Wafer-Thin on the Film

Effective and Energy-Saving Functionalization of Food Films

The Calvasol method provides a flexible, economical, and efficient way to functionalize films with corresponding coatings. Compared to alternative methods, the applied layer thicknesses are in the range of 0.1 to 10 nm which reduces the consumption of chemicals and energy in processing.

A clear view: Preventing the fogging of food packaging film is important. Corresponding functionalizing additives in aerosol form can be applied in a very thin layer to accomplish this (© kalwar)

For standard or high-tech plastic films: Multifunctional application is always the focus. That is why lacquering and coating systems play an ever-increasing role in the development and production of packaging. Physical limits that cannot be overcome currently exist with established coating systems. Application weights between 1 and 4 g/m² are not only a question of the desired coating function, but are essential to overcome the boundary layers and achieve a cohesive coating. This requires adequate adhesion of the substrate being pretreated by an upstream corona treatment and the application of a primer coating.

Avoiding High Energy Consumption for Drying

While most of the energy for solvent-based coating systems is expended for post-combustion, the biggest investment for coatings soluble in water is for drying. Between 1 and 4 g/m² of the coating generally has to be applied to the film surface with both methods in order to obtain the corresponding result on the substrate surface. Since the concentration of solids is typically in the low range of less than 10 %, up to 90 % water or solvents must be evaporated or combusted in a short time. This is only possible with significant energy consumption and modern coating systems. The evaporation of a water-based coating in a drying section for example requires energy consumption of at least 100 kWh. Significant amounts of energy can quickly be consumed at high production speeds due to the combination of multiple driers (for instance in a drying tunnel).

This applies correspondingly for the post-combustion of solvent-based coatings. However, the use of solvent-based coatings is decreasing in the interest of sustainability and the immediate disadvantages for people and the environment. Environmental policy regulations are going to intensify this trend going forward.

Wet chemical application processes are performed either in printing machines or corresponding coating systems intended for the purpose called coaters. When a printing machine is used for instance to apply an antifog lacquer, the remaining printing mechanisms cannot be used since the antifog lacquer is generally applied to the back of the printed material, so that coating in one operation is not possible. Print orders have to be delayed or may also have to be outsourced to supply customers on time. The resulting additional costs due to added process steps, logistics, reduced machine capacity utilization, personnel, and storage space are difficult to pass on through the product. Significant costs are incurred for wet chemical processes both in coating and in printing. For example, the annual production of approximately 30 million m^2 of film coated with antifog lacquer at an application weight of 3 g/m^2 consumes up to 90 t of lacquer.

Treatment and Coating in One Process Step

The kalwar group in Halle, Germany, has combined surface activation and coating in one process step. In the developed Calvasol process, functional aerosols dissolved in water are supplied directly to the discharge area of the corona electrodes, anchoring functional molecules precisely on the film surface as it runs through (**Fig. 1**). These molecules consist for example of antistatic or antifog additives. The magnetic fields that form »

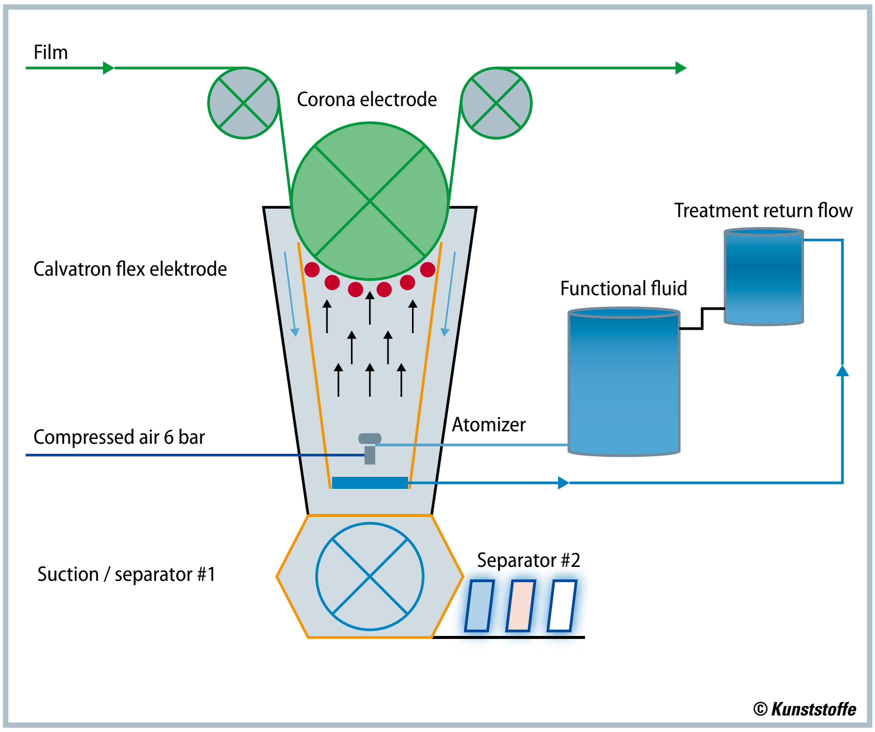

Fig. 1. Schematic representation of the Calvasol method that combines the corona treatment and aerosol application. It is used for the permanent antiadhesion, antifog or antistatic functionalization of films (source: kalwar)

Fig. 2. The aerosols are applied to the film from below. This has the benefit that the functional molecules can be anchored in a very thin and even layer (© kalwar)

around the corona electrodes attract the fine aerosol droplets (**Fig. 2**). As soon as these pass the electrodes in the direction of the film, they are charged and therefore adhere to the substrate surface. The plasma field of the corona electrodes enables the necessary adhesion preparation and simultaneously the anchoring of the aerosols on the film surface.

