Steinhagen, February 25th, 2025

**Using Openair-Plasma to pretreat syringe barrels**

How atmospheric pressure plasma optimizes the use of COC prefilled syringes

**Prefilled syringes are indispensable in many medical applications, from enteral nutrition to high-dose drug delivery. Like conventional disposable syringes, they consist of a syringe body, a syringe plunger with a seal and a Luer lock connection or an attached cannula. After being filled with the medicinal product or nutrient solution, they are sterilized, if necessary. It is important that they function perfectly even after storage.**

Medical applications place high demands on the materials used. In addition to borosilicate glass, plastics such as COC (cycloolefin copolymer) are increasingly being used. This amorphous and biocompatible material is characterized by high transparency, good dimensional stability, barrier properties and chemical resistance and can be sterilized by common sterilization methods such as ETO (ethylene oxide), gamma or electron beams. Unlike borosilicate glass, COC is less susceptible to breakage, which is a significant advantage.

An elastomeric seal is typically inserted into the prefilled syringe plunger. Rubber is the preferred elastomer, but butyl and brominated rubbers and TPEs (thermoplastic elastomers) are also used. These seal the syringe chamber, but tend to press against the inside of the syringe during storage. To prevent this, syringe barrels - and optionally the elastomer seal - are siliconized.

In the case of the syringe barrel, a nozzle dips into the barrel and atomizes silicone oil into fine droplets. It is important that these droplets spread out to form a closed, friction-reducing silicone oil film and also adhere sufficiently to the inner surface of the syringe barrel. The goal is to create a homogeneous silicone oil film with as little silicone oil as possible to minimize any potential interaction with the medicinal product. However, without special surface treatment, the COC will not wet sufficiently with the silicone oil. Pretreatment with Openair-Plasma, for example, can help here.

**Using Openair-Plasma to Improve COC Wettability**

When energy is applied to a gas, it is ionized and enters the high-energy plasma state. Plasmatreat has harnessed this process for industrial use and developed what is known as Openair-Plasma. Compared to low-pressure plasma technology, Plasmatreat's plasma systems and equipment operate at atmospheric pressure and can be integrated directly into production processes. A vacuum chamber is not required. To generate the Openair-Plasma, Plasmatreat uses a high-voltage discharge in a special plasma nozzle through which the process gas is passed and ionized. Various gases can be used as process gases, with compressed air and pure nitrogen being the most common. When the plasma comes into contact with a substrate surface, it interacts with the molecules on the surface and changes their properties.

In this particular application of COC syringe barrels, reactive oxygen and nitrogen compounds are chemically bonded into the plastic surface. This treatment increases the surface energy and thus the wetting behavior of the plastic by introducing the molecules. The silicone oil interacts with the plasma-treated inner surface of the syringe barrel and spreads over it to form a homogeneous, thin film.

**Plasma Parameter Determination in the Laboratory**

One of Plasmatreat's core competencies is setting up a plasma system with the correct plasma parameters on the production line or in the customer's laboratory. The first step is to analyze the current surface energy of the material - either at the customer's site or in the application technology department at Plasmatreat's headquarters in Steinhagen, Germany, or in one of the many subsidiaries.

In this special case preliminary tests for the treatment of the syringe barrels showed that the surface energy of the COC had to be increased to over 50 mN/m (unit of surface tension of liquids or surface energy of solids) in order to ensure optimum wettability with the silicone oil. Untreated, the COC has a surface energy of about 39 mN/m, with a small polar fraction of about 0.5 mN/m, and after plasma treatment it is 52 mN/m, with a polar fraction of about 13 mN/m (measured with a Mobile Surface Analyzer, KRÜSS GmbH).

Decisive for the success of the industrial implementation of plasma treatment is, on the one hand, an optimal plasma system tailored to the application, consisting of generator, PCU (transformer including various quality assurance systems for plasma treatment) and nozzle, and, on the other hand, the development of a stable process window. In addition to the basic settings of the plasma system, this includes the distance between the plasma nozzle and the substrate as well as their relative speed. Since COC, as an amorphous plastic, is particularly susceptible to stress corrosion cracking if overtreated, the process window must be precisely maintained and the parameters constantly monitored. Plasmatreat ensures this with PCU (Plasma Control Unit) technology, which monitors process gas flow, plasma output, nozzle rotation and back pressure, among other things, and records them for quality control and monitoring.

Openair-Plasma technology offers an innovative solution for improving the surface wettability of COC syringe barrels and thereby optimizing their siliconization. The targeted increase in surface energy enables a homogeneous distribution of silicone oil, which increases the functional reliability of the syringes in the long term. With customized plasma solutions and precise process monitoring, Plasmatreat ensures that the benefits of this technology can be efficiently implemented in industrial practice.

For more information, visit: [www.plasmatreat.com](http://www.plasmatreat.com)

***Info box:***

**How Openair-Plasma® and PlasmaPlus® optimize industrial processes.**

When plasma with its high energy level comes into contact with materials, it changes the surface properties, for example from hydrophobic to hydrophilic. Plasma technology requires only compressed air and electricity for operation. Fine cleaning with Openair-Plasma® gently and reliably removes dust, release agents, additives, plasticizers and hydrocarbons from surfaces. Especially with non-polar plastics, plasma treatment achieves surface activation. It supports the increase of surface energy by introducing hydroxyl groups and thus improves adhesion in subsequent processes such as bonding, printing, painting and sealing. Even oxide layers on metal surfaces can be reliably removed inline during the production process using plasma technology. Plasmatreat's PlasmaPlus® technology can also be used to create targeted functionalized surfaces with defined properties by applying (depositing) nanocoatings, e.g. as an additional adhesion promoter layer. Plasmatreat's HydroPlasma® is used to remove stubborn organic and inorganic soils - an innovative cleaning method that uses only water, compressed air and electricity in an environmentally friendly manner.

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**About Plasmatreat**

Plasmatreat is an international leader in the development and manufacture of atmospheric plasma systems for the pretreatment of substrate surfaces. Whether plastic, metal, glass or paper - the industrial use of plasma technology modifies the properties of the surface in favor of the process requirements.

Openair-Plasma® technology is used in automated and continuous manufacturing processes in almost every industrial sector. Examples include the automotive, electronics, transportation, packaging, consumer goods and textile industry, but the technology, cost and environmental advantages of the plasma technology are used in medical technology and in the renewable energy sector as well.

The Plasmatreat Group has technology centers in Germany, USA, Canada, China, and Japan. With its worldwide sales and service network, the company is represented in more than 30 countries by subsidiaries and sales partners.

For more information, visit: [www.plasmatreat.com](http://www.plasmatreat.com)

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**Pictures and captions:**

A close-up of a machine

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Openair-Plasma increases the wettability of COC syringe barrels for optimum adhesion of silicone oil. (Copyright: Plasmatreat GmbH)

A close-up of a couple of blue objects

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Test ink inside the syringe, left untreated and right plasma treated. Plasma treatment improves wettability, even after storage. (Copyright: Plasmatreat GmbH)