



PACKALL

PackAlliance:
European alliance for innovation training
& collaboration towards future packaging

Linking **Academy** to **Industry**.

Training program: modules

- New materials and biomaterials
- **Eco-design & novel manufacturing processing**
- Citizen and Consumer Engagement
- Residue management and valorisation



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Course 2- Novel Manufacturing Processing for Packaging Systems

7. Innovation and sustainability in surface treatments

7.1. Surface treating basics

7.1.1. Wettability, contact angle, surface energy and surface tension

7.2. Corona treatment

7.3. Plasma treatment

7.4. Coating processes

7.5. Sustainability in surface treatments

Surface treatments. What, why, how.



Surface treatments of plastic are ordinary procedures in the packaging industry. They improve wettability leading to proper adhesion of paints, inks, coats, etc.



Poor adhesion is common problem in polymers, which possess non-polar or low surface energies that make them unresponsive to printing, bonding, coating, etc.



The surface energy of the polymer must be changed! Solutions for plastic surface treatments:

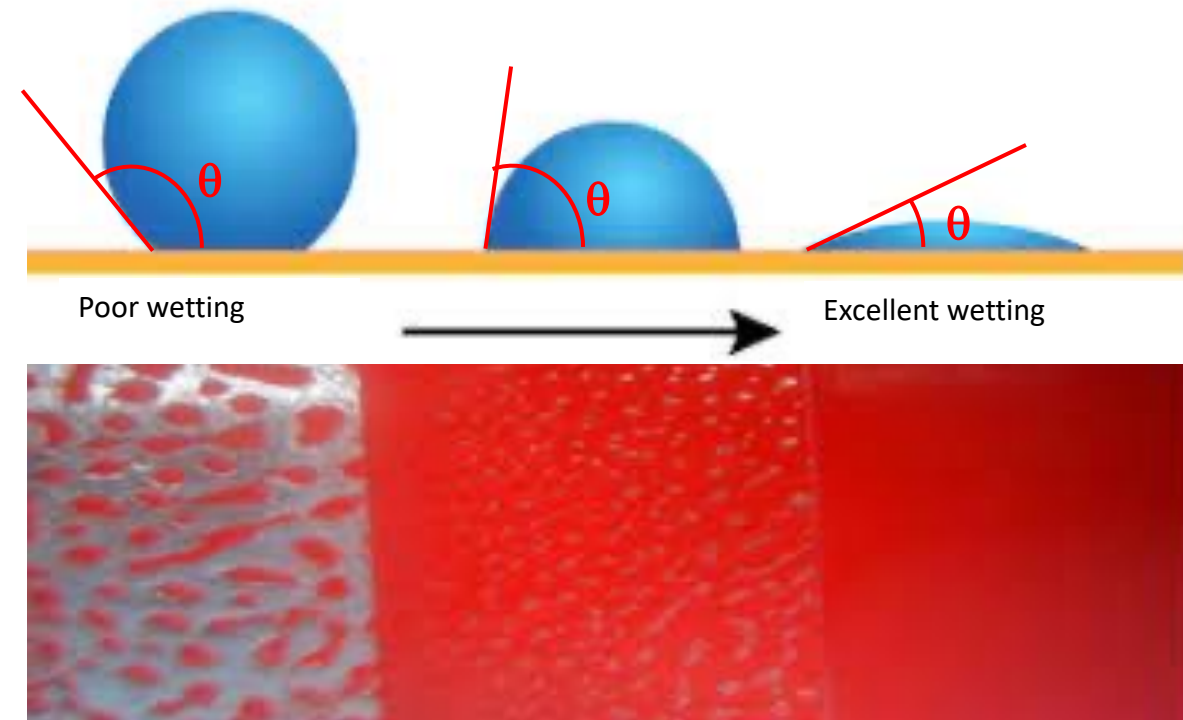
- corona treatments
- plasma treatments
- others ...

Wettability and contact angle

Wettability refers to the ability of a liquid to spread out completely on the flat and horizontal surface of a solid.

Contact angle is the angle θ formed between the surface and the line tangent to the edge of the drop of the liquid deposited on it.

- **Total wetting:** the liquid has a strong affinity for the solid \rightarrow the contact angle approaches 0° and the liquid is completely "spread out".
- **Partial wetting or non-wetting:** the liquid has a low or no-affinity for the solid \rightarrow the contact angle approaches 180° and the liquid forms drops.

