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Polarizerless Nanomaterial Doped Guest-Host LCD Exhibiting High Luminance and Good Legibility

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Polarizerless Nanomaterial Doped Guest-Host LCD Exhibiting High Luminance and Good Legibility

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A polarizerless reflective guest-host LCD, which exhibits high luminance and good legibility has been fabricate by using NLC with $\Delta \varepsilon < 0$ that is doped with nanomaterial molecules, fullerene C_{60}, and dichroic dye molecules, where the NLCs are homeotroptically aligned without rubbing. It is considered that the doped C_{60} molecules may play a role in reducing the order parameter of the host NLC, and in turn, the contrast ratio is enhanced.

Keywords: guest-host LCD; fullerene C_{60} doped NLC; polarizerless GH-LCD

1 INTRODUCTION

Nowadays, there exists strong demand for a reflective LCD that exhibits good legibility with low power consumption. This will be realized by developing a new LCD that has high luminance state in the quiescent condition and good dark state in the energized condition. [1]

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For finding a solution to this difficult problem, we formulated the idea to use a nanoscopic material doped nematic liquid crystal (NLC) as a host LCD of a guest-host (GH)-LCD. [2] Actually used nanoscopic material is C_{60}. [3] Very good light state is realized by adopting homeotoropic alignment of the NLC with $\Delta \varepsilon < 0$ and by without using polarizer. Fairy good dark state is also realized by the existence of C_{60} that may play a role in reducing the order parameter of the host NLC in the energized state; this may randomize the orientation of dye molecules that well absorb incident unpolarized natural light. Thus the GH-LCD attains good contrast ratio.

The present paper reports the fabrication of GH-LCDs and their characterization such as Schlieren textures, order parameters, and electrooptic characteristics.

2 EXPERIMENTALS

Used materials this research are NLC, ZLI-2806 (Merck) with $\Delta \varepsilon < 0 = -4.8$; polyimide for alignment layers, RN1276 (Nissan Chem.Ind), dichroic dye, S-428 (MITSUI TOATU CHEMICALS); and nanomaterial, fullerene C_{60}. The NLC is aligned homeotroptically without rubbing. A conventional optical system and an optical density measuring instrument (Macbeth, Model-RD914) were used to characterize the optical characteristics of GH-LCDs.

3 RESULTS

3.1 Electroopic characteristics

Figure 1 compares the electrooptic performance of GH-LCDs with C_{60} and without C_{60}. The top line (a) shows the relative transmittance of a cell with only NLC; the second line (b) shows the data of NLC doped with only C_{60}; the curve (c) represents the EO performance of the

GH-LCD with only dichroic dye; and further the bottom line (d) indicates the EO performance of a GH-LCD doped with not only dichroic dye molecules but also fullerene C_{60} molecules.

The light state of the cell (d), which produces the curve (d), shows very high lightness reaching $L^* = 70$ owing to polarizerless, and obtained lightness in the dark state of the cell (d) is $L^* = 45$ that were evaluated by a reflective optical density measurement. In this way, the obtained lightness difference is shown to be enhanced by 60 % over that of the cell (c).

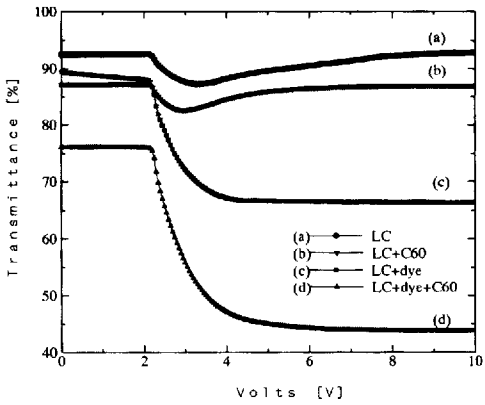

FIGURE1 Electrooptical characteristics of GH-LCD

3.2 Schlieren textures

A NLC molecules with $\Delta \varepsilon < 0$, which is aligned homeotroptically, tend to incline form the vertical conformation to the inclined conformation accompanying defects called "umbilicus" and the medium exhibits Schlieren textures. Figures 2 shows the variation of Schlieren textures of the cells (a) through (d), respectively, with increasing applied voltages. It is clearly recognized that the cell (d) containing C_{60} has a more fine texture as increasing applied voltages

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compared to those of the cell (c) without doping C_{60}. This phenomenon may suggest that C_{60} molecules, which are dissolved into the GH-LCD cell, may play a role in reducing the order parameter of the host NLC. This may contribute to randomize the distribution of dichroic dye molecules that absorb natural unpolarized light incident upon the cell. In this way, our GH-LCD cell produces good dark state. This, in turn, results in high contrast ratio.

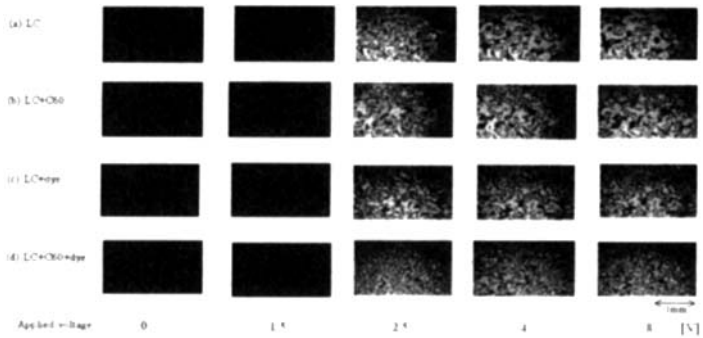

FIGURE2 Microscopic textures of GH-LCD cells

3.3 Order parameters

Along with the observation of Schlieren textures, we came up with an idea to measure the order parameter of a GH-LCD cell (d) doped with C_{60} in comparison to a plain GH-LCD cell (c).

On Table 1 we compare the measured valued of order parameters of GH-LCD cell (c) and (d), respectively.

A GH-LCD cell doped with both dye and C_{60} shows lower order parameter comparing to a cell with only dye molecules at quiescent condition. This result is in agreement with the data shown in Fig.1 and 2.

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Table 1 Order parameter of GH-NLC cells

Cells	Order parameters
(c) with dye only	0.6
(d) with dye and C_{60}	0.57

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4 DISCUSSIONS

As regards the role of C_{60} dissolved into NLC as a host of the GH-LCD cell, it is suggested that the C_{60} molecules may contribute to reduce the order parameter of the host NLC of the GH-LCD; this, in turn, randomizes the distribution of dichroic molecules especially as increasing applied voltage. The dichroic molecules in this state distribute at random but are almost parallel to the substrates. These dichroic dye molecules well absorb unpolarized natural light incident upon the cell. This may contribute increase contrast ratio.

5 CONCLUSIONS

A GH-LCD fabricated using a NLC with $\Delta \varepsilon < 0$ and doped with not only dichroic dye molecules and also fullerene C_{60} molecules is shown to exhibit very high luminance level of L* = 70 at the quiescent condition owing to polarizerless and to exhibit good dark black state of L* = 45 due to the existence of dissolved C_{60} molecules that may contribute to randomize dichroic molecules, which absorb incident unpolarized natural light. This situation may produces good contrast ratio; according to a reflective optical density measurement, the lightness difference of a GH-LCD with C_{60} increases by 60 % compared to that of a plain GH-LCD cell. Furthermore our GH-LCD will be fabricated easily because of the no use of rubbing process.

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[3] H.W. Kroto et al.: Nature **318** (1985) 162.

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