In contrast to wet chemical application processes, the application of an additional primer coating is omitted. Functionalization is realized in a single step rather than the three steps required for wet chemical application. Since the Calvasol system is barely larger than a conventional corona station, it can be integrated into laminating lines directly after the films are bonded without negatively influencing the laminating adhesives (**Fig. 3**). The consumption of chemicals is so low that the applied substances are barely detectable and are more than 90 % below the specific migration limit currently prescribed by law for food contact (**Title figure**). In reference to the annual production of 30 million m^2 of film cited in the example, the method presented here only consumes about 2 t of water-based chemicals.

Drying is not required since the functional layers are very thin. At speeds of around 200 m/min in a typical laminating system, the residual moisture evaporates immediately due to the laminar flow. Thus, energy is only consumed for the Calvasol technology, which is insignificantly higher compared to a conventional corona system with an output of 20 kWh.

Direct Integration into the Extrusion Process

Aside from applications in the coating printing and lamination process, the method also supports integration directly into the film production process. Many additives extruded either as masterbatch or compound additions can be applied to the film surface inline as aerosols. Slip, antiblock, or antistatic additives can for example be applied without any negative influences on the further processing of the films since they are applied in much smaller quantities compared to the compound or masterbatch process. Specific conditioning of the extrusion process and production environment in order to cause these extruded additives to migrate to the film surface is not required either, since the Calvasol method applies these substances directly where they are needed. Furthermore, the functionalization of the films with bonding agents increases the defined adhesion and makes it possible to achieve adhesion values that are stable in the long term (**Fig. 4**),

Fig. 3. The Calvasol system can be integrated directly into the lamination process with no negative influence on the lamination adhesive (© kalwar)

Previous Development

The roots of the Calvasol method go back to the 1980s. In addition to the fabrication of corona systems, kalwar was also engaged in medical technology making ultrasound atomizers for use in hospitals. Tests were conducted at that time to determine whether it is possible to spray water in the form of aerosols into the high-voltage area of the corona discharge. Continuous further developments and improvements were realized on the basis of these tests. With the current Calvasol systems produced in series, the basic principle is still the same except that the aerosols are no longer produced using ultrasound and application mainly takes place against gravity.

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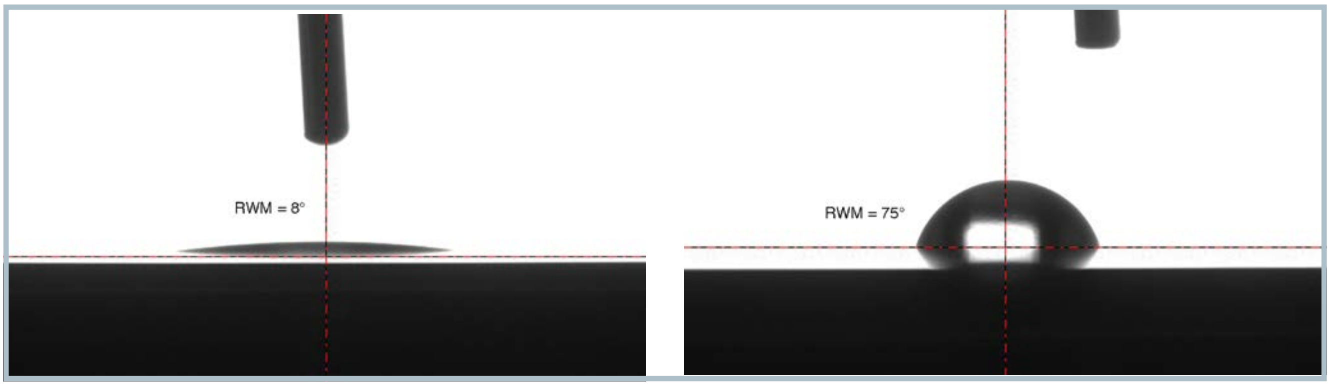

Fig. 4. Measuring the contact angle of a film coated with (left) and without (right) Calvasol shows the influence of the Calvasol antifog function: The goal is to create a surface with maximum hydrophilic properties, indicated by a small contact angle in the measurement with water. The greater the contact angle (image on the right), the poorer the antifog effect (© kalwar)

even when the physical influence of the corona treatment has already decreased. This is of interest in flat film extrusion for unstretched polypropylene (CPP) and production processes for oriented PP (OPP), bi-oriented PP (BOPP), or bi-oriented polyethylene terephthalate (BOPET) films.

Further Development of Functional Chemistry

The Calvasol method is also suitable for the functionalization of paper or other absorbent materials. Antiadhesion properties can for example be produced here with silicon-free aerosols, for instance for labels. Subsequently, printing such surfaces is possible as well. The adhesion of paper can be specifically adjusted as well in order to prepare the surfaces for different printing processes. Configuring the absorbency and printability of nonwoven fabrics with long-term stability is possible. Functional aerosols exist for hygiene products that can create soft touch and antibacterial properties.

The Silane business area of Evonik Resource Efficiency GmbH, Essen, Germany, has been cooperating with the kalwar group in development, marketing, and sales since September 2015. Joint work on additional functionalization applications such as barrier coatings continues. The Calvasol system can also be leased since the beginning of this year to simplify the use of this process technology. ■