PDS International Limited

SUBSTRATES

What do we mean by substrate? The substrate is the surface onto which you can apply a printed image. Some people call it the material and others media. To your average general printer substrate is paper or board and the main differentiator is whether the finish is gloss or matte. To a screen printer a substrate is virtually any stable material that can be supported and make contact with the print side of a stencil. As screen printing breaks into more and more industrial applications so the range of exotic substrates increase. The substrate can be horizontal or vertical or any angle in between. In reality 99% of all print surfaces are horizontal. It is generally in some forms of container printing that vertical printing is used however there is a specialist company in the UK who will screen print onto walls and other vertical surfaces.

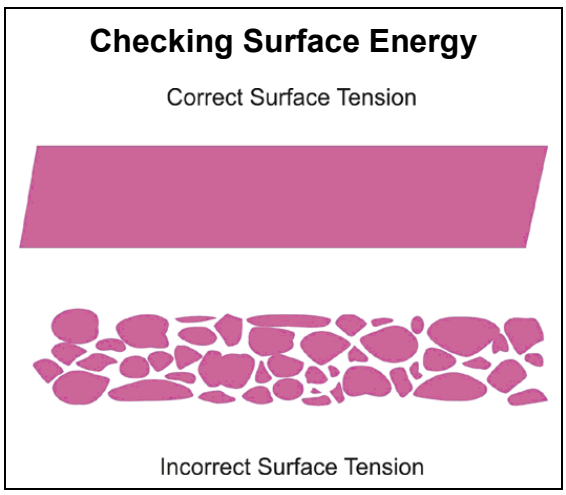
The fact that screen printing is an ink friendly process allows the printer to formulate and use a vast range of ink chemistries. No manufacturer exemplifies this more that Davison Chemographics Limited whose number of ink formulations exceeds 500, the vast majority being screen printing inks, although digital, litho and other processes feature in the markets served by the company. When you examine the list of formulations and the substrates they are used on it can be seen the most versatile system is screen printing.

Whatever the substrate is you want to print on to it must be wettable by the ink. That means that the ink must make full contact with the surface. On most surfaces this is a function of their surface energy and the relationship between that and the surface tension of the ink. Surface tension is the property of a liquid or ink arising from molecular forces that are unbalanced on or near the surface of the liquid. If the surface tension is higher than the surface energy of a material, the ink tends to form droplets rather than spread out. The other name for an ink‘s surface tension properties is its “wettability”.

Surface tension is normally measured in energy units called dynes (mN/m). A dyne is the amount of force required to produce an acceleration of 1cm/sec on a mass of 1g. The dyne level of a solid material is called its surface energy.

The surface energy of a substrate can be indicated by applying a liquid of a known surface tension to the substrate and seeing how it reacts. If the surface tension of the test liquid is lower than the surface energy of the substrate it will form a continuous film for at least two seconds. If the surface energy is lower then the test liquid will immediately form droplets.

Ideally the surface energy of the substrate should 10 Dynes greater than the surface tension of the ink to enable complete wetting. Solvent ink is typically 30 to 32Dynes.



PDS International Limited

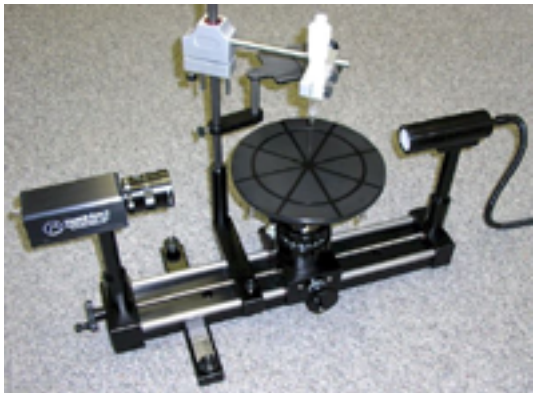
SUBSTRATES

There are more accurate means of measuring surface energy. One is to measure the contact angle of a droplet of water. This is done with a Contact Angle Goniometer.

A good contact angle is less than 60° a poor contact angle approaches 90° and above.

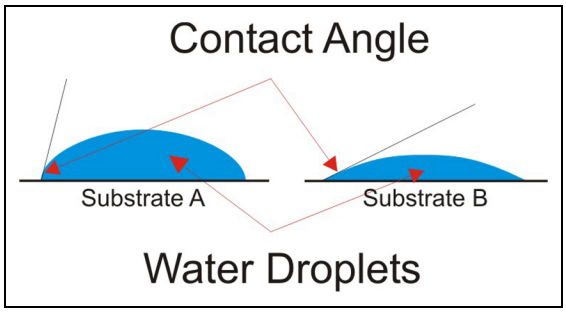
The greater the contact angle, the higher the surface tension of the liquid relative to the substrate. There are formulae that will derive the actual surface tension from the measured contact angle.

