Droplet Lab

The Practical Guide to Surface Science for the Cosmetics Industry

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INTRODUCTION

Understanding how cosmetics interact with the skin depends on the surface tension of liquids and the contact angle, which is the angle generated by a liquid droplet when it encounters a solid surface [1]. These characteristics directly impact the performance and user experience of goods by influencing how they disseminate, adhere, and enter the skin.

Cosmetic formulation is a complex fusion of art and science that aims to create goods that not only embellish but also improve a person's inherent attractiveness [2]. It might be difficult to strike the ideal mix between practicality and beauty. In order to make products that endure the rigors of everyday life while preserving their aesthetic appeal, cosmetic formulators place a high priority on ensuring the best: [3].

Spreadability

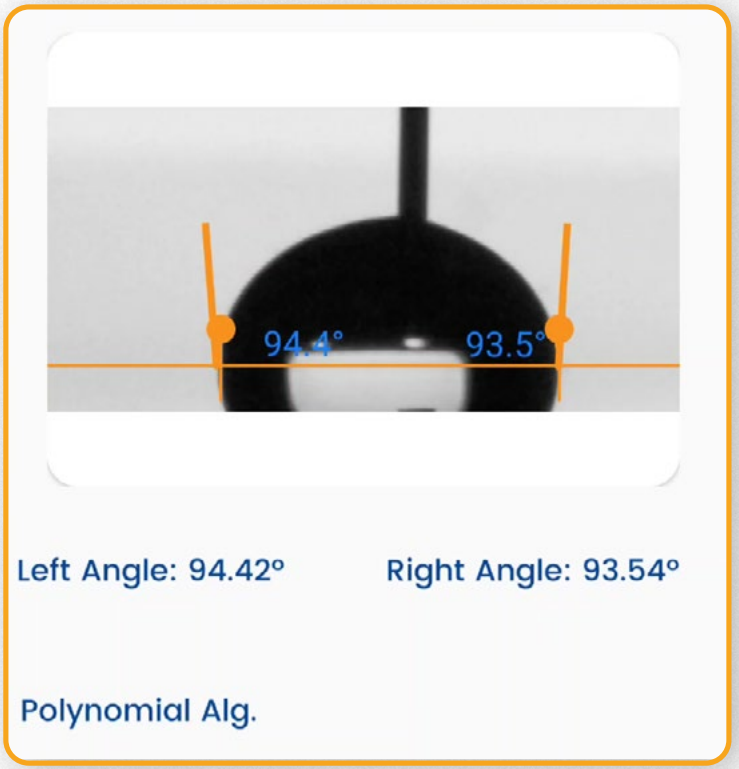
Longevity

Water Resistance

Some of the important surface properties that are used to understand the behaviour of cosmetic products and for their quality improvement are:

Contact Angle Measurement

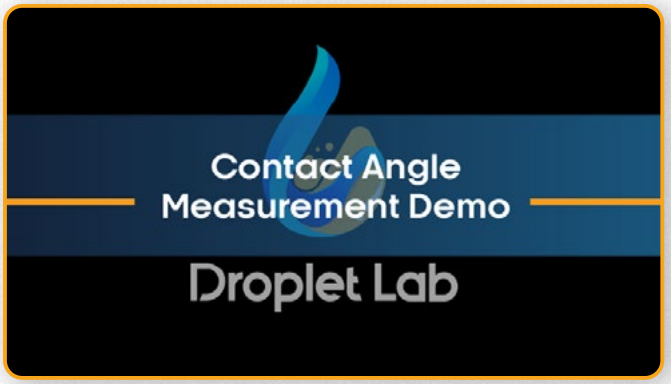
Contact angle quantifies the wettability of a surface, representing the angle between the surface of a liquid and a solid surface.



Sample Image taken from Droplet Lab Tensiometer

Droplet Lab offers both Young-laplace and Polynomial methods in our Tensiometer.

