



Contribution ID: 571

Type: Oral Presentation

Thermodiffusion and thermo-osmosis in porous media

Monday, 22 May 2023 11:35 (15 minutes)

When a temperature difference is applied over a porous medium soaked with a fluid mixture, two effects may be observed, a component separation (the Ludwig-Soret effect, thermodiffusion) [1,2] and a pressure difference due to thermo-osmosis [3,4]. In this work, we have studied both effects using nonequilibrium thermodynamics and molecular dynamics. We have derived expressions for the two characteristic parameters, the Soret coefficient and the thermo-osmotic coefficient in terms of phenomenological transport coefficients, and we show how they are related [5]. Numerical values for these coefficients were obtained for a two-component fluid in a porous matrix where both fluid and solid are Lennard-Jones/spline particles. We found that both effects depend strongly on the porosity of the medium and weakly on the interactions between the fluid components and the matrix. The Soret coefficient depends strongly on whether the fluid is sampled from inside the porous medium or from bulk phases outside, which must be considered in experimental measurements using packed columns. If we use an equimolar methane/decane mixture in the bulk as an example, the results for the Soret coefficient give that a temperature difference of 10 K will separate the mixture to about 49.5/50.5 and give no pressure difference. In a reservoir with 30 % porosity, the separation will be 49.8/50.2 whereas the pressure difference will be about 15 bar. Thermo-osmotic pressures with this order or magnitude have been observed in frost-heave experiments [6].

A detailed study of a two-component fluid in slit pores revealed that the thermo-osmotic effect was driven by a thermal Marangoni effect, by the gradient in a temperature dependent surface tension along the pore walls [7].

Participation

In-Person

References

- [1] C. Ludwig, Sitzungsber. Akad. Wiss. Wien Math. Naturwiss. Kl. 20, 539 (1856)
- [2] C. Soret, Arch. Sci. Phys. Nat. Gen'ève t. II, 48 (1879)
- [3] K.G. Denbigh, G. Raumann, The thermo-osmosis of gases through a membrane I. Theoretical. Proc. R. Soc. Lond. Ser. A Math. Phys. Sci. 210 (1102), 377–387 (1952)
- [4] K.G. Denbigh, G. Raumann, The thermo-osmosis of gases through a membrane. II. Experimental. Proc. R. Soc. Lond. Ser. A Math. Phys. Sci. 210 (1103), 518–533 (1952)
- [5] B. Hafskjold, D. Bedeaux, S. Kjelstrup, Ø. Wilhelmsen, Soret separation and thermo-osmosis in porous media. The European Physical Journal E 45 (5), 1–15 (2022)
- [6] T. Takashi, T. Ohrai, H. Yamamoto, J. Okamoto, 2nd Int. Symp. On Ground Freezing, 1980, Norwegian Inst. Of Technology, Trondheim, pp. 713
- [7] I. Wold, B.Hafskjold, Nonequilibrium molecular dynamics simulations of coupled heat- and mass transport in binary fluid mixtures in pores. Int. J. Thermophys. 20 847 –856 (1999)

MDPI Energies Student Poster Award

No, do not submit my presentation for the student posters award.

Country

Norway

Acceptance of the Terms & Conditions

[Click here to agree](#)

Energy Transition Focused Abstracts

Primary author: HAFSKJOLD, Bjorn (Norwegian University of Science and Technology)

Co-authors: BEDEAUX, Dick (PoreLab, NTNU, Norway); KJELSTRUP, Signe (Norwegian University of Science and Technology, NTNU, Trondheim); Prof. WILHELMSEN, Øivind (PoreLab, Department of Chemistry); Ms DITARANTO, Emma Kirsti Anna (Norwegian University of Science and Technology)

Presenter: HAFSKJOLD, Bjorn (Norwegian University of Science and Technology)

Session Classification: MS17

Track Classification: (MS17) Thermal Processes, Thermal Coupling and Thermal Properties of Porous Media: modeling and experiments at different scales