Gas-phase fluorination systems

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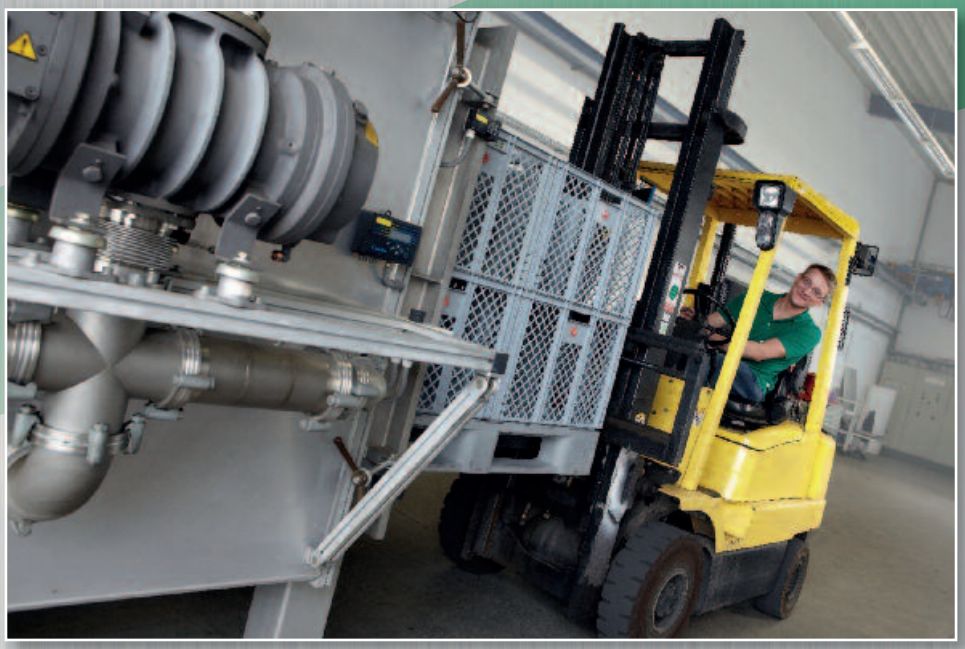
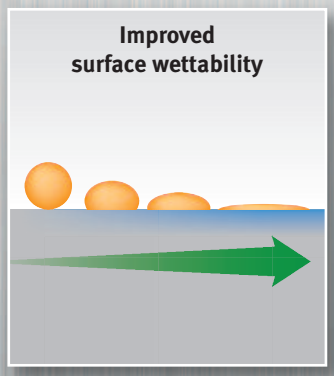
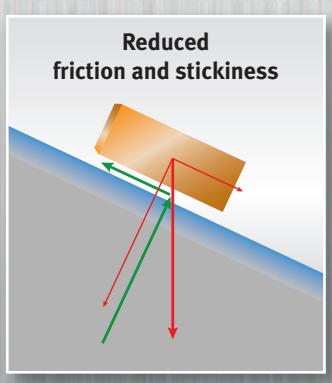
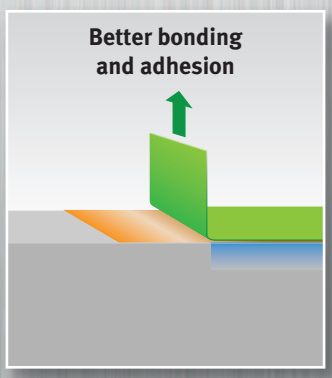
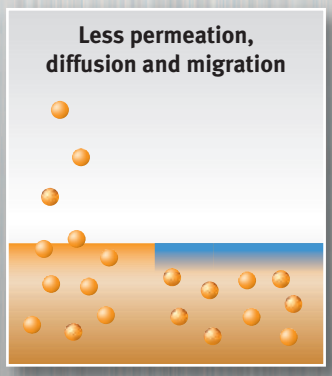
Project planning
Plant engineering
Service









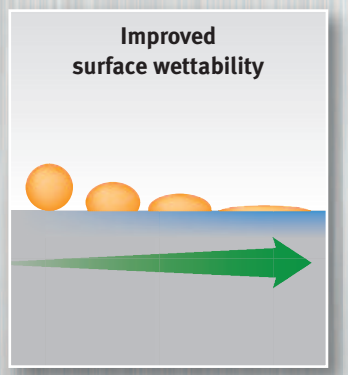


Fluorination of plastics for enhanced surface properties

- High-performance technology
- Easy to operate
- Comprehensive application know-how

