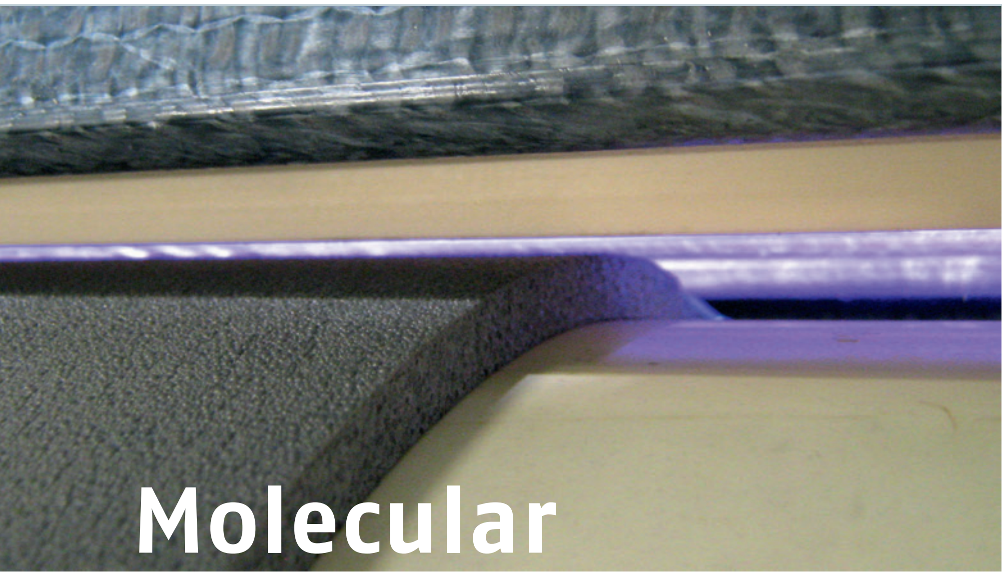

Linear plasma treatment allows surfaces of 8 mm-thick foam to be treated (figures: Softal)

Molecular Functionalization of Polymer Surfaces

Atmospheric Pressure Plasma is highly suitable for treating the surfaces of thermally sensitive polymers. This method can also process materials of any desired thickness. In a further application, plasma in a controlled gas atmosphere offers a replacement for wet-chemical adhesion promoters.

FRANK FÖRSTER

Atmospheric-pressure plasma and corona technology have been widely used for many decades for surface treatment in extrusion and converting of polymers. Atmospheric pressure plasmas continually open up new fields of application. The main focuses are the adaptation of the plasma sources to materials and geometries, and plasma-induced surface functionalization. Against this background, Softal Corona & Plasma GmbH, Hamburg, Germany, has developed linear plasma technology and Aldyne atmospheric plasma treatment.

Plasma Initiates Chemical Reactions

The aim of corona treatment is to adjust the surface energy in a controlled way so as to improve the adhesion of inks, lacquers, adhesives and coatings. The volume properties of the polymer matrix are not changed. Besides its high efficiency, its use is also favored by its controllability, ease of handling and low costs.

During pretreatment, the plasma activates a large number of chemical reactions in the air within the electrode gap and on the polymer surface. The result is the chemical bonding of functional groups, such as hydroxides, ketones, ethers and carboxylic acids to the polymer surface. These groups are polar and increase the surface energy. However, in practice, conventional corona technology is limited to two-dimensional materials with thicknesses of only a few millimeters **(Fig. 1)**.

For the first time, linear plasma surface technology allows materials of unlimited thickness to be treated **(Fig. 2)**. Atmospheric-pressure plasma treatment modifies the surface of plastic sheets, polymer foams and composites in the subnanometer range, so that adhesives, printing inks, lacquers and other coat-

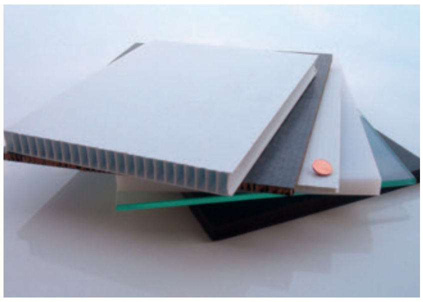

Fig. 1. Besides foams with different surfaces, multiwall panels can also be treated by the linear plasma process; where conventional corona treatment may not be used

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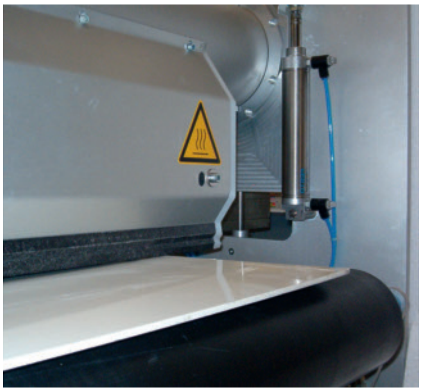

Fig. 2. This surface technology can be used to treat materials of any thickness; atmospheric pressure plasma modifies the surface on a sub nanometer scale

ings adhere reliably. The high efficiency of the plasma source also allows the treatment of highly thermally sensitive materials. Multiwall panels or honeycomb structures can also be activated in this way. In open-pored foam, there is no risk of localized preferential discharges, and closed-pored foams are not perforated (**Title photo**). Furthermore, the edge regions are not damaged by the plasma discharge and, it is not necessary to adapt the material width to the electrode width. In addition, the system can be installed in existing extrusion and converting lines.

