Photoinduced Charge Behaviors in Liquid Crystal Mixtures

Masaru Inoue[1], Sudarshan Kundu[2] and Hiroshi Yokoyama[2]

masaru.inoue@toyotechus.com
[1]TOYOTech LLC, 42840 Christy St., Ste. 110 Fremont, CA 94538 USA
[2]Kent State University, 1425 Lefton Esplanade, Kent, OH 44242-0001 USA
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ABSTRACT

We propose a photoinduced charge measurement of LC mixtures by irradiating a light of a selected wavelength by monochromator. We found that there is an inherent wavelength of the sudden increment of the photoinduced charge which is the amount of mobile ions in an LC cell.

1 INTRODUCTION

Liquid crystal (LC) materials have widely been used for TV sets, smartphones, and many display devices, because of high reliability including long lifetime [1]. Recently, LC materials have been used for smart window applications such as facades of buildings [2][3]. Generally, smart window applications also require a long lifetime even under the sunlight exposure for an LC mixture, thus a UV cut filter should be used to avoid the degradation of an LC mixture. However, it is difficult to cut 100% of UV light under the sunlight by using a filter, so that there is a damage for an LC mixture by means of UV dosage which is caused by continuous UV light leakage to an LC mixture in the future. As far as we know, the impact of particular wavelengths of UV light for degradation of LC mixtures has not been discussed in detail.

When degradation of an LC mixture occurs on conventional applications such as TV and monitors, the ion impurity measurement has been proposed by applying a cyclic triangular waveform voltage to an LC cell to measure the displacement current [4]. In addition to LC director current switching currents, there are current peaks which are calculated areas as charges in an LC cell, if the degradation causes mobile ions.

In this paper, we investigated the change of the photoinduced charge in LC cells under monochromated light and obtained remarkable behaviors on particular wavelengths.

2 EXPERIMENT

2.1 Sample preparation

We prepared two kinds of LC mixtures, 5CB and MLC2132 (Merck Performance Materials Ltd.), and each LC mixture was injected into empty cells having the SiN on ITO glass substrates. The area of the electrode and the cell gap were 1 cm^2 and 4 μm, respectively.

2.2 Measurement of photoinduced charge

We employed SPG-120-REV Motorized Compact Monochromator with Xe lamp (Shimadzu Corporation) and LT1000 Ion Impurity Analyzer (TOYO Corporation) for photoinduced current measurement in LC cells. Figure 1 shows the block diagram of the measurement. We irradiated the light from Xe lamp to cells through the monochromator that can scan the wavelength from 280 nm to 780 nm by 10 nm step.

We applied a ±10 V/1 Hz triangular waveform voltage to LC cells and measured the displacement current to obtain the total charge which is calculated from the entire area of voltage versus current curve in LC cells on each wavelength.

A photoinduced charge on each wavelength is calculated from the difference of total charge between with and without light exposure conditions.

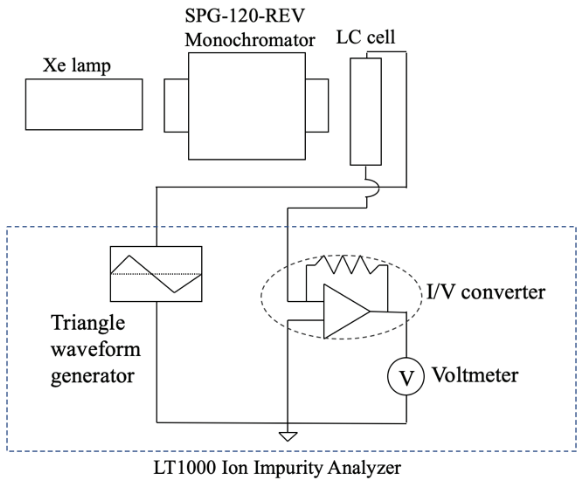
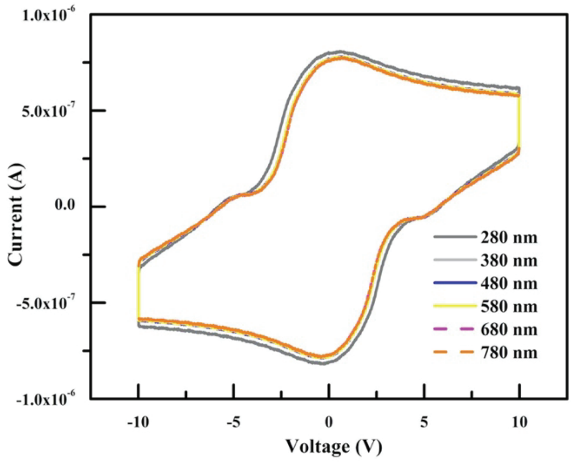


