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INFLUENCE OF THE LIQUID PRESSURE ON GRANULAR FILM OPENING

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Gas marbles are new materials made of gas encapsulated by a granular film composed of a dense layer of particles constrained by a thin liquid film. This object can resist to an inner pressure 10 times higher than the Laplace pressure of a classical soap bubble [Timounay, PRL, 2017]. Investigating the behavior of granular films to triggered opening, Timounay *et al.* have revealed a transition to jamming at particle surface fraction $\phi_s \approx 0.84$ where film opening is inhibited by particles bridging the two interfaces [Timounay, SoftMatter, 2017]. Beyond the surface fraction influence, the exceptional mechanical strength has been attributed to the cohesion between the grains due to capillary forces. However, this cohesion was not controlled in previous experiments. Thus, we have developed a dedicated device to tune capillary forces by controlling the pressure in the liquid of the granular film. Indeed, lowering the liquid pressure curves the liquid/air interfaces around the particles (Figs. 1.d - e) and increases the cohesion forces. For a given high particle surface fraction ($\phi_s \approx 0.9$), the influence of capillary cohesion on the film resistance was investigated from the retraction dynamics consecutive to a hole creation. Experiments led for different particle sizes and various liquid pressure (cohesion forces) revealed three different ruptures: total (liquid-like behavior), intermittent and partial opening (solid-like behavior). The values 0, 0.5 and 1 are respectively assigned to these openings (top-views in Figs. 1.b - c). In Fig. 1.a, averages on 5 experiments reveal a progressive transition as a function of liquid pressure between the different opening dynamics. We evidence that larger is the liquid depression, more likely the opening of the granular film is inhibited. Moreover, larger is the particle size, lower is the pressure of transition from liquid-like to solid-like behavior of the granular film.

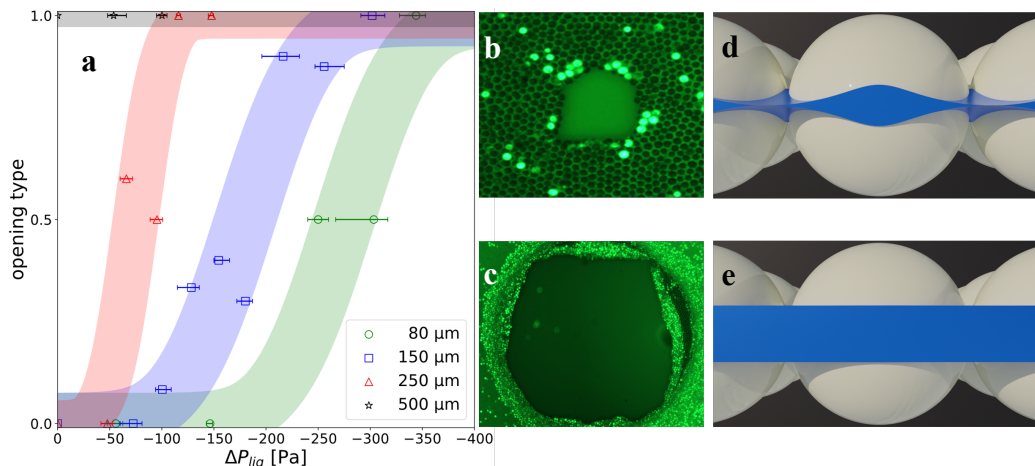


Figure 1: (a) Retraction type as a function of liquid pressure and particle sizes. Final top-view of (b) partial and (c) total film opening. Surface Evolver simulations of a granular film at (d) high and (e) zero liquid depression.

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References

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