Microcapsule Display Based on Polyurethane Acrylates

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Abstract

Waterborne polyurethanes (WPUs) with LC were successfully prepared using polycaprolactone diol (PCL) and 4,4'-Methylene dicyclohexyl diisocyanate (H_{12}MDI) as soft segment of prepolymer, dimethylolbutanoic acid (DMBA) as emulsifier, and trimethylamine (TEA) as neutralizer, ethylenediamine (EDA) as chain extender based on different molecular weight of pre-polymer. Synthesized WPU prepolymer and liquid crystals (LC) were stirred under the constant rate. And de-ionized water (DI) containing bishexamethylenetriamine (BHMT) was added in the reaction mixture to form the polyurea. The study of polymer dispersed liquid crystal (PDLC) are generally carried out based on the combination of UV epoxy and liquid crystal or the mechanical dispersion using membrane filters. The most problem of these studies is the lack of capsule size control and the aggregation of polymer. In this study, it is the control of confirmed microcapsule size by adjusting the molecular weight of the prepolymer. The molecular weights and the functional groups of the WPUs are evaluated through the GPC and FT-IR. Microcapsule LC complexed WPUs could be applied to the various industry fields of next-generation display, such as 3D printer material, smart window and flexible display.

Polymers and Liquid Crystals

Polymerized in LC phase

The network formed freezes in the same anisotropic structure as the original LC mixture

