Droplet Lab

The Practical Guide to Surface Science for the Fabric Industry

Alidad Amirfazli

Department of Mechanical Engineering,
York University , Toronto, Canada

Amit Singh

PhD, Delhi University,
Post Doc - AIST Japan

+1 (647) 490-4644

abhandankar@dropletlab.com

www.dropletlab.com

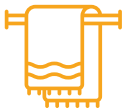
98 Major Wm Sharpe Dr Brampton,
ON L6X 3V1, Canada

TABLE OF CONTENTS

INTRODUCTION

There is a great importance of surface property measurements in fabric industry. Surface property analysis includes the examination of both physical and chemical attributes of a surface. For example water repellent and stain resistant fabric has been in high demand which simultaneously are breathable. Breathability is related to air permeability that is well defined in ASTM D737 standard [1].

Here are specific examples of how surface property measurement is applied in the fabrics industry:



Enhancing wettability for sportswear and outdoor clothing to keep wearers cool and dry.

Reducing fabric friction in clothing to prevent bunching up or snagging.

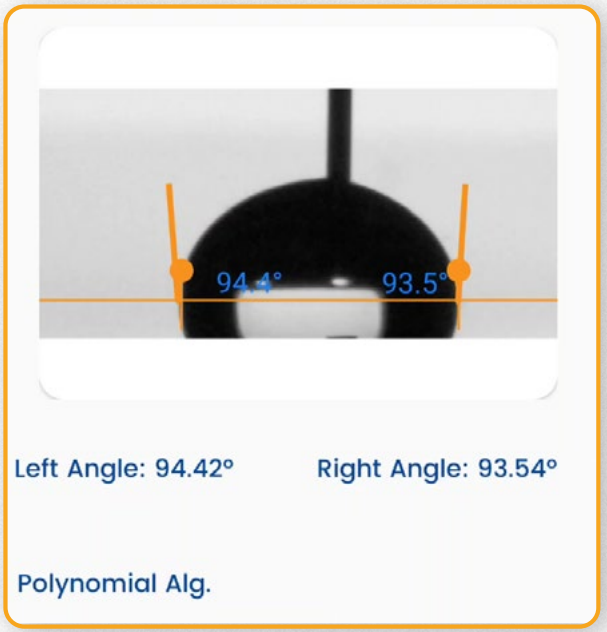
Improving adhesion for medical applications to ensure fabric stays in place securely.

Enhancing fabric drape for formal wear to achieve an elegant and sophisticated look.

Some of the important surface properties that are used to understand the behavior of fabrics and for their quality improvement are:

Contact Angle Measurement

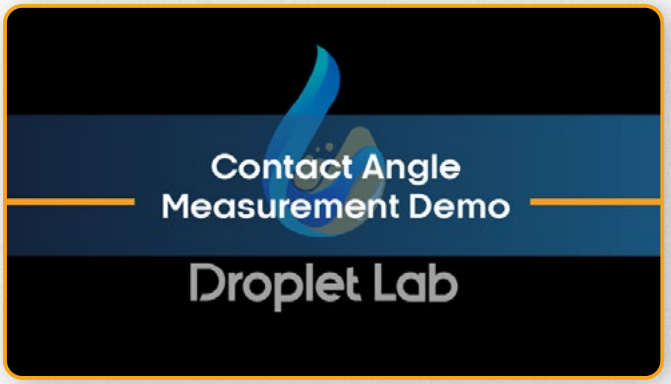
Contact angle quantifies the wettability of a surface, representing the angle between the surface of a liquid and a solid surface. This technique gauges fabric wettability by placing a liquid droplet on the fabric's surface and measuring the contact angle. The angle denotes the force needed to detach the liquid from the fabric [2]. A high contact angle is representative of water-resistant, while a fabric with a low contact angle is indicative of to be more absorbent.



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.



Watch us on:

YouTube

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.

Watch us on:

YouTube

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.