Goniometer



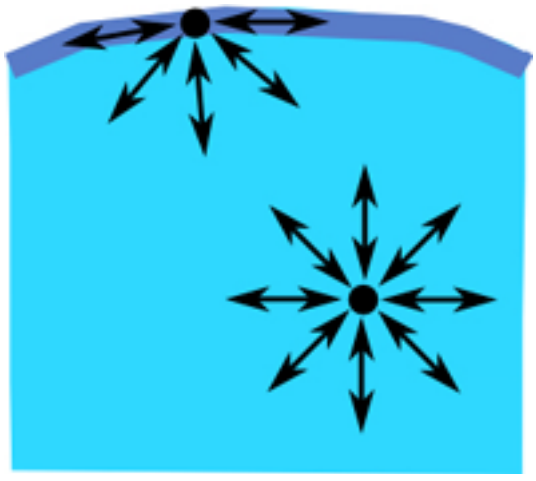
Surface tension exists because the molecules inside a liquid experience roughly equal cohesive forces in all directions, but molecules at the surface experience larger attractive forces toward the liquid than toward gas.

Contamination in the form of oil, grease, mould release or dust and debris will all compromise the adhesion of ink to the substrate. Clean paper and board provide a very good printing surface as they absorb some of the ink. Once other substrates are used particularly plastics matters can change. Many plastics have low surface energies such as polypropylene and polyethylene. To enable ink to stick on these it is necessary to either have inks with special chemistries or better still pre-treat the material to raise its surface energy.



Five methods are used, corona discharge, flaming, cold gas plasma, vacuum plasma and liquid priming. Liquid priming is the least favourite because the liquids contain harmful chemicals that need to be handled and stored very carefully. It is not a process that is recommended. Far superior but with varying levels of capital cost are the gas phase surface oxidation processes of corona, plasma and flaming. All the methods produce a gas plasma that consists of free electrons, positive ions and other species. This combination is extremely reactive. Plasma is considered as the forth state of matter, solids, liquids, gas and with sufficient energy gas will ionize into plasma.

Molecular Forces



	Uses	Advantages	Disadvantages
Liquid Priming	Polypropylene Polyethylene	Cheap	Harmful chemicals use with extreme care. Not recommended
Flaming	Used mainly on three dimensional items. Containers, mouldings etc	In line relatively low capital cost. Can remove thin plastic flash	Can affect the surface. Open flame hazard and difficult to control.
Corona Discharge	Three dimensional items, sheets of material, extrusions and web fed materials	In line relatively low capital cost. Precise control	Will not clean surface. Metal inserts short out the charge. Similarly holes will divert the charge. Affected by humidity. High voltage 500 -2000 volts. Produces ozone.
Cold Gas Plasma	Virtually any material. Can use different gases to suit special applications	Cleans as well as pre-treating. Low voltage	Limited suppliers
Vacuum Plasma	Virtually any material. Can use different gases to suit special applications	Treats large quantities of components on all surfaces. Plastic and metal combinations.	Expensive equipment. Not in line.

So why all this theory about surface tension and surface energy when all we want to do is select a substrate to print on to? Because, the condition of the surface is all important to the printer and the end customer.

Many plastics have low surface tension, frequently less than 28 mN/m. If such materials have to be printed by solvent-based inks they ideally should have surface tensions of over 40 mN/m or over 56 mN/m in the case of UV-drying systems. If pure water-based ink systems are used surface tensions of over72 mN/m are needed. In virtually every case water based systems do contain some wetting agents and co-solvents that reduce their surface tension. There are some inks available that can stick successfully to untreated polypropylene. These contain additional chemicals to assist wetting of the substrate. They are very specialised and limited in application but can be useful. Speak to your ink supplier about such inks.

Normally when a screen printer purchases polypropylene and polyethylene they would already been pre-treated by the supplier. Such substrates should be kept in their wrapping until use and then be carefully handled. Operators should wear clean cotton gloves to avoid contaminating the surface with oils from the skin. Although it was in a bottle printing plant an example of this was when adhesion failures were occurring for apparently no reason. 100,000 bottles were rejected by the client. The printer who was also the bottle moulder had taken every precaution. Spotless working areas, excellent pre-treatment, operators wearing gloves, no reason for the problem. We were called in

to investigate. It turned out to be an operator removing flash from the bottle wearing a glove to pick up the bottle, holding his knife in an un-gloved hand and putting his thumb in the same place every time as he cut off the flash. We thought of changing our name from PDS to CSI. That was a very expensive thumb print.

An increasingly important aspect of substrate use is its environmental impact. PVC materials are banned by some clients who are insisting on polypropylene due to its ease of recycling. Equally Polycarbonate100% recyclable, Acrylic 100% recyclable, Polypropylene 100% recyclable, PET 100% recyclable. Alternatives adding recycled materials to products, products that are bio-degradable. The ideal is closed loop recycled substrate where after printing and use it is collected and reprocessed back into printable substrate.

The biggest problem occurs when a display is made up of layers of different materials such as laminated board or when Self adhesive vinyl is stuck onto fibre board. The way to over come this is to print direct onto the substrate which is where screen printing scores. The huge range of inks available to the process makes achieving compatibility between ink and substrate far more likely. As had been said before screen printing is an ink friendly process.