



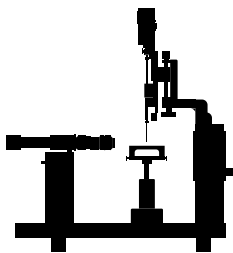
Application Note

Surface tension measurement for high-viscosity liquids with the lamella method

The determination of surface tension for molten polymers and hot-melt adhesives remains a significant experimental challenge. Conventional techniques, such as gravimetric tensiometers, require around 50 g per sample and solidifying melts can be difficult to clean from the probes that are made of platinum iridium without damaging them. Optical methods based on pendant drop contour analysis can be used to measure the surface tension of highly viscous melts, but the pendant drop method faces practical limitations. The dosing of viscous samples using heated syringes and needles is often complex, prone to instability, and requires sophisticated and costly hardware. In addition, issues such as gas bubble formation, contamination, and demanding cleaning procedures can compromise measurement reliability and reproducibility. In extreme cases, generating droplets of a defined and reproducible size becomes difficult or even impossible. To overcome these challenges, the **lamella method**, introduced by **DataPhysics Instruments**, provides a robust and reliable solution for the characterization of **high-viscosity and high-temperature systems**. This method enables rapid and precise surface tension measurements at temperatures **up to 700 °C**, while significantly reducing experimental complexity and measurement uncertainty. Its design minimizes contact with difficult-to-clean components and utilizes an open sample configuration, effectively preventing gas entrapment. In this application note, hot-melt adhesive is used as a representative example to demonstrate and evaluate the performance of the lamella method.

Measurement device

Optical contact angle measuring and contour analysis systems – OCA series



Measurement method

Optical contour analysis systems
Lamella method

Measured quantities

Surface tension

Environmental conditions

120 °C

Samples

Hot-melt adhesive

Industries

High viscosity liquids
Viscous molten polymer
Slow-flowing materials
Adhesives

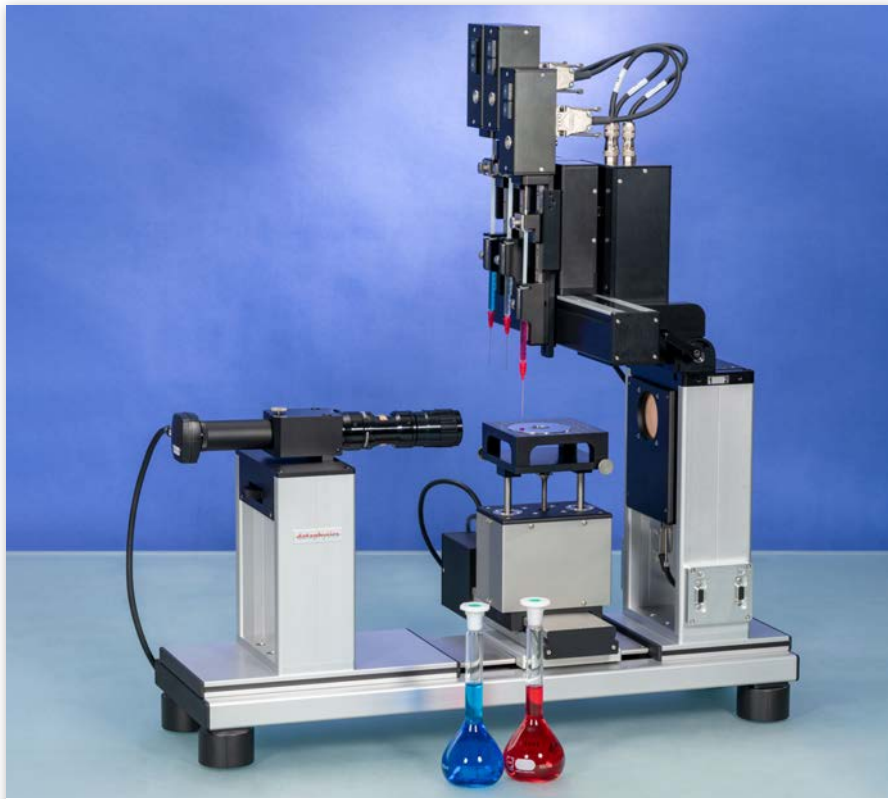


Fig. 1: The optical contact angle measuring and contour analysis systems of the OCA series manufactured by DataPhysics Instruments

Experiment

The measurement was performed at an elevated temperature of 120 °C, maintained by an electrically heated temperature control system (TEC 350), which replaced the standard sample stage of the OCA optical contact angle measuring instrument (Fig. 1)^[1]. Depending on the sample volume, an appropriate sample container and test piece (Fig. 3) were selected.

The hot-melt adhesive was placed into the well of a clean, specially designed sample container and heated to 120 °C until it was fully melted. A spherical test piece was then immersed into the molten sample until its lower end was completely wetted. The test piece was subsequently withdrawn vertically, forming a liquid lamella, as illustrated in Fig. 4. A digital image of the lamella was recorded using the OCA's camera system at the required temperature.

