Roll-to-roll Fabrication of Through-hole Isoporous Structures and Applications as Cell-culture and Filtration Membranes

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In most lithographic processes, etching step is required to remove the residual layer. Etching is typically achieved via either selective chemical dissolution or corrosive gas exposure/radiation, both processes result in alteration of the surface chemistry of the material. Thus, etching is undesirable for applications in which the chemical functionality of the material must be preserved throughout the processing flow. Scalable residual-layer free surface patterning without needing an etching step opens up opportunities for biomedical and filtration applications.

Adapting from the well-established UV roll-to-roll nanoimprinting process, we have developed a residual layer-free UV roll-to-roll patterning of through-hole isoporous membrane [1], see Figure 1. The key differentiating approach in this work lies in the mechanism to achieve residual-free UV resin dispensing. This was achieved via a vertical roller drum design and a mold-edge UV resin dispensing so that capillary-driven filling of UV curable resin is achieved. This process not only produces residual-layer free porous structures, it has also achieved complex surface patterning that is otherwise difficult to achieve by a single-step lithography process. For example, by employing pre-patterned web substrate, multi-scale porous structure is achieved simultaneously in a homogeneous polymer.

The resulting free-standing through-hole isoporous membranes can be readily transferred to a substrate of interest. In one example, isoporous membranes are transferred to pre-functionalised glass substrate from which arrays of micro-pores with differential protein function on the wall and the substrate provides a highly customized 3D environment for cell culture. In a second example, suspended isoporous membranes provide a 3D environment for culture medium perfusion. Isoporous membranes also present a deterministic design for controlling pressure drop in filtration applications, in which pressure drop across well-defined pore architectures can be finely controlled.

[1] Wong, HC; Grenci, G; Wu, J; Viasnoff, V; Low, HY, Roll-to-Roll Fabrication of Residual Layer Free Micro/Nanoscale Membranes with Precise Pore Architectures and Tuneable Surface Textures. ***Ind. Eng. Chem. Res.*** 2018, 57, 13759−13768.

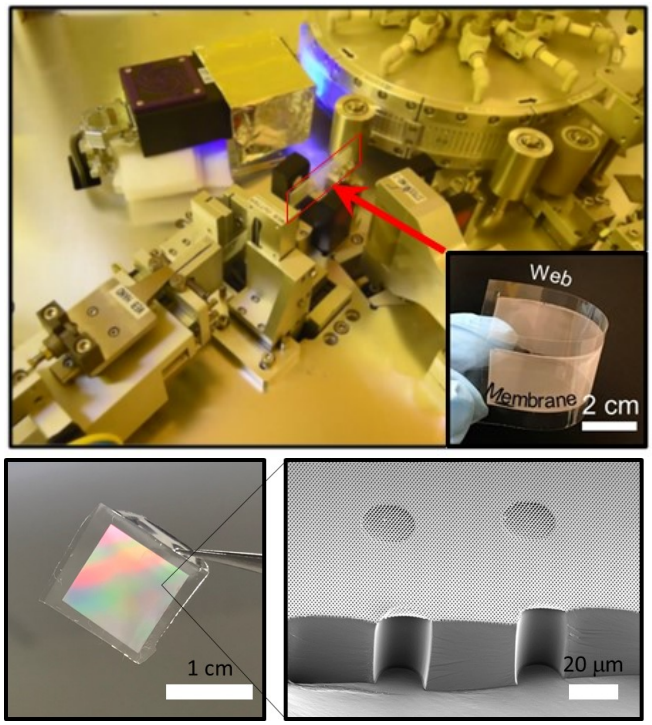

Figure 1: clockwise from top left image: photograph image of roll-to-roll tool with an insert photograph image of a stripe of isoporous membrane supported on PET web substrate, scanning electron micrograph showing nanoscale pores on top of microscale pores (multi-scale pores) in a homogeneous polymer, photograph of the multi-scale porous membrane.