Young - Laplace Method	Polynomial Method
Uses the whole drop profile to calculate the contact angle value	Uses only a certain percentage of the drop profile to calculate the contact angle value.
Only compatible with an axisymmetric drop. This is not always seen in practice, as a needle is typically inserted into the drop to increase/decrease the drop volume.	Compatible with both axisymmetric and non-axisymmetric drops.
Measurement results are more consistent compared to the polynomial fitting method.	Measurement results are less consistent, as they are affected by local surface imperfections.



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Learn how Contact Angle measurement is done on our Tensiometer

Dynamic Contact Angle

Ideally, when a drop is placed on a solid surface, a unique angle exists between the liquid and the solid surface. The value of this ideal contact angle (the so-called Young's contact angle) can be calculated using Young's equation.

In practice, due to the surface geometry, roughness, heterogeneity, contamination, and deformation, the value of the contact angle on a surface is not necessarily a unique value but falls in a range. The upper and lower limits of this range are called the advancing contact angle and the receding contact angle, respectively.

The value of Advancing and receding for a solid surface is also very sensitive and can be affected by many parameters, e.g., temperature, humidity, homogeneity, and minute contamination of the surface and liquid. For example, the advancing and receding contact angles of a surface at different locations can be different.

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Learn how Dynamic Contact Angle measurement is done on our Tensiometer

Dynamic Contact Angle versus Static Contact Angle

Practical surfaces and coatings naturally show contact angle hysteresis, indicating a range of equilibrium values. Measuring static contact angles provides a single value within this range. Solely relying on static measurements poses problems, like poor repeatability and incomplete surface assessment regarding adhesion, cleanliness, roughness, and homogeneity.

Practical applications require understanding a surface's liquid spreading ease (advancing angle) and removal ease (receding angle), such as in painting and cleaning. Measuring advancing and receding angles offers a holistic view of liquid-solid interaction, unlike static measurements, which yield an arbitrary value within the range.

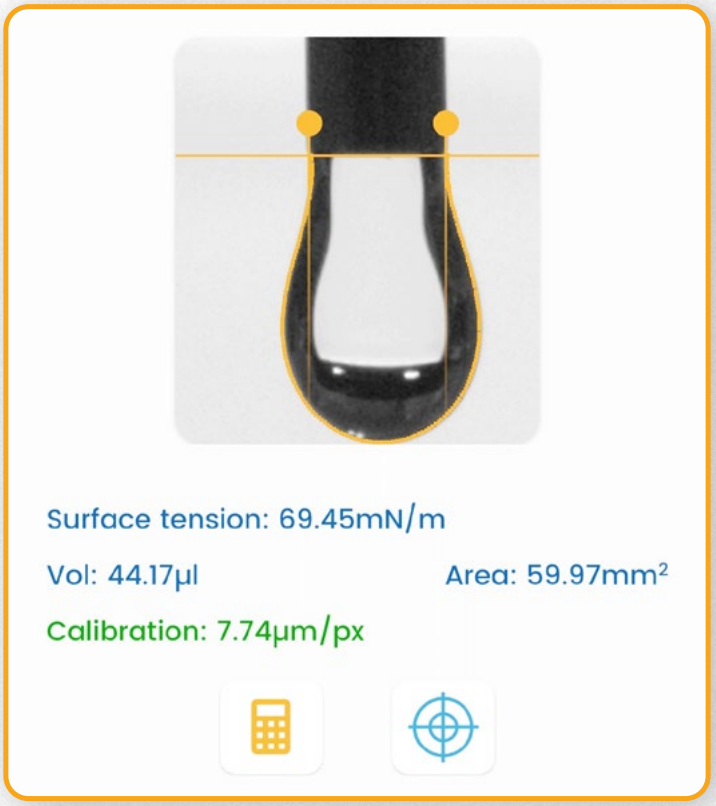
This insight is crucial for real-world surfaces with variations, roughness, and dynamics, aiding industries like cosmetics, materials science, and biotechnology in designing effective surfaces and optimizing processes.

To improve the data quality of your contact angle measurements we recommend you read up on the best practices in the below referenced paper.

