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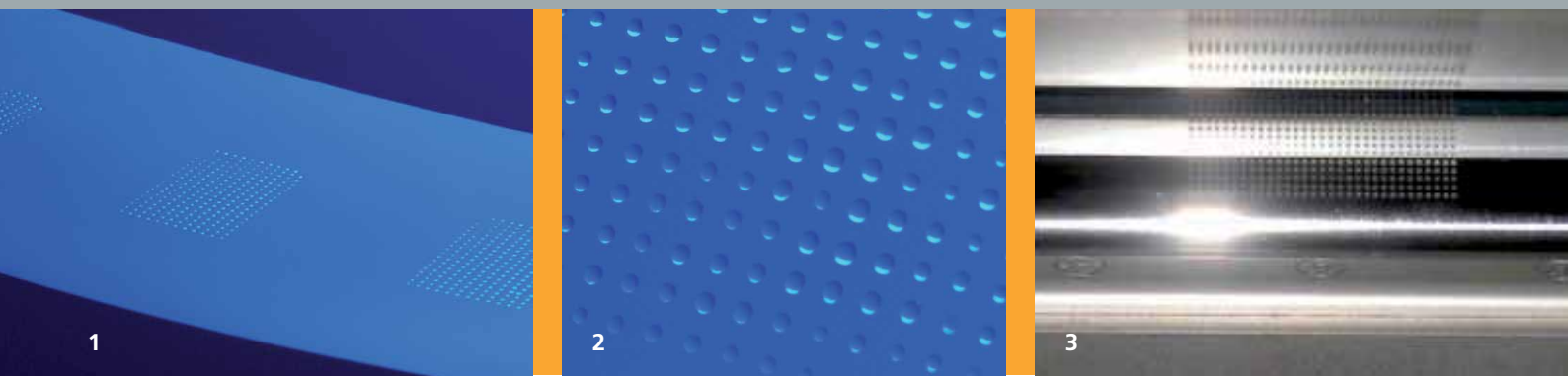

1, 2 *Polyolefin film (COC) with water droplets at the spots where the surface was oxidized.*
3 *Printing cylinder with array pattern.*
4 *Roll-to-roll processing.*

