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Investigation of concentration depended optical properties of PDCLC solution

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ABSTRACT

This paper reports result obtained by analysis of UV-Visible absorption spectra of Polymer Dispersed Cholesteric Liquid Crystal (PDCLCs) solution. The PDCLC solutions of different concentration were prepared using Methyl Methacrylate (MMA) and Cholesteryl Pelargonate (CP). We know that pure CP shows high degree of absorption and MMA transmit almost all the wavelengths at room temperature in the visible range. We investigated PDCLC solution obtained using varying concentration of CP in the polymer solution. We observed that the amount of absorption varies considerably with the concentration. We were able to make a combination wherein the absorption became negligible for the visible range which otherwise for other concentration was very high. The negligible absorption in the visible range of electromagnetic spectra is very useful property in optical devices and in many other applications.

KEYWORDS

UV-Visible absorption spectra;
Polymer dispersed cholesteric liquid crystal (PDCLCs);
Methyl methacrylate (MMA) and Cholesteryl Pelargonate (CP).

INTRODUCTION

Cholesteric liquid crystals (CLCs) have helical structure wherein molecules are arranged in layers with no positional ordering within layers. A director axis varies periodically with layers. PDCLC solutions are made up of CLC dispersed in polymer matrix. There are various methods used for preparation of PDCLCs. We have used MMA and CP, obtained from Numex Chemical Corporation in various concentrations to prepare PDCLC solution. PDCLCs have got applications in light shutters, display devices[1, 2] and optical fibers[3, 4].

Optical fibers are light pipes which are extensively used in communication industry. The main problem of the optical fiber is attenuation which happens mainly due to absorption in the core region of the optical fiber. Attenuation can be minimized by selecting the proper Numerical aperture for the fiber and using core material with lesser impurities. The other option to reduce the absorption is to fill the core region with the solution having negligible absorption in the range of wavelengths used for transmission. Liquid crystals are widely used in optical fibers[5, 6] to overcome such limitations. We in our work were successful in identifying a concentration of PDCLC solution were in the absorption drops to minimum value in the vis-

ible range of spectra.

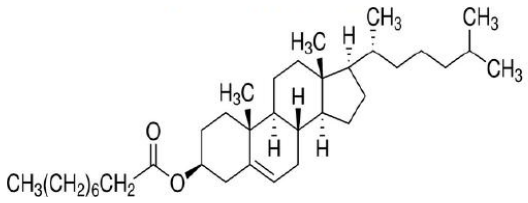
This solution also gives varying refractive index for various colours. The refractive index also varies with the concentration. Refractive Index of suitable value is again a good parameter in deciding the numerical aperture of the optical fiber.

The fibers made using liquid crystals are called Photonic crystal fibers (PCFs) or micro-structured optical fibers. They have micrometer-sized air holes running down the length of the fiber in which PDCLC solution can be filled. In index guiding fibers[7, 8] light is guided by using a principle similar to total internal reflection. In bandgap-guiding PCFs, the light is guided in a low-index core by coherent reflection from a surrounding periodic microstructure[9, 10].

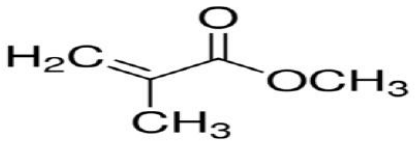
EXPERIMENTAL DETAILS

PDCLC solutions of five different concentrations were prepared by adding different amount (milligrams) of CP to 10 ml MMA.

Sample 1: 10ml MMA+20mg CP
Sample 2: 10ml MMA+40mg CP
Sample 3: 10ml MMA+60mg CP
Sample 4: 10ml MMA+80mg CP
Sample 5: 10ml MMA+100mg CP



The chemical structure of CP



The structure of methyl methacrylate

The solution was mixed properly till the CP got properly dispersed in the MMA. The mixture was then heated to get a clear homogeneous solution. This homogeneous solution was used to perform the experiment at room temperature. Refractive index of the solution was measured using indigenously designed multiwavelength refractometer[11]. The morphology of the PDCLC and how the droplets are in the solution was studied by using Lawrence and Mayo Optical Polarizing Microscope.