Surface Treatment via a Controlled Gas Atmosphere

The Aldyne process – used as surface treatment in a controlled gas atmosphere – achieves the efficiency of wet-chemical coating processes at a fraction of the costs. This permits targeted control of the chemical processes that take place in the plasma, and ultimately on the surface to be treated. As a result, functional coatings of the thickness of a monolayer (typically 0.3 to 0.4 nm) comprising, for example, amide, imide and amino groups, which are covalently bound to the outermost polymer chains. These functional groups allow the polymer to bond to adhesives and other coatings (**Fig. 3**).

In many applications, where adequate bonding is not possible using corona treatment, adhesion-promoting liquid primers are used. This increases manufacturing costs i. e. primer, the production process and the removal of organic solvents. Treatment in a controlled gas atmosphere offers an alternative to liquid primers on polymer surfaces such as polypropylene (PP), polyethylene (PE) and polyethylene terephthalate (PET). In comparison to liquid priming, under normal production conditions, the Aldyne process costs only a tenth of treatment with conventional primers.

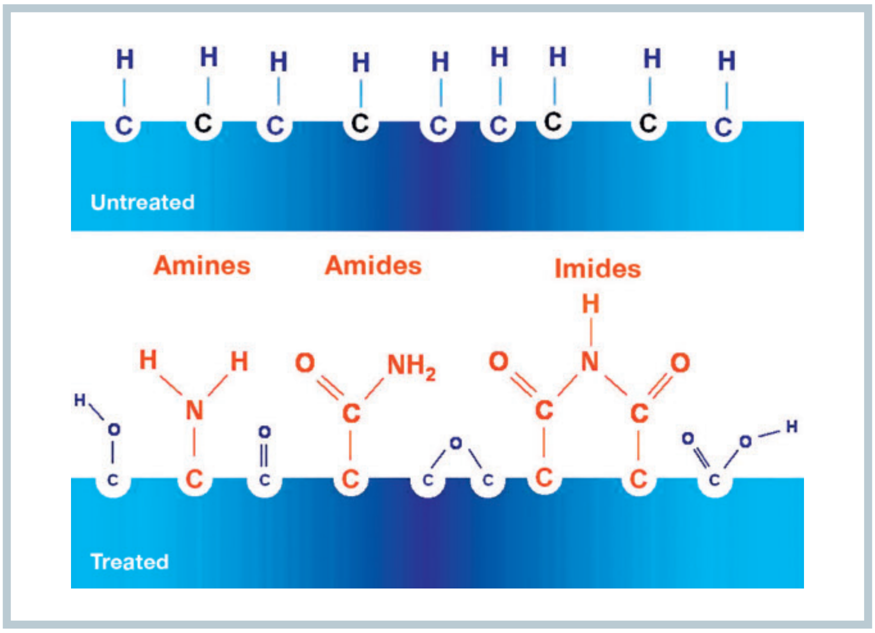

Fig. 3. An untreated surface only has hydrocarbon compounds; treatment in a controlled gas atmosphere creates functional coatings that form a layer with an adhesion-promoting monolayer primer

No liquid or solid materials are involved in the surface treatment, and therefore no residues and contamination can be deposited. Since no solvents are involved, there is also no need for cleaning and drying, and the associated downtimes. There is also no risk of inclusion in the surfaces.

Fig. 4. The stations are designed for inline treatment and can treat, for example, web widths of 2 m at production speeds of 300 m/min

The process gases required for the process are harmless to health, non-hazardous and environmentally safe. The same applies to the layers because of their composition and the small amounts of substance. Since a covalent bond is present, the adhesion promoter is also not volatile.

Water-cooled Electrodes for Plasma Output

The second equipment generation (**Fig. 4**) now incorporates water-cooled electrodes. These allow high plasma outputs to be achieved even with a reduced size, without harming the materials. The chemical processes at the material surface are intensified by the concentrated plasma discharge.

Furthermore, the housing has been optimized and new sealing systems installed to reduce gas consumption and cut operating costs. Customers have a free choice of gas suppliers. It is also possible to provide stations for any desired web sizes and speeds. ■

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