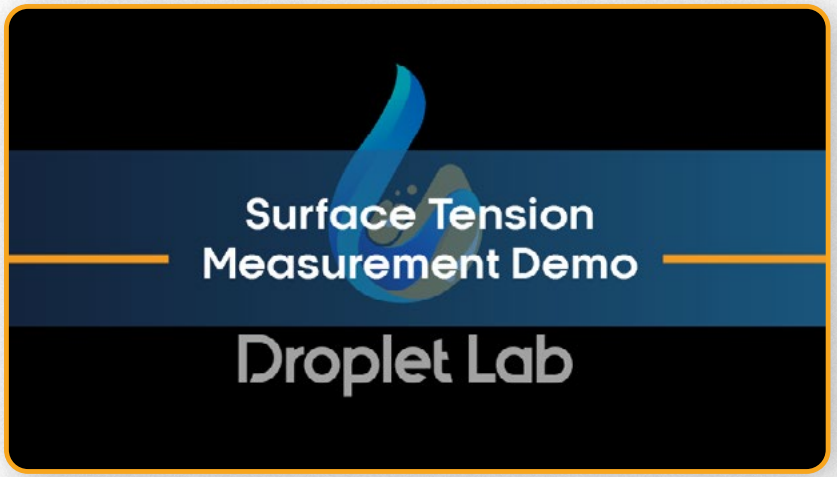
Guidelines to measurements of reproducible contact angles using a sessile-drop technique

Surface Tension Measurement

This property measures the force acting on the surface of a liquid, aiming to minimize its surface area.



Sample Image taken from Droplet Lab Tensiometer



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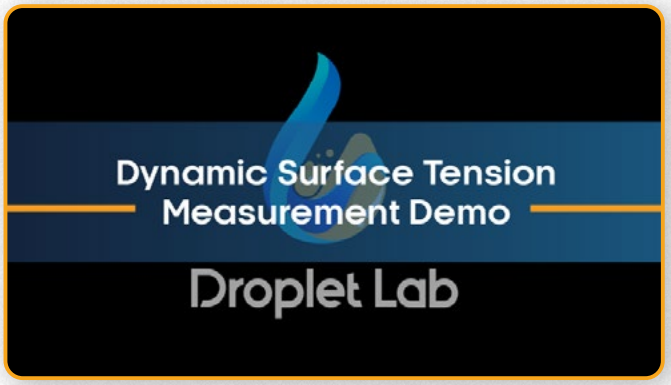
Learn How Surface Tension measurement is done on our Tensiometer

Dynamic Surface Tension

Dynamic surface tension is different from static surface tension, which refers to the surface energy per unit area (or force acting per unit length along the edge of a liquid surface).

Static surface tension characterizes the equilibrium state of the liquid interface, while dynamic surface tension takes into account the kinetics of changes at the interface. These changes could be the presence of surfactants, additives, or temperature, pressure, and/or compositional changes at the interface.



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Learn how dynamic surface tension measurement is done on our Tensiometer

When to use Dynamic Surface Tension Measurement

Dynamic surface tension is particularly important when dealing with processes that involve rapid changes at the liquid-gas or liquid-liquid interface, such as droplet and bubble formation or coalescence (change of surface area), behavior of foams, and drying of paints (change of composition, e.g. evaporation of solvent). It is measured by analyzing the shape of a hanging droplet over time.

Dynamic surface tension has applications in various industries, including cosmetics, coating, pharmaceuticals, paint, food and beverage, and industrial processes where understanding and controlling the behavior of liquid interfaces is essential for product quality and process efficiency.