Fluorination enhances product properties

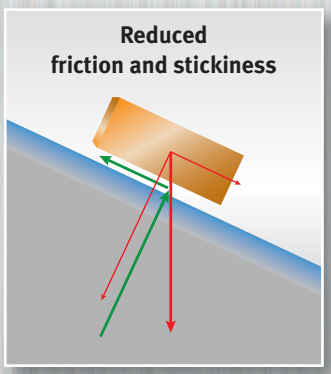
Plastics are selected primarily according to their mechanical and thermal properties, their suitability for processing and their price. After careful selection, it's often found that the surface doesn't meet requirements. However, the surface is the only material property that can be changed independently. Very often, gas-phase fluorination is the solution of choice.
The fluorination process enhances many surface properties. It is highly effective in modifying the top material layer without adversely affecting the properties of the underlying material. No other method can achieve such a targeted effect.



Wettability fluorination

Smoother fluid films and faster drying

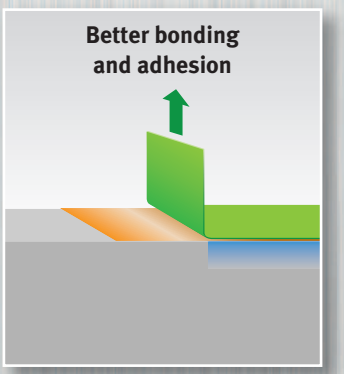
Fluorination hydrophilises surfaces, enhancing coating quality through better wetting, film formation and adhesion properties. This yields significant savings when painting, printing or applying decor to the surface. A smoother water film also means more even drying, a higher print quality and less lime and mould formation.



Anti-friction fluorination

Reduced friction, stickiness and clinging

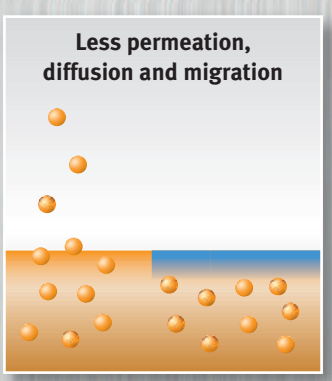
The stickiness of elastomer components made of NBR, HNBR, EPDM or other types of rubber and silicone is reduced to a minimum. Talcum, silicone oils or other additives are no longer required. These properties are long time stable even if the material is regularly cleaned or sterilised. Contaminants don't attract to the surface, so parts remain clean.



Adhesion fluorination

Better bonding and adhesion

Fluorination can improve the adhesion properties of plastic materials. The polarity of the surface is increased, thereby improving adhesion and wetting. Lamination lasts longer, flocking is more durable, and the bonding of adhesives is improved.



Surface barrier fluorination

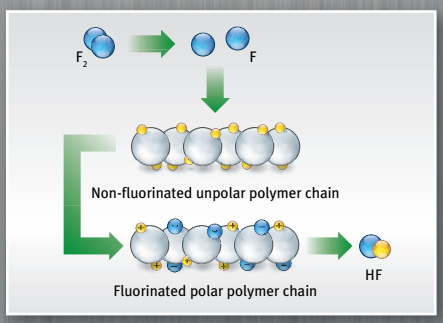
Less permeation, diffusion and migration

This type of fluorination creates a barrier against non-polar substances, reducing permeation, diffusion and migration of short-chain fluids (solvents, petrol, coolants, glycerol, etc.) to a minimum. Additives of the plastic material no longer diffuse through the surface, and elements of the container filling no longer permeate the wall.

Chemical reaction

Plastic surfaces are fluorinated by exposing them to a fluorine mixture. Due to its high reactivity, fluorine partially replaces hydrogen atoms in the material surface. Its properties are modified mainly by the higher surface energy and the surface polarity. Systematic process control allows the result of the fluorination process to be optimally adjusted to the original polymer and the specified application.

Fluorination is a chemical reaction, not a coating. Accordingly, fluorine atoms penetrate the substrate's molecular structure. The process doesn't affect the properties of the base material, and its dimensions remain unchanged.

