The relationship of wettability to absorbency

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A significant amount of time has been spent studying wood and textile individual fibers. These scientists have employed a Thermo Scientific CAHN recording balance as a Wilhelmy balance apparatus similar to the Thermo Scientific CAHN DCA (Dynamic Contact Angle Analyzer). Research in this area points to textile of the absorbency rate by a modification of both fiber morphology and surface chemistry. Two factors are in control; the individual fiber-liquid interaction, and the geometrical structure of the fiber network. The DCA can be readily applied in determining the first factor, fiber-liquid interaction and results compared to bulk absorbency data for fiber networks.

To briefly summarize the mathematics involved, two fundamental relationships must be considered. The Laplace equation which relates the driving pressure (ΔP) for liquid movement through a capillary to three variables: liquid surface tension (γ), advancing contact angle (θ_a), and the pore radius (r):

$$\Delta P = 2 * \gamma * \cos\theta_a / r$$

The rate of liquid uptake can be described by another relationship known as the Washburn equation which relates the rate of uptake of a liquid *(dV/dt)* to the effective pore size (r), liquid surface tension (γ), liquid viscosity (η), volume of liquid absorbed (V) at any time (t), and advancing contact angle *(θ_a)*:

$$dV/dT = \pi^2 * \gamma * \cos\theta_a * r^5 / 4\eta V$$

The above equation shows the rate of liquid uptake is directly related to wettability in a pore capillary. To encourage liquid to move into a pore, for example, the $\cos\theta_a$ parameter must increase, ie; the advancing contact angle must be decreased. Traditional practice to increase the rate of uptake is to lower the surface tension (γ) of the liquid by the addition of surfactants. This will only work, however, if the net change in the wettability function, $\gamma * \cos\theta_a$ is increased. Thus, lowering the surface tension of the liquid may decrease the rate of liquid uptake if the advancing contact angle is not also decreased.

An increased interest in wettability measurements has been seen in the paper and textile industries as knowledge of the critical importance of wetting properties in these processes has been researched and published. And, because a large fraction of these samples are fibers, the DCA is the instrument of choice, far outpacing the goniometer in accuracy and simplicity of measurement.

In addition to roughness and homogeneity, the polarity of both the substrate surface and the ink formulation is also demonstrated by Bassemir and Krishnan to be a critical element that must be controlled and well characterized. Matching the polarity of an ink with the corresponding polarity of the substrate is required for optimum adhesion. This has become an especially important issue as ink formulations are changing from solvent-based to water-based systems. Corresponding changes in the substrate surface energy and polarity is thus required to match the new ink formulations.

References

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