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High-performance elastomers and plasma polymer coatings to replace fluoropolymers in technical applications: new Fraunhofer project

Users of poly- and perfluorinated alkyl compounds (PFAS), also known as "forever chemicals", are under pressure due to regulatory proposals from the European Chemicals Agency (ECHA). This also affects the use of fluoroelastomers, whose economic significance is enormous. Fraunhofer experts initiated the "HATE-FLUOR" project at the beginning of February. Together, they want to develop high-performance elastomer compounds to replace fluoropolymers in certain technical applications. Various industries can benefit from this, including manufacturers of semi-finished and finished parts as well as companies in mechanical engineering industry, medical engineering, clean room and semiconductor technology, chemical process technology and electrical applications.

Many companies are looking for alternatives to poly- and perfluorinated alkyl compounds (PFAS), as their possible uses in the future are uncertain and voluntary commitments are expected. PFAS are found in everyday products such as coated pans, pizza boxes and outdoor jackets, as well as in medical engineering, heat pumps and batteries. While there are already fluorine-free substitutes for some everyday applications, there is a great need for new individual solutions to replace fluoropolymers for technical applications that have to withstand extreme conditions

PFAS replacement: coated elastomers and customizable modular solutions

In the newly initiated "HATE-FLUOR" project, teams of experts at the Fraunhofer Institute for Structural Durability and System Reliability LBF and the Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM will develop fluorine-free coated elastomers and offer customizable modular solutions to meet the growing market demand. The solution comprises three main steps: improving the thermal stability of fluorine-free elastomers with novel antioxidants, producing customized elastomer formulations and developing a coating system to protect the elastomer from oxidative and chemical attack.

The modular structure of this system, consisting of paint and plasma coatings, is intended to cover a broad spectrum in the section of fluorine alternative seals. The

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target properties are determined by the areas of application of the fluoroelastomers that are being replaced in the project.

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Bundled Fraunhofer expertise

In the "HATE-FLUOR" project, the Fraunhofer Institute for Structural Durability and System Reliability LBF is concentrating on the development of high-performance elastomers as a replacement for fluoropolymers in technical applications. One focus is on improving the thermal and thermo-oxidative stability of fluorine-free elastomers using innovative antioxidants. In addition, application-optimized elastomer formulations are being developed to ensure maximum resistance and optimum adhesion. This is complemented by the formulation of a coating system for the elastomers. The latter is being developed at the Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM to protect the material from oxidative attack and chemical degradation.

Fraunhofer IFAM is also working within the project on coatings for these elastomers to improve their friction reduction and barrier properties. A particular focus is on the development of polyimide coatings in combination with layered silicates that prevent the permeation of harmful gases and moisture. These coatings are used in particular for high-performance electronics and other demanding applications. In addition, the modification of the layered silicates is being investigated to reduce the permeation of water vapor and oxygen through the coating by up to 99%. The application of these coatings shows significantly reduced ageing and prevents dendrite growth as a result of exposure to harmful gases.

The Fraunhofer institutes LBF and IFAM are combining their expertise to develop new solutions and application-ready technologies. Both institutes already have extensive expertise in PFAS substitution thanks to many years of development and project work. The "HATE-FLUOR" project is funded by the Fraunhofer-Gesellschaft as part of the PREPARE program and will run for three years.

More information: www.hate-fluor.de/en

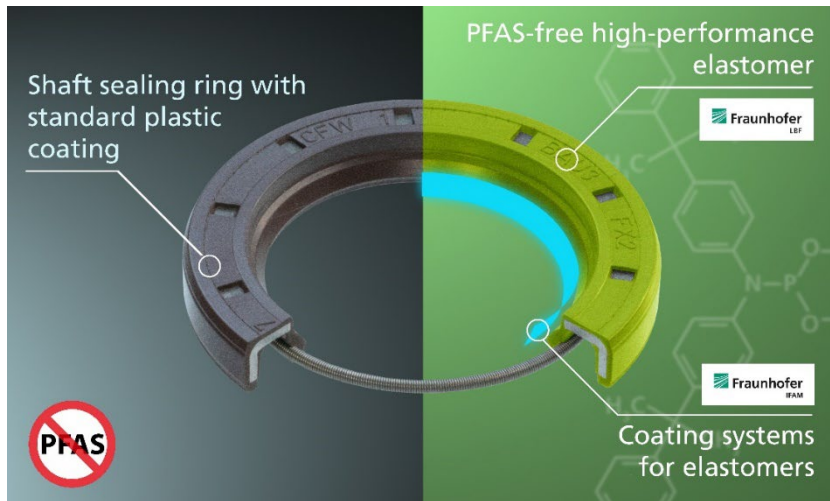
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In the future, a commercially available fluorine elastomer sealing ring could consist of a fluorine-free high-performance elastomer with adapted antioxidants, formulations and a specially developed coating. Graphic: Fraunhofer IFAM



Kick-off: The Fraunhofer project team and the industry advisory board of "HATE-Fluor" at the first meeting on Tuesday, April 8, 2025. Photo: Fraunhofer IFAM.

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The Fraunhofer-Gesellschaft, headquartered in Germany, is one of the world's leading organizations for applied research. It plays a major role in innovation by prioritizing research on cutting-edge technologies and the transfer of results to industry to strengthen Germany's industrial base and for the benefit of society as a whole. Since its founding as a nonprofit organization in 1949, Fraunhofer has held a unique position in the German research and innovation ecosystem.

With nearly 32,000 employees across 75 institutes and legally independent research units in Germany, Fraunhofer operates with an annual budget of €3.6 billion, €3.1 billion of which is generated by contract research — Fraunhofer's core business model. Unlike other public research organizations, base funding from the German federal and state governments is merely the foundation for the annual research budget. This serves as the basis for groundbreaking precompetitive research that will become important for the private sector and society in the years ahead. Fraunhofer's distinctive feature is its large share of industry revenue, guaranteeing close collaboration with the private sector and industry, and the consistent focus of Fraunhofer's research on the market. In 2024, industry revenue accounted for €867 million of its budget. Fraunhofer's research portfolio is augmented by competitively acquired public-sector funding, pursuing the right balance between public-sector and industry revenue.
