Cork Tech Talk News

Manufacturers of Waterbase, UV+EB Curable Coatings, Varnishes and Adhesives

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SURFACE ENERGY AND SURFACE TENSION

Surface tension and surface energy are two parameters that affect printing on any sub-strate, especially non-porous ones. All liquids and solids have a measurable surface tension expressed in dynes per centimeter.

Nature in our world always moves toward the lowest energy state. In this effort to lower the total energy of a system, nature will always move to cover a high energy surface with a lower energy surface.

While many of us are not now, nor have been, students of surface chemistry, many common examples around us can bring us an understanding. Gasoline has a surface tension of 20 dynes/cm while water has a surface tension of 73 dynes/cm. One drop of gas placed on a large surface of water will spread until it is only one molecule thick. Remembering natures' rule, here nature has covered as much of the higher energy surface as possible with a lower energy surface. The relationship of surface tension and surface energy are seen once more when water beads on a waxed auto finish.

The surface tension of 73 dyne water causes spherical beads to form on the lower 23 dyne waxed surface as the forces present cause each droplet to shape itself into a sphere. Each sphere having the smallest surface area possible for the one drop volume. A perfect sphere would only make point contact and not cover any of the 23 dyne surface with 73 dyne water. However, gravity pulling downward on the water drop causes it to flatten slightly while surface tension is acting to hold the sphere perfectly round.

Now, if the auto finish were unwaxed and oxidized the water drop would spread out, wetting the auto finish, because the surface energy of the finish would be higher than the surface tension of the water. Again we see natures' effort to move toward a lower energy state by covering a higher energy surface with a lower energy surface.

Consider another example, place a drop of water into a flask of gasoline. The drop will form a perfect sphere as gravity causes it to free fall toward the container bottom. Once bottom contact is made the sphere will be slightly flattened just as the spherical water drop was flattened on the waxed auto finish by gravity.

Let's look at water in a glass and also in a poly cup for another example. If you look at a water filled glass viewing across the glass rim at eye level, you'll observe that the water will be higher at the edges and lower at the center or concave. This results from the force of 73 dyne water trying to cover the higher 300 dyne glass surface while gravity pulls the water downward. Now in a poly cup the water will be viewed as being higher in the center and lower at the edges or convex. This results from the 73 dyne water trying to form a sphere to resist covering the 35-38 dyne treated poly. These results can be altered by adding 21.4 dyne IPA to the water, lowering the surface tension to say 45 dynes. Now, the mix will be viewed as nearly flat at eye level as it will not have enough energy to try to form a sphere to prevent covering the nearly dyne matched poly. The same mix viewed in the glass will be seen as even more concave as the greater force differential tries even harder to climb the glass rim covering the 300 dyne glass with the now much lower 45 dyne mix.

How does all of this relate to printing and coating? Simply, what follows is that in order to print or coat successfully with good lay and with good adhesion to a substrate, the surface tension of an ink or coating must be equal or less than the surface energy of the substrate (a contact angle of zero degrees). Think of it this way, optimal wetting is necessary to provide maximum surface contact. Successful printing is dependent upon both attraction to the substrate and acceptance of inks and coating by the greatest number of reactive bond sites that are available on the substrate to allow wetting.

Substrates on which we attempt to print and coat vary widely in surface energy. All solids have natural surface energy levels which may be lowered if contaminated by finger prints, oils, plasticizers, etc.

Paper and paperboard substrates generally do not present a concern due to porosity, roughness and more than adequate bond sites but, paper coatings, laminations and treatments can alter this.

Substrate	**Dynes/cm**
Clay Coated Board	*100*
Polyethylene	*31*
Aluminum foil	*45*
Polypropylene	*31*
Polystyrene	*33-35*
Polyester	*43*
Polyvinyl chloride	*38-43*
Polyvinyl fluoride (Tedlar)	*28*

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The surface energy level of substrates can be raised by primers or by surface treatments that increase roughness. These include flame, corona, and chemical modifiers that oxidize a substrates surface. Plastics generally have low surface energy levels because plasticizers used to provide flexibility migrate to the surface continually.

The surface energy of a non-porous solids can be tested by a number of means. Dyne solu-tions with varying surface tensions are used to determine wettability. When a solution wets a surface the solution has a dyne level lower than the substrate's; if it beads up, it's dyne level is greater than that of the substrate. Water contact angle measurement is another test method used mainly in labs because of expense. In this test the angle of contact that a drop of dyne solution makes with a substrate surface is measured.

Understanding the relationship between the surface tension of inks and coatings and the surface energy of substrates is critical to printing success. A future issue of Techtalk will discuss this at length.

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