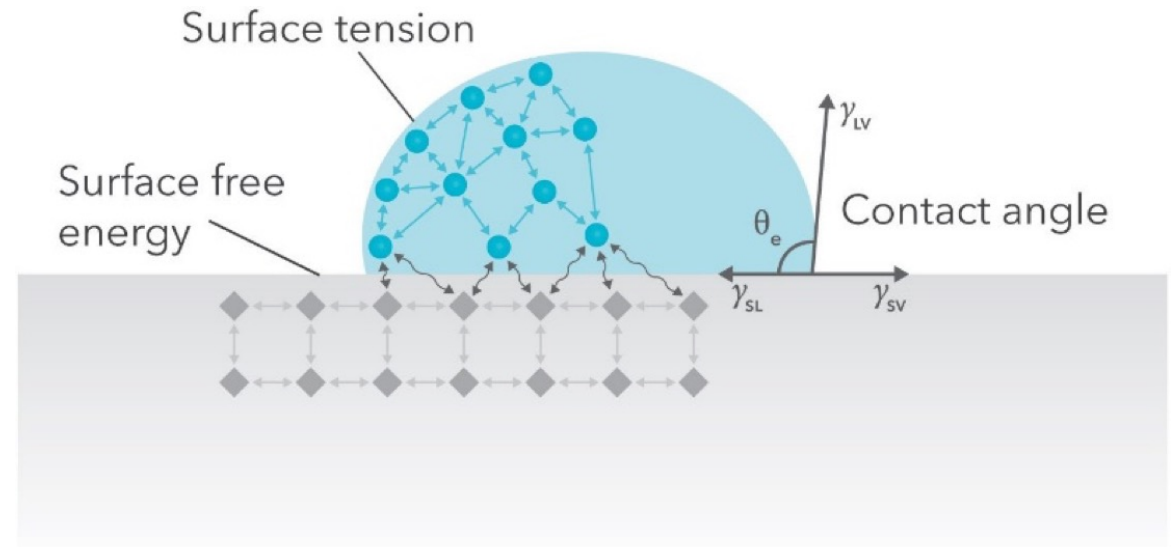


Lower is the **contact angle**, higher is the wettability!

Wettability, surface tension and surface energy

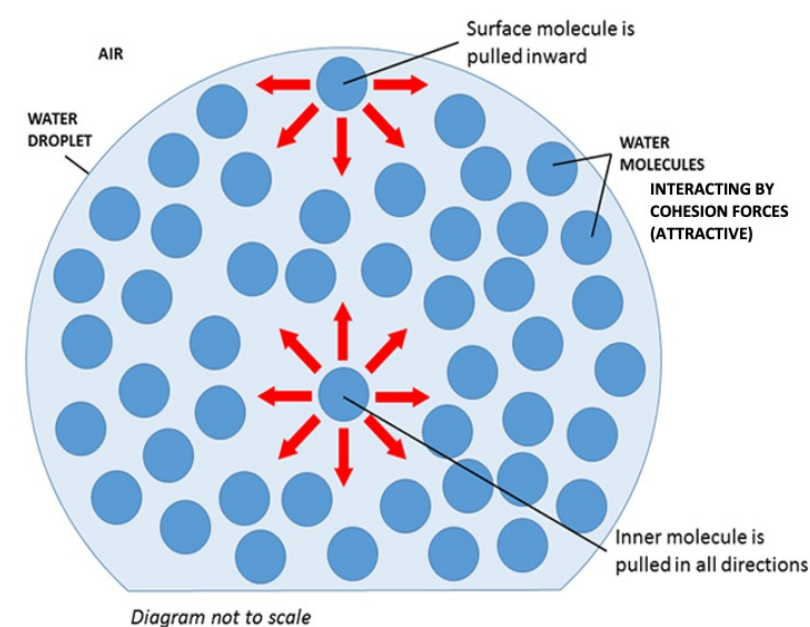
When a liquid is deposited on the surface of a solid material, the two materials' molecules interact one with another: **wettability** is related to the forces acting on the drop of liquid from the surface: strong forces pull hard on the liquid, causing it to wet out.

The way in which the solid reacts to different liquid substances strongly depends on the surface tension of the liquid and on the surface free energy of the solid.



Surface tension and surface free energy

Surface tension is the elastic tendency of a fluid surface which makes it acquire the least surface area possible.



Some effects of surface tension



Rain water drops are spherical!



