

TECH PAPER

START RIGHT – TO FINISH RIGHT!

**Why the correct surface treatment at extrusion is
critical to all downstream processes**

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Plastic film is non-absorbent – fact!

But plastic film has become an integral part of our daily life, and none more so than in the field of packaging where it needs to be printed, laminated, and converted. So how do you ‘persuade’ the non-absorbent filmic substrate to accept ink, lacquer, and adhesive? Simple – by surface treating it and changing the chemical construction of its surface layer. This technical paper sets out to explain the process of surface treatment and the importance of getting it right from the very beginning.

The importance of secure adhesion

All who work in the commercial production of plastic film material for printing, converting, and laminating purposes appreciate the importance of surface treatment to ensure a smooth workflow. The need to strike a balance between the surface energy of the liquid and the solid to which it is being applied is fundamental in flexible packaging and while known, it is often misunderstood.

As we have explained in our previous technical paper, it is important to understand the fundamental principles of surface treatment before looking in depth at its role in the process of extrusion. As everyone knows, plastic poses a problem when it comes to the adherence of a liquid. Use a ballpoint pen to write on a plastic bag and you can smudge the ink by rubbing your finger across it. The problem is a mismatch of surface energy between the two, and this is resolved by modifying the molecular structure of the plastic surface in a process known as corona treatment.

A carefully controlled application of an electronic discharge at close range to the plastic film changes the chemical make-up of its surface layer by breaking down long molecule chains and allowing the liquid to adhere. Instead of ‘beading-up’ the liquid ‘wets out’ and secure adherence is achieved. By increasing the surface energy of the plastic film, which is measured in dynes, it is possible to perform a range of different printing and converting processes that would otherwise prove impossible. And, this process of surface treatment starts at the very beginning of plastic film manufacture, when it is extruded.

But, like most industrial processes, it is not straightforward. Different plastic film formulations have different dyne values and different processes demand different dyne levels to be successful. For example, in Fig 1(*on page 2*), if we look at basic materials like PP, PE-LD, PE-HD, and BOPP there is a range of native dyne values from 29 to 32. However, the dyne level requirement, for example, of printing with solvent-based inks, or water-based inks, or for coating or laminating vary from 40 - 42 at the low end to 46 - 56 at the high end. To achieve these higher dyne levels, the corona system will require more power.