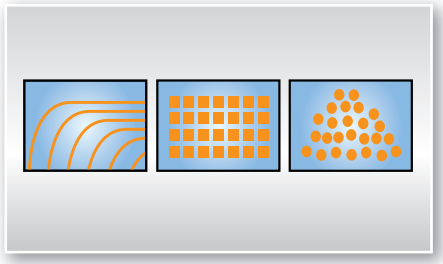


FTS develops and manufactures fluorination systems

Fluor Technik System GmbH

Gas-phase fluorination is a dry method for treating surfaces. It is easy to use, and its reproduction accuracy is high. The method can create many effects that aren't possible with other methods. The fluorination systems offered by FTS reflect the latest technological knowledge. They can be customised to meet individual requirements. Long-term stability and careful treatment of the material are the characteristic features of fluorination, as are its environmental compatibility and cost efficiency.

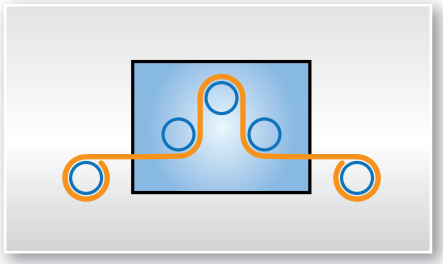
Offline batch fluorination



Three-dimensional parts are treated in a discontinuous process. They are pre-treated in a vacuum chamber according to the formula specifically developed for the purpose. The following materials can be used:

- Plastics
- Caoutchouc
- Rubber
- Silicone
- Elastomers
- Plastics made of renewable raw materials

Inline web material fluorination



Fluorination is often used to make web material hydrophilic before coating, applying adhesive, painting, etc. The material is fed continuously into the treatment chamber via a gate system. After fluorination, the material leaves the chamber via a downstream gate system and is rolled up.

- Filter media
- Films
- Fabrics
- Foams
- Technical textiles
- Non-woven fabrics

Long-term stability

The bond energy of the carbon-fluorine compound created in the surface is extraordinarily high. Accordingly, the process of fluorination is not reversible. The surface properties achieved remain stable over long periods.

Fluorination at room temperature

Fluorination is the method of choice even for thermosensitive parts. The treatment is applied at steady, low temperatures, usually even at room temperature, avoiding local temperature peaks.

Complex geometries

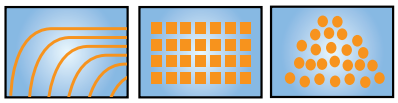
Gas-phase fluorination yields absolutely consistent application results. Cavities, undercuts, recesses and wraps, as well as textured and coarse surfaces, are treated homogeneously and without any shadowing. The result is consistent surface quality across all parts.

Suitable for many industries

Significant new properties are created on the surfaces of parts and materials, and often more cost-efficient solutions can be achieved without having to search for alternative materials or processing methods. Fluorination is successfully applied in many industries:

- Automotive
- Construction materials
- Lighting
- Print products
- Electrical engineering
- Filtration
- Aerospace
- Medical technology
- Building services
- Technical textiles
- Tunnelling
- Packaging
- Household appliances