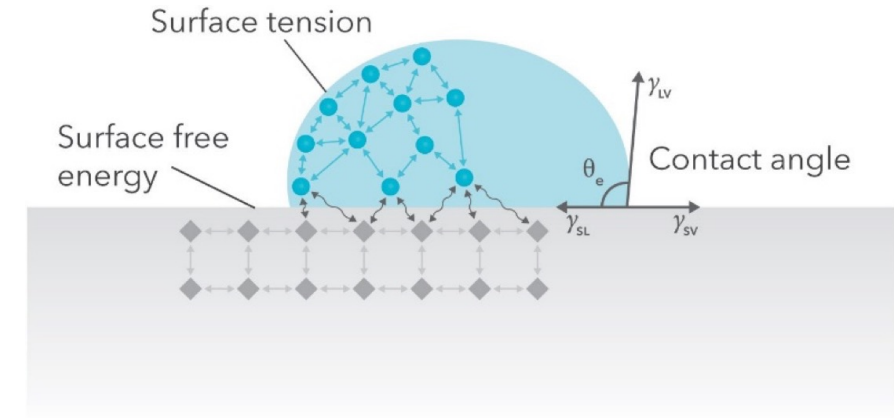
A paper clip can float in a glass of water
→ surface tension dominating on gravitational force!

Surface free energy is the same thing as the surface tension, but it is referred to solids!

Wettability, surface tension and surface energy

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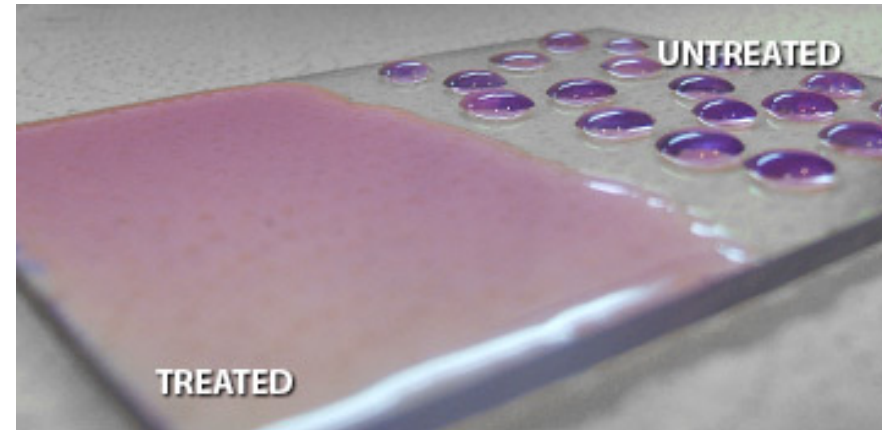
Both the surface free energy and the surface tension are attractive forces what holds a substance together into a cohesive form.

We usually use **surface tension** when referring to **liquids** and surface energy when referring to **solids**, but in reality they are the same thing.

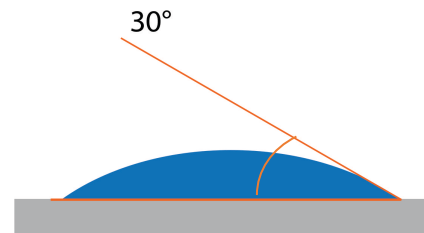
Wettability and surface energy

Surface treatments of plastic substrates increase their surface energy.

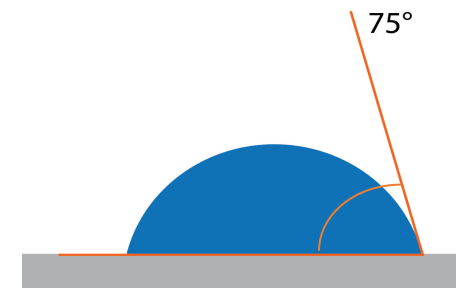
High surface energy pulls hard on the liquid, causing it to wet out.



