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.

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-
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Anita Kanwar and Pritee Mhatre

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 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.

TABLE 1: Refractive index values for various solutions

<table>
<thead>
<tr>
<th>Wavelength (nm)</th>
<th>Sample 1</th>
<th>Sample 2</th>
<th>Sample 3</th>
<th>Sample 4</th>
<th>Sample 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>405</td>
<td>1.41647</td>
<td>1.41442</td>
<td>1.41318</td>
<td>1.41339</td>
<td>1.41421</td>
</tr>
<tr>
<td>436</td>
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<td>1.40906</td>
<td>1.40803</td>
<td>1.40824</td>
<td>1.40947</td>
</tr>
<tr>
<td>546</td>
<td>1.40057</td>
<td>1.39974</td>
<td>1.39808</td>
<td>1.39933</td>
<td>1.40057</td>
</tr>
<tr>
<td>578</td>
<td>1.39891</td>
<td>1.39766</td>
<td>1.38345</td>
<td>1.39683</td>
<td>1.39766</td>
</tr>
</tbody>
</table>
Investigation of concentration depended optical properties of pdclc solution

Full Paper

Figure 1: Variation of refractive index for five different samples

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

Figure 2: Absorption spectra of Pure MMA

Figure 3: Absorption spectra of Sample 1

RESULT AND DISCUSSIONS

We know that CP is a birefringent material\textsuperscript{[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\textsuperscript{[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.
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
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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REFERENCES