Scientific Validation of our Instrument:

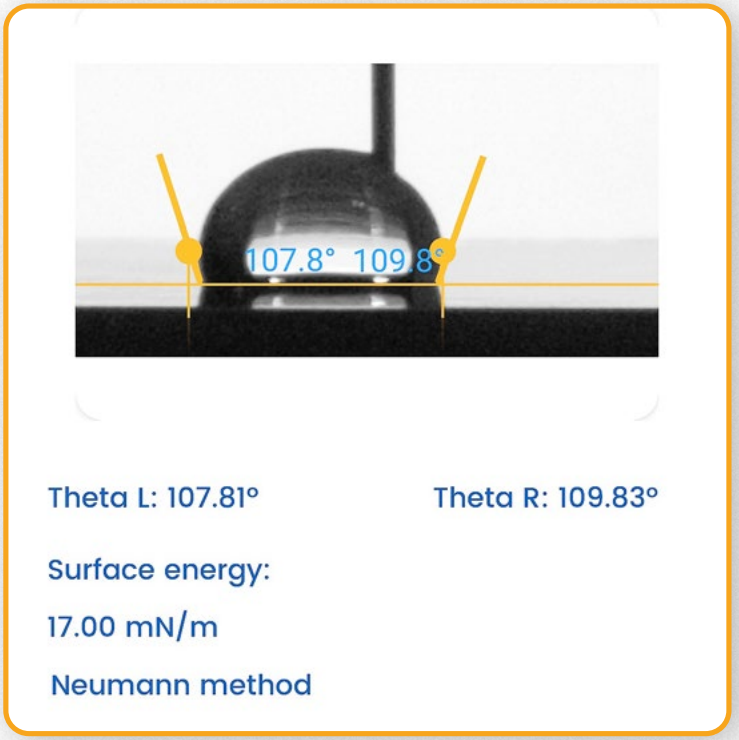
Accuracy and reliability are the cornerstones of any scientific instrument, and concerns regarding the precision of our setup are both understood and acknowledged. While our state-of-the-art tech lays the foundation, it's our unwavering commitment to validation that sets us apart.

This promise of transparency and scientific rigor is supported by two peer-reviewed papers that thoroughly detail and validate the performance of our instrument:

1. Review of Scientific Instruments
2. Colloids & Surfaces A

Surface Energy Measurement

Surface energy refers to the energy required to create a unit area of a new surface.



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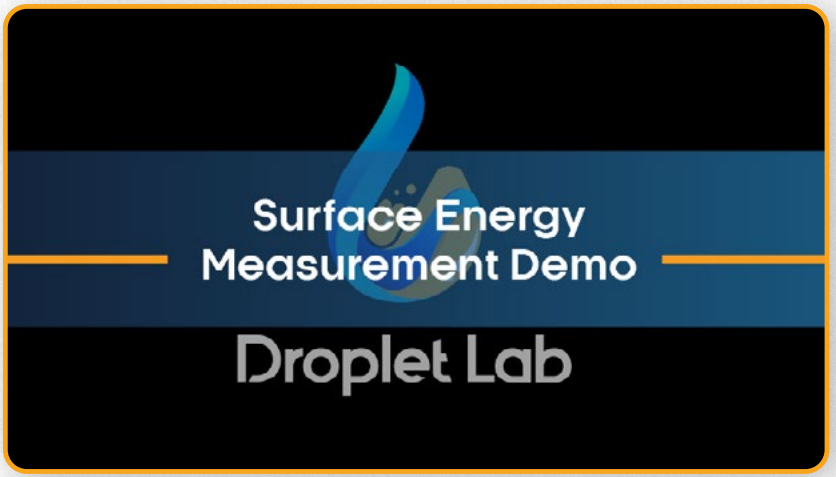

