Power and Clean Water from Thermal Energy (PoreWatt)

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Thermodynamic driving forces, as chemical, osmotic and thermal forces can cause transport of fluids in porous media. So far, most of the two-phase flows in porous media have been investigated at isothermal conditions, with the pressure gradient as the only driving force. Fluid transport in porous media due to a temperature gradient therefore still poses unsolved practical as well as theoretical problems. In fact, it was shown in the literature that a temperature difference of only 40°C can overcome a hydraulic pressure difference of more than 10 bar [1]. Simulations suggest that an even higher hydraulic pressure might be achievable at a smaller temperature difference. Understanding these phenomena may open up a possibility for further generalizations of the description of the two-phase flow and could also give valuable information for practical applications like sea water desalination. The aim of the project is to understand the role of thermal driving forces for fluid transport in porous media, when it is acting alone or in combination with mechanical forces. For a full understanding of thermal transport, a suitable description of the pressure is needed. The pressure in nano-pores depends of the size and shape of the pore. We derive expressions for the pressure for different pores, based on Hill‘s thermodynamics for small systems [2]. We investigate the thermal forces with non-equilibrium molecular dynamics simulations for nano-pores for one or two immiscible fluids in a porous membrane. An improved description of two-phase flow in porous media is developed which can be used to optimize properties of porous media in a more realistic manner and may even lead to the development of new applications.

[1] - Anthony Straub, Ngai Yin Yip, Shihong Lin, Jongho Lee, and Menachim Elimelech,.Harvesting low-grade heat energy using thermo-osmotic vapour transport through nanoporous membranes. Nature Energy, 1:16090, 2016.

[2] - Hill TL.Thermodynamics of Small Systems . New York, NY: Dover (1994).