Liquid Crystals
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713926090

Reversible electro-optical switching of a memory type PDLC using two-frequency-addressing liquid crystals

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To cite this Article Hasegawa, Naoki , Kawasumi, Masaya , Usuki, Arimitsu and Okada, Akane(1996) 'Reversible electro-optical switching of a memory type PDLC using two-frequency-addressing liquid crystals', Liquid Crystals, 21: 5, 765 — 766

To link to this Article: DOI: 10.1080/02678299608032890

URL: http://dx.doi.org/10.1080/02678299608032890

LIQUID CRYSTALS, 1996, VOL. 21, NO. 5, 765–766

Reversible electro-optical switching of a memory type PDLC using two-frequency-addressing liquid crystals

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(*Received 18 March 1996; accepted 24 May 1996*)

A memory type PDLC has been prepared by sandwiching a mixture of two-frequency-addressing liquid crystals and acrylate monomers with a hydoroxy group between two glass substrates with ITO electrodes followed by UV irradiation. This PDLC can be electrically switched between a transparent state and a light scattering state, which are maintained over several months without electric fields.

It is well known that polymer dispersed liquid crystal (PDLC) devices have been attracting interest as a light scattering display, because of their light controlling capability without polarizers [1]. The PDLC devices can be electrically switched from a light scattering state (in the field-OFF) to a transparent state (in the field-ON). Recently, Sato *et al.*, reported a memory effect in PDLCs with polymer ball type morphology, which were prepared from 2-hydroxyethylmetacrylate (HEMA) and liquid crystals with positive dielectric anisotropy [2]. Kreuzer *et al.*, also reported a similar memory effect in nematic fluids mixed with colloidal silica [3]. However, these systems required heating to reset the transparent memory states. Meanwhile, we recently studied a memory effect in a novel liquid crystalline composite based on nematic liquid crystals and fine plate clay minerals [4]. This composite exhibits a bistable and reversible light scattering effect, by using two-frequency-addressing liquid crystals (TFALC), whose alignment can be controlled by changing the frequency of applied electric field.

In this paper, we present a memory type PDLC using TFALC, which can be switched between a transparent state and a scattering state only by electric field.

Materials used for the preparation of PDLCs are nematic TFALC (DF-05XX, produced by Chisso Co.), HEMA and diacrylate (Kayarad R167, produced by Nippon Kayaku Co.) as UV-curable monomers, 2-hydroxy-2-methyl-1-phenylpropan-l-one as a photo-initiator. The TFALC is a mixture of low molar mass liquid crystals, whose cross over frequency is about 1 kHz at 25°C. It shows positive dielectric anisotropy at a lower frequency than the cross over frequency, as well as negative dielectric anisotropy at the higher frequency.

The mixture of TFALC and the monomers was sandwiched between two glass substrates with ITO electrodes. The mixture consisted of 59·4 wt% TFALC, 27·0 wt% HEMA, 11·6 wt% diacrylate and 2·0 wt% of photoinitiator. The thickness of the cell was controlled by 12 μm spacers. The cell was irradiated with UV light (3·5 mW cm^{-2}) for 3 min at 120°C, thus polymerizing the monomers. This PDLC exhibited a polymer ball morphology according to SEM observation.

Figure 1 shows a typical change in the light transmittance of the PDLC cell at 25°C. The collection angle of scattered light for transmission was about 2°. The light transmittance of the cell just after UV irradiation

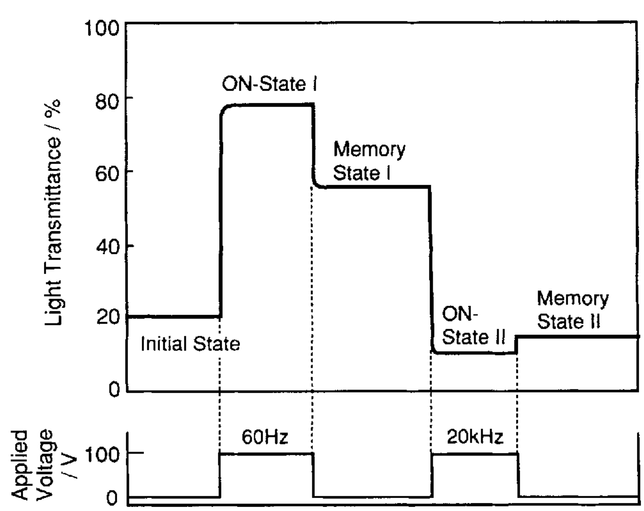

Figure 1. The change in the light transmittance of the memory type PDLC.

