Adjustable Pretilt Angle of Liquid Crystal Alignment Materials

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Abstract

We have developed a series of fluorinated dimethacrylate copolymers. Our work has covered the synthesized derivatives of alignment materials, characterized the pretilt angle and uniformity of liquid crystal alignment layer. The pretilt angle can be tailored by using the fluorinated copolymer. Excellent uniformity was achieved as shown in experimental results.

1. Introduction

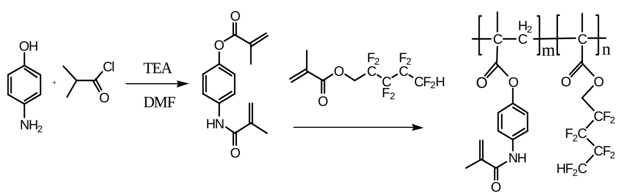
Recent years, we have seen considerable interests in liquid crystal (LC) alignment of non-contact mode, such as in photo[1,2,3] and energized particles alignments[4,5,6] to replace the current rubbing method[7]. Some photosensitive materials have been treated with polarized UV light to make a LC alignment layer. Such as azobenzene, polyimides containing cinnamate[8] or coumarin side groups can be produced LC alignment films by the photodimerization[9].

We have developed a photosensitive material of dimethacrylate homopolymer which can be used for photo induced LC alignment layer. We have also developed the fluorinated dimethacrylate copolymer for adjusting polarity and surface interaction with liquid crystal. Therefore, the pretilt angle can be tailored through fluorinations. Those dimethacrylate polymers can be applied to the photo induced alignment layer.

2. Experimental

2.1 Synthesis of fluorinated dimethacrylate copolymers

The molecular structures and synthesis process are shown as in Scheme 1.



Scheme 1. Molecular structure of fluorinated dimethacrylate system and synthesis scheme.

The monomer of 4-(methacrylamido) phenyl methacrylate(MPM) and 2,2,3,3,4,4,5,5-octafluoropenthylmethacrylate(F8) were mixed at 1:0, 1:0.5, 1:1 and 1:2 mole ratio to form the reaction solution, respectively. Then, added initiator of 2,2′ -azobisisobutyronitrile(AIBN) and dimethylformamide (DMF) in each reaction solution. The reactive temperature was controlled around 80℃. The molecular weight of the synthesized polymers were controlled within the range of 20000 ~ 40000 (Mw). The molecular weight distribution was maintained at around 1.5~1.8.

2.2 Photo-induced process

3% solid content polymer solution was prepared and spin coated on indium tin oxide coated glass substrates at 1500 rpm for 20 s. The coated films were soft baked at 90℃ for 10min and were illuminated with UV exposure systems in two steps. We irradiated the tilted 45° specimens with a 1000W Oriel Hg–Xe lamp of UV for 12 mW/cm2 and then irradiated the specimens again with a Glan-Taylar prism for 2.8

mW/cm2.

3. Results and discussion

3.1 Characterization of the fluorine content in fluorinated dimethacrylate copolymer

The fluorine content of polymer was characterized by Electron Spectroscopy for Chemical Analysis (ESCA) and NMR. Figure 1 shows that the fluorine content increases as the monomer of 2,2,3,3,4,4,5,5-octafluoropenthylmethacrylate(F8) in the fluorinated dimethacrylate copolymer. Result show that the peak high ratio of fluorinated copolymers is increasing with the number of F8 monomer feeding mole ratio and hence the fluorine content.

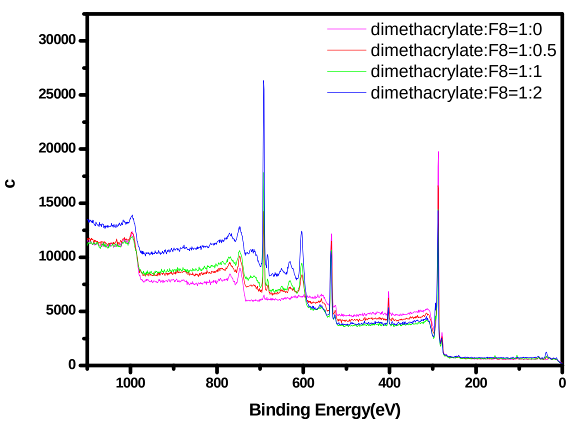


Figure 1. The fluorine content of ESCA results increase as F8 in the fluorinated copolymers.

