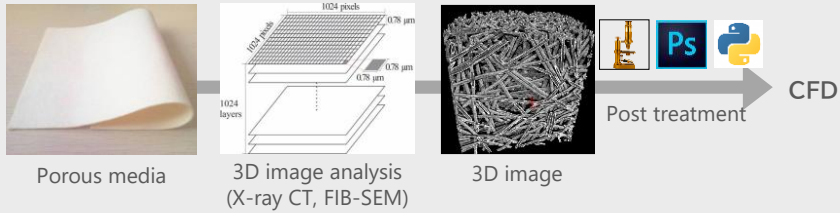


# Mesoscale numerical modeling of dispersed flows

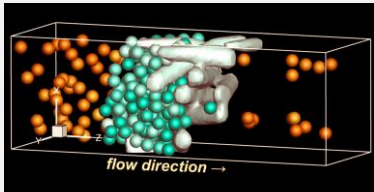
## Dispersed flows in porous media coupled with microstructures obtained via 3D image analysis



Developed **versatile, arbitrary-shaped wall boundary models**

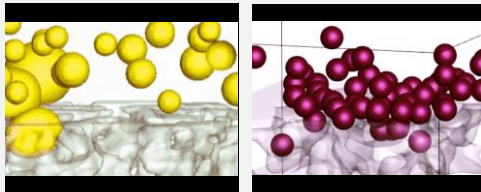
- Immersed boundary method: Rozy et al., *AIChE J.* (2020)
- Free-energy model: Ueda et al., *Langmuir* (2020)
- Signed distance function: Rozy et al., *Powder Technol.* (2021)

### Bagfilter



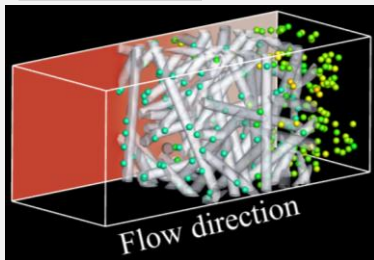
Shirzadi et al., *Phys. Fluids* (2026)  
 Seki et al., *Chem. Eng. Sci.* (2024)  
 Rozy et al., *Powder Technol.* (2021)

### Microfiltration (LL / SL)



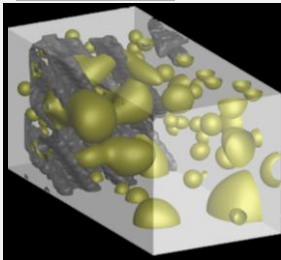
Kawashima et al., *Powder Technol.* (2022)  
 Shirzadi et al., *Langmuir* (2022)

### Airfiltration



Rachmawati et al., *IECR* (2024)  
 Hada et al., *AIP Adv.* (2022)  
 Rozy et al., *AIChE J.* (2020)

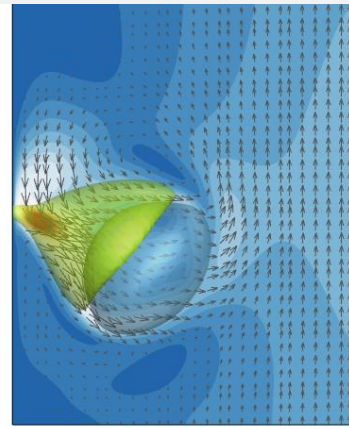
### Coalescer



Ueda et al., *IECR* (2021)  
 Ueda et al., *Langmuir* (2020)

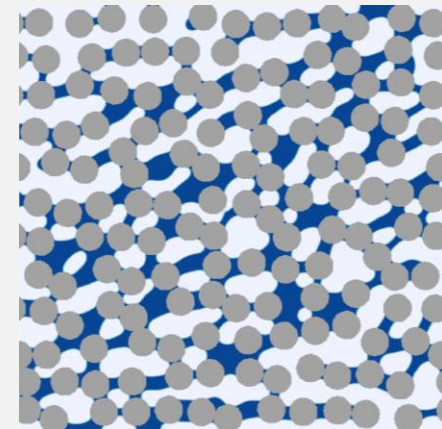
## Numerical modeling of three-phase, four-phase and n-phase flows