Offline fluorination
Systems for three-dimensional substrates



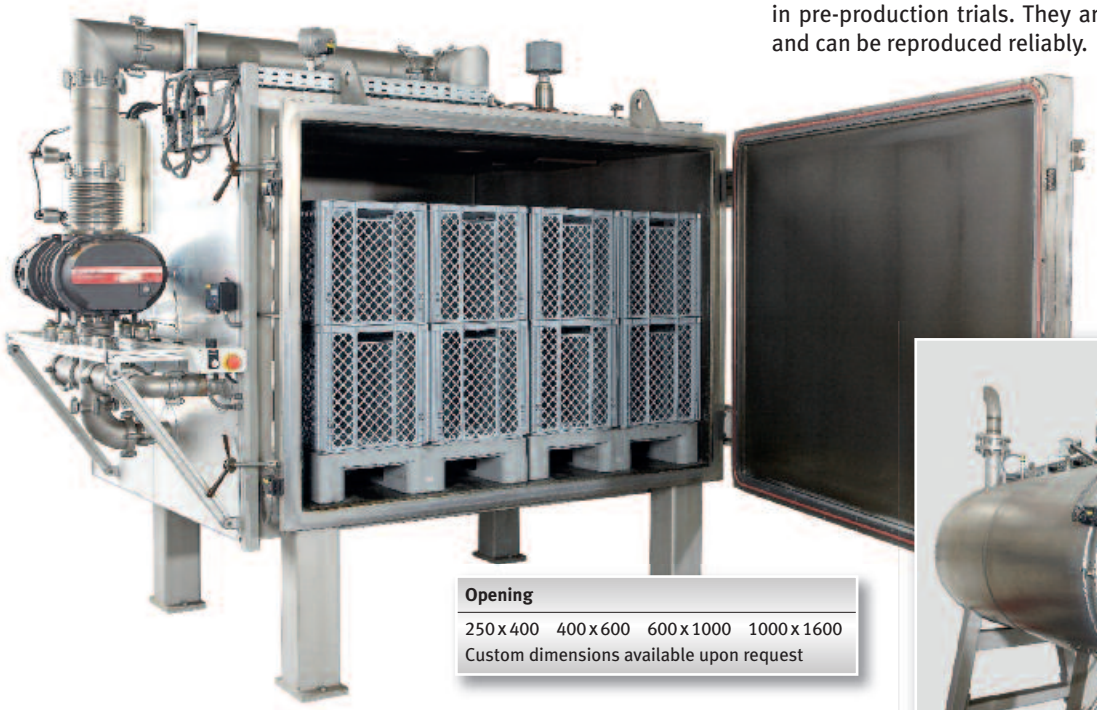
Offline systems apply fluorination to three-dimensional parts in batch cycles: Shaped parts are fed into the vacuum chamber, fluorination is applied, and the parts are subsequently removed. The vacuum chamber is the core of any offline fluorination system made by FTS. It is optimised for the parts to be treated and for their quantity, the transport units and the loading and unloading procedure. All systems come complete with vacuum pumps and fixtures, fluorine supply and removal equipment, and control and safety devices.

Cube- or cylinder-shaped vacuum chamber

The cube-shaped chamber accepts larger or mechanically sensitive parts in transport units or in loose arrangement. The cylindrical chamber accepts small parts as bulk material, moving them carefully to ensure uniform fluorine exposure.

Treatment process

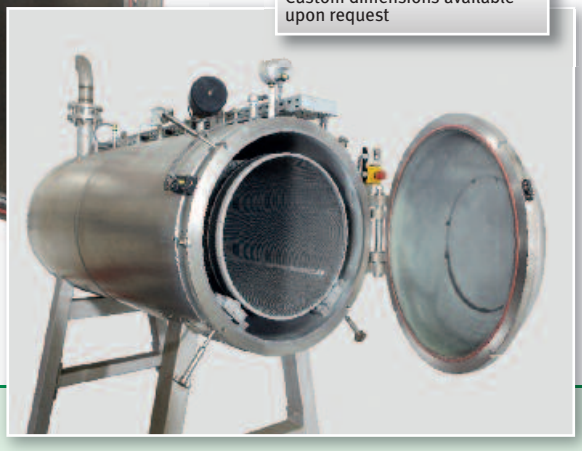
For fluorination, products in the vacuum chamber are exposed to a fluorine/nitrogen mixture. Treatment duration, fluorine concentration profile and process temperature are adjusted to the specific product and application characteristics. The parameters inside the chamber are homogeneous at all times. All parameters are tested in pre-production trials. They are stored as a formula in the PLC and can be reproduced reliably.



Opening

250 x 400	400 x 600	600 x 1000	1000 x 1600

Custom dimensions available upon request



Diameter

400	600	1000	1600	2000

Custom dimensions available upon request

Occupational safety

Fluorine is the most reactive element in the periodic system. Its processing is subject to legal and other regulations pertaining to occupational safety. Our systems process only fluorine mixtures of type F2/N2 10/90, i.e. 10% fluorine and 90% nitrogen. To control these mixtures, we rely on type-approved valves and pressure regulators that are implemented as redundant units.
State-of-the-art technology has been used for many years to store F2/N2 mixtures and to supply the fluorine. The threshold limit value (TLV) is monitored continuously for additional safety, and alarm and shut-down functions are triggered if required.

