4th Conference on Micro Flow and Interfacial Phenomena (μFIP)
21 – 24 June 2024, Hong Kong

MOLECULAR TRANSPORT THROUGH ANGSTROPOROUS 2D CRYSTALS

Pengzhan Sun[1]
[1] *Institute of Applied Physics and Materials Engineering, University of Macau, Macau SAR, China*

ABSTRACT

It is widely believed that, despite being one-atom thick, graphene and other 2D crystals is completely impermeable to all gases and liquids. In this talk, I will present my recent research[1-4] on the topic "Molecular transport through angstroporous 2D crystals."

Using monocrystalline container made from atomically flat graphite, which is tightly sealed with graphene, we have achieved measurements that put the permeation limit through 2D materials at 8–9 orders of magnitude lower than previously, such that we would discern (but did not observe) just a few helium atoms per hour crossing micrometer-size membranes. This detection limit is also valid for all other gases tested, except for hydrogen. Hydrogen shows noticeable permeation, even though its molecule is larger than helium. The mechanism of this anomalous observation is proposed and later corroborated by experiments. To make the generally "impermeable" graphene not only "permeable" but also highly "selective", we have developed a perforation technique which involves a short-time exposure of the graphene membrane to low-energy electrons. Using the same monocrystalline containers, we are able to study gas transport through the created individual graphene pores with an effective size of about one missing carbon ring. Helium and hydrogen permeate easily through these pores whereas larger molecules such as xenon and methane are blocked. Permeating gases experience activation barriers that increase quadratically with the kinetic diameter, and the transport process crucially involves surface adsorption.

1. **P. Z. Sun, et al. *Nature* 2020, 579, 229.**
2. **P. Z. Sun, et al. *Nat. Commun.* 2021, 12, 7170.**
3. **P. Z. Sun, et al. *PNAS* 2023, 120, e2300481120.**