SYNTHESIS AND CHARACTERIZATION OF SHAPE MEMORY POLYURETHANE GRAFTED WITH A PH INDICATOR

In-Hong Jung[1], Yong-Chan Chung[2], Jae Won Choi[1], Byoung Chul Chun[1]

[1]*Department of Nano Engineering, Center for Nano Manufacturing, Institute of Basic Science, Inje University, Gimhae 621-749, Korea*
[2]*Department of Chemistry, The University of Suwon, Hwasung, 445-743, Korea*
E-mail : jungihh@naver.com[1]

Abstract: Shape memory polyurethane (SMPU) was grafted with a pH indicator (Thymol Blue, Alizarin Yellow GG, Bromocresol Green and Bromocresol Purple) having OH functional group for coupling. The SMPU showed a quick response to pH change, did not lose the dye in aqueous solution, and could be reused for several times. The SMPU was characterized by UTM, IR, UV-Vis, DSC, NMR, and Viscometer, which showed that high tensile strength and shape recovery compared to linear SMPU, UV peak shift depending on the surrounding pH, and the increase of melting temperature with the increase of dye content. Therefore, a smart SMPU that can detect pH change could be successfully made.

1. Introduction

Shape memory polymers, especially shape memory polyurethane (SMPU), have been extensively studied due to their properties such as practical and adjustable phase transition temperature ranges, high and reproducible shape recovery capabilities, easy and simple processing, and chemical resistance. Commonly used pH indicator grafted with the shape memory polyurethane that reacts to changes in acidity is to study the shape memory polyurethane,

2. Experimental

2.1. Synthesis

A mixture of MDI and PTMG was placed in a 500 mL fournecked beaker-type flask equipped with a mechanical stirrer, condenser, and nitrogen purge. The mixture was allowed to react for 3 h at 50 ºC to prepare the prepolymer. As a chain extender BD was dissolved in 20 mL of DMF and added to the prepolymer, and the reaction continued for 1 h. Subsequently, a second quantity of MDI was added to the above reaction mixture, and the reaction continued for 1 h. Finally, Thymol Blue, Alizarin Yellow GG, Bromocresol Green and Bromocresol Purple was added with an additional 50 mL DMF. This mixture was stirred under the same conditions for 2 h. After polymerization ended, the polyurethane (PU) products were reprecipitated in water and washed. Final products were dried in a 60 ºC oven for 3 days.

2.2. Characterization

A Fourier-transform infrared (FTIR) spectrophotometer (JASCO 300E) equipped with attenuated total reflectance capability was used to take infrared spectra of the SMPU samples. For each sample, 25 scans were taken at 4 cm^{-1} resolution and a 2 mm/s scan speed. A differential scanning calorimeter (DSC Q20, TA instrument) was used to take calorimetry data for both heating and cooling scans at a rate of 10 ºC/min between -50 and 250 ºC. Tensile mechanical properties were measured with a Universal Testing Machine (UTM, LR10K, Lloyd instrument, UK) according to the ASTM D638 standard with a 20 mm gauge length, a 10 mm/min crosshead speed, and a 500N load cell. UV-Visible spectra were recorded on Shimadzu UV 2501PC spectrophotometer.

3. Results and Discussion

Figure 1 shows that the absorbance of the PU solutions grafted with pH indicator increased with increasing pH. Depending on the type of pH indicator, absorbance changes were observed in the pH range. The absorbance of PU solution grafted with Thymol Blue (Fig. 1(a)) was observed in the pH range 1.2~2.8 and 8.0~9.2. Also, other PU solutions grafted with pH indicators (Fig. 1(b), (c), and (d)) was similar to the Fig. 1(a). The transition ranges of Alizarin Yellow GG, Bromocresol Green and Bromocresol Purple were displayed 10.0~12.0, 3.8~5.4 and 5.2~6.8.

