Fluorination improves the surface properties of plastics

FTS
Fluor Technik System GmbH

Long-term stability with no dimensional changes

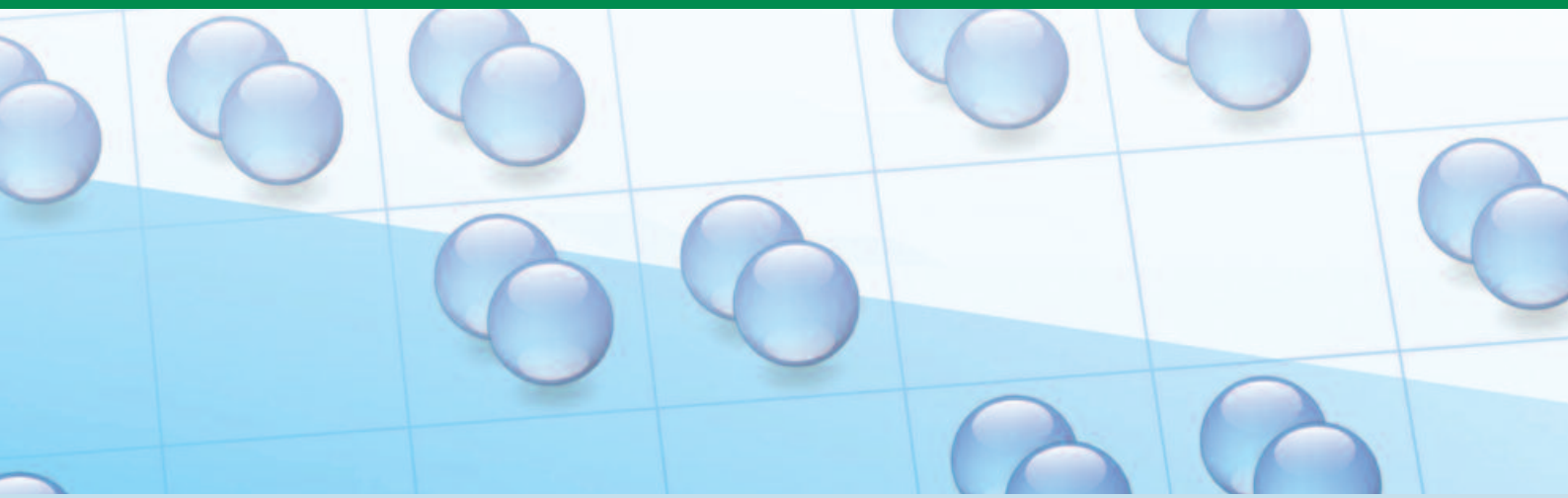
Job order production for your success

Improved surface wettability

Reduced friction and stickiness

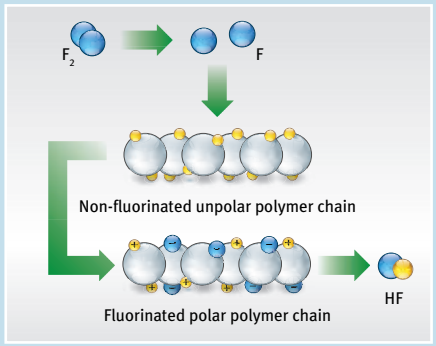
Better bonding and adhesion

Less permeation, diffusion and migration



Plastics are selected primarily according to their mechanical and thermal properties, their suitability for processing and their price. Then, 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.

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.

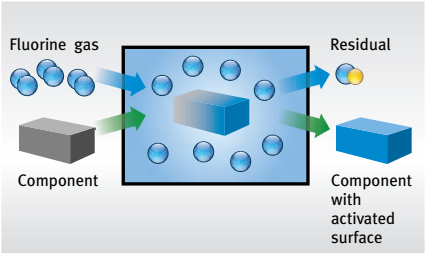
Fluorination is a chemical reaction, not a coating. Accordingly, fluorine atoms penetrate the substrate's molecular structure. The process doesn't affect the properties of the base material, and its dimensions remain unchanged.

Treatment process

All relevant treatment parameters are adjusted to the product and the specific objective of the treatment during a test phase. The values obtained are then applied as a formula for series production.
The following relevant process parameters are controlled automatically and reproducibly:

- Fluorine concentration
- Treatment duration
- Process temperature

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. Small parts of only a few mm in size are fed into the cylindrical chamber as bulk material. The cube-shaped chamber accepts larger or mechanically sensitive parts in crates, grid boxes or transport units. These may fill the chamber almost entirely.

