When should low-pressure plasma be used as a substitute for PFAS and other coatings

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Abstract

The global industrial landscape is facing a significant shift due to the increasing regulatory pressure and health concerns surrounding per- and polyfluoroalkyl substances (PFAS). Known for their exceptional chemical inertness and thermal stability due to the strong carbon-fluorine (C-F) bond, PFAS are found in countless applications, from non-stick coatings to industrial seals. However, as environmental regulations tighten, identifying viable, high-performance alternatives is crucial. This presentation explores the potential of plasma technology, specifically low-pressure plasma (Aurora system), as a sustainable solution to replace PFAS while maintaining or enhancing surface functionalities.

Technological Framework Plasma is an ionized gas that serves as a highly reactive medium for surface modification. The presentation distinguishes between two primary technical implementations:

- **Atmospheric Pressure Plasma (Openair-Plasma®):** Ideally suited for inline processing and localized treatment of large areas, offering high reactivity with low thermal impact.
- **Low Pressure Plasma (Aurora):** Operating in a vacuum, this method allows for the treatment of complex 3D geometries and the use of a wide range of chemical precursor gases
- **The Aurora Low-Pressure System as a PFAS Alternative** The Aurora system is presented as a "dry" deposition method that avoids the use of harmful solvents. The process is cost-effective, operates at ambient temperatures to protect sensitive substrates, and typically requires a cycle time of only 2 to 20 minutes.

Experimental Validation and Durability To ensure industrial reliability, the plasma coatings underwent rigorous aging and stability tests. Findings include:

- **Chemical Stability:** Coatings demonstrated resistance during solvent immersion tests (e.g., IPA and Acetone).
- **Environmental Resistance:** Samples showed high stability against UV irradiation and elevated humidity/temperature in environmental chamber tests.
- **Surface Energy Control:** Water contact angles (WCA) exceeding 90° were achieved on various substrates, including glass and aluminum, matching the performance of PTFE-like surfaces.

Industrial Applications The versatility of low-pressure plasma is demonstrated across multiple sectors:

- **Medical Technology:** Development of biocompatible, blood-, and tissue-repellant coatings for surgical instruments such as forceps and needles.
- **Materials Engineering:** Significant improvement in peel strength for fluorocarbon materials (e.g., PFA, FEP) compared to traditional etching methods.
- **Textiles and Biomedicine:** Surface functionalization of thermoplastic composites and surgical sutures via roll-to-roll (R2R) plasma processing.

Conclusion Low-pressure plasma technology represents a mature and versatile alternative to PFAS-based treatments. By enabling the deposition of tailored, high-performance thin films on a variety of substrates without the need for hazardous chemicals, Plasmatreat's Aurora system offers a path forward for industries seeking to comply with new environmental standards while maintaining product excellence.