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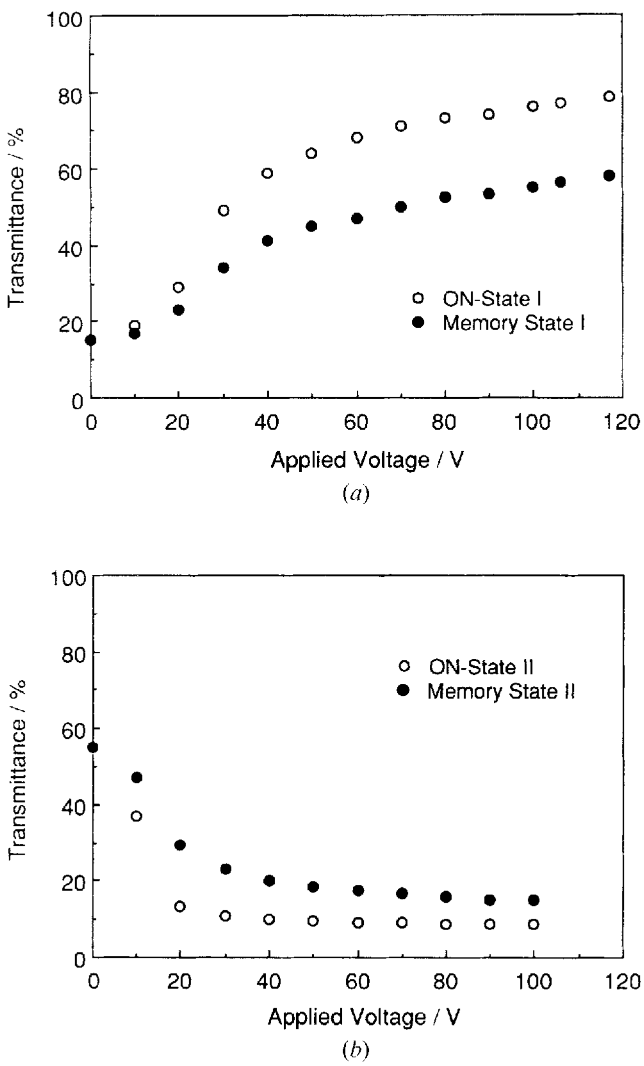

Figure 2. Plot of the transmittance of the cell against the applied voltage: (*a*) The change of the light transmittance when a low frequency electric field (60 Hz) was applied to the cell in the memory state II and (*b*) the change of the light transmittance when a high frequency electric field (20 kHz) was applied to the cell in the memory state I.

(the initial state) was 20 per cent. When a low frequency electric field (60 Hz–100 V) was applied to the cell, it became transparent. Even after the electric field was turned off, although a decrease in the transparency was observed, the transparent memory state was maintained. The light transmittance of the memory state I was 55 per cent. On the other hand, when a high frequency electric field (20 kHz–100 V) was applied to the cell, the transparent memory state was cancelled and returned to the scattering state. Even after the electric field was turned off, although an increase in the transparency was observed, the scattering memory state was maintained. The light transmittance of the memory state II was 15 per cent. Both the memory states I and II were maintained over several months.

Figure 2 shows a plot of the light transmittance of the cell against the applied voltage. When a low frequency electric field was applied, the light transmittance of the ON-state I and Memory state I increased and saturated with increasing the applied voltage. When a high frequency electric field was applied, the light transmittance of the ON-state II and Memory state II decreased conversely.

In summary, this new memory type PDLC using TFALC can be electrically switched between the transparent state and the light scattering state, which are maintained even in the field-OFF case. This memory type PDLC device consumes less electric power compared to the conventional no-memory type PDLC, for which it is necessary to keep applying an electric field for maintaining the transparent state. Therefore, this PDLC would have potential for advanced applications such as light controlling panels, long-term information storage devices, and so on.

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