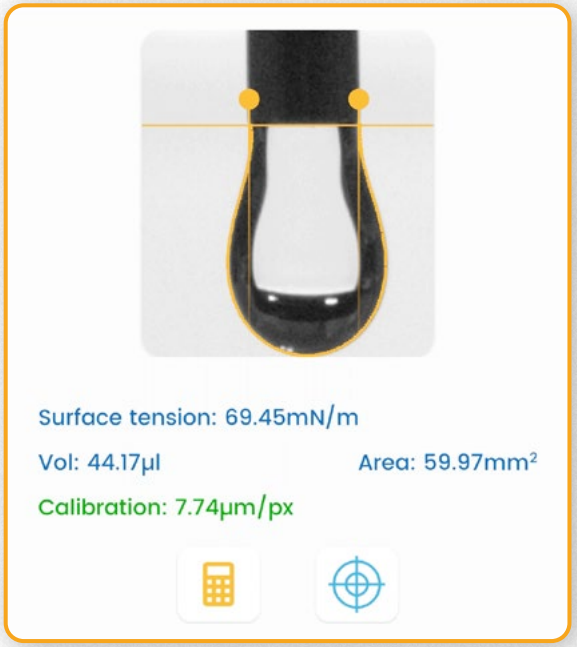
This insight is crucial for real-world surfaces with variations, roughness, and dynamics, aiding industries like fabrics, materials science, and biotechnology in designing effective surfaces and optimizing processes.

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

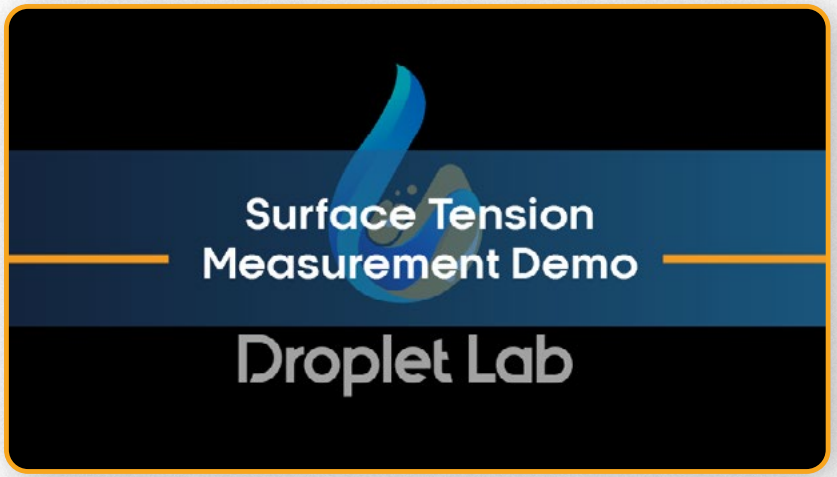
Guidelines to measurements of reproducible contact angles using a sessile-drop technique

Surface Tension Measurement

This property measures the force acting on the surface of a liquid, aiming to minimize its surface area. For synthetic fiber fabrics, measurement of polymeric materials surface tension can help with developing new fivers that can perform for stain resistance or breathability. At the same time knowledge of surface tension of liquids that come into contact with various liquids can help with designing fabrics that are very effective for personal protection equipment (PPE).



Sample Image taken from Droplet Lab Tensiometer



Watch us on:

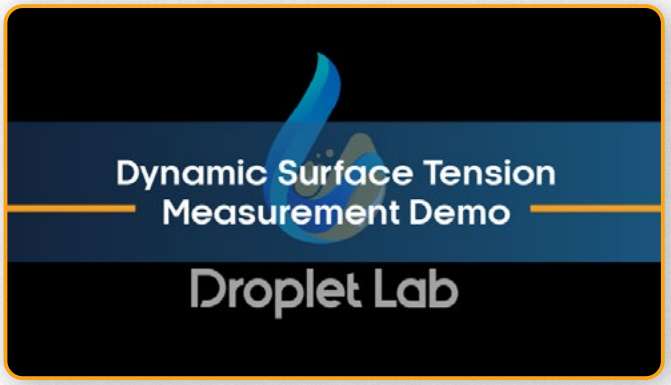
YouTube

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.



Watch us on:

YouTube

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 fabrics, coating, pharmaceuticals, cosmetics, 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:

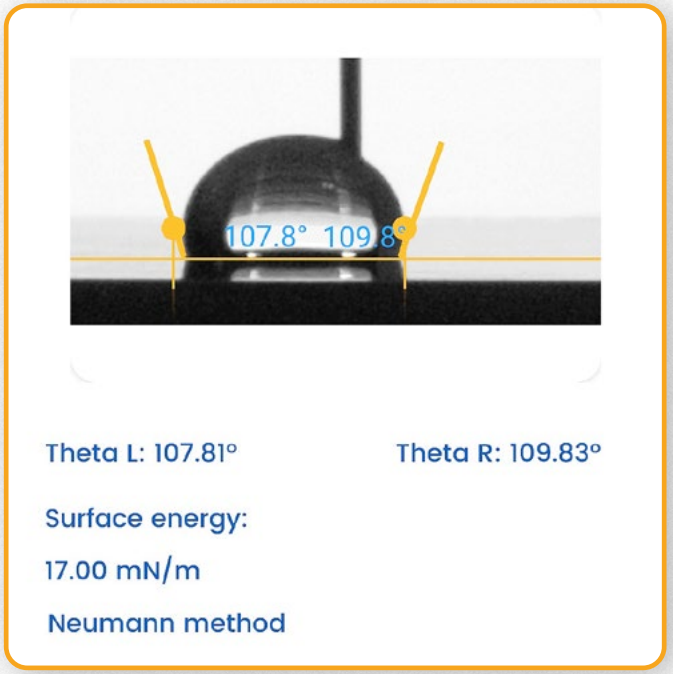
Accuracy and reliability are the cornerstones of any scientific instrument, and concerns regarding the precision of our setup are both understood and acknowledged. While our state-of-the-art tech lays the foundation, it's our unwavering commitment to validation that sets us apart.