Inline fluorination
Systems for web material

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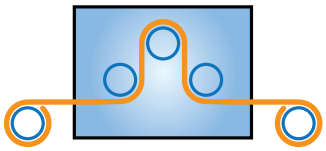


Inline systems fluorinate web material in a continuous process. The material enters and exits the fluorination chamber via a gate system. Films, fabrics and foams of almost any origin and thickness can be processed. Inline fluorination systems from FTS comprise a treatment chamber and two gate systems incorporating a flushing zone. The systems come complete with vacuum pumps and fixtures, the fluorine supply and disposal system, and control and safety devices. Unwinders and winders are available as options.

Material width and thickness

Inline systems are designed to the maximum width and thickness of the material to be processed. The material's maximum length is determined by the choice of winder.

Treatment process

For fluorination, products in the vacuum chamber are exposed to a fluorine/nitrogen mixture. Treatment duration is defined by the length of the active treatment section inside the chamber and the material feed rate. The fluorine concentration profile and process temperature are adjusted to the products and the specified treatment results. The parameters inside the chamber are homogeneous at all times. Optical measurement in the UV range is applied to monitor fluorine concentration. Any deviation from the target value is compensated by a dosing and control valve system. All parameters are trial-tested in advance and are stored as formulas in the PLC to ensure reliable repeatability.

Frequent applications

The following web materials are treated prior to printing, coating, laminating or hydrophilising:

- Foams
- Technical textiles
- Fabrics
- Films

Frame width			
400	1000	2000	5000
Custom dimensions available upon request			

Environmental protection

Fluorination is an environmentally friendly way of pre-treating surfaces:

- to avoid waste-water flow,
- to eliminate solvent-based paints and adhesives, and
- to save energy thanks to low temperatures.

$$2\,F_2 + 2\,CaCO_3 \rightarrow 2\,CaF_2 + 2\,CO_2 + O_2$$

Fluorination systems do not emit any harmful substances

Gas-phase fluorination is a dry chemical process neutralising the fluorine mixture and the resulting byproducts directly within the process. Exhaust air is fed through an absorber containing calcium carbonate grit (CaCO3). Inside the absorber, the gas is converted into calcium fluoride (CaF2), also known as fluorspar, a frequently occurring mineral that is non-toxic, environmentally neutral and non-water-soluble. The calcium carbonate absorber is designed to comply with current legal limits as well as any limits to be expected in the future.

Objectives

Wettability fluorination

Smoother fluid films and faster drying

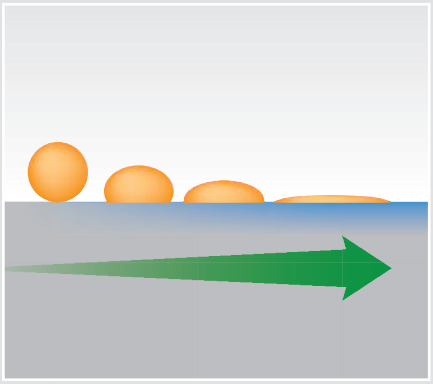
Process background
The wetting properties of plastic materials depend on the polarity pairing: different polarities cause the liquid to form drops on the surface. Fluorination creates higher surface energies in polar plastics that are thus adjusted to the surface energy of the liquid. Such surfaces are very suitable for wetting with polar liquids.

Use
The larger and smoother surface of the liquid covering a component has the following benefits:

- Faultless liquid films
- More uniform coating
- Enhanced printability
- Faster drying
- Better draining of liquids
- Prevention of mould formation
- Improved lubrication effect of liquid

Wetting plastic surfaces is much easier after they have been fluorinated.

- **Enhanced liquid films**
- **More uniform layers**
- **Improved drying**
- **Smooth draining of liquids**



Surface energies

		Non-fluorinated (mN/M)	Fluorinated (mN/M)
Polyethylen Low Density	LDPE	32	54
Polyethylene	PE-UHMW	37	54
Polypropylene	PP	29	66
Polyoximethylene	POM	40	72
Polyethylene	PET	32	72
Ethylene propylene diene co-polymer	EPDM	40	58
Polybutylene	PBT	30	72
Polycarbonate	PC	32	56
Polyphenylene sulfide	PPS	32	60
Polysiloxan elastomer	SI	32	54

Source: Fluor Technik System GmbH

Adhesion fluorination

Better bonding and adhesion

Process background
Fluorination increases surface roughness, enlarging the contact surface and hence improving adhesive bonding. Adhesion fluorination is used whenever the application requires extensive and uniform layer bonding: increasing surface energy also improves wetting and film formation, as well as the bonding of paints and adhesives. When applied as a pre-treatment, fluorination creates absolutely consistent results, even in complex geometries with undercuts, recesses or wraps.

