Application Note
C-112

Dynamic Contact Angle Analysis of Polymers

Polymers are among the most studied of all materials. For decades they have been stretched and compressed, heated and cooled, fractured and annealed, molded and extruded, oxidized and reduced, melted and dissolved, and shaped into more useful products than any other material in history.

Despite the extraordinary versatility of most polymers, there is one property that markedly reduces its application, a very hydrophobic surface. This property makes the typical polymer difficult to wet, difficult to coat, or difficult to adhere to or paint. With a surface energy lower than most materials, polymers are often incompatible with other higher energy materials, and when placed in a relatively hydrophilic environment such as the human body, the surface can be rejected. If, however, the bulk properties of the polymer do have the desired characteristics to fit the application, reformulating the polymer from scratch is not often the best solution, and may well have an adverse affect on the favorable bulk properties of the material.

If you're interested in changing the surface without changing the polymer, a surface modification procedure may be the solution. Plasma and corona discharge treatments are often the methods of choice for polymeric materials. And to carefully control and characterize the polymer before and after treatment, a wettability scan of the surface is needed not only in the research and development stage to define and design the treatment parameters, but also in the manufacturing stage to insure a consistent, high quality product.

Biomedical Polymers

Polymers are the material of choice for a wide range of disposable medical products. Some of the more familiar products include disposable cuvettes, test tubes and micro-centrifuge tubes, cell culture dishes, and multi-welled plates used in clinical diagnostic instruments and medical test kits.

In addition to their utility as disposable products, biomedical polymers are also widely used to make medical devices such as catheters, vision products such as contact lenses and intraocular lenses, and implant materials such as heart valves and artificial arteries.

The efficacy of these products is largely dependent on the surface chemistry of the polymer. There are many examples in which the surface properties of the polymer are critical:

In determining blood compatibility of a catheter, a clot formation at the blood/polymer interface may be minimized with proper surface treatment.

The wettability of a blood or urine sample against the sides of a test tube, along the inner or outer walls of a syringe, or at the surface of a diagnostic test plate may be a critical element in accuracy of the test procedure.

The adhesion of a specific type of bacteria or other microorganism onto a polystyrene tissue culture dish is largely dependent on the surface properties of the polymer which may or may not be conducive to spreading, cell attachment, and growth.

The inner surface of a polypropylene test tube used in a radioimmunoassay procedure must encourage the adsorption or covalent bonding of antibodies before the introduction of radiolabelled antigen.

The wettability of **PMMA** (polymethyl methacrylate), widely used to make both hard contact lenses and intraocular lenses (IOL's), can be dramatically affected by adding a hydrogel coating to increase the hydrophilic character of the surface.

Industria Polymers

Polymers are the basis of a wide range of industrial products from packaging films to automobile interiors, composite fibers and adhesives to non-stick cookware. Providing a tenacious, mirror-like finish to a polymer surface, however, is not always an easy task. Specially formulated paints and coatings are thus needed to meet this demand and make polymers a viable alternative to traditional metals.

Polymer fibers such as aramid, a polyamide, are widely used as reinforcing material in the manufacturing of composite materials such as aramid reinforced rubber tires. The adhesion of an aramid fiber to the rubber matrix is a surface chemistry problem that must be analyzed to make a good product.

Mylar and polypropylene film are highly marketable commodities used in the packaging industry to protect food and electronic products.

Teflon is a versatile polymer that can be sprayed onto the surface of a synthetic fabric, carpet fiber, or metal surface to provide a non-stick, water-repellent or stain-resistant surface that is protected from the elements.

Wettability scanning of a polymer surface

The examples cited above clearly illustrate the importance of controlling or modifying the surface of a polymer for maximum application versatility. A wettability scan with a Thermo Sientific *DCA RADIAN* is a simple yet powerful tool now available to analyze a polymer surface before and after a surface treatment process has been applied. There are many important properties of a polymer surface that can be revealed with a simple wettability scan:

Wetting Hysteresis
The difference between measured advancing and receding contact angles is an important measure of two physical characteristics of the surface *Surface Roughness and Surface Heterogeneity.*

Surface energy
A measure of the total free energy of the polymer surface is important in predicting fundamental parameters concerning adhesion.

Surface polarity
A measure of the polar and non-polar components of the surface energy as calculated from a series of wettability experiments using a series of well-characterized liquids.

Surface dynamics
A measure of the ability of the polymer surface to reorient surface groups at the interface to minimize surface free energy in response to changes in the local environment of the interface.

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