JOULES ANGSTROM

U.V. PRINTING INKS CORP.

PRINTING ON PLASTIC: WHAT YOU NEED TO KNOW ABOUT SURFACE ENERGY

When inks or coatings fail to adhere to plastic substrates, it is commonly understood that one reason might be the surface energy, or dyne level, of the material. What is it and how does this play a part in ink adhesion?

Ink adhesion depends to a great degree on the surface energy of the plastic substrate. This is commonly measured with dyne solutions (or pens containing such solutions, called "dyne pens"). A "*dyne*" is actually shorthand notation for the unit of measure of surface energy. Its complete name is *dyne per centimeter squared*, which denotes a force applied over an area. In testing plastic substrates, one is trying to ascertain the minimum dyne value that allows the fluid to spread over the film.

The higher the dyne value of the solution, the higher is the surface tension of the solution itself. So…a 38 dyne solution has a lower surface tension than a 43 dyne solution. We speak of "surface tension" when referring to liquids, and "surface energy" when referring to solids, such as the plastic substrate – but they indicate complementary concepts: surface tension is related to the degree to which a material can wet a surface (the liquid) and surface energy is related to the degree to which the surface can be wetted (the substrate).

"Wetting" indicates that the liquid will spread on the substrate surface. In order for ink adhesion to occur, the ink must at least demonstrate good wetting over the plastic surface.

Liquids will wet over surfaces that have *higher* surface energy than the surface tension of the liquid. This principle explains why rainwater rolls off a well-waxed car: washing and waxing the car reduces the surface energy of the car immensely – quite possibly down to about 23 dynes/cm^2, if a good PTFE-containing wax is used. Water, at about 72 dynes/cm^2, is not going to spread and wet over a surface that measures 23 dynes/cm^2 – it forms round droplets that instead roll off!

The same thing is true of plastic films and printing. UV inks possess surface tensions in the 23 – 35 dyne region, depending on components. Hence, a film in the low 30's for dyne measurement is not going to allow the ink to wet its surface well. A viscous ink may initially look as if it has, but on closer inspection, voids and reticulated ink can often be seen under a magnifier. To the naked eye, it will look like the ink is reduced in color strength. Indeed, it is – due to mechanical factors. First of all, the voids will interrupt the visual perception of a contiguous color – and secondly, trying to transfer 33 dyne ink to a 33 dyne substrate does not work very well: the substrate will not be very ink-receptive if dyne levels of ink and film are close to one another. So, overall – less ink will transfer, leading to reduced color strength.

The ideal scenario is to raise the dyne level of the substrate and/or lower the dyne level of the ink. This will enhance ink transfer and leveling, and play a large role in ink adhesion. The best way to raise the dyne level of the substrate is by corona discharge treatment. This is optimally done on press, just before the printing units. The surface of the film is exposed to an electrical discharge; this oxidizes the film surface. The result is that the film surface is charged and also modified in its surface chemistry. The ink will have a closer bond to this functionalized plastic surface.

It is instrumental to note that pretreated films, perhaps corona treated at the manufacturer – will lose their treatment over time. So – storing corona treated film for months prior to printing is not advised. The plastic surface will revert to its original state and ink adhesion will be compromised.

Lowering the dyne level of the ink is another avenue, but it generally involves using wetting additives with silicone chemistry. If the ink surface must subsequently be coated, foil embossed, or laminated in some way, this will not be acceptable. Even with silicone additives present, the minimum surface tension that can be achieved is about 23 dynes.

The greater the gap between surface tension of the ink and surface energy of the substrate, the better the adhesion of the ink will be. If the plastic is treated to 45 dynes or higher, and the ink is at 32 dynes, this will promote better ink wetting and adhesion than if the plastic is only brought to 38 dynes.

Can one overtreat plastics? Yes, this is possible and has been noted with polypropylene in some cases (due to its molecular structure). In an effort to drive the surface energy higher, extended corona treatment can actually cause a fracture layer at the plastic surface. The plastic will appear to have a high dyne level when tested, but the ink may not adhere due to the fact that it is sticking to the fracture layer on the film. Failure will then occur between the fracture layer and the rest of the film, at the microscopic level.

This points out one reason that ink adhesion depends on more than just film wetting. Film surface integrity is important, as noted above – as is the chemistry and matrix structure of the ink itself. Inks that wet a plastic surface of much higher surface energy may still fail adhesion tests if they have too great a tendency to shrink during curing. Proper balance of low and higher-functional monomers and oligomers is important to prevent adverse shrinking during cure.

Contact us if you have further questions about adhesion – we are here to help!