Research topics for graduate students for 2023

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Department of Mechanical Engineering

Acceptable course(s)

- Master's Degree
- Doctoral Degree

Research Topics

Micro and nanoscale fluid transport phenomena play a crucial role in a wide range of mechanical engineering applications, such as the cooling of electronic devices, proton exchange membrane fuel cells, and gas separation membranes. We are investigating such phenomena through both experimental and computational approaches.

1. Microscopic aspects of evaporation at liquid–vapor interfaces

Evaporation of water is a ubiquitous phenomenon in both nature and engineering applications. To gain microscopic insights into evaporation at a liquid–vapor interface, we are exploring a novel experimental method for measuring the nonequilibrium velocity distribution of water molecules evaporating from a liquid–vapor interface. In addition, we are developing a highly efficient numerical scheme for simulating nonequilibrium gas flows near liquid–vapor interfaces induced by evaporation.

2. Water and oxygen transport in the catalyst layers of proton exchange membrane fuel cells

The reduction of oxygen transport resistance is essential for realizing the high current density operation of proton exchange membrane fuel cells (PEMFCs). We aim to clarify the transport mechanism of water and oxygen in the catalyst layers of PEMFCs using experimental and computational approaches and obtain a way of designing highly efficient materials.

3. Gas transport mechanism in CO_2 separation membranes

Membrane-based gas separation technologies attract considerable interest because of their potential high energy efficiency. We are conducting molecular dynamics and grand canonical Monte Carlo simulations to clarify the relationship between gas separation performance and the microscopic structure of polymer membranes.

Articles Related to Research Topics

[1] Z. Lu, I. Kinefuchi, K. Wilke, G. Vaartstra, E. Wang, "A Unified Relationship for Evaporation Kinetics at Low Mach Numbers," *Nature Communications* **10**, 2368 (2019). [DOI: 10.1038/s41467-019-10209-w]

[2] T. Kaneko, Y. Yoshimoto, T. Hori, S. Takagi, J. Ooyama, T. Terao, I. Kinefuchi, "Relation between oxygen gas diffusivity and porous characteristics under capillary condensation of water in cathode catalyst layers of polymer electrolyte membrane fuel cells," *International Journal of Heat and Mass Transfer* **150**, 119277 (2020). [DOI: 10.1016/j.ijheatmasstransfer.2019.119277]

[3] Y. Yoshimoto, Y. Tomita, K. Sato, S. Higashi, M. Yamato, S. Takagi, H. Kawakami, I. Kinefuchi, "Gas Adsorption and Diffusion Behaviors in Interfacial Systems Composed of a Polymer of Intrinsic Microporosity and Amorphous Silica: A Molecular Simulation Study," *Langmuir* **38**, 7567 (2022). [DOI: 10.1021/acs.langmuir.2c00661]