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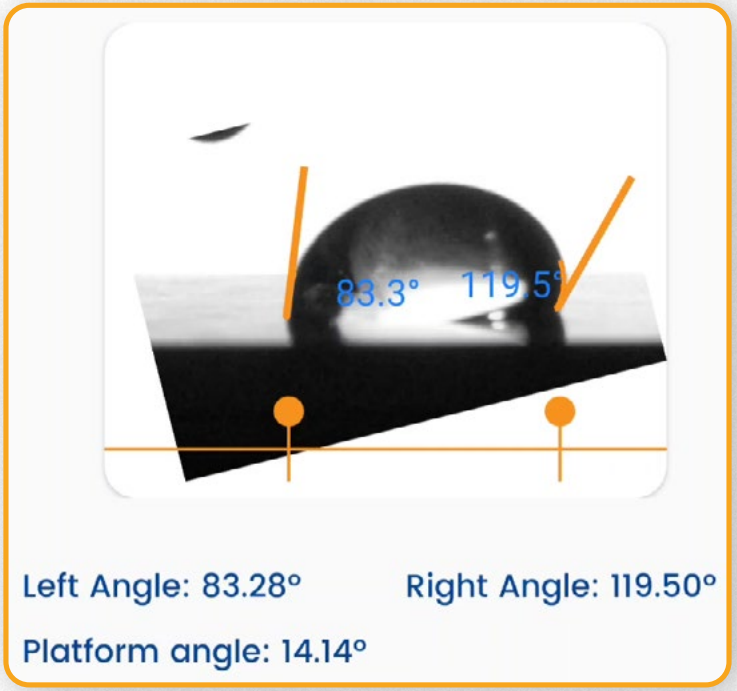
Sliding Angle Measurement

The sliding angle measures the angle at which a liquid film slides over a solid surface. It is commonly employed to assess the slip resistance of a surface.



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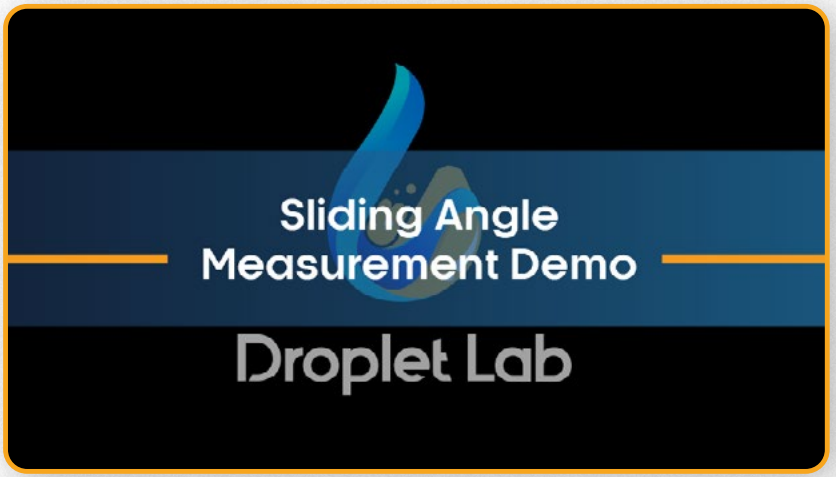

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Learn How Sliding Angle Measurement is done on our Tensiometer

By carefully considering and measuring these surface properties, cosmetics manufacturers can continually improve their products' quality and meet the evolving needs of their customers.

Real-World Implications
Case Studies

Within the cosmetics industry, several case studies exemplify the advantages derived from conducting surface property measurements.

Presented below are a few illustrative instances:

1 Amplifying Sunscreen's Shield

Sunscreen does more than just block the sun—it forms a protective barrier between our delicate skin and those relentless ultraviolet rays. Understanding the underlying science behind this solution has been crucial.

When researchers began examining contact angles between sunscreen droplets and skin, a bigger picture emerged: It was clear that optimizing these angles would provide a more uniform, reliable, resilient, and longer-lasting protective layer.

But this wasn't just about protection. This data also hinted at a possibility of a sunscreen that feltless like a mask and more like a second skin—a sunscreen that you could wear without feeling weighed down.

2 Hydration on a Whole New Level

Moisturizers are key to healthy skin, but not all are created equal. That initial silky feel might seem like the most important aspect, but prioritizing long-lasting hydration is key to a successful
moisturizer.

As such, researchers explored the droplet contact angles and what they found was quite transformative: The moisturizer would penetrate deeper when these angles were optimized, allowing them to nourish multiple layers and not just the surface.

Imagine a moisturizer that works round the clock to not just provide a temporary relief, but also a lasting, deep-rooted hydration. That's what we call science and innovation combined.

3 Crafting the Perfect Mascara

Everyone wants a mascara that stays put, but how do you scientifically make that possible? This is where researchers stepped in to find the answer.