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

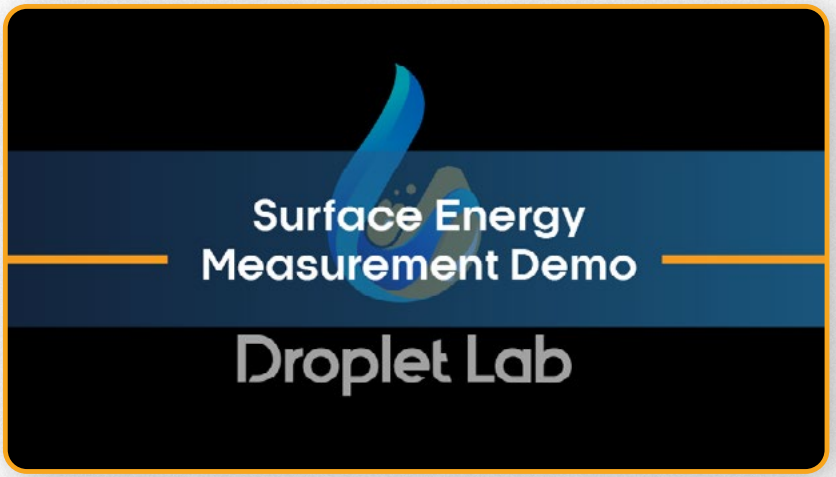
1. Review of Scientific Instruments
2. Colloids & Surfaces A

Surface Energy Measurement

The surface energy is a measure of how strongly a fabric adheres to other materials. Manufacturer do surface energy measurements for ensuring that fabrics will accept dyes evenly and consistently as well as their attachment to other materials in a composite system. Surface energy refers to the energy required to create a unit area of a new surface.



Sample Image taken from Droplet Lab Tensiometer



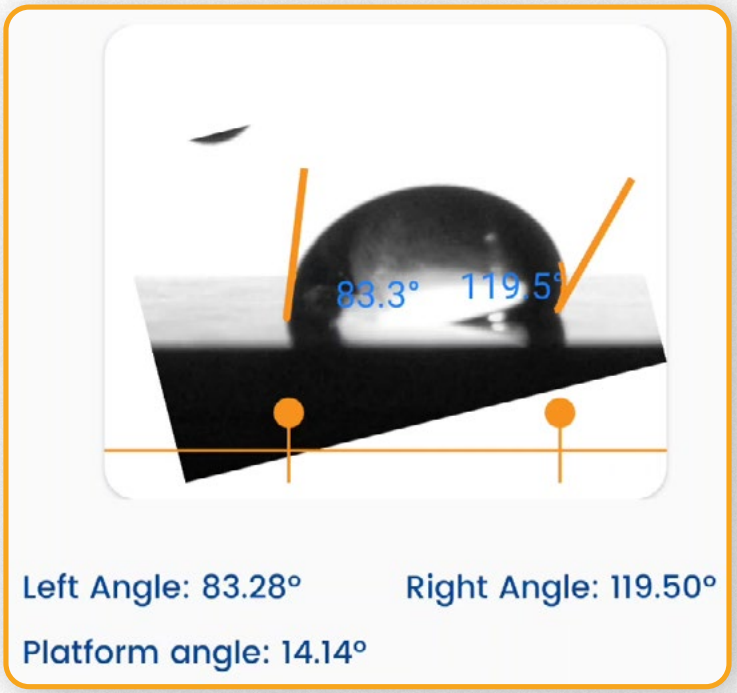
Watch us on:

