THE FLOW OF LIQUID FOAM ON LOCAL, MESOSCOPIC AND MACROSCOPIC LENGTH SCALES

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Aqueous foams are cellular materials consisting of gas bubbles closely packed in a soapy liquid. The macroscopic flow of these materials is accompanied by intermittent ”T1 processes” which are rearrangements of the packing on the bubble scale. In recent theoretical work, such processes have been modelled on a mesoscopic scale where the physicochemical composition and the details of the bubble shape and packing are ignored [1]. On this scale the flow of foams may be compared to the plastic flow of amorphous metals. Molecular dynamics simulations have evidenced mesoscopic shear transformation zones where the local packing of atoms undergoes irreversible structural changes [2]. We propose that on a mesoscopic scale, T1 processes can be considered as the analog of these shear transformation zones. The coupling between such mesoscopic processes and macroscopic flow in amorphous metals has been modelled in an analytical ”STZ” model [2].

In this context, have studied numerically and analytically the link between macroscopic, mesoscopic and local rheology of foams. We have performed numerical quasistatic flow experiments with disordered dry 2D foams using the surface evolver software. Our results provide a quantitative link between the local change of the foam structure upon a T1 event and the strain far field that it induces. Furthermore, we have performed an analytical calculation that links this far field to the macroscopic strain and stress. A fully tensorial description is required at this level, going beyond the scalar approach considered in most STZ models. Our results provide the elements that will help to construct a full constitutive model of foams that should explain phenomena like the jamming transition and shear banding. Besides plastic flow, we have studied the origin of linear viscoelastic creep of foams that has recently been evidenced experimentally [3]. Contrary to glasses, the time scale of creep flow in foams is not set by thermal dynamics, but by another source of intrinsic dynamics, due to the diffusive gas transfer between neighboring bubbles driven by Laplace pressure differences. This coarsening process induces T1 processes, even if the sample is subjected to stresses much too weak to induce plastic flow. Our study has shown how even a very weak stress can bias the outcome of these rearrangements and we present a physical model explaining creep flow of foams on this basis.

References

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Keywords: foams, flow, constitutive models