Photo-aligning materials and technology: Physics and application in Liquid Crystal Devices

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Abstract

As the technology products are getting more popular nowadays, the visual interfaces play an important communication role between people and these electronic devices. It lends an impetus to enhancing the development of display technology. The display quality of LCD is highly concern of people. Therefore, investigations on different LCD optimization methods are become important for LCD manufacturers. Usage of photo-alignment in making the alignment layer is potentially help to improve the display quality. However, the photo-aligning materials still present room for improvement. In our project, we explored the new dyes for LCD.

- Improve the display quality
- Find out the optimal condition of dyes
- To lower the production cost of LCD

The benefits of investigate the photo-alignment technology and materials

- Improve the technique of display technology
- Replace the typical materials that still have room of improvement

Seventeen new dyes are tested by us and five (CD-1, BCMOO, BY, CBY, DR-23) are selected for detail research like: measuring different parameters and cell fabrication. Based on the result, CD-1 acts as the best dyes among all we investigated. It has excellent alignment quality. BY is another good dye since it has good performance in the measuring parameters.

Aims and Objective

Our ultimate goal is to determine which photo-aligning material is effective for making the alignment layer for LCD. We also analyzed and evaluated the physical and specific properties of the dyes, and compared the features of each material.

Final Year Project CV2-07

Investigate the physical advantages and drawbacks of different photo-aligning materials

- Order Parameters
- Solubility
- Isomerization
- Dichroic Ratio
- Uniformity
- Anchoring energy

Determine which material is good for making the alignment layer for LCD

- Analyze and evaluate the collected data
Methodology

1st stage - Research the basic knowledge of LCD
Study the basic principle of LCD and photo-aligning technology

2nd stage – Look for and prepare the materials to be investigate

<table>
<thead>
<tr>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dyes + Solve</td>
<td>Checking solubility</td>
</tr>
<tr>
<td>15x20mm ITO glass</td>
<td>Solubility of dyes</td>
</tr>
<tr>
<td>Test films with coated surface</td>
<td>Test films with coated surface</td>
</tr>
<tr>
<td>UV light exposure</td>
<td>Test films with alignment layer</td>
</tr>
</tbody>
</table>

3rd stage – Study the specific properties of the selected materials

<table>
<thead>
<tr>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dichroic spectra</td>
</tr>
<tr>
<td>Cis-trans isomerization</td>
</tr>
<tr>
<td>Order parameter</td>
</tr>
<tr>
<td>Dichoric ratio</td>
</tr>
</tbody>
</table>

4th stage – Cell Fabrication

<table>
<thead>
<tr>
<th>Glass</th>
<th>Twisted Nematic(TN) cell</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITO</td>
<td>Parallel cell</td>
</tr>
<tr>
<td></td>
<td>Block diagram of fabricated cell</td>
</tr>
</tbody>
</table>

5th stage – Study the specification of cells

<table>
<thead>
<tr>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Azimuthal anchoring energy</td>
</tr>
<tr>
<td>Uniformity</td>
</tr>
<tr>
<td>Stability</td>
</tr>
<tr>
<td>Various</td>
</tr>
<tr>
<td>UV-light exposure time</td>
</tr>
<tr>
<td>Concentration</td>
</tr>
</tbody>
</table>

Graph of anchoring energy various different parameters
The absorbance spectra with different azo dyes under UV-light exposure are shown below. The wavelength indicates the dyes color. Apart from the data shown on the graph, CD-1 shows cis-trans isomerization phenomena like SD-1. Both CD-1 and SD-1 is exhibiting very fast response after switching off the light, which is good for creation of optical rewritable displays.

In our research, we concluded that **CD-1** is the best dyes among CD-1, BY, CBY, BCMOO and DR-23. It can acts as good photo-aligning materials which shown cis-trans isomerization phenomena and have excellent alignment quality:

CD-1 is an available azo dye exhibits perfect quality of photo alignment which can be successfully used for display industry and also many other applications. Since anchoring energy is very promising and also thermal and photo stability results made this dye attracting for many devices.

BY is also a good photo-aligning material which obtains high dichroic ratio and order parameter. It also shows excellent alignment for different liquid crystals.

The summarize table for the properties of all dyes:

<table>
<thead>
<tr>
<th>Azo dyes</th>
<th>Color</th>
<th>Absorption peak (nm)</th>
<th>Dichoric ratio</th>
<th>Order parameter</th>
<th>Anchoring energy for exposure 3-50mins UV (*10^4J/m^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CD-1</td>
<td>Colorless</td>
<td>392</td>
<td>1.91</td>
<td>-0.189</td>
<td>0.28 &lt; W_a &lt; 2.52</td>
</tr>
<tr>
<td>BY</td>
<td>Yellow</td>
<td>418</td>
<td>6.57</td>
<td>-0.394</td>
<td>0.20 &lt; W_a &lt; 2.19</td>
</tr>
<tr>
<td>CBY</td>
<td>Colorless</td>
<td>412</td>
<td>1.40</td>
<td>-0.107</td>
<td>0.20 &lt; W_a &lt; 4.18</td>
</tr>
<tr>
<td>DR-23</td>
<td>Red</td>
<td>503</td>
<td>1.10</td>
<td>-0.034</td>
<td>0.38 &lt; W_a &lt; 1.10</td>
</tr>
<tr>
<td>BCMOO</td>
<td>Red</td>
<td>531</td>
<td>1.13</td>
<td>-0.039</td>
<td>0.30 &lt; W_a &lt; 1.09</td>
</tr>
</tbody>
</table>