For calculating the surface tension, the system determines the weight of the lamella based on its geometry as detected by the camera system. This requires knowledge of the density of the molten material and the magnification factor of the recorded image. The sample density is provided by the operator, while the magnification factor is calculated from the ratio between the number of pixels representing the upper part of the test body in the image and its known physical dimensions.



Fig. 3: Sample vessel and test piece for lamella method

Theory

The **lamella method** is an optical technique for determining the surface tension of high-viscosity liquids, particularly molten polymers and hot-melt adhesives. The method is based on analysing the shape of a liquid lamella (thin film or bridge) formed between defined geometries.

Similar to the pendant drop method, the lamella method relies on the equilibrium between gravitational forces acting on the liquid and its surface tension. Fig. 2 schematically illustrates the formation of a lamella when a vertical test piece is brought into contact with a liquid. The shape of the lamella depends on the contact angle between the liquid and the test piece. For contact angles between 0° and 90°, the lamella curves upwards, indicating wetting behaviour. For contact angles between 90° and 180°, the lamella curves downwards, while at a contact angle of 90°, the liquid surface remains essentially flat with no curvature.^{[2][3][4][5]}

The formation of the lamella is driven by the liquid's tendency to wet the test surface. Surface tension acts to minimize the newly created surface

area, while gravity acts in the opposite direction, limiting the rise of the liquid. At equilibrium, these opposing forces are balanced. By analysing the lamella shape—specifically its contour, which is determined by the density and geometry of the liquid—the surface tension can be calculated. This evaluation is based on the **Young–Laplace differential equation**^[2]^[3], which describes the relationship between surface tension and interface curvature.

With modern advances in image acquisition systems, high-speed computing, and optimized evaluation algorithms, as implemented in the optical contact angle measuring and contour analysis systems of the **OCA series** by DataPhysics Instruments (Fig. 1), surface tension can now be determined easily and quickly.

