Profile Analysis Tensiometry (PAT) provides a suitable tool for surface tension measurements in static or weak dynamic conditions. The instruction is such that, at first, a drop of liquid is formed at the capillary tip and then the digital images of the drop are recorded over time to fit the Young–Laplace equation to accurately determine the surface tension (±0.1 mN/m). The Young-Laplace equation is based on the balance of forces (surface tension and body forces including gravity/buoyancy) in equilibrium and no inertia/drag forces contribute to drop profile. Under dynamic conditions, PAT is only useful for the long-time adsorption dynamics and is limited to 0.2 Hz for drop oscillation experiments. In this presentation we mostly discussed the possibilities for increasing the application of PAT for surface tension measurements under dynamic conditions.

In dynamic conditions, in addition to body forces, inertia forces of the internal phase and drag forces of the external phase contribute to the shape of a drop. In such cases, for a fixed capillary size, and a proper drop size, the standard deviation of the drop profile fitting with the Young-Laplace equation suddenly increase beyond a certain liquid flow rate. For lower flow rates, although far from static conditions, the Young-Laplace equation is yet applicable for the description of the drop profile, while the obtained surface tensions have incorrect values. The main target is to find the limits for different variables until which the Young-Laplace equation describes properly the drop profile and to discuss approximate methods for considering the contribution of inertia and drag forces to the dynamic drop shape to estimate the surface tensions with a reasonable accuracy.

This presentation is mainly focused on liquid/gas systems in which the effect of the drag force on the drop profile is negligible. Then the inertia force is considered as extra apparent body force which is combined with the gravity force. We test the proposed procedure for predicting the surface tension values from growing drop experiments of pure liquids. The results are compared with capillary pressure experiments in order to estimate the limits of the applicability of the dynamic drop profile for measurements of dynamic surface tensions of surfactant solutions.

Figure: Example of the shapes of water drops of different size under static (top) and dynamic conditions (bottom) with an inflow of liquid $Q = 42$ mm$^3$/s.