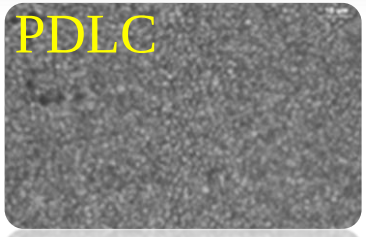
Polymerized in isotropic phase

The network formed is not ordered by the anisotropic materials

Polymer stabilized LC modes

Scattering LC modes

Liquid Crystals



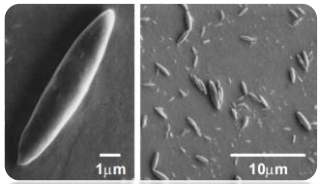
Blue-mode

SVA

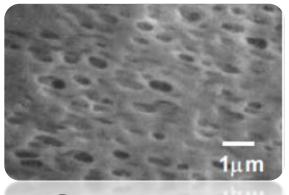
Reactive mesogen

Non-active components

Isotropic polymers



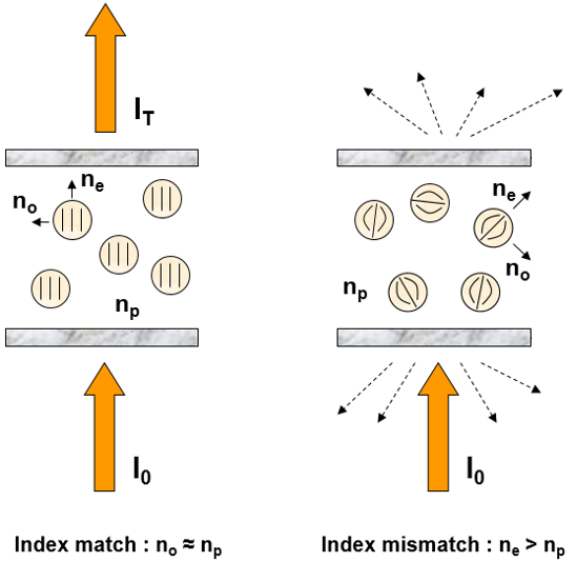
Anisotropic polymer particles

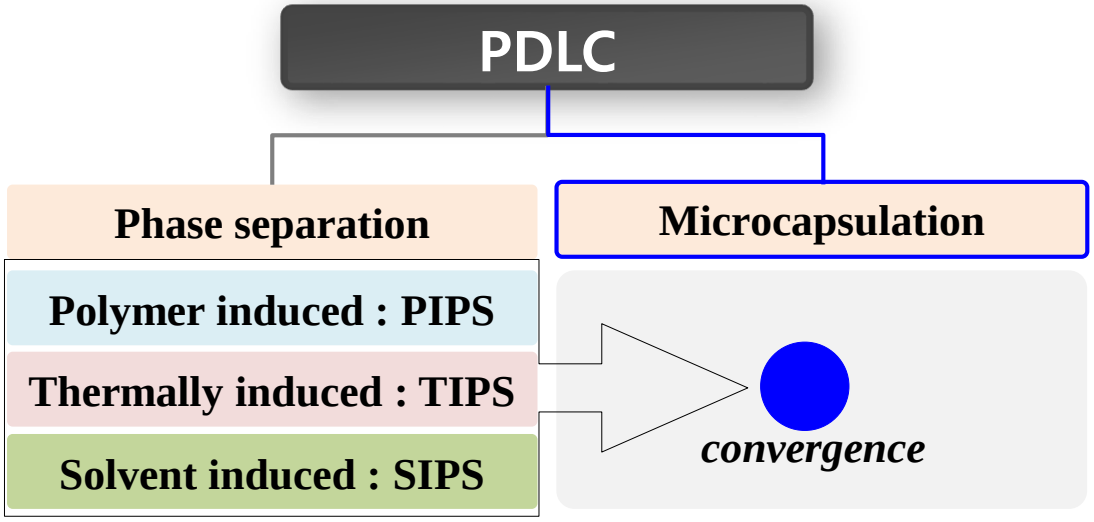


Scattering polarisers

PDLC Tech. (Smart Window)

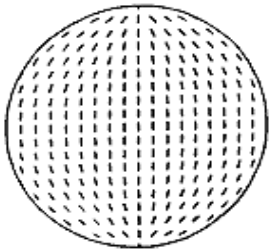
Conventional polymer dispersed liquid crystal film consist of a thin film of polymer that contains micron-sized droplets of a nematic liquid crystal. In the undriven state, the liquid crystal director in the nematic droplets has no preferred orientation with respect to the plane of the film. The film therefore appears opaque. When an electric field is applied to the film, the nematic liquid crystal in the droplets reorients so that the director is parallel to the field, and therefore perpendicular to the plane of the film. If the ordinary refractive index of the liquid crystal is matched to the refractive index of the polymer, then light incident normal to the film does not encounter any variation in refractive index, and passes through the film without being scattered. Such films are therefore opaque in the off state but become clear when a voltage is applied. From the power consumption in the smart window field, research on normally transparency PDLC is very important.





Key technology is the control of droplet size

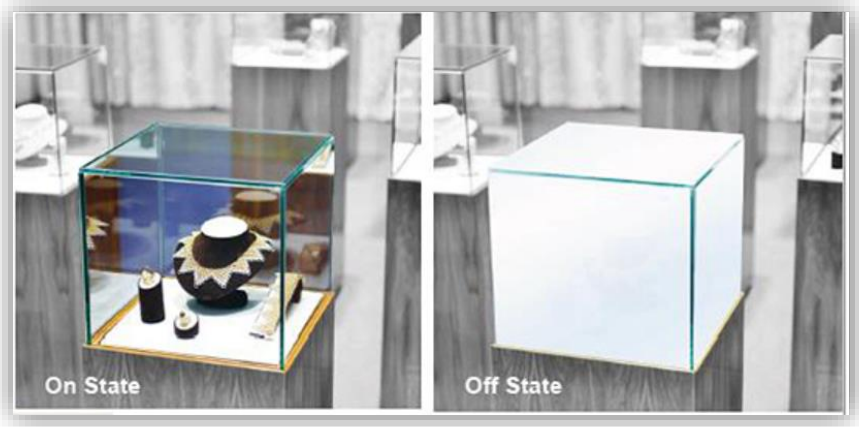
for a bipolar configuration LC



R: Average droplet radius,
L : Droplet aspect ratio(R1/R2)
d : Cell gap
K : Elastic constant
E0 : LC dielectric permittivity
△e : LC dielectric anisotropy

