Contribution ID: **557** Type: **Oral Presentation**

Influence of interaction between confined hydrogel beads on their growth swelling dynamics

Wednesday 24 May 2023 14:30 (15 minutes)

Hydrogels are polymeric materials that can absorb large amounts of water, swelling and increasing considerably in size. They are used in a wide range of applications, including some in which the hydrogel is required to absorb liquid under pressure. For example, for soil remediation and water storage in agriculture, hydrogels maybe located deep underground and must withstand the mechanical stress from the soil while swelling the water and at the same time absorbing any heavy metal ions present in the soil.
In this work we study the influence of confinement and interaction between hydrogels beads during their swelling. A large cylindrical vessel was used, where a single hydrogel can swell freely without interaction with the side walls. A initially dry hydrogel bead, diameter (2.8 ± 0.2) mm, is submerged in an aqueous solution containing a small amount of dissolved fluorescein, which allows UV light visualization but does not affect the swelling. A top piston is placed in contact with the hydrogel. The piston can move vertically with negligible friction until it reaches a force sensor at a fixed and controllable height H. H determines the vertical confinement and is varied between 4 and 12 mm. The force exerted by the hydrogel on the piston is measured during swelling. Three different kinetic regimes were identified in the swelling of a single hydrogel bead, independent of the confinement H: 1) “flower like” swelling, in which the hydrogel bead presents a dry core surrounded by a wet shell of wavy geometry due to a surface instability; 2) isotropic and homogeneous swelling and 3) confined swelling, after the hydrogel bead reaches a size equal to H and swells under compression in the vertical direction. The force exerted by the hydrogel bead on the piston was found to increase with confinement (as H decreases). The pressure exerted by the hydrogel bead on the piston agrees with Maxwell’s viscoelastic model at constant strain. The measured pressure and deformation at long times show an elastic behavior for all the values of H studied. Finally, the influence of interactions between hydrogels in confined media is studied varying the total number of hydrogels beads (NH) between 5 and 30. It is observed that, for a given H, the force exerted on the piston increases with the number of hydrogel beads present in the cell. However, the total force depends linearly on the number of hydrogel beads until NH=20.

Participation

In-Person

References

Hou, X., Li, Y., Pan, Y., Jin, Y., & Xiao, H. (2018). Controlled release of agrochemicals and heavy metal ion capture dual-functional redox-responsive hydrogel for soil remediation. Chemical Communications, 54(97), 13714-13717.

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Session Classification: MS04

Track Classification: (MS04) Swelling and shrinking porous media