

Article

Characterization and Neutral Atom Beam Surface Modification of a Clear Castable Polyurethane for Biomicrofluidic Applications

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Received: 1 December 2018; Accepted: 26 January 2019; Published: 1 February 2019

Abstract: Polyurethanes (PU) are a broad class of polymers that offer good solvent compatibility and a wide range of properties that can be used to generate microfluidic layers. Here, we report the first characterization of a commercially available Shore 80D polyurethane (Ultraclear™ 480N) for biomicrofluidic applications. Studies included comparing optical clarity with Polydimethylsiloxane (PDMS) and using high-fidelity replica molding to produce solid PU structures from the millimeter to nanometer scales. Additionally, we report the first use of NanoAccel™ treatment in Accelerated Neutral Atom Beam (ANAB) mode to permanently roughen the surface of PU and improve the adhesion of breast cancer cells (MDA-MB-231) on PU. Surface energy measurements using Owens-Wendt equations indicate an increase in polar and total surface energy due to ANAB treatment. Fourier-transform infrared (FTIR) spectroscopy in attenuated total reflectance (ATR) mode was used to demonstrate that the treatment does not introduce any new types of functional groups on the surface of Ultraclear™ PU. Finally, applicability in rapid prototyping for biomicrofluidics was demonstrated by utilizing a 3D-printing-based replica molding strategy to create PU microfluidic layers. These layers were sealed to polystyrene (PS) bases to produce PU-PS microfluidic chips. Ultraclear™ PU can serve as a clear and castable alternative to PDMS in biomicrofluidic studies.

Keywords: Surface modification; contact angle; hard polyurethane; PDMS; neutral atom beam; surface energy; ATR-FTIR spectroscopy; microfluidics; cell viability; 3D printing.

1. Introduction

Microfluidics involves the precise manipulation of fluids at submillimeter scales leveraging fabrication technologies developed by the semiconductor and microelectromechanical system (MEMS) industries [1]. A device built using microfluidic principles is commonly referred to as a micro total analysis system (μ TAS) [2] or a Lab-on-a-Chip (LoC) [1]. There are certain distinct advantages to conducting experiments in a microfluidic setting rather than on the macroscale [1]. Microfluidic chips need substantially smaller sample volumes that reduce the cost of reagents. They allow simplified analysis of multiple samples in parallel to generate maximum data per batch, while also providing greater control of spatiotemporal fluid dynamics. Additionally, multiple targets can