Up-scaling transport in porous polymer membranes using asymptotic homogenization

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Efficient numerical assessment of performance is particularly important in digital material design of porous materials. We present an up-scaled approach to virtually investigate permeation of fluids through a real porous filter membrane with heterogeneous micro structure. Despite many applications of asymptotic homogenization [1] in the field of filtration, no studies on the application and validation of homogenization to filter membranes have been presented yet, although they represent a large segment of filtration technology.

We apply the method of asymptotic homogenization on the permeation of different fluids through a porous polymer membrane. The permeation of an unladen fluid flow through a porous polymer membrane with a porosity profile in direction of flow is considered. The structural parameters of the micro-structure are directly obtained from SEM image analysis of a commercial filter membrane without fitting procedures and are averaged over the axial coordinate to obtain the mean radial porosity and pore size distribution.

The simulation results are compared to permeation experiments of gaseous nitrogen and liquid water. We found that variations in the pressure gradients across the membrane, resulting from the heterogeneity of pore structure, need to be considered. Remarkable agreement between simulations and experiments is observed.

Literatur

[1] G. Allaire, Homogenization of the stokes flow in a connected porous medium, Asymptotic Analysis 2 (1989) 203-222.