### Three phases (GLL)



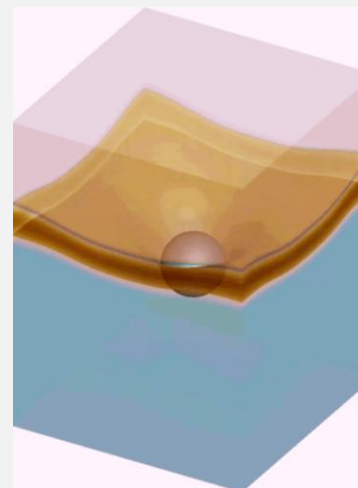
Shirzadi et al., *Langmuir* (2025)  
 Yuhara et al., *AIChE J.* (2024)

### Three phases (SLL)



Ishigami et al., *Soft Matter* (2022)  
 Ishigami et al., *Granular Matter* (2019)

### Four phases (SGLL)

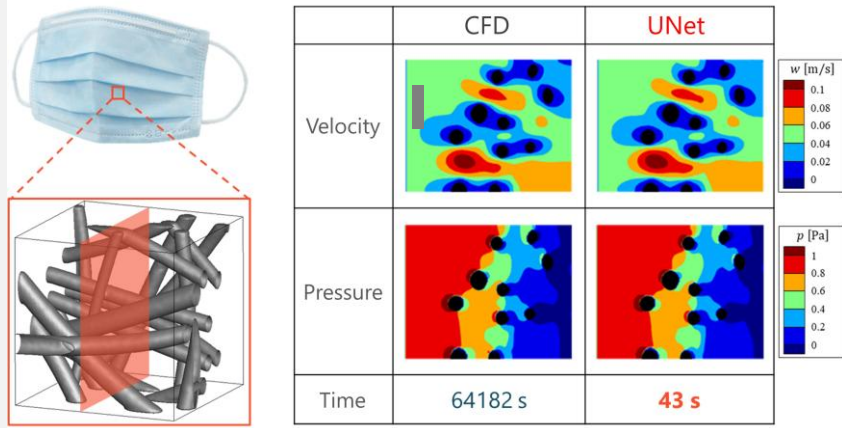
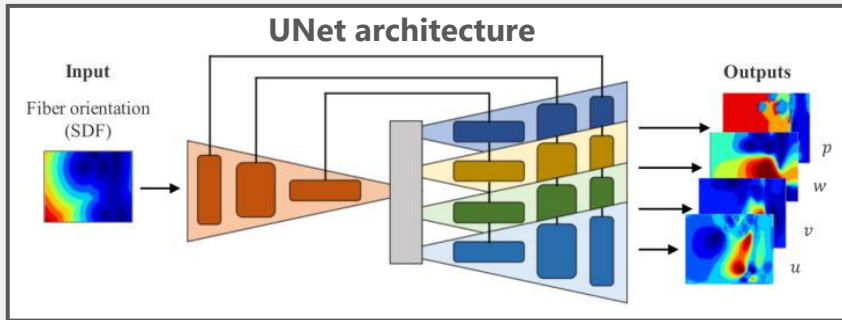


