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P02

濡れ性の異なる粒子状多孔質体内における単一液滴の毛管現象

Capillary Wicking of a Liquid Drop in Porous Medium with Wettability Difference

村上岳 [1]，黒瀬築 [2]，桜井誠人 [3]，上野一郎 [2]
Gaku MURAKAMI[1], Kizuku KUROSE[2], Masato SAKURAI[3], Ichiro UENO[2]
1　東京理科大学大学院，Tokyo University of Science
2　東京理科大学，Tokyo University of Science
3　宇宙航空研究開発機構，Japan Aerospace Exploration Agency

Separation of gas-liquid two-phase flow into gas and liquid single phases under microgravity is essential for long-term manned space activities. In particular, passive gas-liquid separation technology utilizing spontaneous flow by the capillary force is effective for space facilities with limited energy availability. Hence, various gas-liquid separators applied the capillary force have been developed. Weislogel and Jenson[1)] demonstrated the application using the combined effect of surface tension, wetting, and container geometry. Richard et al.[2)] proposed a device that separates gas and liquid by changing capillary-force gradient inside a porous medium. In our research group, we propose the separation system composed of hydrophilic and hydrophobic fibrous porous mediums. This separator is expected to be applied in a gas-rich two-phase flow, i.e., the liquid flows into the separator as droplets. Despite of several previous studies on liquid control and transport techniques using porous mediums [3)], there have not been enough research under microgravity; it is necessary and indispensable to accumulate knowledge. In this study, we investigate via numerical simulation the behavior of droplet impregnation and unidirectional transport in porous medium.

We model a particulate porous medium with a simple and symmetric geometry compared to the fibrous porous medium, as shown in **Fig. 1**. The porous medium consists of hydrophilic (static contact angle θ_{p} = 27°) and hydrophobic (θ_{p} = 141°) layers. A droplet is placed just on the boundary of the layers. Effect of inlet gas velocity, U_{gas}, on the impregnation is examined. The InterFoam solver of OpenFOAM is used as the numerical analysis solver, which solves gas-liquid two-phase flows using the Volume of Fluid (VOF) method. We consider the water and the air as the test liquid and gas, respectively, by applying their physical properties at room temperature. The gravity term is neglected in the present series of the simulations. We discuss the impregnation by making comparison with the previous study with fibrous medium [4)].

Figure 2 (a)-(c) shows the temporal variation of a droplet impregnation for the respective inlet gas velocity U_{gas}. As shown in **Fig. 2 (a)**, the droplet totally impregnates into the hydrophilic side without inlet gas velocity, or $U_{gas} = 0$ m/s. It is emphasized that the impregnation inevitably stops inside the porous medium due to the balance of upward and downward capillary forces. **Panels (b)** and **(c)** in **Fig. 2.** show the results under U_{gas} = 15 m/s and 30 m/s, respectively. In the case of (b) $U_{gas} = 15$ m/s, the droplet completely inflows to hydrophilic layer and reach at the bottom of the porous medium. Whereas in the case of $U_{gas} = 30$ m/s, the pressure of the gas flow becomes dominant, which results in the impregnation of the part of the droplet into the hydrophobic layer as well.

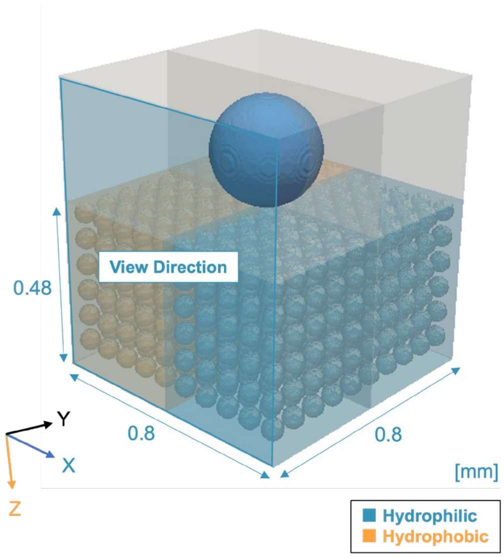

Figure 1. Numerical model to simulate droplet impregnation on particulate porous medium with different wettability.

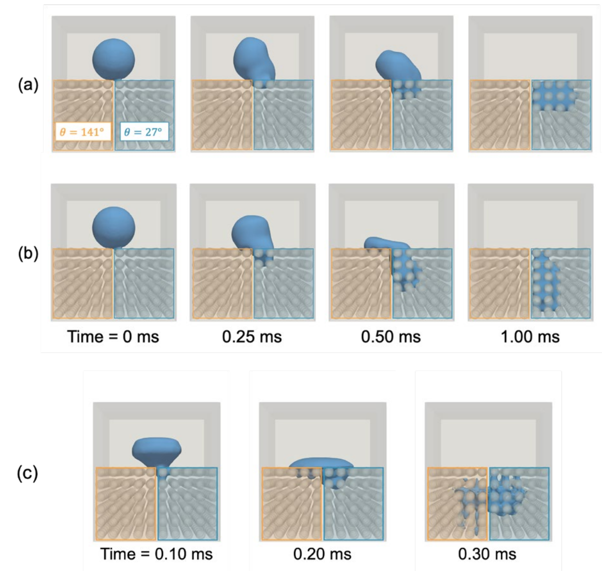

Figure 2. Impregnation behaviors on porous medium with different wettability under $U_{gas} =$ (a) 0 m/s, (b) 15 m/s, and (c) 30 m/s.

References

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