High Surface Energy

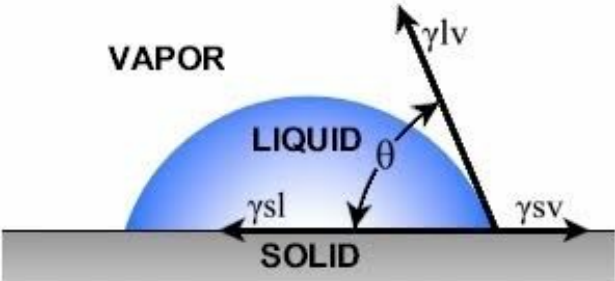


Low Surface Energy



The relationship between surface tension, surface energy and contact angle of the liquid, solid, and liquid-solid interface

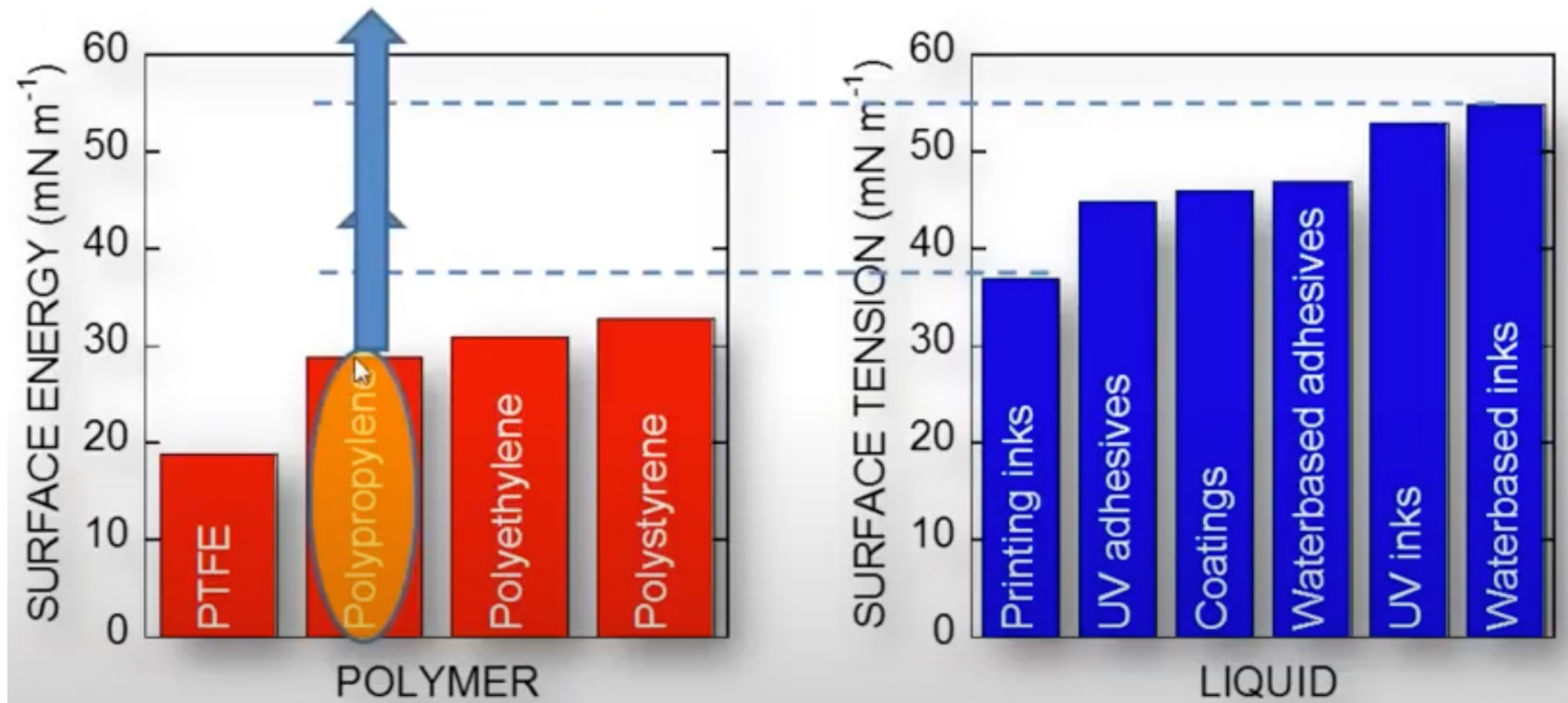
Young's Equation

$$\gamma^{sv} = \gamma^{sl} + \gamma^{lv} \cos\theta$$


θ is the contact angle
 γ^{sl} is the solid/liquid interfacial free energy
 γ^{sv} is the solid surface free energy
 γ^{lv} is the liquid surface free energy (tension)

ramé-hart instrument co.

Surface free energy of some common polymers vs surface tension of some liquid formulations



For good wettability, the polymer surface energy must be at least 10 mN/m higher than the surface tension of the liquid that you want to apply!



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