Through exploration into how mascara bonds with the skin and eyelashes, discoveries have paved the way for a mascara that promises enduring brilliance. By digging into the contact angles of mascara droplets, formulators can identify a formula for a smudge-free, long-lasting wear.

With this kind of precision, wearers can say goodbye to regular touch-ups and hello to confidence that lasts.

4 Tailored Elegance in Color Cosmetics

The world of color cosmetics is as vast as it is complex, and formulators realized that there was an opportunity to bridge the gap between color, texture, and individual skin types.

Cosmetic research opens the doors to products that don't only sit on the skin but become a part of it—or at least take on that appearance. Precision-measured interactions mean cosmetics can adapt and respond to different skin conditions, leading to a more personalized beauty experience.

This is more than a mere enhancement—it's a revolution in users' relationship with their makeup.

5 Eco-Elegance: Green Cosmetology

The environment matters to both consumers and businesses, and sustainable cosmetics have become more than just a trend—they're a necessity. Industry-wide ventures into surface science have not only optimized product performance but have also championed environmental responsibility.

By understanding molecular-level interactions, research can assist formulators in creatingproducts that are both efficient and eco-friendly. In a world grappling with environmental challenges, this kind of research and insights offer a beacon of hope—as well as a roadmap for a greener future in cosmetics.

At the heart of these tales is a common thread: the undeniable power of surface property measurements. When wielded with precision and insight, they transform challenges into success stories, ensuring that pigments do more than just color surfaces; they also interact, adhere, and last.

We are your partners all the way in solving your Business & Technological challenges

If you are interested in implementing these or any other applications you can send an email to us at abhandankar@dropletlab.com

We would also be interested to hear from you if you face any sample related difficulties. Book a call with our engineer to discuss the same with the below link https://calendly.com/gsaini-ob4

Standards and Guidelines

In an industry where precision reigns supreme, where does one turn to ensure that their products can survive this scrutiny? The answer lies in standards and guidelines: the compass that guides cosmetics manufacturers through the complex maze of quality and performance.

The American Society for Testing and Materials (ASTM) technical standards on surface property measurement are widely used to ensure the quality of cosmetics. For example:

- **ASTM E104: Using Aqueous Solutions to Maintain Constant Relative Humidity, Standard**

  Practice ASTM E104: This standard focuses on preserving constant relative humidity, which can be crucial when researching how cosmetics behave under various humidity levels. It might have an indirect effect on how different humidity levels affect how cosmetics interact with skin surfaces. [5]

The International Organization for Standardization (ISO) develops and publishes international standards that are also relevant to the quality of cosmetics. ISO has several standards and guidelines on surface property measurement, including:

- **ISO 22716-** Cosmetics - Good Manufacturing Practices (GMP) - Recommendations for GMP: Good manufacturing practices are outlined in this ISO standard for the cosmetics sector. Even though it is not directly related to surface science, it is essential for ensuring the quality and safety of cosmetic products that come into contact with the skin. [6]

- **ISO 9073-12 -** "Textiles - Test Methods for Nonwoven," says: Liquid strike-through time for nonwoven fabrics: determination In cosmetic products like makeup removal wipes, nonwoven fabrics are frequently used. This standard might shed light on how liquids interact with nonwoven materials, which is important for interactions in thecosmetics industry. [7]

Sources

[1] Eudier F, Savary G, Grisel M, Picard C. Skin surface physico-chemistry: Characteristics, methods of measurement, influencing factors and future developments. Advances in Colloid and Interface Science 264 11-27 (2019).

[2] Preparation and techniques for advanced cosmetics formulation; let's make it simple for formulators https://onlytrainings.com/Preparation-and-techniques-for-advancedcosmetics formulation

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[4] Portilho L, Aiello LM, Vasques LI, Bagatin E, Leonardi GR. Effectiveness of sunscreens and factors influencing sun protection: a review. Brazilian Journal of Pharmaceutical Sciences 58 (2023).

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[6] https://www.fda.gov/media/86366/download

[7] https://www.iso.org/obp/ui/en/#!iso:std:30169:en