

Wilhelmy Balance Measurement of Absorbing Surfaces: Applications to Inkjet Receptors

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Abstract

We have used the Wilhelmy balance technique to examine the surface thermodynamics of absorbing wettable materials. Surface energetics of water soluble polymers were measured, as well as the addition of surfactants to these polymers. Interesting hysteresis effects were observed with some test liquids and various samples. Discussion and a possible interpretation of these results will be presented.

Introduction

The Wilhelmy balance, or as it is alternatively called, dynamic contact angle analysis, is used in characterizing the wetting behavior of polymeric materials, composites, fibers, metals, and ceramics. Advancing and receding contact angles are obtained with this apparatus. Characterization of a surface can be made continuously during hydration. Wetting behavior can be measured and correlated to surface composition and surface treatment. In this paper, we will consider the effects of wettability of some water soluble materials used in experimental inkjet receptors.

Experimental

The Wilhelmy balance used in these studies was manufactured by Cahn Instruments, Inc., Cerritos, CA. We used standard instrumental settings to do the experiments including computer data collection and storage. The rate of the test plate into the solution was 0.14 mm/second. Experiments were carried out at ambient room temperature (22 C). We used high purity liquids as test liquids for these experiments. To determine surface energetics more accurately, one uses a set of liquids ranging from nonpolar to polar. We chose n-hexadecane (Aldrich Chem. Co., 99% purity), ethylene glycol (Aldrich Chem. Co., 99 +% purity), and water (EM Science, HPLC grade purity). Small volumes (30 ml) of these test liquids were put into a glass beaker. The experimental materials were coated out of water onto a polyester film and dried in a laboratory oven at 110°C for at least 2 minutes. Test samples (approximately 30mm by 10 mm) were cut and fixed back-to-back by Super Strength Adhesive (3M) and left to dry with pressure for 24 hours. Samples were recut carefully before their circumferences were measured, and then placed on the sample holder attachment above the test liquid. The experiment was begun and controlled by the computer into the test liquid, to a stop after 20 mm to determine the advancing contact angle, and then withdrawn from the liquid to determine the receding contact angle. A new sample was chosen to test in each liquid.

Materials that were tested in this apparatus included water soluble polymers such as polyvinyl alcohol (Aldrich, MW= 30,000-50,000) and hydroxyethylcellulose (Aldrich). Some experiments also used the addition of a surfactant such as the non-ionic surfactants from 3M such as FC-170c. These materials were used as received. Solutions were made by dissolving the polymer in DI water at room temperature for 24 hours, then adding the surfactant to the level desired. Polyvinyl alcohol concentrations of 5% by weight of the total solution, while hydroxyethylcellulose was used at less than 2% of the total solution weight. Surfactant weights of up to 10% with respect to polymer weights were studied.

Results

The output from an individual Wilhelmy experiment is a plot of force (mg) vs. distance(mm). Typical Wilhelmy data will be shown at this talk. The data taken for the polymeric samples only look to be fairly typical, regardless of the test liquid used. For samples containing certain non-ionic surfactants, at concentrations greater than 1%, Wilhelmy data that was unusual was observed. This was true for the cases where polar solvents (especially water) were used. Marked oscillations in the advancing contact angle data are present, as well as a large difference between advancing and receding traces.

Nonpolar test liquids (n-hexadecane) show much less discrepancy between samples, other than slopes of the traces that give rise to the contact angles actually measured. This appears to be true regardless of the amount or chemical composition of the surfactant. Other results will be tabulated and presented in this talk.

Discussion

The unusual hysteresis effects measured in these experiments are indicative of a strong interfacial effect between the polar liquid and the top layer of the coated material. That the effect of the surfactant to increase the surface energy of the solid surface, and also change the hysteresis behavior is somewhat unexpected. Possible interpretations of this behavior will be discussed. Other experimental methods to examine the surface will also be presented.