$$V_{on} = \frac{d}{R}\sqrt{L^2 - 1}\sqrt{\frac{4\pi K}{\Delta\varepsilon}}$$

$$V_{th} = \pi\sqrt{\frac{K_1}{\Delta\varepsilon}}$$



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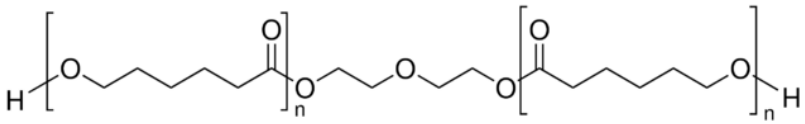
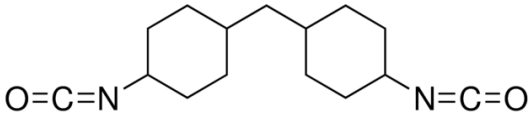
Experimental

- **Materials**

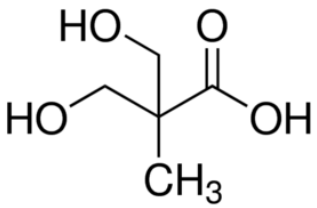
- Polyol : PCL (polycaprolactone)



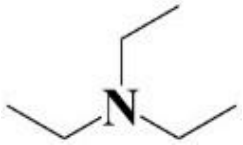
- Isocyanate : H_{12}MDI (4,4'-Methylene dicyclohexyl diisocyanate)



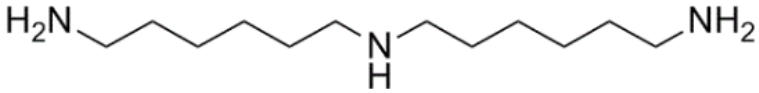
- emulsifier : DMBA (dimethylolbutanoic acid)



- neutralizer : TEA (trimethylamine)



- Cross-linker: Bis(hexamethylene)triamine



- LC : Negative LC
- RM : photoreactive methacrylate groups
- SAm : Self alignment monomer

Scheme

PCL + $H_{12}MDI$

$H_{12}MDI$

DMBA

TEA

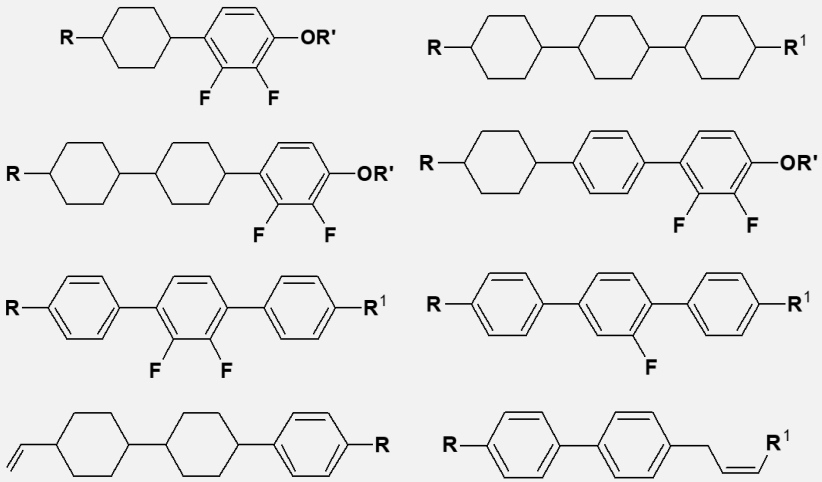
NCO-terminated Prepolymer (Mpre)

