Highways for water vapor transport: Interplay between nanostructure and performance of block copolymer membranes

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Introduction

Removal of water vapor from humid streams is an important process in many industrial processes (e.g., air conditioning system, flue gas dehydration, humidity adjustment for fuel cells, and moisture control in space shuttles). Effective dehumidification has the potential to reduce drastically the energy consumption and decrease the overall cost of the process stream. Membranes technology can be used to reduce the energy needed for removing unwanted water vapor from a stream. Various polymeric and mixed matrix membranes have been proposed for flue gas dehydrations and air conditioning systems (Akhtar *et. al.*). Among them Nexar™, a well-defined pentablock copolymer, has been identified as a promising candidate (Willis *et. al.*).

We will show how the internal morphology of Nexar™ films plays a crucial role for an efficient water vapor transport. Films with ordered nano-channels of hydrophilic domains present 5 times higher water vapor transport compared to films with disordered domains. When a polymer solution of Nexar™ is cast, it can self-assemble into non-equilibrium morphologies with interconnected sulfonated styrene micro-domains. The nanoscale morphology can be controlled due to the incompatibility between the blocks of the pentablock polymer. Choosing the appropriate solvents can lead to the segregation of micro-domains generating different nanostructures and morphologies. In this work, we use a combination of solvents that generated interconnected hydrophilic nano-channels. Such channels act as "highways" for the transport of water vapor. The transport in Nexar™ films with nano-channels is enhanced to a great extent compared to the disordered structures currently used.

Results and discussion

Figure 1 shows the morphology of the membranes cast from a mixture of solvents and THF. The membranes cast from a mixture of toluene and IPA (Nexar-Tol/IPA) have rather disordered spherical lead-stained sulfonated cores embedded in an unstained matrix composed of both the hydrophobic blocks (Figure 1a). On the other hand, we observed a completely different self-assembled structure (Nexar-THF) when the pentablock copolymer film is prepared using THF as a solvent (Figure 1b). The TEM cross sectional image shows hexagonally packed nonionic non-stained cores. In the Nexar-Tol/IPA films, the hydrophilic cores seem to be partially isolated, surrounded by the hydrophobic coronas. The water vapor transport would depend on random percolation of partially merged micelles. A completely different arrangement is observed for Nexar-THF with dramatic consequences for the transport properties. While the cylinder cores are hydrophobic, the coronas clearly assemble, forming hydrophilic nanochannels, which serve as

highways for an exceptionally fast water vapor transport. The reason for this high water vapor transport and selectivity over inert gas will be discussed in detail during my presentation.

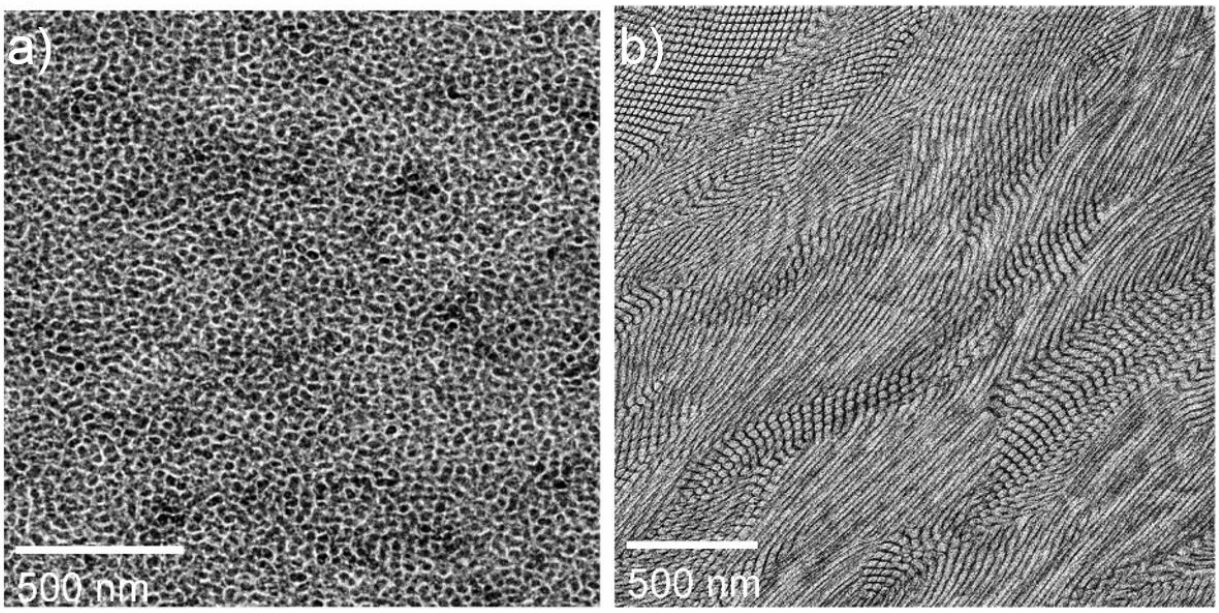


Figure 1. TEM images of (a) Nexar-Tol/IPA and (b) Nexar-THF membranes.

References

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