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Production of polyamide-12 membranes for microfiltration through selective laser sintering

Shushan Yuan¹, Dieter Strobbe², Jean-Pierre Kruth², Peter Van Puyvelde*¹, Bart Van der Bruggen*¹

¹Department of Chemical Engineering, KU Leuven, Celestijnenlaan 200F, B-3001 Heverlee, Belgium

²Department of Mechanical Engineering, KU Leuven, Celestijnenlaan 300, 3001 Leuven, Belgium

Abstract

This study investigates the feasibility of manufacturing polyamide-12 microfiltration membranes through selective laser sintering (SLS). This process is different from traditional solvent casting methods, which have limited control over the membrane structure. The SLS technique also eliminates the usage of solvent, which lowers the production cost and avoids environmental issues. In this study, different processing parameters including laser power, hatch spacing and laser scan count are used to optimize the membrane performance. The laser energy density is shown to be directly linked with pure water flux and rejection. A laser energy density of 0.1 J/mm² results in membranes with the highest rejection and relatively high pure water flux. This work offers an alternative approach for fabrication of membranes for microfiltration. The findings in this exploratory study offer a perspective for optimization of membrane performance in future work.

Keywords: membrane; selective laser sintering; microfiltration; polyamide

1. Introduction

Recently, the application of membranes has been extended from water treatment, to gas purification, the energy and pharmaceutical industry. This has increased the demand for effective polymeric membrane fabrication techniques [1-3]. In the last several decades, extensive studies have investigated membrane fabrication methods including phase inversion, interfacial polymerization, stretching, track-etching and electrospinning to produce membranes with high performance in terms of selectivity and permeability [4].

Among these membrane synthesis techniques, phase inversion methods, i.e. nonsolvent-induced phase separation (NIPS), thermally induced phase separation (TIPS) and vapor induced separation are the most commonly used processes because of their simplicity and easy to scale up [5-7]. However, in these processes, a large amount of solvent is consumed, resulting in a large waste stream, leading to air and water pollution. Similar observations can be made for interfacial polymerization and electrospinning. Solvent-free processes have been developed as well. Membranes fabricated by track-etching have a very low porosity, and corresponding relatively low permeability. Additionally, high cost hinders its extensive application [8]. Stretching offers a promising perspective in terms of environment and cost, but the strict material property requirements limit its use to semi-crystalline polymers, for instance, polypropylene. Thus, there is still a long way to go to find a membrane fabrication process with a perfect control of the membrane structure, at low cost and without the extensive use of solvents. New manufacturing techniques developed in other fields may therefore be of interest for membranes.

Additive manufacturing (AM), popularly known as rapid prototyping or 3D printing, is defined as the group of techniques that uses layer-by-layer joining of materials to make parts from 3D model data [9-11]. The techniques make use of either extrusion, jetting, photo-curing, laminating or fusion of materials. Fused deposition modeling (FDM), stereolithography (SLA) and selective laser sintering (SLS) are the most important AM techniques for polymer processing [12,13]. These technologies have the possibility to revolutionize the current membrane technology and can potentially reduce the energy consumption and solvent usage in the membrane fabrication process.

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