

Improving measurements of surface viscosity of filaments and membranes

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Credit: *Physical Review Letters* (2020). DOI: [10.1103/PhysRevLett.125.114502](https://doi.org/10.1103/PhysRevLett.125.114502)

Researchers at the Universidad Carlos III de Madrid (UC3M) have

published a scientific paper that lays the foundation for developing a more precise method of measuring surface viscosity in liquid filaments and biological membranes with viscous surfaces. This development could be applied in the food, pharmaceutical or biomedical industries.

Liquid filaments can be found in various contexts in our everyday lives, such as a stream of tap water, shower gel or the milk we put in our coffees. On a biological level, they are present in processes that occur inside organisms, "such as in the stretching and breakup of vesicles, in cell division or in the protein-covered filaments within cells, among others. In addition to this, they are crucial in a multitude of technologies where the precise control of drop production is required, such as in 3D printing and the additive manufacturing, for example.

These liquid filaments are inherently unstable due to their [surface](#) tension, resulting in a process in which small disturbances are amplified causing the drops to fragment. This can be seen in saliva filaments, for example, that form on our lips and eventually end up being expelled in the form of droplets during speech, or in the water stream in showers which "breaks" when it is very narrow and ends up forming small droplets. "This is because spheres are the geometric shape with the smallest surface for a fixed given volume, so adopting a [spherical shape](#) minimizes [surface energy](#)," explain Alejandro Martínez Calvo and Alejandro Sevilla Santiago from the UC3M's Fluid Mechanics Group.

In their research, recently published in the *Physical Review Letters* journal, they have theoretically and numerically studied a case in which the [filament](#) surface is viscous, which occurs when the surface is covered by a concentration of molecules (usually called surfactants). In some cases, these types of molecules are able to form a complex structure that gives the surface some resistance to flow, which manifests itself through surface viscosity.

The measurement of the coefficient of surface viscosity of liquid filaments and [biological membranes](#) consisting of these molecules is a challenge at the moment, due to the physiochemical complexity associated with hydrodynamic coupling of the filament's surface with its interior. In their work, the scientists have discovered a new universal framework where the [surface tension](#) is in dynamic equilibrium with the surface viscous force, resulting in an exponential thinning of the filament radius until it ends up taking the form of drops of spherical vesicles, with a time decay that depends only on the surface properties, among which is the surface viscosity.

This work would be a significant step for the development of a non-intrusive method of measurement of viscosity coefficients which would have a greater accuracy than those currently available. Current methods of measurement make use of moving mechanical parts that distort the interface, such as cones, plates, cylinders, or rings that are placed on the surface and moved around in a controlled manner. These intrusive methods create variations in molecule concentration that give rise to surface elastic forces, in addition to their own surface viscose forces that are intended to be measured. "In this configuration we have studied, the distortion of the interface is not caused from the outside of the system through mechanical methods but occurs spontaneously. Thus, the measurement technique that could be developed with our idea would be non-intrusive, as measuring the rate at which the filament is distorted using photographic techniques would be sufficient," state the researchers.

More information: A. Martínez-Calvo et al. Universal Thinning of Liquid Filaments under Dominant Surface Forces, *Physical Review Letters* (2020). [DOI: 10.1103/PhysRevLett.125.114502](https://doi.org/10.1103/PhysRevLett.125.114502)

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