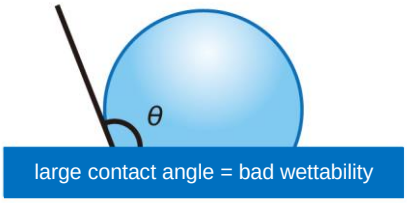
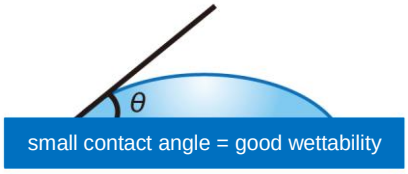
Applications of Contact Angle Measurements

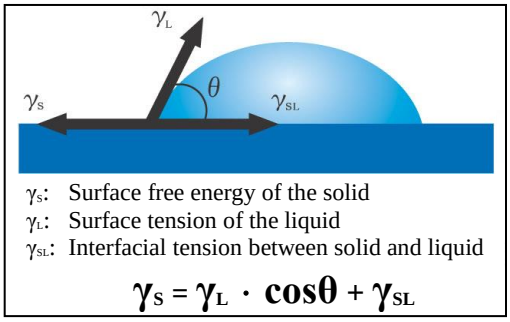
The contact angle is an easy measurement method to determine the wettability of a solid substrate by a liquid. When depositing a droplet onto a solid substrate, the liquid will form a drop shape. The point, where the solid, the liquid and vapor meet, is called the three-face point and it determines the contact angle. The contact angle is also an indicator for the wettability, which is dependent on the combination of solid substrate and liquid, as well as on the environment.

In general, the following rule applies:
The larger the contact angle the worse the wettability, the lower the contact angle the better the wettability.





The relationship between the contact angle, the solid surface free energy, the liquid surface tension and the interfacial tension between solid and liquid is defined by the **Young's-Equation**:



Evaluation of hydrophobicity

(Measurement of the Static Contact Angle using the Sessile Drop Method or measurement of the Roll-Off Angle using the Sliding Method)

1. Automobile, Wax, Coatings, Paints
   To protect an automobile body, chassis or windshield from rain or muddy water, the effectiveness and the hydrophobic properties of paints, waxes and glass coatings have to be determined.

2. Fibers for Rain Gear, Building Materials, Paints, Electric Cables, Ceramic Insulators
   In order to make umbrellas and rain gear water-repellent; to make muddy water or snow not adhere to roofs, traffic signs and ceramic insulators, hydrophobic properties of materials and paints have to be determined.

3. Glass, Ceramics, Materials used in Humid Environments
   To prevent glasses and bathroom mirrors from condensation (fogging up), their surface have to be treated to make them hydrophobic, or vice versa, hydrophilic.

Evaluation of hydrophilicity

(Measurement of the time-dependent Contact Angle using the Sessile Drop Method)

1. Detergents, Cleaning Solutions, Surfactants, Fats and Oils, Plating Solutions
   In washing processes, the better the permeability of water the better detergents can penetrate deeper into fabrics, thus enhancing the washing and cleaning results.
   In plating processes the wetting properties of cleaning solutions help to ensure that the metal is free of oils and dirt, which is necessary for good plating results.

2. Pharmaceuticals, Food, Agricultural Chemicals, Paints, Printing
   Testing of how agricultural chemicals will wet waxy or hairy leaves; testing the effectiveness of pretreatments for plastic surfaces to enhance their wettability by paints or coatings.

(ES) Equipements Scientifiques SA - Département Bio-Tests & Industries - 127 rue de Buzenval BP 26 - 92380 Garches
Tél. 01 47 95 99 90 - Fax. 01 47 01 16 22 - e-mail: bio@es-france.com - Site Web: www.es-france.com

3. CD's, Hard Disks, Consumer Electronics, Adhesives

In thin film coating processes, a good wettability of the substrate by the coating agent is essential for complete wetting and for control of the coating thickness.

To increase the permeability and adhesive strength of bonding agents, material combinations with good wetting interactions have to be investigated.

4. Cosmetics, Pharmaceuticals, Contact Lenses

Cosmetics and hair styling products have to wet skin or hair, eye drops have to wet eyes, lens cleaning solutions have to wet contact lenses. To ensure or enhance their effectiveness the wetting properties have to be investigated.

Adhesive strength · Control of wettability

(Evaluation of the Surface Free Energy (SFE) using the Sessile Drop Method)

1. Paints, Ink, Adhesives, Laminates

Adhesives are being used for bonding wood, metal, glass, plastics, etc. The adhesive strength of the same adhesive differs widely among combinations of different adherents.

Using the data of sessile drop measurements from liquids with known surface free energy properties, the surface free energy of the solid adherent and the film adhesive can be determined. The surface free energy of a solid can be expressed by a one component model (Zisman Theory), a two component model (e.g. Owens-Wendt Theory, Kaelble-Uy Theory or Wu Theory) or a three component model (e.g. Oss and Good (acid-base) Theory or Kitazaki-Hata Theory). The Kitazaki-Hata Theory, for instance, divides the surface free energy into a dispersive, a polar and a hydrogen bonding part:

By theoretically analyzing the work of adhesion and the interfacial tension between two phases, it is possible to control their adhesive strength and wettability.

Changing wetting conditions

(Measurement of Dynamic (Advancing/Receding) Contact Angle using the Extension/Contraction Method)

1. Inks, Pulp and Paper, Bureau Machines, Printing

The dynamic wetting behavior between fluids and substrates, such as changes of the contact angles when inks spread throughout plastic or films, have to be measured constantly.

2. Discs, Thin Films and Coatings, Aluminum Printing Plates,

Whether if the photoresist is spreading out during the spin coating process, if a magnetic film is building-up during the dip-coating process, or if water is wetting aluminum plates in offset-printing processes, in all cases the liquid surface is in motion. By reproducing these dynamic changes when measuring the wettability, the quality of materials can be controlled and production processes can be monitored.

3. Detergents, Surfactants

During washing or cleaning processes the liquid surface is in constant motion and new surfaces and interfaces are being created. Knowing the dynamic wetting behavior helps to control the quality of products and to develop new products.

Evaluation of Cleanliness

(Measurement of Static Contact Angle using the Sessile Drop Method)

1. Semiconductor Wafers, OLED Panels, Cleaning Systems, Cleaning Solutions

The evaluation of the cleanliness after the micro-cleaning process is being done by determining the contact angle of a water drop on the cleaned surface. This is a simple yet very effective method to check the effectiveness of the cleaning process at the production site.

Powder Wettability

(Measurement of Powder Contact Angle using the Washburn-Method)

1. Inks, Paints, Chemicals, Pharmaceuticals, Foods

The dispersibility of powder substances in fluids and the wettability of, for example, pharmaceutical powders by water or gastric acid; pigments or fillers by solvents; or cement by water can be best evaluated using the Washburn-Method. Here a surface tensiometer is used to measure the increase in weight over time of a powder filled Teflon column, which is immersed in the liquid.