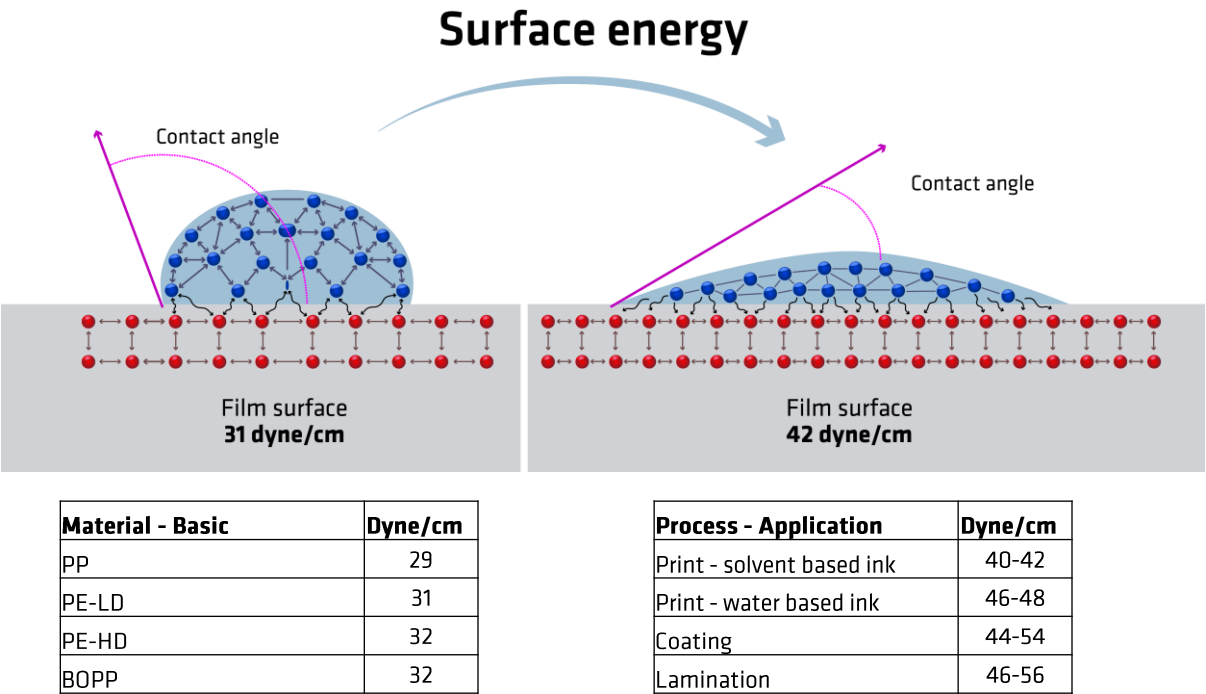


Fig. 1

During the extrusion process it is easy to increase the dyne level from say 32 to 52 or more. By increasing its surface tension, the substrate becomes more willing to accept the liquid (wettability) because the long molecular chains at the surface are broken up to create more free links to which oxygen molecules can attach. But after extrusion, the polymer chains take 48 – 72 hours to post-crystallise, with additives like slip agents and those for anti-fogging migrating back to the surface and in turn affecting the adhesion level.

Therefore, correct treatment at extrusion is vital for two reasons: first, because dyne levels decline over a period of time – typically 4 - 6 dynes over a period of 2 - 3 weeks before stabilising; and second, because subsequent ‘boost’ or ‘bump’ treatment may be required at a later date depending on the intended process, and this may not be possible if corona treatment during extrusion was poor. If you look at Fig 2 ‘Durability’, you can see the different rates at which different substrates lose their dyne levels, and importantly, the power required to regain the necessary dyne level for various converting processes by boost treating with the corona system.

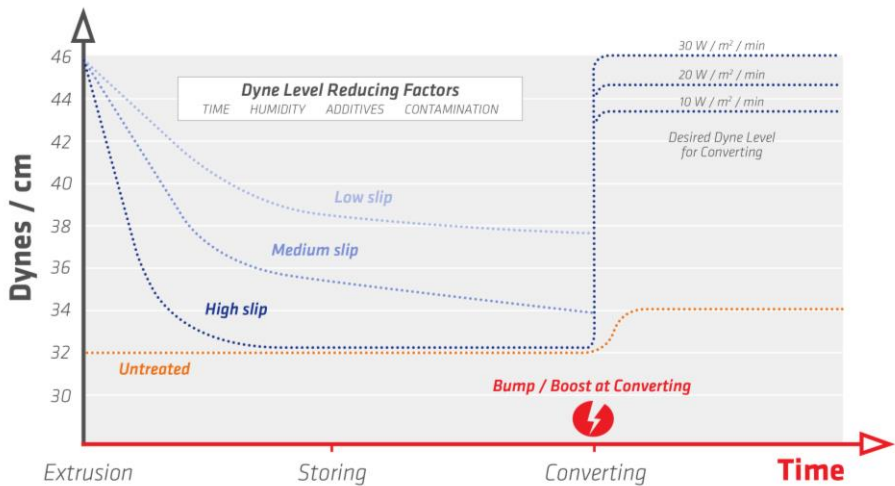


Fig. 2

These calculations are only possible because at extrusion we can precisely calculate the power required as we know the intrinsic surface tension of the polymer and all the applicable material factors. There is a simple formula for calculating the boost power required. It is $POWER = W (\text{substrate Width}) \times S (\text{line Speed}) \times F (\text{Faces}) \times M (\text{Material Factor (W/m}^2/\text{min)})$. So, what is the 'material factor'? Material factor is the term used to specify the generator power required to be discharged onto each square metre of film to achieve sufficient surface energy for the desired process. It can be difficult to determine as it depends on the material type, age, and additive content amongst other factors. If you look at Fig 3 you can see the variations relating to different types of freshly extruded and aged PE, as well as variations of three other substrates.