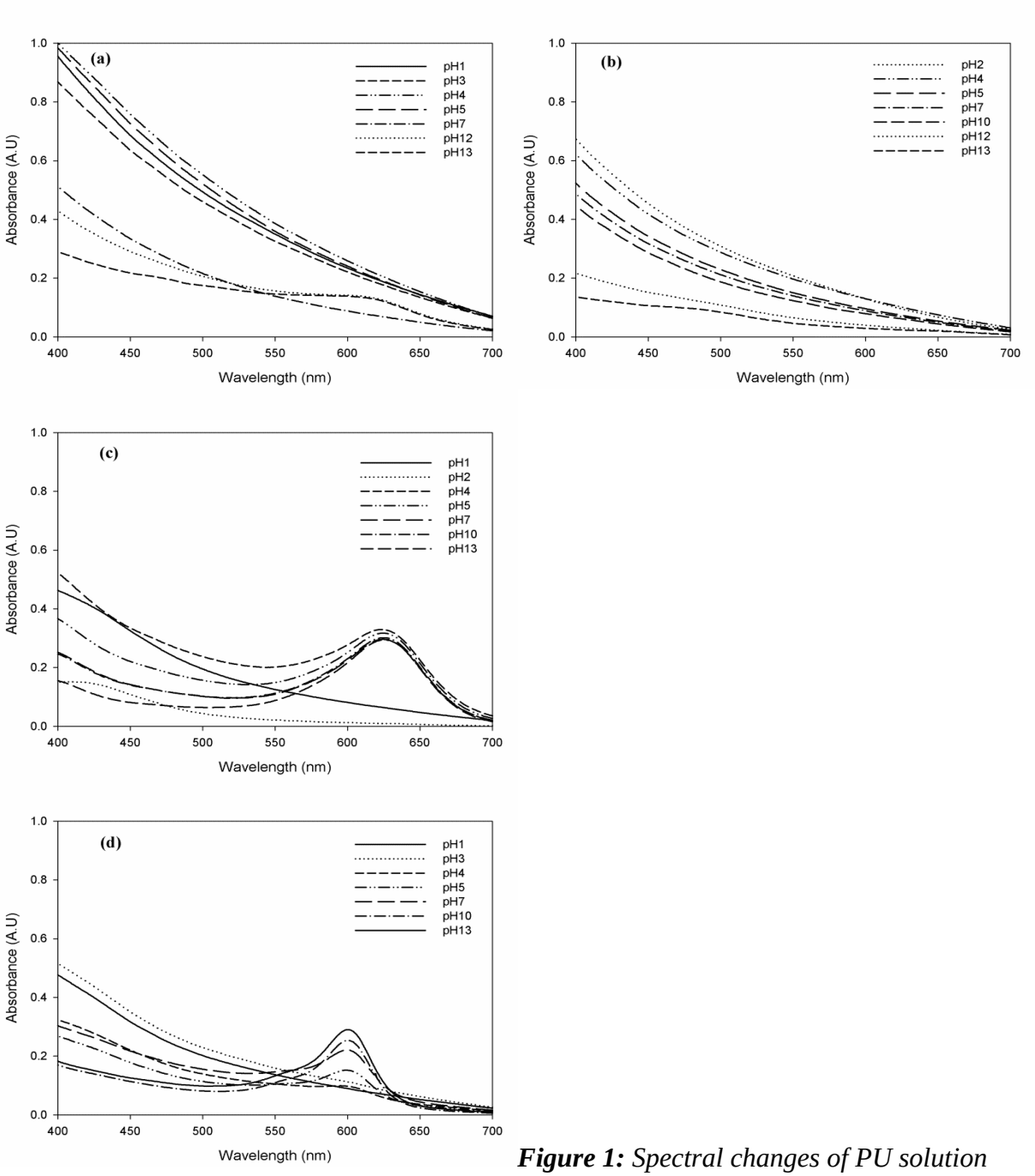

Figure 1: *Spectral changes of PU solution grafted with (a) Thymol Blue, (b) Alizarin Yellow GG, (c) Bromocresol Green, and (d) Bromocresol Purple at different pH values.*

The Mechanical property of PU grafted with pH indicator is increase approximately 40% compared to linear polyurethane. However, when the indicator amount is increase, stress and strain are decrease. Especially, Maximum stress of Thymol Blue and Alizarin Yellow GG series are decreases rapidly. However, Increasing amounts of the indicator, percentage of strain at break of Thymol Blue series is also increases.