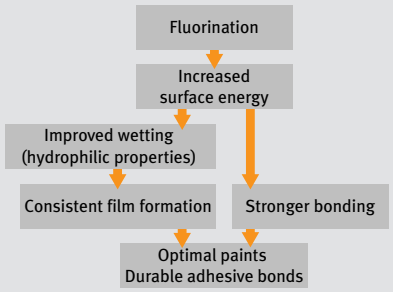
Use
- To apply paint, flocking or decor
- To produce compound plastics
- To bond plastics with other materials using adhesive
- To treat man-made and natural fibres
- To pre-treat reinforcement fibres for compounds

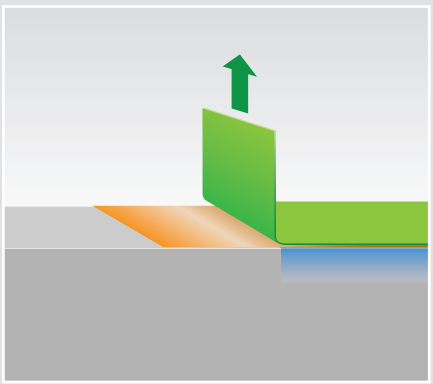
Three physical effects have a significant impact on the bond between adhesives or paints and the component. Fluorination can enhance these effects:

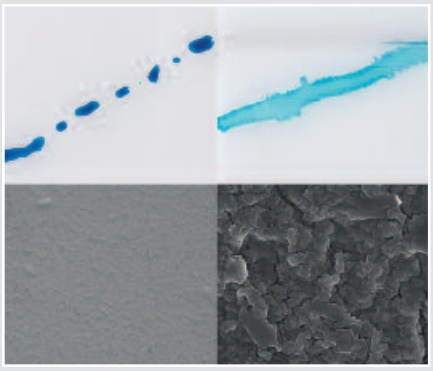
- **Wetting**
- **Film formation**
- **Adhesion**

Fluorination for better adhesion yields cost benefits.

- No primer is needed
- Environmentally friendly water-based paint can be used
- More cost-efficient paint and adhesive systems can be used
- Fewer paint layers are needed







Non-fluorinated Fluorinated

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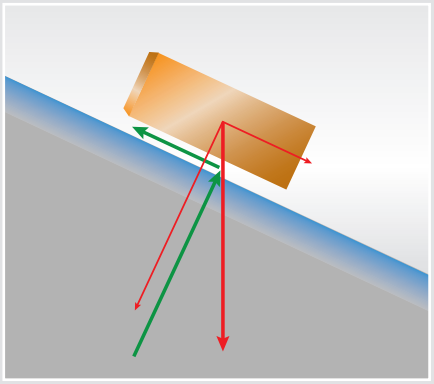
Anti-friction fluorination

Reduced friction coefficient, stickiness and clinging



Non-fluorinated Fluorinated

Many components made of elastomers such as NBR, HNBR, EPDM, silicone and other rubbers have a dull surface. These are often sticky and don't slide well across other surfaces. This may cause difficulties during assembly and adverse effects during use. Additives, talcum and silicone oils are often used as a remedy.
Fluorination significantly reduces contamination by additives and avoids other disadvantages. Fluorinated surfaces retain their properties over long periods even when subject to regular cleaning and sterilisation. Reduced surface stickiness also reduces soiling, enhancing the components' visual appeal.

Friction forces on glass [N]

		Non-fluorinated	Fluorinated	
			Formula 1 [N]	Formula 7 [N]
Silicone	LSR2650B	15.6	3.9	1.0
	LSR2630B	10.1	6.3	0.7
	FSL7651A	9.2	5.6	0.8
	FVMQ	12	11	6
	Silplus60Ex	9.2	2	0.8
Rubber	NBR	9.2	5.5	
	PPE	8.5	4.2	
	EPDM	10.5	4.6	

Source: Innovent e.V.