The absorption spectra of PDCLC solution of different concentration was studied using UV-Visible spectrometer.

OBSERVATIONS

CLC are birefringent materials having two refractive indices. Even when dissolved in other liquids they make the resulting solution birefringent. Here what we observed is that when dissolved in MMA the resulting solution had only one refractive index.

The TABLE 1 shows variation of refractive index for wavelengths obtained using mercury source with varying concentration solution. Figure 1 shows graphical variation of refractive index of various samples. TABLE 2 shows wavelengths absorbed using UV visible spectrometer. Figure 2 to Figure 7 shows absorption spectra of MMA and Sample 1 to Sample 5 respectively. It is clearly observed from the UV- visible spectrometer graphs of various samples that MMA does not absorb light in the visible range. It is only when CP is added to it sample starts absorbing the light in the visible range. It is also observed that the absorption increases with the concentration of CP with the exception for Sample 2. Figure 8 to Figure 10 show how texture of the PDCLC sample change with increasing concentra-

TABLE 1 : Refractive index values for various solutions

Wavelength (nm)	Refractive Index Values				
	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
405	1.41647	1.41442	1.41318	1.41339	1.41421
436	1.41051	1.40906	1.40803	1.40824	1.40947
546	1.40057	1.39974	1.39808	1.39933	1.40057
578	1.39891	1.39766	1.38345	1.39683	1.39766

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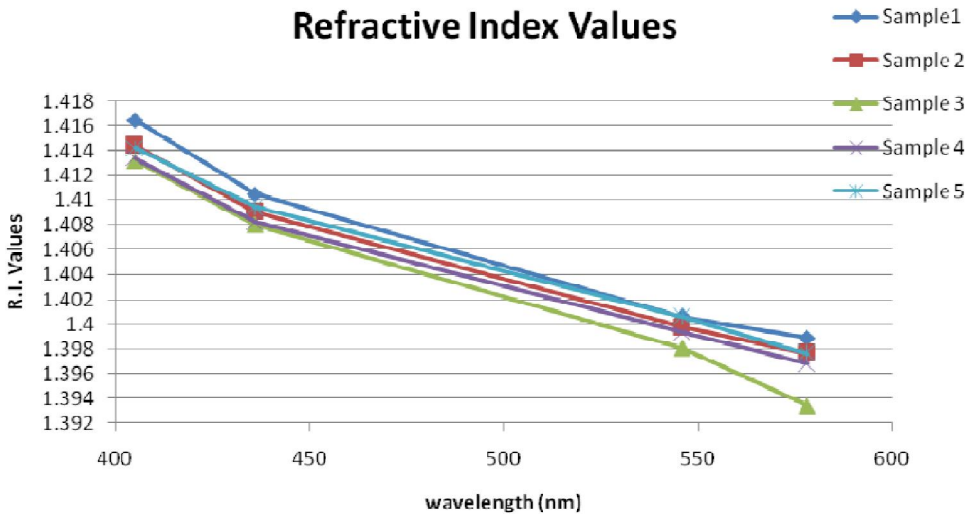

Figure 1 : Variation of refractive index for five different samples

TABLE 2 : Absorbed wavelengths for various samples as per UV visible spectra

Sample	Wavelengths (nm)	Absorption
Sample 1	424.0, 726.4	0.019, -0.011
Sample 2	--	--
Sample 3	493.6, 733.6	-0.015, 0.047
Sample 4	479.2, 580.0, 743.2, 774.4	0.146, 0.081, 0.269, 0.027
Sample 5	440.8, 458.8, 487.6, 652.0, 668.8, 748.0	-0.066, -0.059, -0.056, -0.119, -0.095, -0.057

