Antifoam dynamics of oil droplets in protein-stabilized aqueous thin films

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A drastic reduction in foaming functionality due to the antifoam activity of oil droplets can occur in protein-based foams, such as those generated from milk (analogues), protein extracts, or beer. Oil contents as low as 0.006 wt% caused notable foamability reductions in solutions covering a range of protein concentrations (0.5-1 wt%) [1]. General trends were observed across multiple protein and oil types, with reduced antifoam activity at either very low oil contents or at very high oil and/or protein contents. Dynamic conditions were found to be a prerequisite for antifoam activity in whipping tests, as only foamability and not foam stability was reduced [1]. The dynamic nature of the antifoam activity in protein-based systems was further supported by results showing that differences in susceptibility to antifoam activity across protein types correlate strongly with either adsorption kinetics at short timescales and/or high dilatational interfacial viscoelasticity [2].

Consequently, previously established insights to explain antifoam activity based on equilibrium surface tension values do not adequately describe the observed dynamics protein-based systems [3,4]. Instead, protein adsorption kinetics, the strength of the viscoelastic interfacial network and disjoining pressure between interfaces govern observed antifoam trends in protein-based foams. At 1 wt% protein, thin films with and without oil droplets are extremely stable in quasi-static tests at both small and large applied pressures. Only in dynamic tests with extreme thin film radius expansion rates (i.e. large pressure steps), increased rates of oil droplet entrainment and subsequent antifoam activity were observed, substantiating the dynamic nature of the antifoam effect in protein-based systems.

In conclusion, the unique dynamic nature of antifoam activity in protein-based foams was related to adsorption kinetics and viscoelastic interfaces, which is different from most of the previously established antifoam principles relevant to low-molecular-weight surfactants. Furthermore, the novel use of the thin film balance instrument granted new insights into those antifoam dynamics on the scale of a thin film, substantiating the dynamic nature of antifoam activity in protein-based foams.

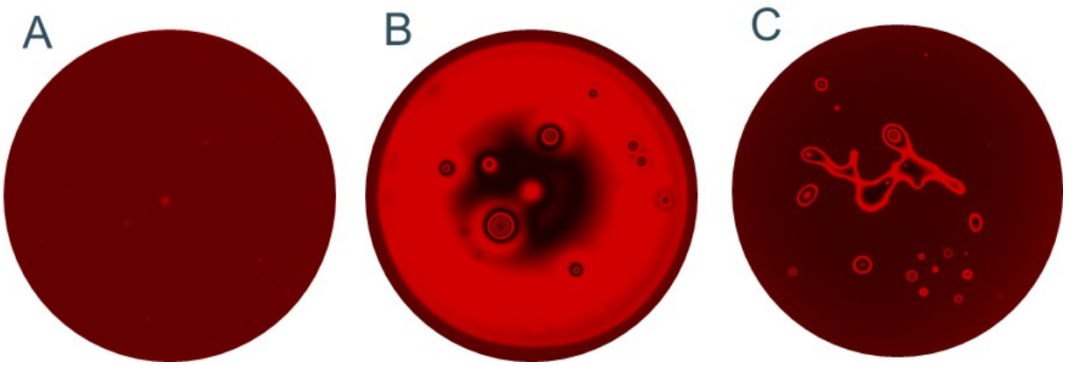

Figure 1: A: 10 minute old thin film with no entrained oil droplets at 1 wt% potato patatin protein, B: 10 second old thin film with entrained oil droplets at 1 wt% potato patatin protein, C: 10 minute old thin film with entrained oil droplets at 1 wt% potato patatin protein

References:

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