YouTube

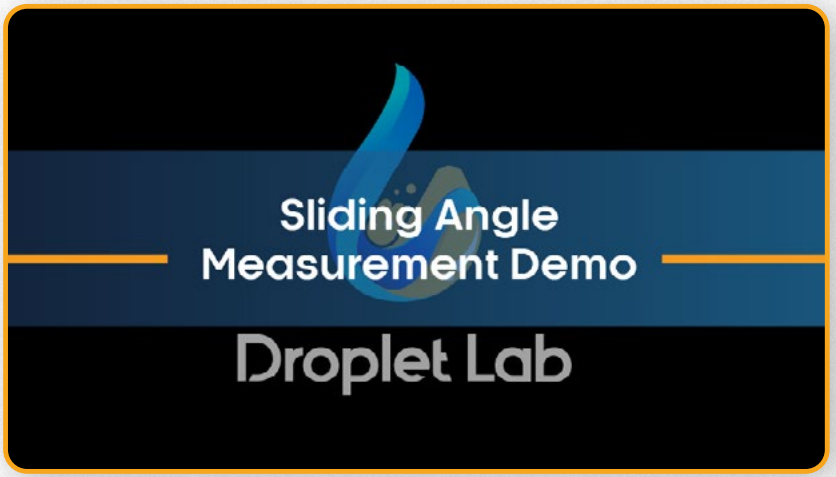
Learn how Surface Energy measurement is done on our Tensiometer

Sliding Angle Measurement

The sliding angle measures the angle at which a liquid film slides over a solid surface. It reflects how easily liquid will roll-off a fabric and is always linked to the comfort [3]. By measuring the sliding angle, manufacturers can determine their fabrics stain resistance performance.



Sample Image taken from Droplet Lab Tensiometer



Watch us on:

YouTube

Learn How Sliding Angle Measurement is done on our Tensiometer

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

What Droplet Lab Can Offer

Surface science involves diverse materials, and fabrics or membranes are no exception. But traditional methods of taping or crudely fastening samples? That's yesterday's news. We're embracing the future with our custom Fabric Sample Holder.

This piece of innovation allows you to stretch, clamp, and hold samples with ease. You can even gauge the degree to which your sample stretches and say goodbye to the cumbersome practice of snipping out sample portions

Prototype Fabric Sample holder designed by Droplet Lab

Real-World Implications
Case Studies

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

Presented below are a few illustrative instances:

1 Crafting Water-Resistant Outdoor Gear

Scenario: Think about a company dedicated to crafting outdoor gear that can withstand the elements. They're particularly interested in making fabrics that repel water effectively. They meticulously measure how water droplets interact with the fabric's surface to achieve this.

Application: Essentially, they're gauging how much the water "likes" or "dislikes" sticking to the fabric. This helps them ensure that raindrops will roll off the fabric instead of seeping through. By checking these measurements, they guarantee their products will keep adventurers dry and comfortable.

2 Revolutionizing Inkjet Textile Printing

Scenario: Consider the fascinating world of printing intricate designs on textiles using inkjet technology. Behind the scenes, experts are busy tweaking the fabric's surface properties.

Application: A textile and printing company will typically analyze surface tension and contact angles to guarantee that the fabric can hold the ink in just the right way. It's all about ensuring the ink doesn't smudge or blur, leading to sharp, vibrant, and eye-catching patterns.

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

- **ASTM D7334-08 (2022):**

  This standard providexs the standard practice for surface wettability of coatings, substrates and pigments by advancing contact angle measurement. As per this standard, hydrophilic and hydrophobic surfaces are defined for the contact angle <45 and >90 respectively. A surface between hydrophilic and hydrophobic comes under the angle between 45 and 90. Water can be used as a test liquid for contact angle measurement [4].

- **ISO 19403:**

  This series provides the description of optical test methods to measure the contact angle, to determine the free surface energy of a solid surface and surface tension of liquids. These description are applicable to the characterization of substrates, coatings and coating materials [5].

Sources

[1] 7 - Repellent finishes, Editor(s): Asim Kumar Roy Choudhury, In Woodhead Publishing Series in Textiles, Principles of Textile Finishing, Woodhead Publishing, 2017, Pages 149-194. https://doi.org/ 10.1016/B978-0-08-100646-7.00007-2.

[2] "Contact Angle Determination on Hydrophilic and Superhydrophilic Surfaces by Using r–θ-Type Capillary Bridges", Langmuir 2019, 35, 5202–5212. 10.1021/acs.langmuir.9b00442.

[3] "Understanding of sliding and contact angle results in tilted plate experiments", Colloids and Surfaces A: Physicochemical and Engineering Aspects, Volume 323, Issues 1–3, 20 June 2008, Pages 73-82. https://doi.org/10.1016/j.colsurfa.2007.09.032.

[4] https://www.astm.org/d7334-08r22.html.

[5] https://www.iso.org/standard/64808.html.