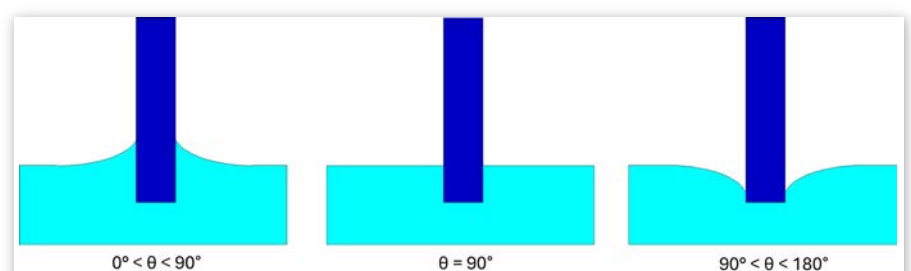


Fig. 2: Schematic illustration of lamella formation

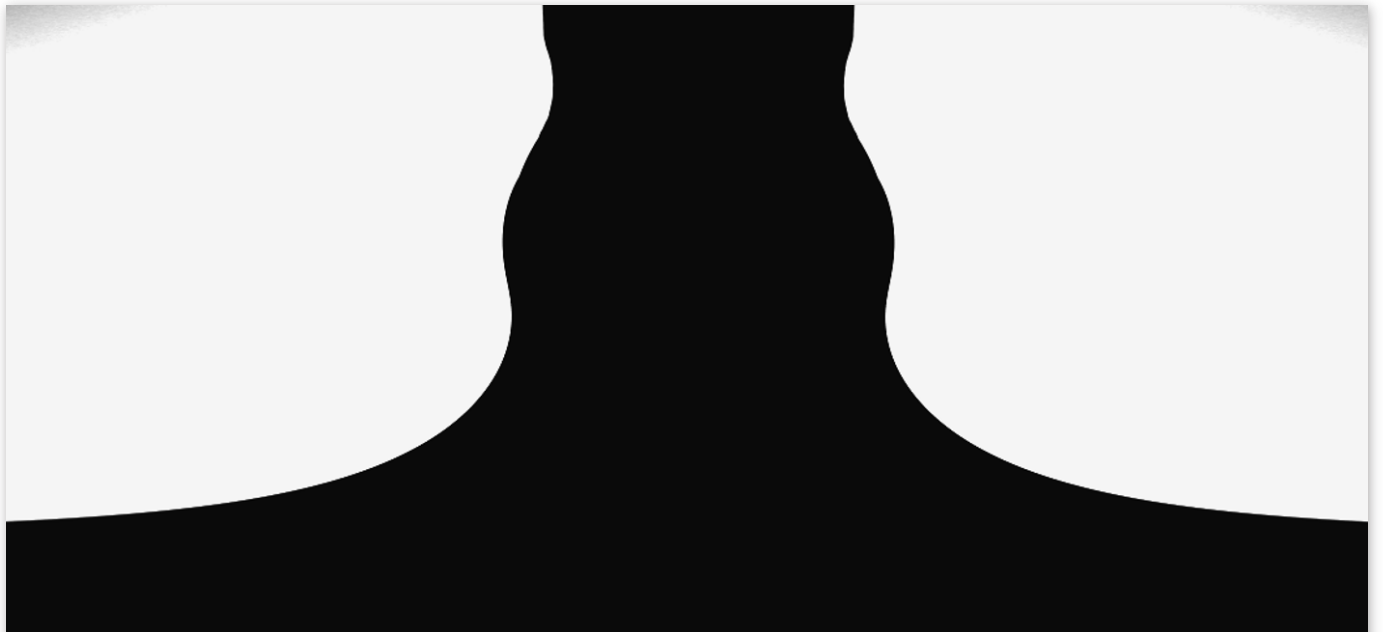


Fig. 4: Lamella of the hot-melt adhesive at 120 °C

After the measurement, both the test body and the sample container can be easily cleaned, for example using an ultrasonic bath.

Results & Discussion

In this application note, a viscous hot-melt adhesive was investigated, assuming a density of 1.0518 g/cm³.

The material was analysed using the lamella method. The corresponding image is shown in Fig. 4, where both the lamella and the spherical test piece are clearly visible. Based on this measurement, a surface tension of 34.81 ± 0.35 mN/m was determined using the Young–Laplace equation.

For comparison, the same material was also analysed using the pendant drop method. Fig. 5 shows a pendant drop at 120 °C. From this image, a surface tension of 35.16 ± 0.04 mN/m was obtained.

Overall, the results from both methods show excellent agreement, with a deviation of less than 1%.

Summary

The results demonstrate that the lamella method provides reliable and accurate surface tension measurements for high-viscosity liquids, such as molten polymers and hot-melt adhesives. The excellent agreement with the established pendant drop method, with a deviation of less than 1%, confirms the validity of this approach. In addition, the lamella method enables simplified sample handling, reduces experimental complexity, and avoids common issues such as droplet instability and gas bubble formation.

Overall, the lamella method represents a robust and efficient alternative for surface tension determination at elevated temperatures and high viscosities, making it particularly well suited for both industrial and research applications involving challenging liquid systems.



Fig. 5: Pendant drop of the hot-melt adhesives at 120 °C

Reference

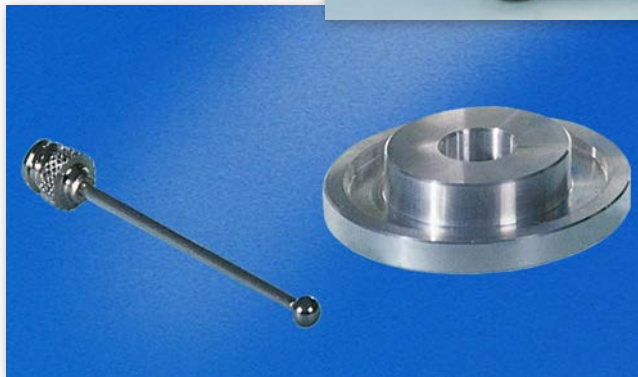
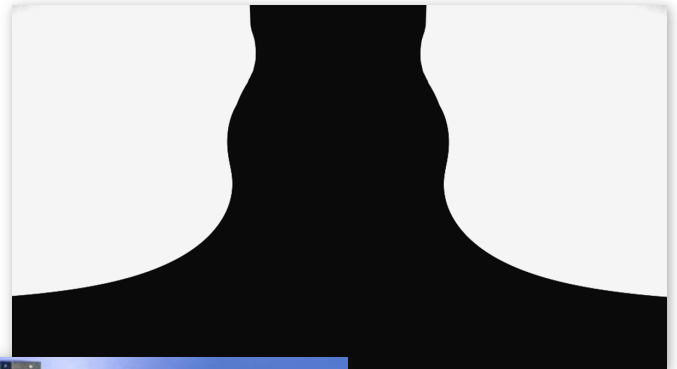
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- [5] Orr, F. M.; Scriven, L. E.; Rivas, A. P. Pendant Rings between Solids: Meniscus Properties and Capillary Force. *J. Fluid Mech.* **1975**, 67 (4), 723–742.

Table 1: Surface tension of the hot-melt adhesive at 120 °C

Method	Surface tension (mN/m)	Std (mN/m)
Lamella method	34.81	0.35
Pendant drop method	35.16	0.04

Optical contact angle measuring and contour analysis systems – OCA series

-Lamella method



We will find a tailor-made solution for your surface science use case and will be pleased to provide you with an obligation-free quotation for the system that fits your needs. For more information please contact us.

DataPhysics Instruments GmbH • Raiffeisenstraße 34 • 70794 Filderstadt, Germany
phone +49 (0)711 770556-0 • fax +49 (0)711 770556-99
sales@dataphysics-instruments.com • www.dataphysics-instruments.com

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