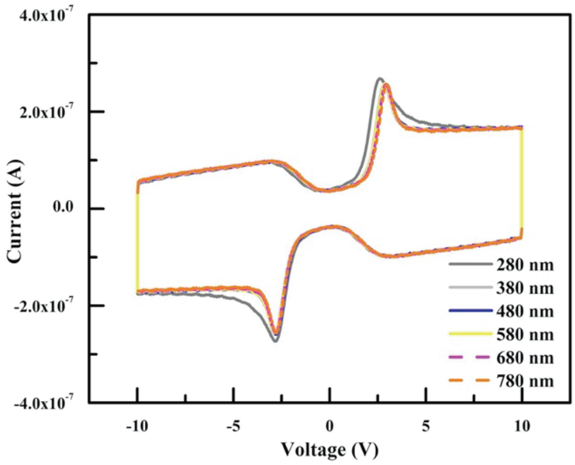
Fig. 1 Block diagram of photoinduced charge measurement

3 RESULTS

Figure 2 shows the voltage versus current data of the LC cells that are 5CB (a) and MLC2132 (b) on different wavelengths (280 nm – 780nm: 100 nm step) of the irradiated light. There were positive and negative current peaks at the ±5 V region, and we found that the peak areas of 280 nm wavelength which is proportional to the charge were larger than others as shown in Figure 2 (a). On the other hand, there are no huge current peaks between -5 V to +5 V region, but we can see the LC director switching current at ±2.5 V region and the LC dielectric anisotropy as shown in Figure 2 (b). We also found that the areas of LC director switching current of 280nm wavelength were larger than others.



(a) 5CB



(b) MLC2132

Fig. 2 Voltage vs. current data of 5CB and MLC2132 from 280nm to 780nm

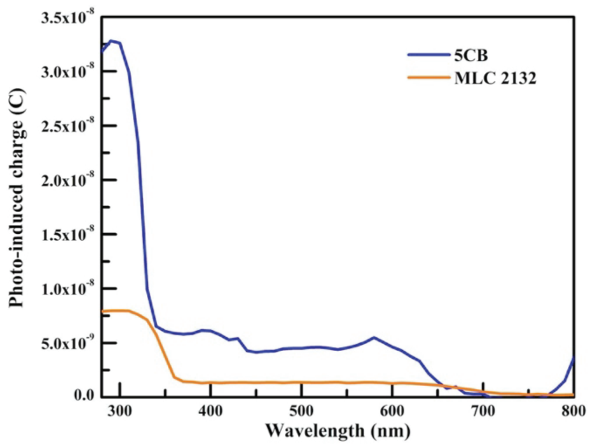


Fig. 3 Wavelength dependency of photoinduced charge of LC mixtures

Figure 3 shows the wavelength dependency of photoinduced charge of LC mixtures from 280 nm to 780 nm by 10 nm step. We found that the photoinduced charges of each LC mixture started to increase at 700nm and drastically increased at UV region. We also confirmed that the sudden increment wavelengths of photoinduced charge at UV region of 5CB and MLC2132 were 330nm and 350nm, respectively.

4 DISCUSSIONS

We obtained the huge current peaks on 5CB of Figure 2 (a). The area of peaks corresponds to the amount of mobile ions in LC cells, thus the result suggests that the difference of photoinduced charge between 280nm and others comes from the increment of mobile ions. On the other hand, there is no obvious ion peak on MLC2132, but we suppose that the ion peaks were overlapped on the LC switching peaks at 280 nm.

Regarding the wavelength dependency, the result suggests that there is an inherent wavelength of the increment of photoinduced charge which is sensitive to the degradation of an LC mixture.

5 CONCLUSIONS

We proposed a photoinduced charge measurement by using Xe lamp, monochromator and an ion impurity measurement equipment, and confirmed that there is an inherent wavelength of the sudden increment of photoinduced charge at UV region for LC degradation.

We will need to measure additional various LC mixtures to understand the mechanism of the degradation, especially for smart window applications.

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