Contribution ID: **218** Type: **Oral Presentation**

Contact angle on rough curved surfaces and its implications in porous media

Monday, 13 May 2024 14:10 (15 minutes)

Equilibrium contact angle depends on both the chemistry of the two fluids and solid base, and the microstructure on the solid surface. Actual surface of the pore wall in porous media is typically rough and curved, which has not been well-considered in related applications. This work uses a free interfacial energy minimization approach to theoretically derive the equilibrium contact angle on two specific surface structures on flat surfaces and extends the derivation considering the surface curvatures in porous media. Results reveal the equilibrium contact angle is not dependent on the curvature of spherical surfaces, and we further prove that this conclusion applies to any point along the apparent common line at solid surfaces with any arbitrary curvature. The fundamental physics is the local mechanical balance of a composite contact among three interfacial tensions. Furthermore, the contacting mode can shift from non-wetting to wetting when the pressure difference between two fluids exceeds the entry pressure of the microstructures, which should be considered in relative dynamic scenarios such as rain droplet impact and fluid displacement in porous media. Note these conclusions are from pure theoretical analysis based on idealistic assumptions and real circumstance may deviate from these assumptions.

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References

Liu Lei, Lei Liang. 2023. Contact Angle on Rough Curved Surfaces and Its Implications in Porous Media. Langmuir 39: 4507-17

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Session Classification: MS06-B

Track Classification: (MS06-B) Interfacial phenomena across scales