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Hyper-cross-linked thin polydimethylsiloxane films

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Abstract

Polydimethylsiloxane (PDMS) elastomers are widely used in many applications, such as in microfluidic devices or as membranes. These slightly cross-linked PDMS networks suffer from severe swelling upon contact with, especially non-polar, organic solvents, thereby drastically reducing the performance of the device. Here, we report on a new method to prepare ultra-thin, highly cross-linked PDMS films in a localized fashion by the interfacial polymerization of PDMS with polyhedral oligomeric silsesquioxane (POSS). The resulting thin poly(PDMS-POSSimide) films (~150 nm) showed to have a drastic reduction in swelling upon contact with *n*-hexane vapor (~15 fold decrease) and ethyl acetate vapor (~5 fold decrease). These poly(PDMS-POSSimide) films showed an increase in swelling upon contact with ethanol vapor (up to a 4 fold increase) as compared to conventional PDMS. We attribute this increase in swelling to the enhanced affinity for polar solvents of these poly(PDMS-POSSimide) films due to the presence of positively charged ammonium groups. Despite the highest swelling in ethanol, the poly(PDMS-POSSimide) films are found to have extremely low ethanol permeances (<0.1 L m^{-2} h^{-1} bar^{-1}), thereby making them potential barrier materials.

Keywords: PDMS, POSS, interfacial polymerization, hybrid materials, thin films

1. Introduction

Polydimethylsiloxane (PDMS) is an organosilicon polymer, that has the general formula $[Si(CH_3)_2O]_n$. PDMS is widely used because it is optically transparent, flexible, inert, bio-compatible, and non-flammable. Most applications require the cross-linking of PDMS chains. Typically, cross-linked PDMS is prepared from the hydrosilylation of a liquid divinyl-terminated PDMS, with a multifunctional organosilane cross-linker, followed by a (thermal) curing step [1]. The reaction rate of this cross-linking reaction at ambient conditions is sufficiently low to allow for processing the PDMS by methods such as spin-coating, molding, or casting.

Example application areas of PDMS are sensors, medical devices, microfluidics, or membranes [2, 3]. In microfluidic devices, thin PDMS films are commonly applied as, *e.g.*, microlenses [4–6], valves [7, 8], or actuators [9, 10]. In addition, thin PDMS films are used as membranes in organic solvent nanofiltration (OSN), or as gas separation membranes [11].

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