SURFACE RHEOLOGY: THE EFFECT OF INTERFACIAL VISCOELASTICITY ON LIQUID THIN FILM RUPTURE AND ADVANCED APPLICATIONS

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The study of surface rheology has become of crucial importance. Interfacial properties predominate over bulk properties in structures such as liquid thin films, which are ubiquitous in a variety of research fields. In biophysics, thin films are present as lung coatings or tear films. In engineering applications, they find their importance in the formation of foams and/or emulsions. Most studies have focused on liquid thin films formed by aqueous solutions with surface active molecules (polymeric or low PM surfactants, proteins).These molecules is adsorbed to the fluid-fluid interface, reducing the interfacial tension and endowing the interface with additional properties, e.g. elasticity. Interfacial viscoelasticity is a mathematical model to describe the behaviour of the interface between a viscous fluid and an elastic solid. Interfacial viscoelasticity plays an important role in spray coatings, liquid-liquid depositions, two-phase flows etc...

The thin film interfacial viscoelastic behaviour is due to the formation of networks of surface active molecules at the fluid-fluid interface. For example, proteins spontaneously diffuse from the solution bulk to the interfaces in order to minimize interactions between their hydrophobic regions and the aqueous solution. Then, interfacial tension decreases and proteins layers are formed. Globular proteins behave like deformable spheres (e.g. BSA or lysozyme) and different studies show that the interface elastic modulus is greater than the interface viscous modulus. The conformation and thickness of these layers depends on the type of protein and the deformation history of the material.

The stability of thin films (drainage, evaporation and film thickness), the formation of azimuthal instabilities and new curved thin film rupture dynamics are influenced by interfacial viscoelasticity.

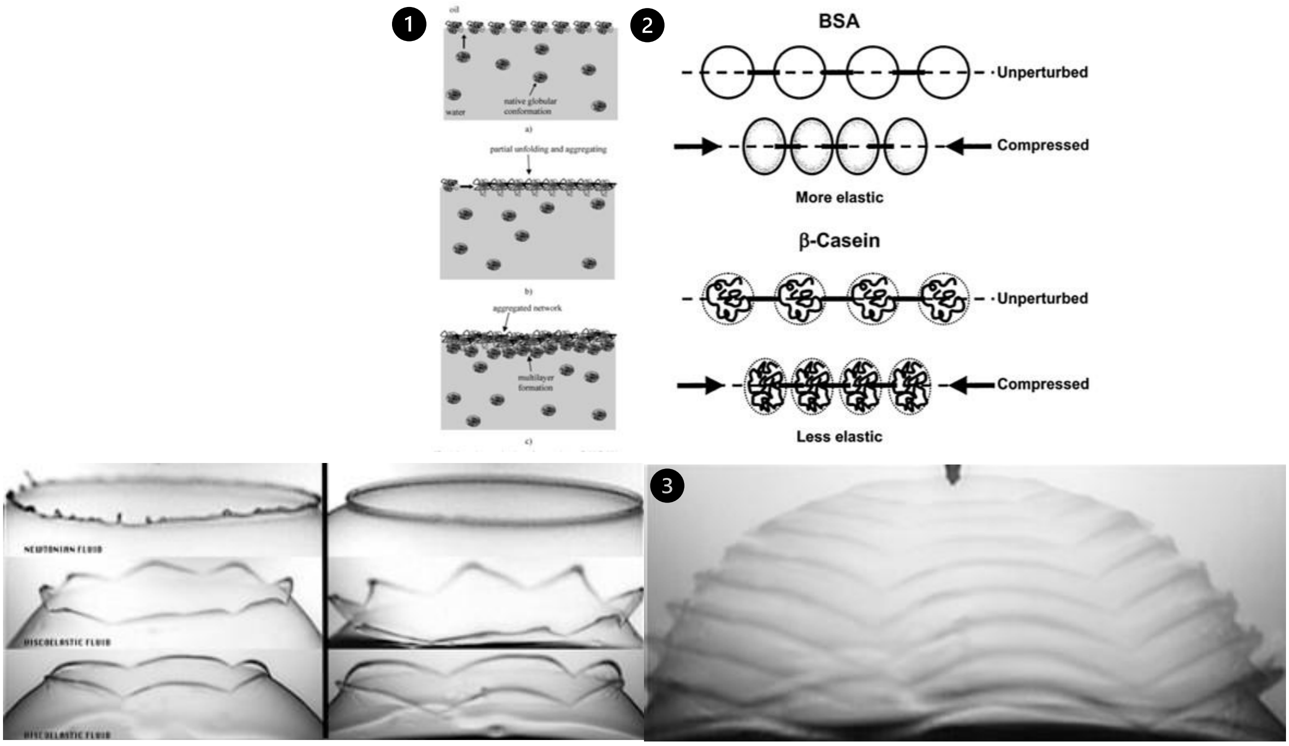
I report two example of the interfacial viscoelastic effects. The tear film consists of an outer lipid layer. The physical properties of the lipids are fundamental to governing the stability of the film. The interfacial viscoelastic properties of human meibomian lipids have been studied. Meibomian lipids form a viscoelastic film at the air-water interface with an elastic response at room temperature. The presence of the viscoelastic monolayer stabilises the film and the critical thickness for dehumidification decrease in order to form a thinner aqueous sub-phase.

Another example is about the bursting of curved thin films. When a Newtonian bubble bursts, the dynamics of film retraction is controlled by surface, inertial and viscous forces. When considering a liquid with a viscoelastic interface, the scenario is enriched by the appearance of a new significant contribution, the elastic force. The amount of elastic energy stored in the thin film forming the bubble depends on the deformation history (i.e. inflation) and influences the film's retraction velocity and its opening dynamics, which resembles the blossoming of a flower. *(Tammaro, Gala et al., "Flowering in bursting bubbles with viscoelastic interfaces" - in PNAS review)*

I want to study surface rheology and thin films surface instabilities formation in order to obtain the aim of my research project: the control of thin film formation (i.e. the control of thin film thickness or the formation/suppression of specific thin film surface patterns).

I think that my research can bring a development in a lot of engeneering fields, particularly:

1. Non miscible polymer blends are considered as colloid or suspension and particles change their form under shear stress. Interfacial tension between polymer is an important parameter which caracterize the blend stability. For example, PS-PMMA blends show different morphologies due to preparation method. During preparetion, the effect of elasticity on the blend stability is very important.
2. Perovskite solar cells suffer oxygen atmosferic concentration, humidity and ultraviolet radiation. Then, polymer thin films can be used as coatings.



1. *Surface-active molecules diffusion from bulk to interface.* ***2.*** *Globular proteins behaviour as deformable sphere.* ***3.*** *Effect of interfacial viscoelasticity on bubble rupture.*

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