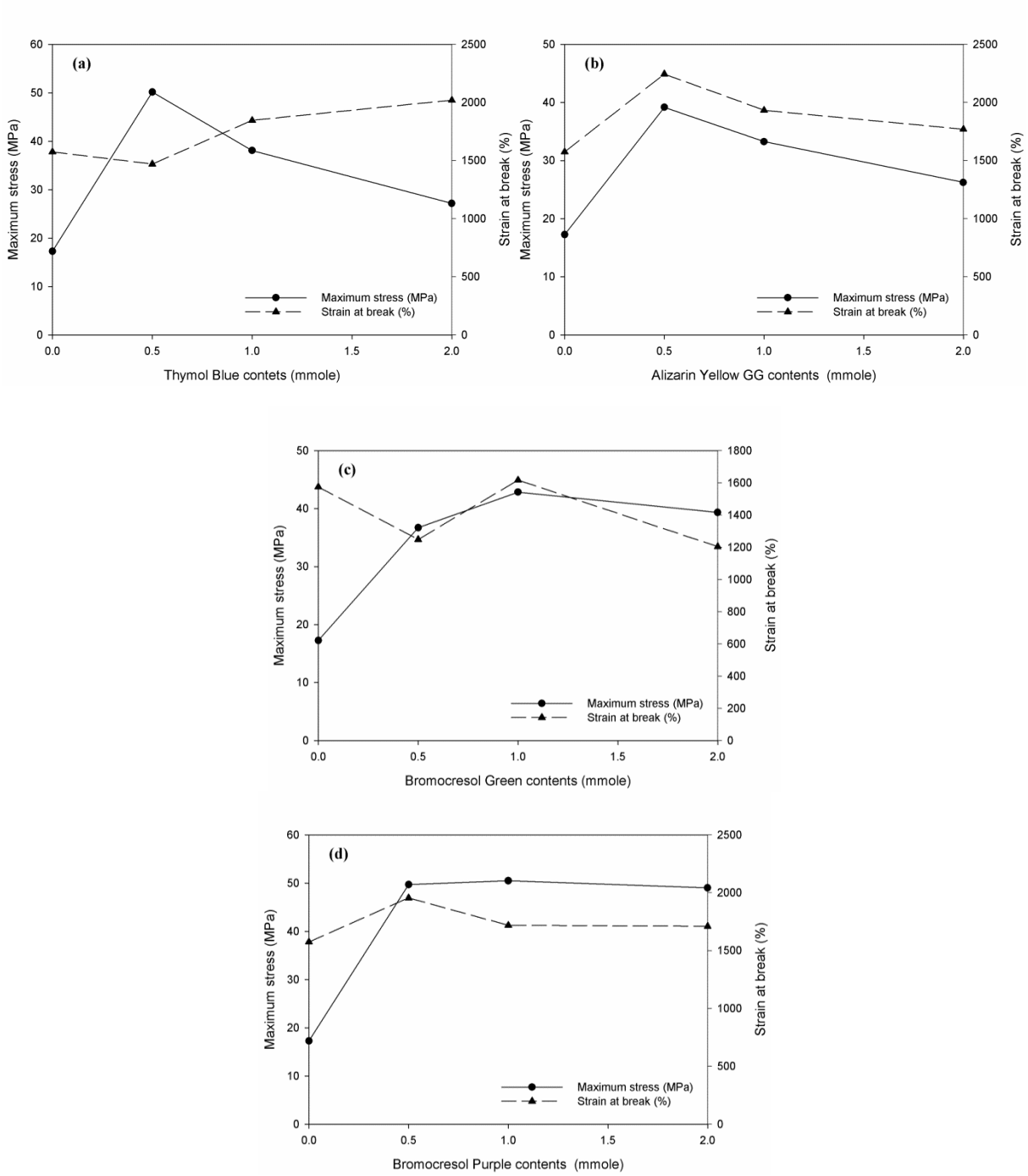

Figure 2: *Maximum stress and strain at break of (a) Thymol Blue, (b) Alizarin Yellow GG, (c) Bromocresol Green, and (d) Bromocresol Purple series.*

4. Conclusion

SMPU grafted with pH indicator Thymol Blue, Alizarin Yellow GG, Bromocresol Green, and Bromocresol Purple which showed that high tensile strength and shape recovery compared to linear SMPU, UV peak shift depending on the surrounding pH, and the increase of melting temperature with the increase of dye content. Therefore, a smart SMPU that can detect pH change could be successfully made. From now on using changes in pH condition depending on absorption wavelength of the acidic and basic materials that can be easily detected portable sensor. Depending on the pH change it can be reused so in terms of economic and environmental advantages.

References

[1] Y.A Son.; S.H Kim.: *Dyes and Pigments*, **64**, (2005), pp.154, 0143-7208
[2] Y.C. Chung.; D.K. Nguyen.; J.W. Choi.; B.C. Chun.: *J. Appl. Sci*, **120**, (2011), pp.2063, 1097-4628
[3] Y.C. Chung.; D.K. Nguyen.; B.C. Chun.: *Polym. Eng. Sci*, **50**, (2010), pp.2457, 1548-2634