Highly Efficient Polymerization Behavior Using Molecular Flow Field Induced by Scanning Wave Photopolymerization

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The existence of macromolecules became widely recognized in the 1930s with the acceptance of Staudinger's macromolecular theory. Since then, the effects of external forces on polymers have been actively studied. Mechanical force and flow fields applied to polymers was considered the main cause of the degradation of polymers. In recent years, the relationship between polymers and external forces has been reevaluated as a source for the functionalization of polymers. For example, mechanical force changes the color of mechanophores, and the flow field accelerates the crystallization of polymers.[1,2] Recently we have developed a novel photopolymerization process with spatiotemporal photoirradiation, termed scanning wave photopolymerization (SWaP), which induces molecular diffusion and flow during the polymerization.[3] This photoinduced flow aligns the polymer main chains and side chains along the flow direction, allowing the creation of various functional materials. Since polymerization proceeds in the flow field induced by polymerized molecules themselves, this method has the potential to cause distinct polymerization behavior. In this study, we investigated the effect of molecular flow on polymerization reaction and found specific polymerization behaviors.

A photopolymerizable sample was prepared by mixing an anisotropic methacrylate monomer and a photoinitiator Irgacure 651. The mixture was injected into a glass cell, and irradiated with a scanned UV slit light or static UV light throughout the cell (**Figure 1**). Finally, polymer films were obtained by rapid cooling. Molecular weight and monomer conversion of the obtained polymers under various exposure energies were evaluated by size exclusion chromatography. As a result, the exposure energy of SWaP to reach 95% conversion was ten times lower than that of static polymerization. Furthermore, SWaP synthesized polymers with larger molecular weights than static polymerization at the same conversion. These results strongly suggest that molecular flow induced by SWaP enhances polymerization efficiency dramatically and yields high molecular weight polymers. Furthermore, we applied SWaP to commodity monomers and investigated the versatility of this specific polymerization behavior.

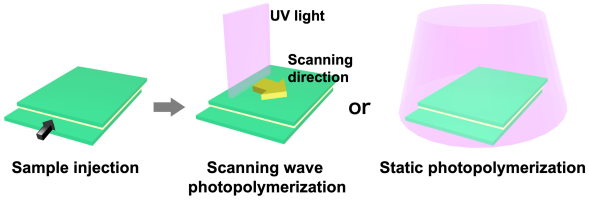

Figure 1. Schematic illustration of a photopolymerization process.

1) K. Imato, H. Otsuka, *et al*., *ACS Macro Lett.* **2015**, *4*, 1307. 2) Z. Wang, L. Li, *et al.*, *Macromolecules* **2016**, *49*, 1505. 3) K. Hisano, A. Shishido, *et al*., *Sci. Adv.* **2017**, *3*, e1701610.