Journal of Fiber Bioengineering & Informatics 5:4 (2012) 411–421
http://www.jfbi.org | doi:10.3993/jfbi12201206

Mechanically Robust Polyurethane Microfibrous Membranes Exhibiting High Air Permeability

Jianfeng Ge [a], Aikifa Raza [a], Fu Fen [b], Yang Si [a]
Yang Li [a], Jianyong Yu [c], Bin Ding [a,c,*]

[a] *State Key Laboratory for Modification of Chemical Fibers and Polymer Materials, College of Materials Science and Engineering, Donghua University, Shanghai 201620, China*

[b] *College of Textiles, Donghua University, Shanghai 201620, China*

[c] *Nanomaterials Research Center, Modern Textile Institute, Donghua University Shanghai 200051, China*

Abstract

Microporous polyurethane (PU) nano-microfibrous membranes exhibiting robust mechanical property with high air permeability were prepared using one-step electrospinning method. The role of compositions of electrospinning solution on the morphology, hydrophobicity and mechanical property of PU membranes were discussed, and a probable two-step break mechanism upon the external stress is proposed. Furthermore, the as-prepared membranes exhibited good air permeability (5.9 mm/s), high water resistance (5.7 kPa), and water vapor transmittance (7868 g/m^2, 24 h), and comparable tensile strength (15.95 MPa), suggesting their use as promising materials for various potential applications in protective clothing, membrane distillation, bioseparation, tissue engineering and catalyst carriers, etc.

Keywords: Polyurethane; Microfibrous Membranes; Multi-syringe Electrospinning; Air Permeability

1 Introduction

In recent times, the research pertaining to the fabrication of microporous polymer materials has increased considerably due to their potential applications in biological controlled release, breathable protective clothing, intelligent sensing/filtration, and separation processes [1-7]. These polymeric membranes are made practical accordingly by incorporating the complex multiple chemical functionalities into the microporous framework or at the pore surface [8, 9]. The hydrophobic nature and unique interconnected pore structure of the membranes with a pore size close to the dynamic diameter of gas molecules plays an important role in discrimination between the atmospheric precipitations and the gas molecules, since molecular sieving mechanism can be realized in such a pore system [10, 11].

*Corresponding author.
Email address: binding@dhu.edu.cn (Bin Ding).

December 2012

The conventional methods to fabricate the microporous membranes, including isothermal immersion-precipitation, lithography, micro-contact printing, freeze-immersion techniques, leaching methods, and micro-molding in capillaries are limitedly applied due to the complex methods and limited pore structure of the resultant membranes [12-18]. Recently, electrospinning has been proven to be a powerful technique for the preparation of microporous fibrous membranes with significant gas permeability from virtually any soluble polymer at the nano- and microscales [9, 19-21]. The method appears to be straightforward, but in reality a rather complicated process whose success depends on the balance of molecular process and technical parameters.

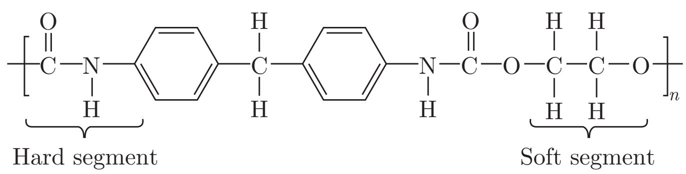
Polyurethanes (PU) are a class of thermoplastic polymer that is mostly chosen as the starting polymer for the preparation of hydrophobic breathable membranes owing to a range of desirable properties such as elastomeric, resistant to abrasion, and excellent hydrolytic stability. Combining the favorable intrinsic properties of the PU with the unique characteristics of a nano-microfibrous structure, it is possible for PU to be used in a tremendous number of applications including filtration, wound healing, and protective clothing and so on. Also reported is the preparation of PU membranes such as PU/polypyrrol, PU/polyvinylidene fluoride, PU/polystyrene and PU/ poly(ethylene glycol) methacrylate, and PU/Nylon-6 [22-27]. Our previous work has demonstrated the controllable fabrication of large-scale PU nano-nets via regulation of the solution properties and several processing parameters [28]. But still there is a need to fabricate the PU microfibrous membranes for large scale applications with good mechanical strength.

In this contribution, we present the fabrication of microporous PU nano-microfibrous membranes with robust mechanical property and high air permeability. The one step electrospinning method has created the enough roughness, thus endowing the hydrophobicity to the as-spun membranes. The effects of PU concentrations on the morphology, surface wettability and porous structure of resultant membranes were investigated. The air permeability of as prepared membranes is also presented.

2 Experimental

2.1 Materials

PU (Elastollan 2280A10) was purchased from BASF Co., Ltd. *N*,*N*-dimethylformamide (DMF) was purchased from Shanghai Chemical Reagents Co., Ltd, China. All chemicals were of analytical grade and were used as received without further purification. The chemical structure of PU is given in Scheme 1.



Scheme 1: The chemical structure of PU