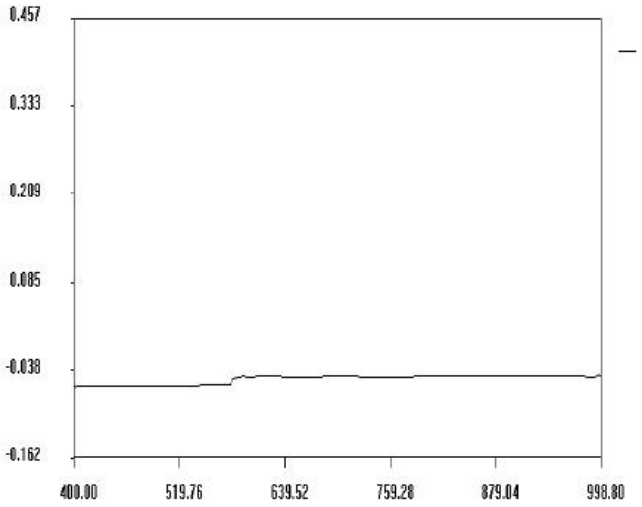

Figure 2 : Absorption spectra of Pure MMA

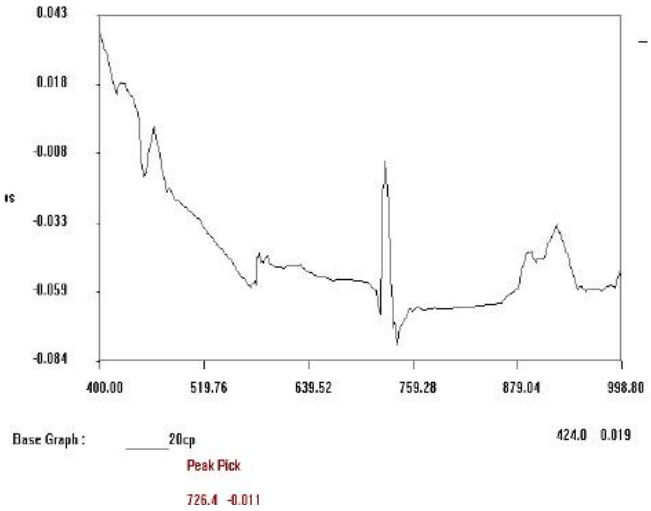

Figure 3 : Absorption spectra of Sample 1

tion of CP in MMA under optical polarizing microscope.

RESULT AND DISCUSSIONS

We know that CP is a birefringent material[12]. What we observed is when we dissolved CP in different concentrations in MMA the resulting solution had only one refractive index. The texture studies show that the cholesteric nature of the CP is maintained in all the solution. It is observed that initially refractive index of the solution decreases with the concentration for sample 4 and then it increases again for sample 4 and sample 5. As we know that the refractive index is generally increased after the polymerization[13], we can conclude that solution polymerizes in case of sample 4 and sample 5. It can also be attributed to change in the cholesteric pitch

