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Dissolution and swelling in porous media

Monday, 31 May 2021 11:25 (15 minutes)

Transport in porous materials is a problem of relevance for several real-life applications such as disintegration of pharmaceutical tablets [1], groundwater contamination [2], and oil extraction [3]. In several cases the fluid changes the medium, and these changes are expected to feedback into the fluid flow. Examples of these changes are: i) erosion; ii) swelling; and iii) dissolution of solute. In a previous work, we focused on studying the dynamics of a porous medium that swells and erodes and showed that swelling can greatly impact the erosion of a porous medium [4]. Here, we study the competition between swelling and dissolution. We consider a porous medium composed of compacted non-overlapping spheres of size dispersion 5%. We use the Lattice-Boltzmann Method to resolve the fluid flow coupled to an advection-diffusion equation for the solute, to obtain the velocity field and solute concentration. The fluid flows due to an imposed pressure drop. On the surface of each sphere there is a flux of solute that depends on the solute concentration gradient and on the solid dissolution mass transfer coefficient [5]. The implementation of the sphere swelling is based on the discretization of an empirical law [6] consisting of an exponential increase of the sphere volume. Swelling has two competing effects on the solute transport: i) swelling decreases the average velocity of the fluid which causes a decrease on the solute throughput; and ii) swelling causes an increase in the surface area of the porous medium which in turn enhances solute dissolution. We investigate the impact of this competition on the extracted solute over time and determine an empirical equation that describes the extracted solute concentration.

Time Block Preference

Time Block B (14:00-17:00 CET)

References

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[4] Matias, A. F. V., Coelho, R. C. V., Andrade Jr., J. S., & Araújo, N. A. M. Flow through time-evolving porous media: swelling and erosion. arXiv:2012.15624
[5] Bear, J. (2018). Modeling Phenomena of Flow and Transport in Porous Media (Vol. 31). Cham: Springer International Publishing.
[6] Mateus, M. L., Rouvet, M., Gumy, J. C., & Liardon, R. (2007). Interactions of water with roasted and ground coffee in the wetting process investigated by a combination of physical determinations. Journal of Agricultural and Food Chemistry, 55 (8), 2979–2984.

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