PE LOW SLIP	Fresh extruded	PE	Curve 1	Aged PE	Curve 2
PE MEDIUM SLIP	Fresh extruded	PE	Curve 2	Aged PE	Curve 3
PE HIGH SLIP	Fresh extruded	PE	Curve 3	Aged PE	Curve 4
POLYPROPYLENE	(Copolymer)	PP	Curve 1	PP (Homopolymer)	Curve 3
ORIENTED POLYPROPYLENE		OPP	Curve 3	BOPP	Curve 4
POLYESTER	Pure material	PET	Curve 1	PET with additives	Curve 3

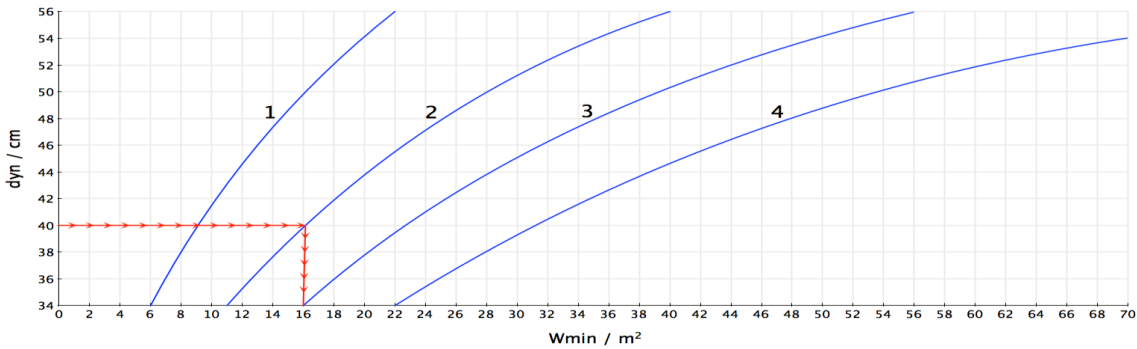


Fig. 3

That's the theory behind surface treatment and its importance – now it's time to look at the extrusion process. Essentially there are two basic methods:

- 1 Blown film extrusion
- 2 Cast film extrusion

Both form the first step in creating a flexible packaging material (film), and depending on the final product required, one or other will be the chosen method.

How this works in practice – Blown film

With **blown extrusion**, the film is extruded vertically and wound into one flat tubular or two reels that are then converted by printing/coating/sealing into the final packaging product. Blown extrusion is typically for PE based materials which require a surface energy of 15w/m²/min in 95% of cases. The corona station is usually located at the top where the flattened tubular film is treated on the outside only. It is then split in two and can be either treated additionally, which is rare, or alternatively on the inside before being wound onto reels. On the latest extruders, the winder can operate in both directions so just one double-sided corona treater can be used.

General features of blown film extrusion include multi-layer polymers like LDPE, LLDPE, mLLDPE and MDPE with thicknesses of 20 – 200micron and line speeds of 150 – 200m/min with a required treatment level of 42 Dyne. Product applications include pallet hoods, collation shrink film, stretch hoods, lamination film, deep freeze film, heavy duty film, protective film, and food packaging film. These are single layer up to normally 3 layers but can be up to 11 layers in the case of food packaging film. With 3-layer collation shrink film using solvent-based inks, a material factor of 10 – 15 w/m2/min can be used. For 3-layer lamination, where more adhesion is required, the material factor to be used is 20 w/m2/min.

In most of the applications, the reels produced are subsequently passed through a converting process where the final package takes its definitive shape. Welding is normally part of this process, and it is therefore important to evaluate the impact of the corona effect on the welding area. Corona treatment is notoriously the enemy of welding because the oxidation generated by the corona process weakens the welding area.

There are several solutions that can deliver a perfect result in this situation, starting with multi-lane films, where a pattern is repeated many times across the layflat. A slit sealing device is generally used to simultaneously cut and seal the edge of multiple tubulars which are collected at the end of the welding machine. Segmented electrodes are the perfect solution for limiting the corona effect in this area, avoiding the possibility of a weak sealing effect. Segmented electrodes are available from 10mm down to 2mm to secure the best accuracy. The reason for 2mm segments is to make it possible to locate the segment exactly where it is needed.

Another option is the SKIP Function. This is essential if you want to produce bags with a top and bottom welded area where a secure seal must be provided. This function is even more important when the bag has side gussets because four layers need to be welded to secure good strength without affecting the film stability.

Multilayer high barrier film structures are by nature more complex as is illustrated by Fig 4.