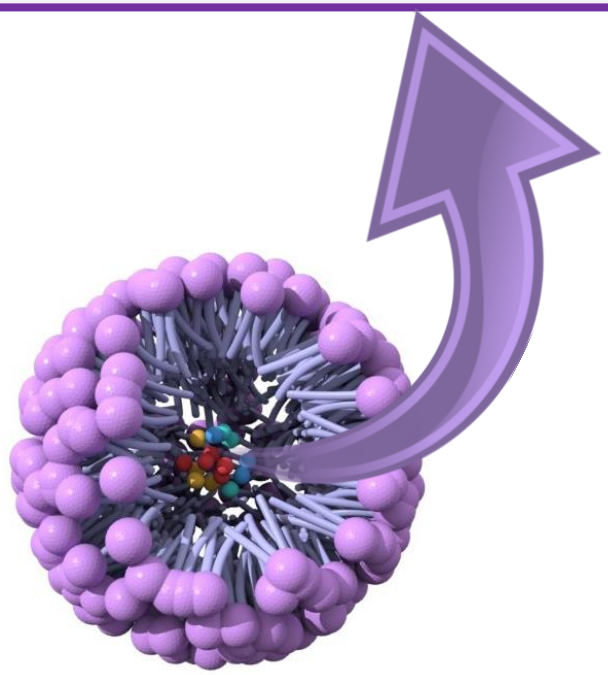
Water

BHMT

Liquid Crystals

※ Tni~80℃ / Dn 0.15 / De -4 / r1~300

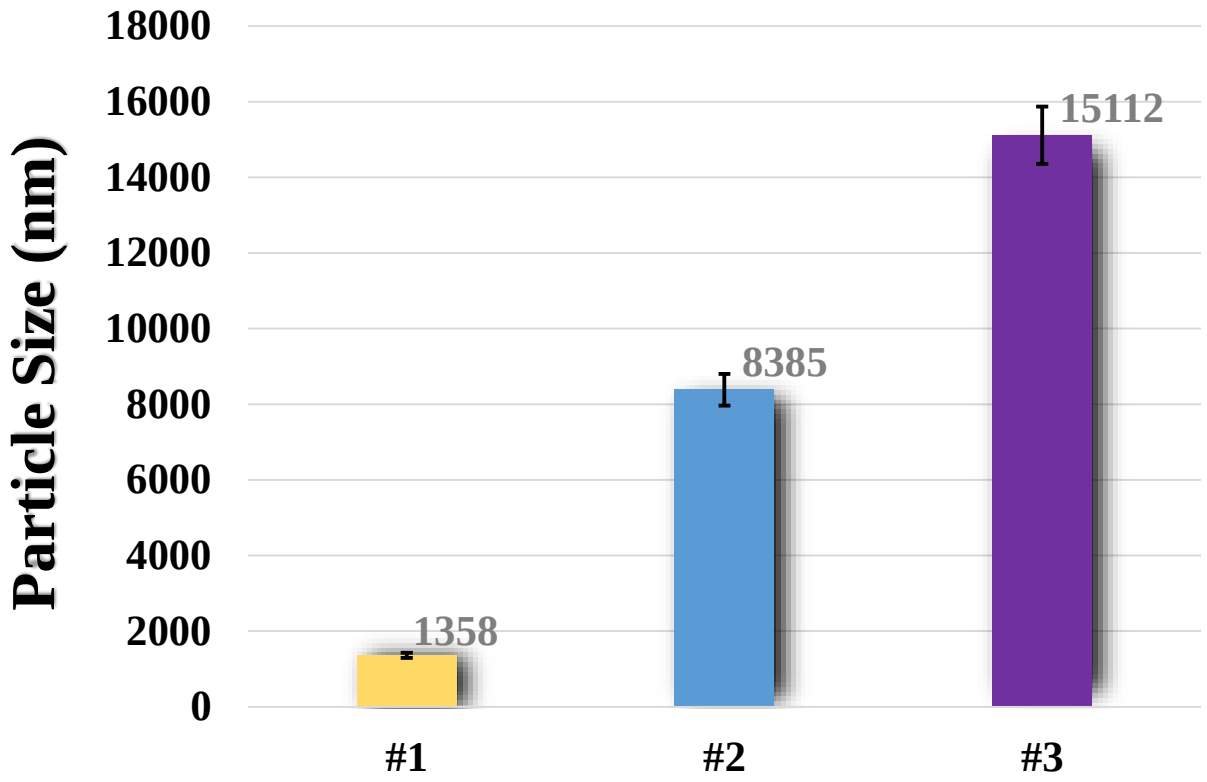




Waterborne Polyurethane microcapsule with LC

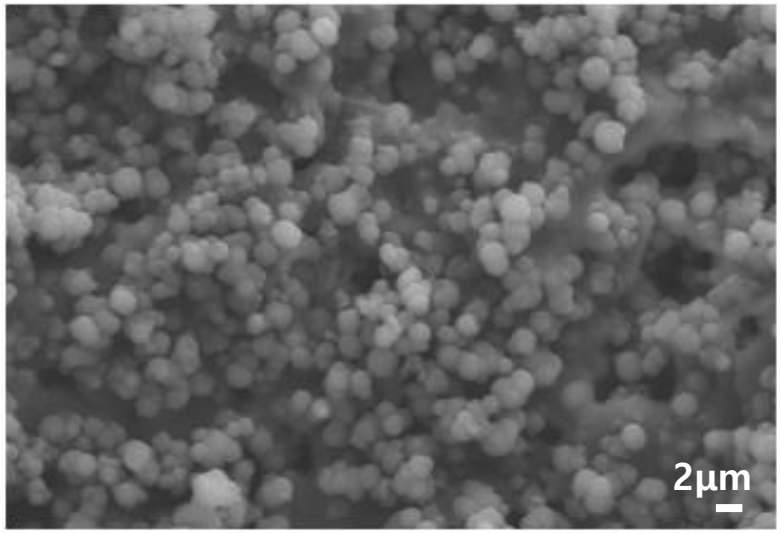
Analysis of GPC & DLS(Particle Size)

	M_n	M_w	PDI
#1	3840	8420	2.19
#2	6700	17670	2.64
#3	17100	48540	2.84



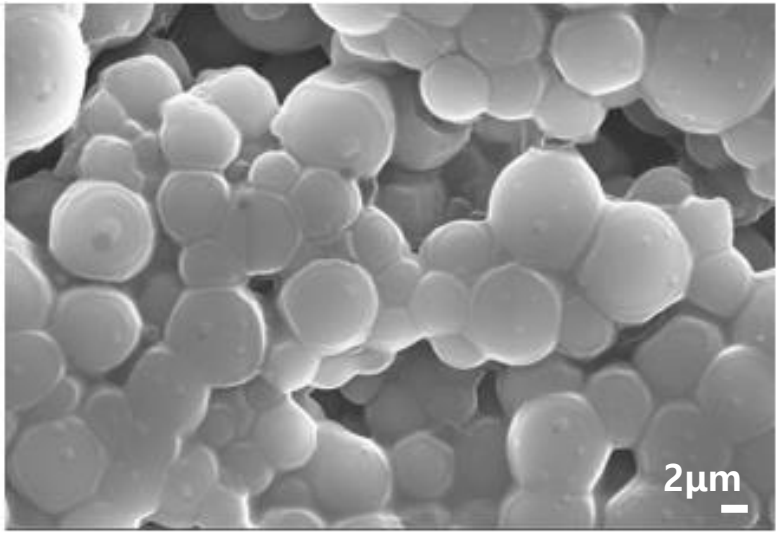
Morphology of LC Capsules : FE-SEM

#1



diameter: 1.83±0.32 μm

#3



diameter: 8.72±1.63 μm

Conclusions

- Waterborne polyurethanes (WPUs) with LC were successfully synthesized to micro size.
- LC capsule size was controlled by molecular structure and weight design of PU prepolymer.
- The formed LC microcapules were observed by FE-SEM.
- Microcapsule of WPUs with LC have potential to applications of smart window materials.

Acknowledgement

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THANK YOU