Surface treatment and coatings of Paper & Packaging Applications

Conventionally, packaging is used for safe transport and storage of products contained within. The packaging materials used in such applications essentially consist of a layered combination of individual materials to comply with the package requirements. Adhesion and wettability are two important mechanisms relating to the design of unique packaging materials. In order to understand and improve the interfacial phenomena between the layers in the packaging material, surface property measurements are considered.

Paper based packaging material

Paper has typically become the material of choice for use in packaging applications due to its inherent eco-friendly and recyclable nature. The process of paper manufacturing predominantly uses fibre pulps from renewable sources as raw material. Innovative modifications by surface treatment and coatings have been used to improve the functional, structural and mechanical properties of packaging paper. The influence of changes in the surface of the material can be examined in terms of surface tension, contact angle, sliding angle and surface energy.

The use of polymers to laminate paper surfaces to elevate its performance in packaging is a common practise. Fossil-oil based and other synthetic polymers used as barrier coatings have been largely replaced by use of biopolymers for sustainable packaging. Nanoscale polymer composite coatings render novel functionalities, aid in processing and improve performance of the packaging material. Nanofiber modification of paper, such as use of cellulose nanofibers has shown to improve the mechanical strength of paper.

Adhesion and wettability of packaging materials

The chemical and topographical characteristic of the base substrate plays a key role in optimization of adhesion and surface wetting properties. Good adhesion between the layers of the packaging material is critical and depends on the interfacial interaction between the surfaces. This is characterized by the surface energy of the material and varies directly with the variation of the adhesion forces between the physical layers. The interfacial adhesion between

the layers is influenced by the wettability of the substrate which can be characterized by the contact angle measurement. Another measure of the material wetting property is the sliding angle measurement. Surface energy is another quantifiable property that determines the extent of wetting and adhesion possible between the packaging material layers.

Influence of surface roughness on adhesion and wettability

The wetting ability of the material can be influenced by the surface roughness characteristic of the base substrate. This is because with an alteration in surface roughness, a change in the contact angle of the material is usually observed. Consequently, there occurs a change in the surface energy and therefore, the adhesive forces between the substrate and deposited layers are also essentially influenced by the differences in surface roughness of the material.

What we offer?

Dropletlab introduces dropometer, a smartphone based optical tensiometer to measure the surface properties of materials. The system has been shown to achieve 0.01% accuracy in contact angle measurement with respect to Young-Laplace and polynomial fitting models and an accuracy of 0.001% for surface tension measurements. The tensiometer is simple to operate, consumes less space, economic and portable. A list of potential applications of the dropometer is listed below.

- Measure contact angle and sliding angle of paper and packaging materials
- Measure surface tension of liquids
- Determine contact angle of coating polymer solutions on substrate surface
- Evaluate surface roughness of paper by measuring surface energy
- Optimize adhesion between layers in packaging materials
- Determine the wettability of paper for printing applications
- Optimize ink adhesion properties on paper
- Surface characterization of paper and packaging materials on coating/ surface treatment

Our Industrial Clients

- Avery Dennison Corporation, Glendale, California
- Teledyne FLIR LLC, Wilsonville, Oregon

Some relevant case studies

1. Coating and surface treatment of paperboard

Coating, in general enhances the surface quality of the material with respect to the features such as brightness, opacity, smoothness, printability, etc. In packaging applications, coating of paperboard improves the barrier and mechanical properties of the material. The optimization of coating material can be evaluated by measuring the surface properties of coated paper. For example, paperboards coated with biopolymers such as alginate and soyprotein isolates showing variations in contact angle depending on coating material and further treatments have been reported[i]

Material	Measured Contact angle
Uncoated paperboard	56.3 ± 3.8
Alginate coated paperboard	42.4 ± 3.2
Alginate coated paperboard treated with calcium chloride	41.2 ± 5.7
Alginate coated paperboard treated with organically modified montmorillonite	35.3 ± 3.2
Soy protein isolate coated paperboard	40.1 ± 2.8
Soy protein isolate coated paperboard treated with calcium chloride	48.6 ± 2.9
Soy protein isolate coated paperboard treated with organically modified montmorillonite	46.1 ± 1.1

2. Ink adhesion and Printing applications

Surface property measurements, in particular the determination of contact angle is critical in printing applications. The quality of the printed material can be enhanced by understanding the interactions between the paper coating and ink formulations. For example, the surface properties of matte and glossy coated paper have been reported to improve on treatment with plasma in argon atmosphere. The results showed an increase in surface energy with increase in time of plasma exposure. An increase in the wettability of the paper surface favouring the adhesion of ink onto the paper with decrease in contact angle (shown in the table below) observed with increase in plasma treatment time has been reported[ii].

Paper type	Matte coated paper	Glossy coated paper
Contact angle of untreated paper	91.1	82.2
Contact angle of plasma treated paper	60.4	54.0

[i] 10.1016/j.lwt.2005.05.008

[ii] 10.1108/PRT-08-2021-0086