Process background

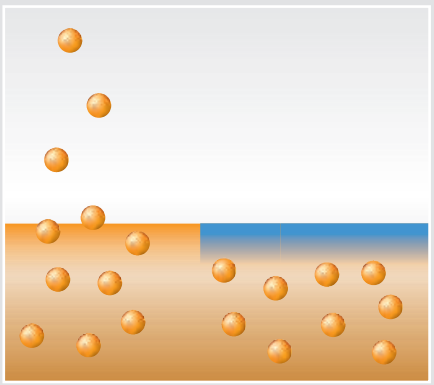
Intensive fluorination causes the fluorine atoms to be embedded in the surface. Stickiness and static and dynamic friction are significantly reduced. This effect is enhanced by the inherent increase in surface roughness while the rubber-specific properties remain unaffected.

Use

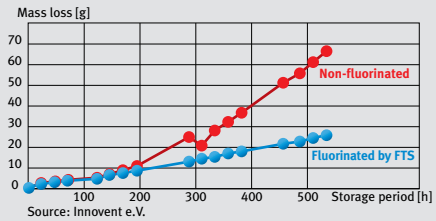
- To minimise friction and soiling
- To reduce creaking and crackling caused by high static friction between rubber and mating surfaces
- To reduce stick/slip effect in sliding motion
- To facilitate assembly
- To enhance visual appeal
- To reduce stickiness: Release agents become obsolete, parts are easier to separate, and parts subject to static load release without effort.

Surface barrier fluorination

Less permeation, diffusion and migration



Plastics are inherently permeable to certain gases and liquids. This is why plastic containers lose some of their contents over time. Such permeation causes odours and impacts the environment. The weight and properties of the contents change, and labels may peel off. Components migrating from plastic materials may change the product properties to an extent that causes component failure. Fluorination prevents such adverse effects, and very often a more cost-efficient packaging material can be used.



Source: Innovent e.V.

Process background

Fluorinated surfaces act like a barrier against nonpolar substances. Inner and outer container surfaces modified by fluorination reduce the permeation of short-chain solvents, coolants, glycerine and petrol. The diffusion of material components through and from the fluorinated surface is significantly reduced.

Use

- To reduce the the permeation of petrol and diesel fuel from tanks of motor vehicles and other equipment
- To limit the migration of softeners and other additives, preventing plastics from becoming brittle
- To improve resistance to acidic and caustic solutions, preventing surfaces from swelling or becoming greasy

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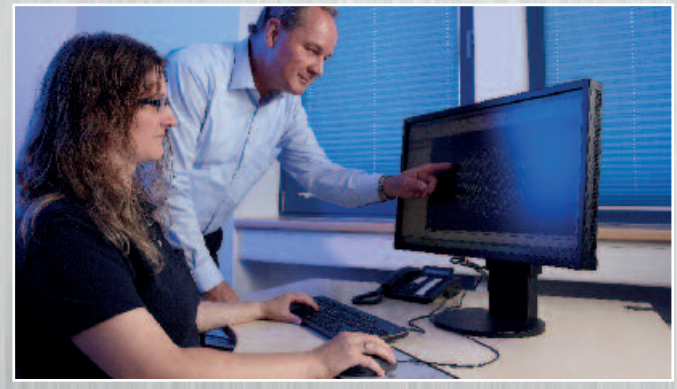

FTS has focussed on the development and manufacture of fluorination systems and fluorination services for more than 20 years. Realised projects, memberships in trade associations, cooperation with universities and research institutes, as well as many patents, are proof of FTS' expertise. We are member of the Flock Association of Europe FAoE e.V.

Flock Association of Europe
...be part of the leaders

Consulting
FTS advises on actions, potential applications and effects of gas-phase fluorination of plastics and other materials. For optimal results, FTS tests the treatment parameters in its own laboratory in close cooperation with its customers.

Development and engineering
FTS develops and designs systems that are customised to our customers' individual requirements. We utilise our extensive experience in plant engineering and operation – from planning and construction to installation and commissioning.

Plant engineering
FTS builds inline and offline systems for gas-phase fluorination, adjusting them specifically to the requirements defined by the product or operation. Ancillary systems such as fluorine supply, calcium carbonate absorber and work safety devices are included in the equipment design.

TÜV CERT DIN ISO 9001

Service
FTS offers a full range of services: from operator training and routine maintenance to system extension and conversion. We support the approval and certification of the systems.

Job order production
FTS refines the surfaces of supplied products for further processing and installation: bulk material, products placed in transport units, web material, etc.
Please feel free to inquire.

FTS
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