Mass transfer phenomena in nanostructured bijel films

Jesse Steenhoff, j.m.steenhoff@uu.nl
Supervisor: dr. M.F. Haase
Sponsor: NWO, since November 2021

Keywords: Bicontinuous emulsions, membranes, mass transfer

The spinodal decomposition of two immiscible liquids is characterised by the emergence of an intricate structure of continuously interwoven channels of distinct phases. This structure can be kinetically trapped through the adsorption of nanoparticles on the interface between the different phases, effectively creating what is known as a bicontinuous interfacially jammed emulsion gel (bijel). The interwoven structure of the bijel imparts it with a large internal surface area between the different phases, on which a semi-permeable membrane can be formed. Combined with pore-sizes ranging from 100 nm to 5 μm, bijels are thus a very promising template for high-surface area membranes suitable for nanofiltration or reverse osmosis.

The main goal of this project is to realise such bijel-templated high-surface area membranes and study the related mass transfer phenomena involved with their functioning. To this end, a bijel film will be grown on top of a specifically tailored support structure (Figure 1). In this nanostructured bijel film, the external pores are connected to both a feed flow and the opposite face of the support structure, therefore simultaneously carrying in the initial feed and draining off the concentrate. The interconnections between the internal pores and the support structure allows for the permeate to be carried off, completing the separation process.

The effectiveness of the intended membrane will be influenced by the mass transfer phenomena occurring through the entirety of the nanostructured bijel. For example, concentration polarisation in the channels of the bijel will increase the working pressure of the membrane through an increase in the osmotic pressure. This project will study the formation and evolution of such mass transfer processes through a combination of theoretical modelling and experimental methods such as confocal microscopy. The interplay between theory and experiment aims to garner a deeper insight into the fundamental principles underlying the functioning of these types of membranes, aiding their realisation on a laboratory scale.

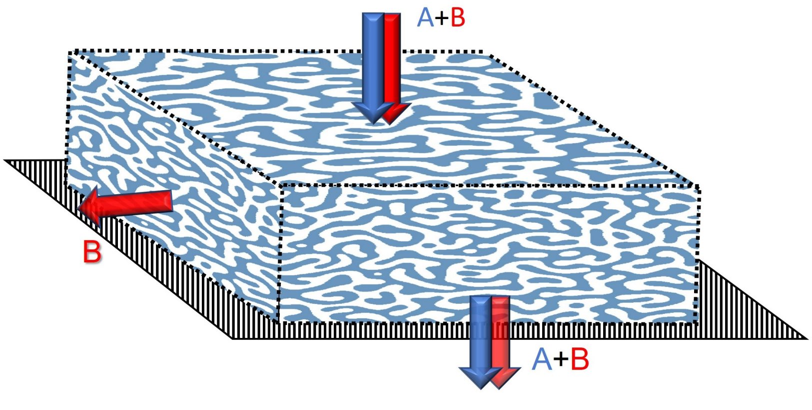

Figure 1: Schematic depiction of the nanostructured bijel film acting as the template for a high-surface area membrane. The external pores are connected to the feed flow containing species A and B. Species A permeates through the membrane into the internal pores and is subsequently drained off. The concentrate flow of species A and B is carried off at the face of the support structure opposite to the feed.