

Contact angle measurement for surface treatment evaluation in packaging industry

This application note illustrates how Theta optical tensiometers can be used for evaluation of surface treatments in packaging industry processes.

Introduction

Control of surface properties is very important for variety of industries such as packaging, electronics, medical and life sciences. In the packaging industry, adhesion and wettability play a key role in many processes. Packaging material typically includes various layers of different materials to fulfill all the requirements to protect and promote the product inside the package. Adhesion and wettability properties of these materials are often not sufficient for printing, and therefore different surface treatments are utilized. This application note describes how contact angle measurement can be used to evaluate the quality of plasma and flame surface treatments in packaging processes.

Plasma surface modification is an effective way to control the surface energy and chemical properties of substrates without affecting the bulk material. Plasma is a state of ionized gas, sometimes referred as "fourth-state-of-matter", consisting of reactive particles such as electrons, ions and radicals. Plasma-solid interactions can be roughly divided into three sub categories; (i) plasma etching or cleaning, where material is removed from the surface (ii) plasma activation, where the surface is physically or chemically modified by species present in plasma and (iii) plasma coating, where material is deposited in the form of a thin film on the surface. Depending on the conditions in which the plasma is created, plasmas can be categorized into vacuum or atmospheric plasmas. Vacuum plasma treatments are widely used for example in microelectronics applications, but on-line processes require atmospheric methods.

One kind of atmospheric plasma activation, so-called industrial corona treatment, has already been used for decades in the



Theta optical tensiometers

converting and printing industry, for example to improve adhesion between paper and polymers in extrusion processes. In addition to plasma treatments, flame treatment is many times utilized in

packaging industry. Flame treaters work by burning gas, whose excess oxygen becomes reactive by the high temperature. When the substrate passes through the plasma activation or flame state, various chemical reactions occur increasing the surface energy of substrate. It is well-known that atmospheric pressure plasma activation and flame treatments creates polar molecular groups on the surface, and thus increases the surface energy. Changes in the topography properties have also been reported.

In packaging industry, wide range of materials, such as paper and board, plastic, metal and glass, are used depending on demands for the package. Fiber-based materials are many times preferred since they are environmental friendly choice due to recyclable and compostable properties, while being cost effective at the same time. Paper or board by itself is often not suitable as packaging material since it has poor barrier properties for example against moisture. For this reason one or several plastic layers are often applied to provide better barrier properties and increases the durability of the packages. Extrusion coating and lamination are typically used processes to combine paper and plastic layers together. In the lamination process at least two different solid state materials are combined with adhesive such as primers. Contact angles can be used to check the cleanliness and homogeneity of the lamination materials or wettability of chosen adhesive on the lamination materials. In the extrusion coating, moving web is coated with molten polymer film.

Next case study illustrates how Attension optical tensiometers can be utilized in development and quality control for surface treated packaging materials. Attension Theta and Theta Lite can be used for effective quality control of surfaces. Fully automated Theta makes QC user-independent and fast for the most reliable results.

Case study: Evaluation of plasma treatments on extrusion coated paper by contact angle measurement

Extrusion coated papers and paperboards are used in various consumer packages such as food, medical and cosmetic packages. Plasma and corona treatments are often utilized to promote adhesion between paper and polymer melt in this process, and contact angles can be used to evaluate the level and homogeneity of the treatment. Apart from protecting the product, another important feature of the package is its appearance; packages contain product information and contribute to the buying decision. When non-absorbing and low surface energy plastic surfaces are printed, adhesion between ink and substrate is a challenge. It is well-known that surface free energy of substrate should be higher than that of the ink. Therefore, prior to printing, the surface free energy of the coated substrates has to be increased by using some surface treatment methods, such as plasma and flame treatments.

Tuominen et al. studied different surface treatments on low density polyethylene (LDPE) and polypropylene (PP) extrusion coated paper and their effect on printability [1]. Attension (formerly KSV Instruments) CAM200 Optical tensiometer was used to measure contact angle of native and corona, flame and helium and argon on-line plasma treated surfaces (see table 1).

	Native	Corona	Flame	Helium Plasma	Argon Plasma
LDPE	103	75	77	75	76
PP	108	81	83	86	89

[Table 1]: Contact angles in degrees of native and surface treated LDPE and PP surfaces

Contact angle results showed that all the surface treatment methods improved wettability and increased surface free energy of the extrusion coated paper surfaces and therefore improved the ink-substrate adhesion. In Table 1 can be seen that corona treatment provided better wettability than argon plasma treatment on PP surface. The morphological changes in micro and nano scale were observed only on the flame treated LDPE surface and they were found to be beneficial for printing quality

References:

- [1] M. Tuominen, J. Lahti, J. Lavonen, T. Penttinen, J.P. Räsänen and J. Kuusipalo, The influence of flame, corona and atmospheric plasma treatments on surface properties and digital print quality of extrusion coated paper, *J. Adhes. Sci. Technol.* 24, 471-492 (2010).