

SOLVING THE PROBLEM OF ADHESION TO PLASTICS IN MEDICAL DEVICE MANUFACTURE

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WHY IS BONDING TO PLASTICS SO DIFFICULT?

The age old problem of obtaining good adhesion of coatings, adhesives and printing inks to traditionally hard to bond to materials like polypropylene, has challenged engineers ever since its development and introduction by ICI in the late 1930's. Examples of the materials in question are Polypropylene (PP) Polyethylene (PE), Cyclo Olefin Polymer (COP); all of which have low surface energies of between 29 and 34 Dynes/cm² (mN/m).

Achieving any level of adhesion to low surface energy materials e.g. P.P., P.E., C.O.P., P.T.F.E., is difficult at the best of times and sometimes near impossible. Basically, these materials are non-stick; printing inks rub off, glued parts fail, gaskets and seals won't bond, paint & coating will not adhere. Typically these problems are experienced throughout the medical device manufacturing industry and in fact in any industry that has to bond, print, or coat plastic or even rubber components. These problems are becoming increasingly commonplace with the increase in usage of polyolefins.

Generally polyolefins have what is called "low surface energy" or "non-polar" surfaces and no matter how much you attempt to clean or abrade the surface they remain hard or often impossible to coat, print or bond to without resorting to harsh, environmentally damaging chemicals or high temperature flame torch treatments.

This problem was recently experienced by a major UK medical device manufacturer when they attempted to glue needles to a range of COP syringes. After insertion of the needle, an adhesive was applied to the injection moulded component and UV cured. On testing, the finished parts failed due to very poor bond strength between the adhesive and the COP surface of the components; the needles simply pulled out.

To make things worse, the ever increasing drive towards the use of UV curing or water based adhesives, paints, inks & coatings means that even materials that have traditionally given

acceptable bonding results e.g. ABS, Nylon (PA) Glass Filled Nylon and Composites to name but a few, can also become difficult to bond to. This problem was highlighted earlier this year at another major UK component manufacturer when they introduced a new product moulded from Glass Filled Nylon and needed to apply a water based coating. Quickly the company realised that the coating was failing the adhesion test. Along with gluing and painting, printing on to plastics often presents a similar adhesion issue, this can be critical on medical devices or where high print quality is required e.g. syringe marking, barcodes etc.

The strength of attraction between a material and a coating is determined by the relative surface energy and surface tension of the materials. The higher the solid's surface energy relative to the liquid's surface tension, the greater the molecular attraction; this draws the paint, ink or adhesive closer for high bond strength. The lower the solid's surface energy relative to the liquid's surface tension the weaker the attractive forces are; this will repel the coating. The challenge faced by producers of extruded or injection moulded components is to increase the surface energy (polarity) of the material to a level significantly higher than that of the surface tension of the paint, coating, adhesive or printing ink, so that the surface acquires a strong chemical attraction to paints, coatings, sealants, adhesives etc. leading to significantly enhanced wetting and adhesion. Typically the Surface Energy of the substrate will need to exceed the Surface Tension of the ink, paint, coating or adhesive by at least 10 - 15 Dynes/cm² (mN/m).

HOW CAN BOND PERFORMANCE TO PLASTICS AND RUBBER BE IMPROVED?

Firstly, we need to understand what surface properties are required to obtain the ideal conditions for adhesion. There are many common misconceptions about what are the best conditions required for the strongest bond; should the surface be heated? abraded? solvent wiped? Sometimes these pre-treatments do no harm and may on some occasions even help a little, however, it is widely recognised that the ideal surface to bond to should be:

- ✓ Clean
- ✓ Dry
- ✓ Dust free
- ✓ Smooth
- ✓ Non-porous

- ✓ Wettable (high surface energy)
- ✓ Polar

Preparing a clean, dry, dust free, smooth and non-porous surface requires little discussion, however, creating a surface that exhibits good wettability and is “polar” clearly does. There are several methods of increasing the Surface Energy and Polarity of plastics and rubbers, they include: wet chemical treatments which are often harsh and environmentally damaging, high temperature flame torch treatments, high voltage corona treatment and finally plasma surface activation which we will discuss in this edition.

PLASMA SURFACE ACTIVATION.

Exposing low surface energy extruded or injection moulded components to the highly active environment of either vacuum or atmospheric plasma is a very effective and long lasting method for increasing their surface energy and polarity. The component undergoes a very efficient surface treatment that is environmentally friendly, does not alter the bulk properties of the treated part and does not mark or discolour it in any way. The resulting highly activated surface will now have the required high surface energy and polarity necessary to ensure good wetting and adhesion of printing inks, paints, adhesives, coatings, potting materials etc. Plasma surface modification is widely used throughout a diverse range of industries and onto an ever increasing range of substrates. In simple terms, plasma is generally described as a super ionised gas or as an electrically neutral medium of positive and negative particles and neutrals (atoms, radicals & molecules) and can react with a wide range of materials. "Ionised" refers to the presence of free electrons which are not bound to an atom or molecule. Plasma is created when a gas is subjected to a high energy discharge; the gas breaks up into electrons, ions, highly reactive free radicals, short wave UV light photons and other excited particles. In general terms, when you subject atoms or molecules to enough energy, what happens very quickly is that the electrons around the nucleus start to "boil off", the temperature becomes too high for them to stay contained in orbit around the nucleus. Plasma is not new; it was first described by Sir William Crook way back in 1879 and is the most common type of matter in the known universe whether measured by mass or volume. Every star is a giant ball of plasma, even the space between all of the stars is composed of plasma. Plasma is considered to be the 4th state of matter after solid, liquid & gas.

The free radicals and other particles that exist in the highly active plasma discharge can attach to the material's surface resulting in the formation of additional polar groups, these have a strong chemical attraction to paints, coatings, sealants, inks and adhesives leading to significantly enhanced surface energy, polarity and therefore adhesion. Plasma surface modification equipment is available in two industrial configurations i.e. vacuum plasma chambers that can process large volumes of parts in a single operation and atmospheric plasma nozzles that can be fixed and are ideal for extruded parts, or robot mounted for parts with more complex geometries or where selective treatment is required.

UK based company Dyne Technology Ltd offers Plasma treatment equipment as a cost effective and efficient solution to the medical device manufacturing industry to solve the problem of obtaining a strong adhesion of coatings, printing inks, glues, paints, sealants and potting materials to low surface energy / low polarity and therefore difficult to adhere to plastic and rubber components. Plasma surface modification is widely used throughout a diverse range of industries and onto an ever increasing range of substrates. A growing list of companies in the medical device manufacturing industry are turning to Plasma solutions supplied by UK based Dyne Technology. www.dynetechology.co.uk

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Dyne Technology Ltd is a leader in Plasma & Corona Surface Treatment Technology that enables manufacturing companies mainly in the Plastics & Rubber Industries to improve performance whilst lowering costs and environmental impact. Dyne Technology Ltd is a UK based company.

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