Surface Charge Density of Nanofluidic Devices with TMPTA UV Resins of Different Cross-Linking Agent Concentration Fabricated by UV Nanoimprint Lithography

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Polymer nanofluidic devices have great potential to replace silicon and glass-based nanofluidic devices in biomedical applications due to their advantages such as low material and fabrication cost, various physiochemical properties and well-developed surface modification protocols [1-3]. In nanofluidic sensing applications, single molecules such as DNA are introduced into the fabricated nanochannel or nanopore and their physiochemical properties are measured optically and electrically. Surface charge density determines the magnitude of electrophoresis and electroosmosis in the nanostructures and thus is a key material property of nanofluidic devices related to the capture of single molecules. To facilitate the capture of single molecules into nanofluidic devices, polymers containing poly(ethylene glycol) (PEG) are preferred due to their low surface charge density and reduction of surface fouling of biomolecules. However, a drawback of PEG-based polymers is a weak chemical and mechanical stability due to swelling effect and low surface hardness when in contact with electrolytes [4].

This work presents an improvement in the chemical and mechanical stability of a nanochannel device formed in poly(ethylene glycol) diacrylate (PEGDA), a PEG-based UV resin for UV-NIL, by adding a cross-linking agent. We studied the effect of the cross-linking agent content on surface charge density of nanochannels and on translocation of DNA molecules through the nanochannels. Five different compositions of PEGDA resins with varied amounts of a cross-linking agent, trimethylolpropane triacrylate (TMPTA), were used (pure PEGDA, ratio 5:1, 1:1, 1:2, and 1:5). As the cross-linking agent content increases, the surface hardness of PEGDA-TMPTA resin increases. Surface charge density of these nanofluidic devices was obtained via the conductance of 1 M KCl solution through 5 nanochannels (100 nm in width, 132 nm in depth, and 19μm in length), which amounted to -16.8 $\pm$ 1.95 mC/m^2, -18.2 $\pm$ 1.01 mC/m^2, and -19.8 $\pm$ 5.16 mC/m^2 for pure PEGDA and PEGDA:TMPTA ratios of 1:1 and 1:5, respectively. This work indicates that addition of a cross-linking agent into the PEGDA UV resin improves mechanical properties of nanofluidic devices but only slightly affects the surface charge density, facilitating the capture of single molecules.

1. J. Choi, C. Lee, and S. Park, Microsyst. Nanoeng. **5**, 12 (2019)
2. Z. Jia, J. Choi, and S. Park, ACS Appl. Mater. Interfaces **10**, 40927 (2018)
3. J. Wu, R. Chantiwas, A. Amirsadeghi, S. Soper, and S. Park, Lab Chip **11**,

2984, (2011)

4. A. Amirsadeghi, J. Lee, S. Park, Applied surface science **258,** 1272-1278 (2011)