coating are shown in Figure 5. Note the shift of the peaks in the curves G′ and H′ and the introduction of a new peak in the curve I′. Although the curves G, H and I were modified by the LC polysiloxane coatings, the additive colour properties cannot be fully confirmed from the examination of the curves G′, H′ and I′. It is possible that there is some interaction between the substrate and the LC polysiloxane coating or the coating itself, which introduces some absorption. This is unlike cholesteric ester coatings and is the subject of further investigation.

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CONCLUSIONS

The above study shows that LC polysiloxane coatings have a colour gamut larger than that of real surface colors, such as pigments and dyes, and they can be also used to modify such surface colours.

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References

1. D. Makow, *Color Research and Application*, **4**, 25 (1979).
2. D. Makow and C. L. Sanders, *Nature*, **276**, 48, 9 (1978).
3. J. E. Vandegaer, *Microencapsulation and Applications*. Plenum, New York (1974).
4. J. Quigley and W. Benton, Mesolab, Pittsburgh. Private Communication.
5. H. Finkelmann and G. Rehage, *Makromol. Chem., Rapid Commun.*, **1**, 31 (1980); **1**, 733 (1980); and **3**, 859 (1982).
6. H. Finkelmann, *Polymer Liquid Crystals*, Academic Press, Inc. (1982).
7. F. H. Kreuzer, *Fluessigkrist.*, **11**, 5 (1981).
8. J. Adams, W. Haas, J. Daily, *J. Applied Physics*, **42**, 4096 (1971).
9. D. Makow, *Applied Optics*, **19**, 1274 (1980).
10. G. Wyszecki, W. S. Stiles, *Color Science*, 2nd Edition, John Wiley and Sons, New York, (1982).
11. M. R. Pointer, *Color Research and Applications*, **5**, 145 (1980).