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Per- and polyfluoroalkyl substance (PFAS) replacement in paints production

Paints composition and function on PFAS

Per- and polyfluoroalkyl compounds (PFAS) are a group of synthetic organic substances that are very stable and resistant to natural decomposition due to strong carbon-fluorine bonds, earning them the name "forever chemicals". Because of their stability and other valuable properties, PFASs are widely used in industry to make many everyday consumer products, from nonstick pans, paper and paints to cosmetics and pharmaceuticals.

More than 100 different surfactants are used in the manufacture of paints, coatings and other finishing products.

In the paint and varnish industry, fluorinated compounds are typically used in concentration up to 0.1% as surfactants to reduce the surface tension of paint to ensure its uniform spreading and glossy appearance of the coating. Polymeric and non-polymeric fluorinated compounds are also added to paints and varnishes to obtain thermal stability of the coating, increase its resistance to dirt and stains, providing oil- and waterproofing or anti-corrosion properties. Table 1 shows examples of fluorinated compounds used in the production of paints and varnishes.

The problem of PFAS: analysis of the Ukrainian paint market

According to estimates, almost 20% of paints in the global decorative coatings market contain PFAS. This share can increase to 50% for industrial paints.

Ukrainian-made decorative paints and varnishes account for 80% of the total national production of paints and varnishes, which was estimated at 163 thousand tons as in 2021, fell by 55% in 2022, but rose by 45% the following year (for decorative paints). Thus, the total annual production of decorative paints can be estimated at 106 thousand tons. Thus, the production of PFAS-containing paints in Ukraine is approximately 21 thousand tons.

For every 1 ton of paint, 1 kg of fluorinated surfactants enter the market, i.e., 21 tons per year, given the annual production of paints in Ukraine.

In Ukraine, as in many other countries, there is no ongoing monitoring of PFAS content in paints and varnishes. Most consumers do not have sufficient information about PFAS and do not pay attention to this aspect when choosing paint and varnish products.

Table 1 - Example of PFAS used in paints and varnishes

Substance	CAS
C4-fluorinated polyesters (e.g., methyl nonafluorobutyl ether)	163702-07-6
Perfluorobutane sulfonyl fluoride (PBSF)	375-72-4
Polyvinylidene fluoride (PVDF)	24937-79-9
Polytetrafluoroethane (PTFE)	65530-85-0
Fluoroethylene vinyl ether (FEVE)	146915-43-7 207691-69-8
Perfluoropolyether (PFPE) blend (with polyurethane)	76415-97-9
Short-chain polymeric ester of fluoroalkyl acid	661476-43-3

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Despite the fact that PFACs are generally used in small quantities, fluorinated compounds have to be phased out from industrial products, including paints. Elimination of PFAS and switching to safer alternatives is a necessary step to protect human health and the environment. While this process can be complex and require significant investment, it is essential to ensure sustainable development.

What are the dangers of PFAS and why should we abandon them?

Currently, there is a tendency to limit the application of PFAS in various areas, including paint and varnish production. This is due to the identified health and environmental risks.

1. Stability in the environment

Due to their strong carbon-fluorine bonds, PFAS practically do not decompose naturally and accumulate in the environment in significant quantities.

2. Health risks

Exposure to some PFAS is associated with negative health effects, such as cancer, immune system suppression, hormonal, liver, and kidney disorders.

3. Public and environmental safety

PFAS have been found in air, water, soil and human blood around the world, often exceeding safe concentrations. This poses a threat to all living organisms, regardless of their habitat.

4. Regulatory pressure

Governments, especially in the EU, are increasingly imposing bans, restrictions and limits on the production and use of PFCs, thus driving the urgent need to replace them. Producers, who fail to adapt, risk-losing access to key markets.

5. Economic and legal implications

Removing PFAS from the environment is an extremely expensive and technically challenging process. Companies, that use PFAS, risk incurring significant costs due to lawsuits and loss of consumer confidence.

6. Availability of safer alternatives

Replacing PFAS with safer materials is already possible due to innovations in the chemical industry. Switching to alternatives will contribute to the long-term sustainability and competitiveness of companies.

Legal restrictions on the use of PFAS

At present, European legislation, and the Stockholm Convention on Persistent Organic Pollutants in particular, has already banned certain PFAS (perfluorooctanesulfonic acid (PFOS), perfluorooctanoic acid (PFOA), perfluorohexanoic acid (PFHxA), perfluorohexanesulfonic acid (PFHxS), perfluorinated carboxylic acids (C9-C14 PFCAs).

In addition, in February 2023, the European Chemicals Agency (ECHA) published a comprehensive proposal to restrict approximately 10 thousand PFAS under the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH) Regulation. The proposal is intended to restrict the production, placing on the market and use of these substances to reduce the risks to human health and the environment. The proposal is currently being evaluated and is expected to come into force no earlier than 2026. The restrictions will affect almost all industries, including the paint and varnish industry.

"Technical Regulation on the Safety of Chemical Products" was approved by the Resolution of the Cabinet of Ministers of Ukraine № 847 of July 23, 2024, which will come into force on January 26, 2025. The Regulation is based on Regulation (EC) No. 1907/2006 on the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH). Thus, the restrictions on the use of PFAS in the EU will soon also affect Ukrainian producers.

The Regulation applies to chemical products that are imported, present/offered on the market or produced in Ukraine. Chemical products may not enter the Ukrainian market if they do not meet the requirements of the Regulation.

Green alternative to PFAS

Fluorocontaining surfactants are not easily replaced because they provide simultaneously a number of performance characteristics for paints and coatings. Conventional surfactants typically do not offer this wide range of performance, but some surfactant families can successfully compete with fluorosurfactants in certain categories (examples are given in Table 2).

A widely tested alternative to fluorine-containing surfactants in paints is a silica-based coating. Silicone polymers made from silanes and siloxanes are used in paints as leveling agents and wetting agents. They also provide the painted surface hydrophobic properties and resistance to high temperature, that is, due to the structure of silicone resins, they are able to exhibit some characteristics of PFAS.

The silicone polymer used as a base in chemical hybrids of silicone and organic compounds has a surface energy of 20 mN/m at the 0.1%. Since there are no conventional surfaces that require less than 20 mN/m for wetting, PFAS can be replaced in this function.

Silicone-based leveling agents provide good leveling properties due to strong surface tension reduction and controlled tension, improving wetting properties of paint.

Long-chain polysiloxanes are the most common leveling agents in the coatings industry. Depending on the type of side chain, they are suitable for solvent, water-soluble and solvent-free applications.

Table 2 - Non-fluorinated compounds used in coatings, paints and varnishes

Substance	CAS	Function
Polyester	113669-97-9	Weather resistance, durability
Polyurethane	9009-54-5	Weather resistance, durability, corrosion resistance
Epoxy resin	90598-46-2	Corrosion resistance, weather resistance
Polysiloxane	63148-53-8	Weather resistance, durability
Silicone polymers (made of silanes and siloxanes) (for example, non-ionic modified silicone polyether)	67674-67-3	Surfactant, heat resistance, weather resistance
Sulfosuccinates (Sulfosuccinate mixed with water and 2,2 dimethylpropane-1,3-diol)	577-11-7	Wetting agent

The publication was developed by the Resource Efficient and Cleaner Production Centre in Ukraine, the national implementing partner of the United Nations Industrial Development Organization's project 'Global Green Chemistry Innovation and Networking Programme' (GreenChem), funded by the Global Environment Facility. The program is implemented by the Center for Green Chemistry and Green Engineering at Yale University, USA.