### N phases

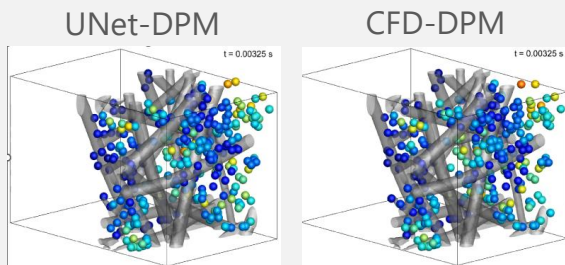


# Integration of numerical simulation and AI technologies

## Surrogate modeling for fast prediction of flow field in porous media microstructures



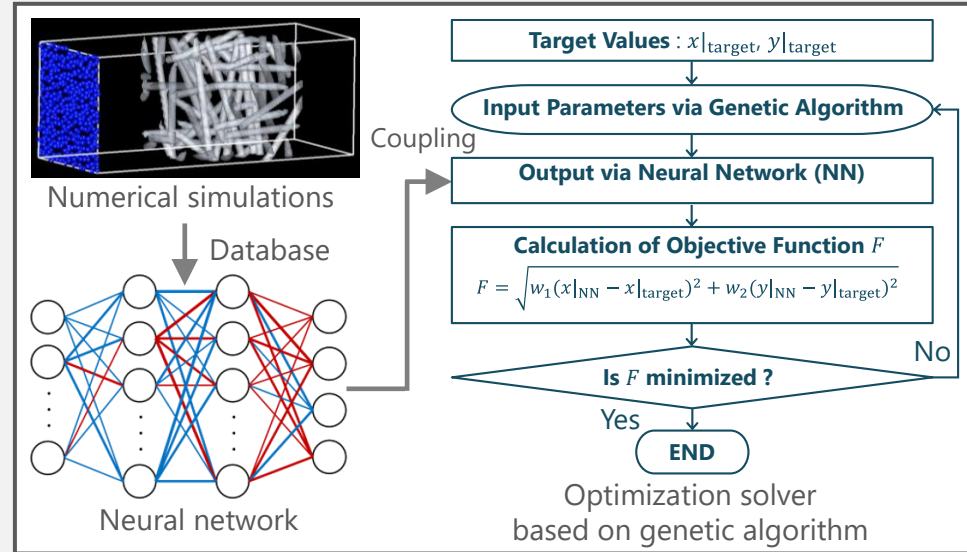
## Coupling of surrogate model and granular simulation (UNet-DPM)



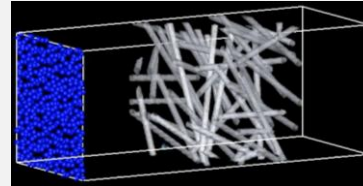
Hada et al., Chem. Eng. J. (2025)  
Shirzadi et al., Chem. Eng. J. (2023)

Hada et al., Phys. Fluids (2024)  
Shirzadi et al., Phys. Fluids (2022)

## Data-driven optimization through the integration of machine learning and numerical simulation

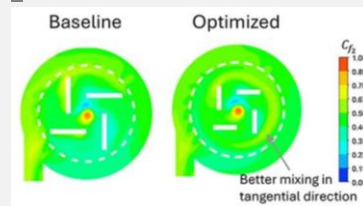


## Airfilter microstructure



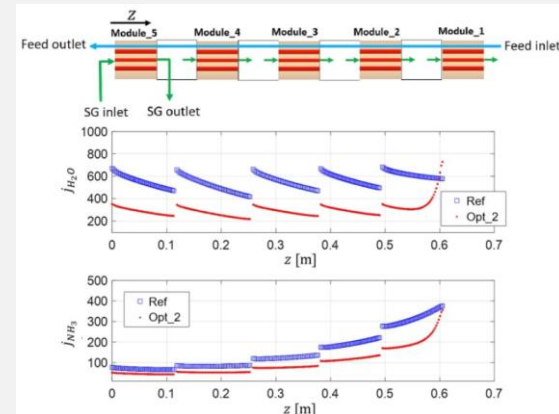
Tsuzuki et al., Chem. Eng. Sci. (2026)

## Rotor-stator mixer



Shirzadi et al., Chem. Eng. J. (2024)

## Membrane distillation modules



Shirzadi et al., Chem. Eng. J. (2024)

Shirzadi et al., Chem. Eng. J. (2023)

Shirzadi et al., Ind. Eng. Chem. Res. (2022)