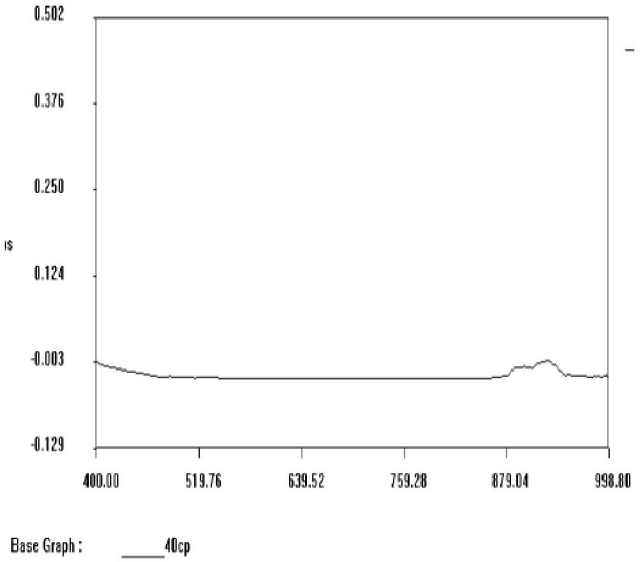

Figure 4 : Absorption spectra of Sample 2

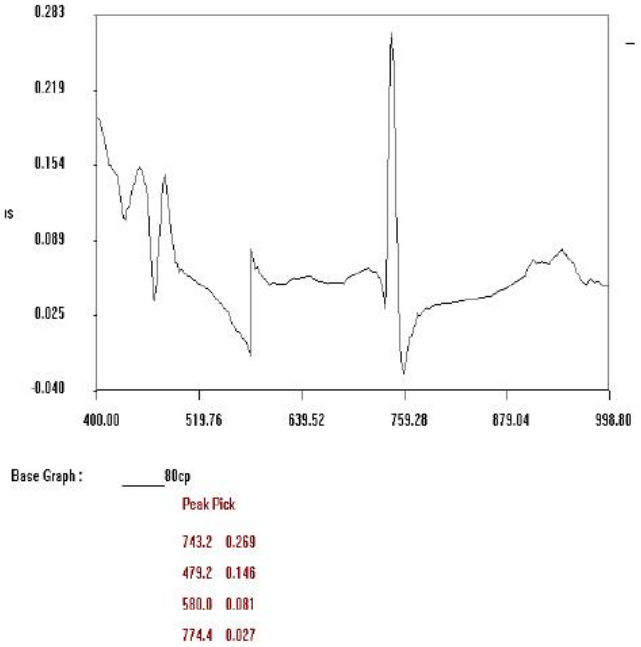

Figure 6 : Absorption spectra of Sample 4

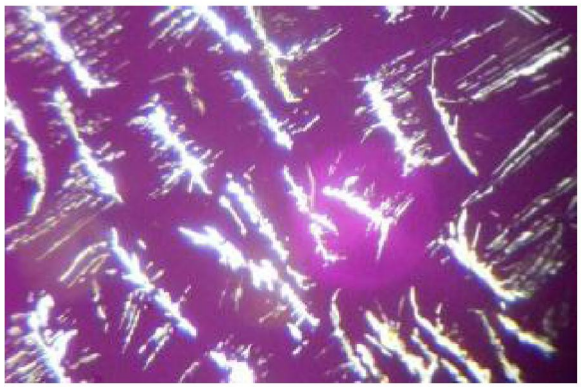

Figure 8 : Texture of Sample1

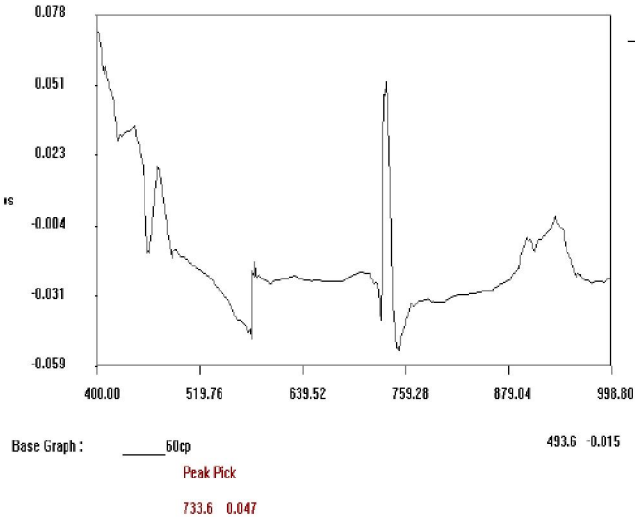

Figure 5 : Absorption spectra of Sample 3

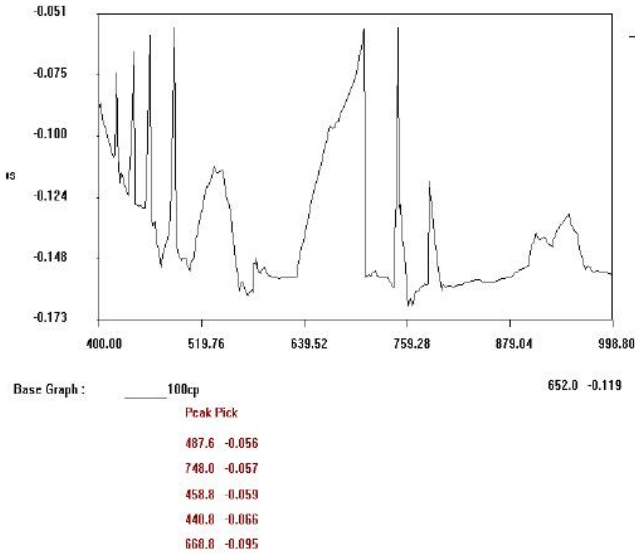

Figure 7 : Absorption spectra of Sample 5

Figure 9 : Texture of Sample2

as indicated by the textures of various samples. The change in the cholesteric pitch happens due to increase in volume shrinkage ratio of the MMA with

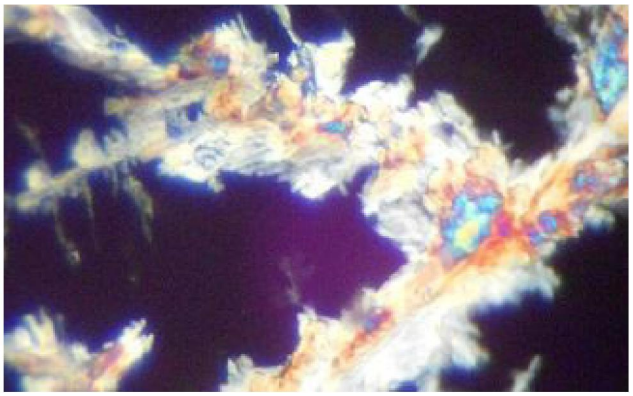

Figure 10 : Texture of Sample3

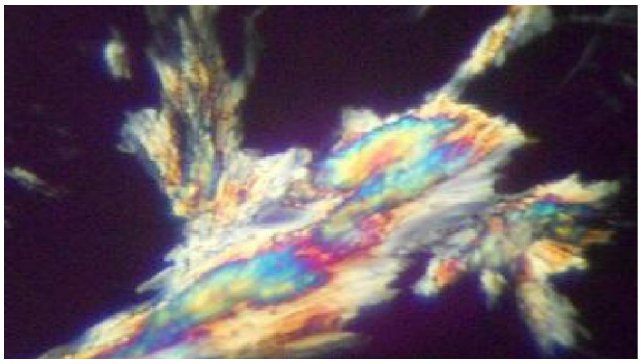

Figure 11 : Texture of Sample 4

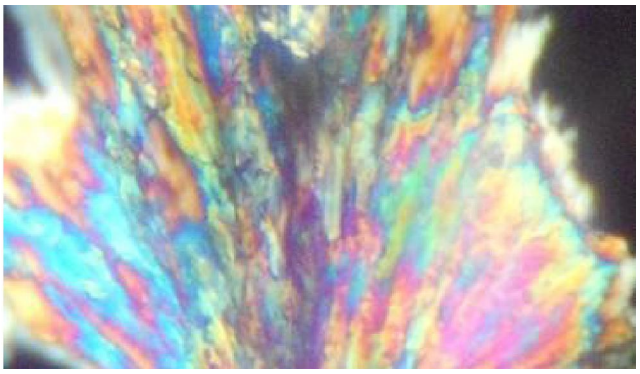

Figure 12 : Texture of Sample 5

concentration during polymerization. TABLE 2 and UV- visible spectrum of various samples also indicate that initially number of wavelengths absorbed were two for sample 1 then it decreased to zero for sample 2 and then again it started increasing from sample 3 to sample 5 from two to higher number with concentration[14, 15]. It is known fact that the absorption moves to longer and longer wavelengths as the amount of delocalization in the molecule increases with increasing concentration[16].

The PCFs filled with sample 2 are more suitable because the absorption locally raises the temperature of the LC and the PBGs shift accordingly[17] causing problem in the transmission. In case of our sample the absorption is nil therefore the problem of increasing temperature and changing refractive index and photonic bandgap is automatically sorted out.

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