PRINTED CHEMISTRY

SURFACE FUNCTIONALIZATION PRODUCED BY PRINTING TECHNOLOGY AND R2R PROCESSING

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pioneers in polymers

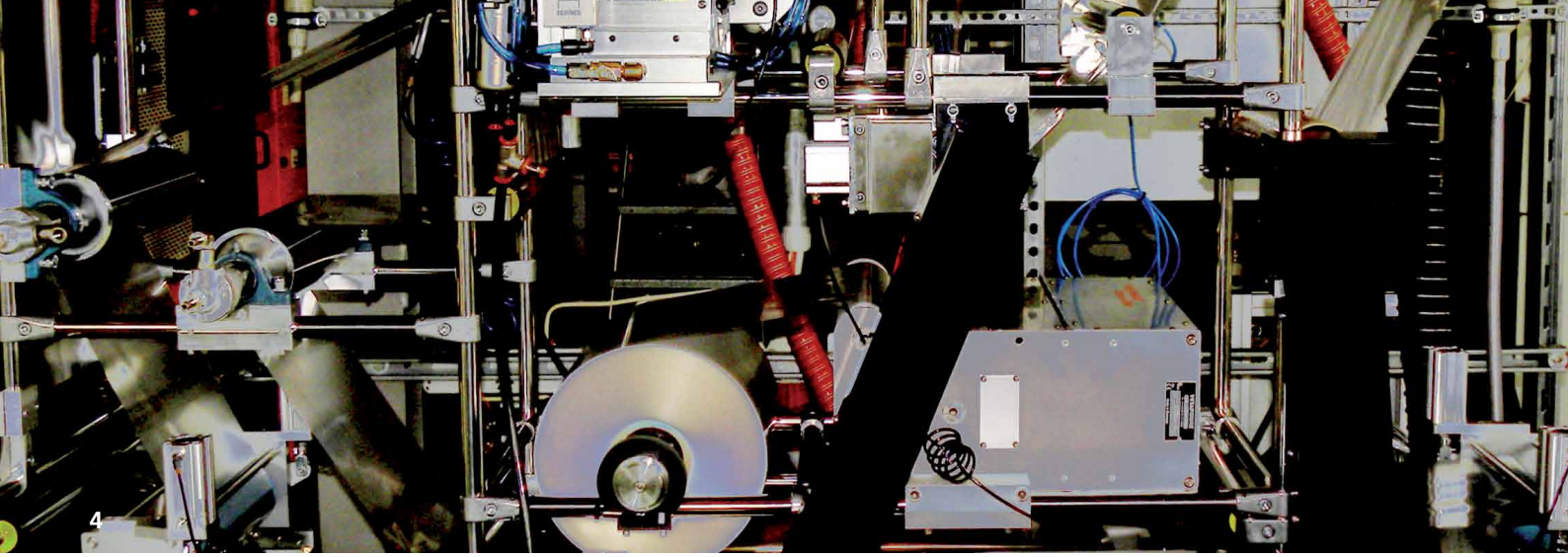
Summary

Polymer films are activated in efficient processes on an industrial scale in order to alter the surface properties for e.g. improved printing and adhesive joining. The variability of the surface chemical properties, however, is rather limited with this kind of treatments and some applications cannot be served well such as optimized high performance adhesive joining or materials for the immobilization of biological molecules for medical diagnostics. The combination of an activation process with wet chemical conversion is one way to produce a more specific surface chemistry. The efficient activation renders the inert polymer surface reactive and creates some functional groups which then can be used for more specific reactions with low molecular weight substances or with functional polymers. We demonstrated to use printing technologies for the second chemical conversion step.

Our services

At the Fraunhofer IAP we have many years of experience in the surface functionalization of natural and synthetic polymers, in the thin film preparation of organic materials, and with combined processes. The know-how can be applied to support our clients with

- consulting
- feasibility studies and market surveys
- technology and process development
- design and set up of equipment
- development and implementation of quality control techniques
- analytical and testing service
- trouble shooting
- personnel training



Polymer surfaces

Polymers are very versatile materials which can be processed into almost any shape very efficiently and in high quantities. The low surface free energy is another distinguished property of polymers which gives rise to effects like a bad wettability and poor adhesion. To improve these properties, the surface chemistry must be altered.

Electrical discharges such as coronas and low-pressure plasmas are well established in industry. The process called activation is based on an oxidation of the surface. The higher surface energy results in a better wetting and better adhesion.

Surface functionalization

The high reaction rates of the radical reactions involved in the surface activation results in a rather broad spectrum of different functional groups. Within certain limits the kind and the concentration of the groups can be influenced by the treatment parameters. For producing a defined surface structure the combination of an activation with a second reaction step has been established. Some of the functional groups from the activation are used to carry out chemical reactions with liquid or gaseous agents. These reactions form well defined products with a specific concentration of a particular functional group.

Printed chemistry

Polymer films can be handled very efficiently in roll-to-roll (R2R) processes. For example, the activation of polyolefin films runs at web speeds of 600 m/min and more on an industrial scale.

At the Fraunhofer IAP we use R2R printing technology for the second step in a surface functionalization process. Film converting equipment is used to produce the functionalization.

With our equipment films can be activated by using R2R processes and a corona discharge, an excimer VUV-lamp, or low-pressure plasmas. Then the film can be coated with an agent. Currently, we use gravure printing cylinders (rotogravure technology) which can produce coatings with different thicknesses. Depending on the application, the equipment can be fitted with homogeneously engraved cylinders or with various kinds of patterns such as dot arrays or test stripes.

While in a normal printing process the ink is dried quickly, the agents require some time to react. Different cylinders can be used for heating or cooling in order to adjust the reaction conditions. The heater can be used to increase the reaction rate or to dry the coating.

Applications

The technology can be used wherever a defined chemistry beyond the simple activation is required on a flat surface. The web can be used as a substrate or the plastic film is bonded to the actual carrier. It can be used directly as a web or it is cut at the end of the processing to serve applications with an established format. Compared to the normal film converting the productivity is rather low due to the fact that the reactions require time. However, compared to batch processes of pieces the productivity can be increased considerably. If the volume of the production is sufficiently high the costs per unit are on a much lower level than in a batch process.

Microarrays

Microarrays are good candidates for the application of R2R processing technology if the production volume is in the order of millions per year. Assuming a microscopy slide format (25 mm by 75 mm, 1" by 3") arranged side by side on a film. At 1 m/min web speed 16,800 pc/d can be produced in a 7 h shift which adds up to 3.7 million pc per year.

The coating chemistry can be constant for all the products or it is altered for various types of the product. It is also conceivable to print some kind of basic chemical coating and combine the printing equipment with ink jet type printing stations or with spotters to produce spots with a specific loading.

Technical data

maximum web width	30.0 cm
minimum web speed	0.6 m/min
maximum web speed	80.0 m/min
dryer	8.0 kW
	140 °C
web tension control	
edge control	