3.2 The pretilt angle measurement

The pretilt angle of the nematic liquid crystal alignment was measured with the crystal rotation method (Autronic DMS 101 TBA instrument). Figure 2 show that the pretilt angle increases as the amount of fluorine in copolymer of photo induced alignment film. The results show that fluorine contents have a profound impact on LC alignment characteristic and the pretilt angle. At the increasing fluorine content, the pretilt angle of the LC will be higher because of the lower surface energy can lead to less close contact between the LCs and the alignment layers. Therefore, syntheses of the fluorinated dimethacrylate copolymers can thus adjust polarity and surface interaction with LC.

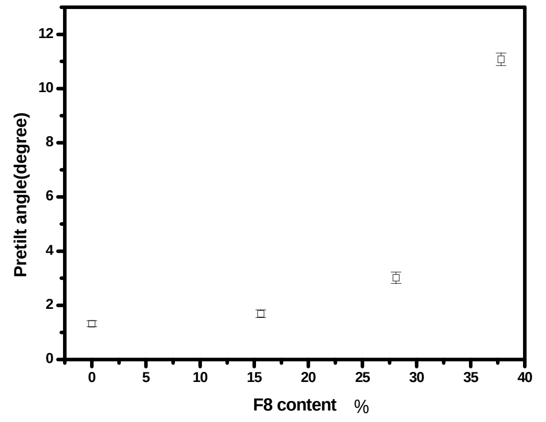


Figure 2. The pretilt angle increases as the amount of fluorine in copolymer of photo induced alignment film.

3.3 Liquid crystal align performance of photo induced and plasma treatment

An anti-parallel symmetric cell was assembled to measure the pretilt angle with the crystal rotation method. The cells were filled with the nematic LC ZLI 2293 from Merck. The alignment uniformity was analyzed with a NIKON Micro Photo FXA. Figure 3 show that good LC alignment uniformity and high contrast have been obtained for using the fluorinated dimethacrylate polymer. They can be achieved through the polarized photo exposure less than 100 mJ/cm2 of treating the dimethacrylate-based materials.

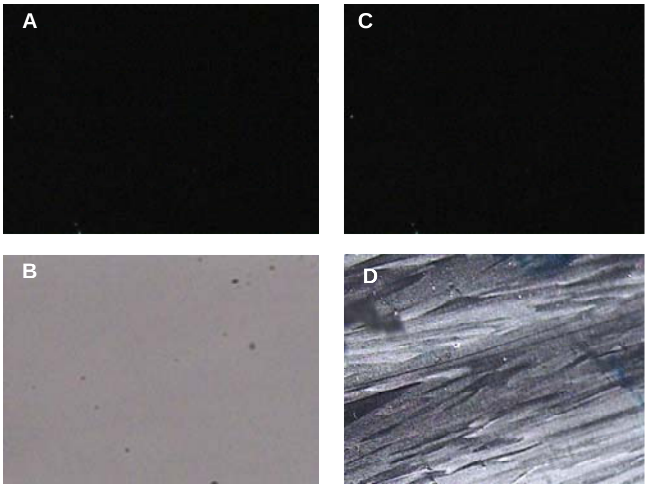


Figure 3. POM images of treated mode of alignment LC cells. A: Photo aligned-Dark state, B: Photo aligned -Light state, C: rubbing-Dark state, D: without treated.

4. Summary

We have successfully synthesized fluorinated dimethacrylate copolymer to adjust the polarity and surface interaction with the liquid crystal. The pretilt angle can be tailored by using the fluorinated copolymer. The new photosensitive material can yield excellent alignment and uniformity for the non-rubbing photo induced and plasma aligned systems.

5. References

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