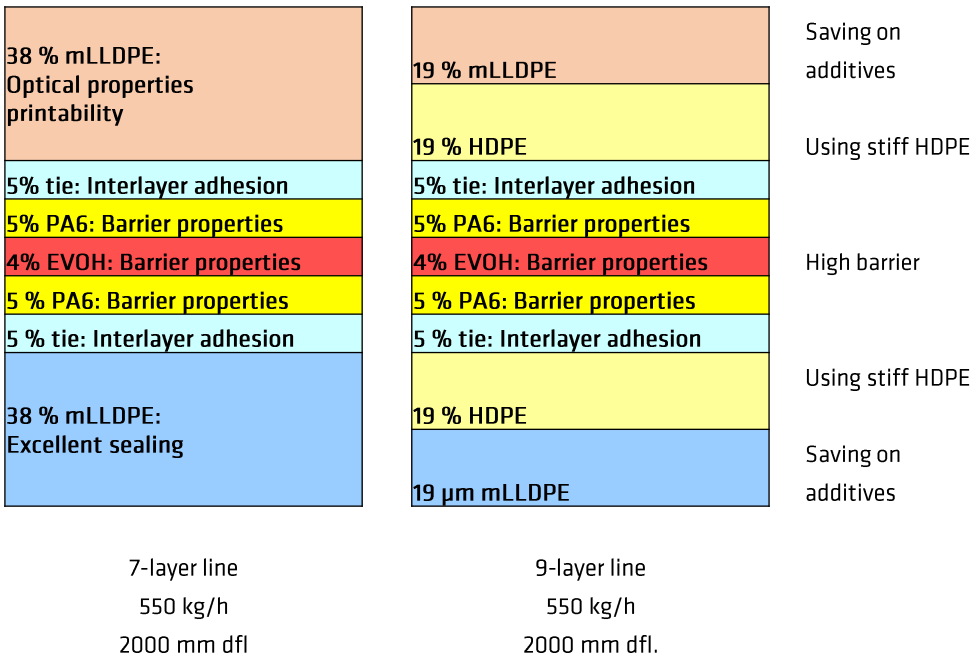


Fig. 4

What is important to remember is that all multilayer films (3, 5, 7, or 9) are always treated on the outside of the bubble, and the material is usually LDPE or LLDPE. These barrier films are typically designed to offer several additional functions including communicating the perceived quality of the product to the consumer. Any foodstuff packaged with a lid will include an 'anti-fog' additive to ensure perfect visibility of the product inside. The problem is that additives migrate to the surface creating an invisible layer that affects the corona treatment. It is important to evaluate this so that it does not affect the welding or other properties.

One important parameter is the thickness of the layer where the antifog is added. Even if the percentage is as low as 1 % to 2 %, the thickness and additive levels are higher, which results in a greater concentration of antifog migrating to the surface. This creates two problems: a larger quantity of antifog is needed in the structure, which is costly; and there is more impact on the corona treatment, so more power is needed to balance the migration effect.

How this works in practice – Cast film

Moving on to **cast film extrusion**, the substrate is produced from a flat die and wound as a single film after being side trimmed. In this type of installation, the corona treater is usually located before the winder but after the first edge trimming zone. Because the edges of the cast film are thicker than the rest of the web they need to be cut off before entering the corona station and winder to prevent any damage to the rubberised rollers.

Cast film extruders have a higher capacity and faster running speed than their blown film counterparts, so a corona treater capable of delivering a higher power is required to achieve the best result. This application would typically require a single-sided treater with an extended shaft (optionally motorised) and has a nip roller to prevent treatment to the reverse side of the web. In most cases the corona unit is used as a pull station.

Cast Polypropylene, normally called CPP and different to stretch film, is used for a wide range of packaging, and normally requires corona treatment. CPP is more complex than PE so needs a higher power setting and a material factor of 25 – 30w/m²/min would usually be recommended for this type of material. In the case of Oxygen Barrier film, the outer LDPE or PP layer is normally corona treated for the next printing or laminating process. Diaper film, typically LDPE, also requires good Corona treatment so a power rating of 20 – 25 w/m²/min is recommended.

As with blown film extrusion, there are a few key points to remember with the Cast method. The layer you are treating is usually LDPE or PP, so you need to be aware of the amount of additives in the film. And, with the Corona treater being used as a pull station, you must remember that the backing roller is driven, water cooled and equipped with a nip.

In summary

As you can see from the above information and explanation of the extrusion process, there are few simple answers and a definite need for specialist knowledge to ensure the best results are obtained. As substrates become more complex to meet new packaging and safety criteria, the need for a detailed understanding of the surface treatment process and what it can offer becomes more important.

With more than 70 years of experience and research data, Vetaphone is unrivalled in its ability to advise, educate and assist production personnel at every stage where surface treatment technology is required. Often misunderstood, it is a process that if managed correctly pays dividends throughout downstream processing from the moment of extrusion. As we said at the beginning: 'Start right - to finish right!'

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