

Influence of the Liquid Phase on the Aging and Microstructure of Gas Marble

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Abstract

A gas marble is an object that can be described as an air bubble surrounded by a liquid film stabilized by particles instead of surfactant (Fig 1.a). Due to their lightness, their shell properties [1] and their three-phase hierarchical composition, gas marbles have many potential applications, especially in gas encapsulation and vibration dissipation processes. The aim of this work is to scale up these gas marbles to the material level by stacking them in order to study their influence on vibration damping. The assembly of gas marbles is a kind of Pickering foam, but with a discontinuous liquid phase. Since these objects made of pure water dry up due to water evaporation and collapse [2], the first task was to develop gas marbles that are more stable with respect to external mechanical stress and over time. A first strategy is therefore to add glycerol to the liquid interstitial phase. Its hygroscopic properties make it possible to create everlasting gas marbles [2]. Using weight measurements coupled with X-ray tomography (Fig 1.b), we show that the glycerol concentration strongly affects the microstructure of the shell, increasing the glycerol ratio increases the number of layers in the shell. Therefore, it is important to be able to characterize the microstructure as it may affect their vibrational behavior. Although these gas marbles with glycerol and monodisperse spherical particles can last forever, the interstitial liquid drains under gravity preventing the gas marbles from stacking due to their coalescence. By replacing the liquid phase with a polyacrylamide hydrogel reinforced with Laponite clay nanodisks, the polymer network cross-linked by Laponite nodes [3] helps to stop drainage. However, when hydrogels are exposed to drying, their elastic modulus rises sharply over time and even becomes brittle in film form. To avoid this effect, glycerol is added to obtain everlasting gas marbles with a soft shell that do not coalesce and can therefore be stacked. The acrylamide monomer/Laponite ratio allows the mechanical properties of the interstitial phase to be adjusted.

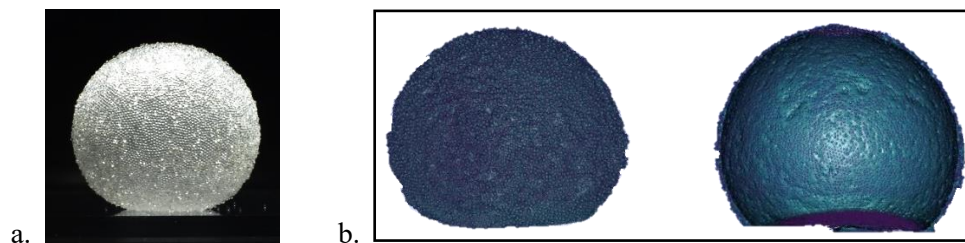


Figure 1: a. Picture of a gas marble (liquid: water, particle diameter: 140 μm). b. 3D reconstruction of the exterior and interior of a gas marble after X-ray microtomography.

- [1] Timounay, Y., Ou, E., Lorenceau, E. & Rouyer, F. (2017). Low gas permeability of particulate films slows down the aging of gas marbles. *Soft Matter*, 42(13), 7712-7720.
- [2] Roux, A., Duchesne, A., & Baudoin, M. (2022). Everlasting bubbles and liquid films resisting drainage, evaporation, and nuclei-induced bursting. *Physical Review Fluids*, 1(7), L011601.
- [3] Haraguchi, K. (2011). Stimuli-responsive nanocomposite gels. *Colloid and Polymer Science*. 5(289), 455-473.