Many industries

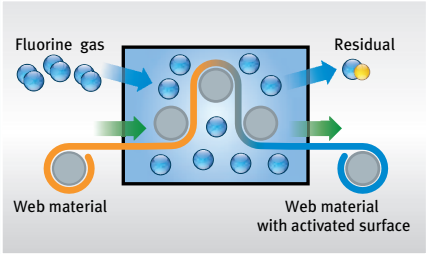
Significant new properties are created on the surfaces of parts and materials, and often more cost-efficient solutions can now be achieved without having to search for alternative materials or processing methods. Fluorination is successfully applied in many industries:

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

Fluorination at room temperature

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

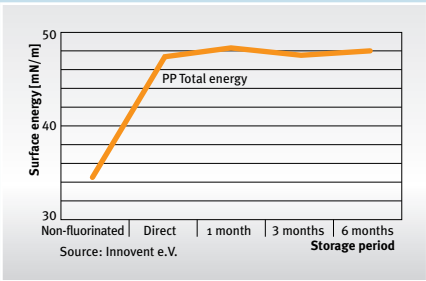
Inline web material fluorination



In an inline system, web material is fluorinated in a continuous process. Treatment results are determined by throughput rate and fluorine concentration. The system is designed to treat a wide range of web materials of varying thickness and widths of up to b = 2.100 mm from roller to roller. We process

- 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.

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. This ensures a consistently high treatment quality right down to the most remote corner of the component.

Better properties in practice

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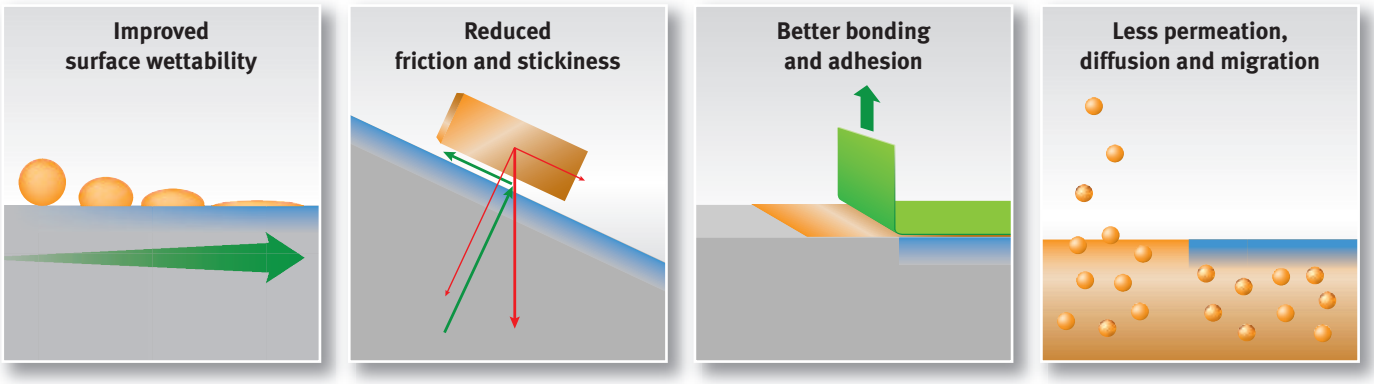
The fluorination process enhances many surface properties. It is highly effective in modifying the top material layer without adversely affecting the properties of the underlying material. No other method can achieve such a targeted effect. Fluorination can be applied to all plastics: ABS, EPDM, plastics made of renewable raw materials, NBR, HNBR, PC, PEEK, PMMA, polyamide, polyester, glass fibre-reinforced polymers, mixed polymers, polypropylene, silicone, TPE, etc.



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 adhere 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.

Objectives

Wettability fluorination

Smoother fluid films and faster drying

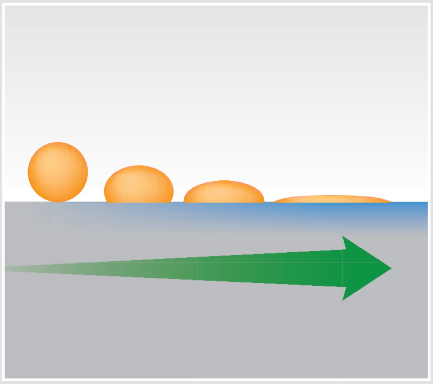
Process background
The wetting properties of plastic materials depend on the polarity pairing: different polarities cause the liquid to form drops on the surface. Fluorination creates higher surface energies in polar plastics that are thus adjusted to the surface energy of the liquid. Such surfaces are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

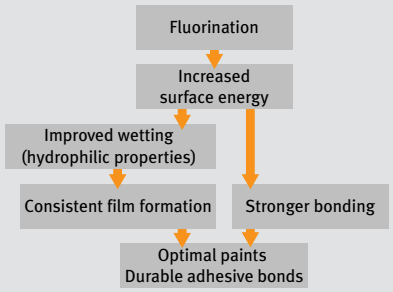
Use
- To apply paint, flocking or decor
- To produce compound plastics
- To bond plastics with other materials using adhesive
- To treat man-made and natural fibres
- To pre-treat reinforcement fibres for compounds

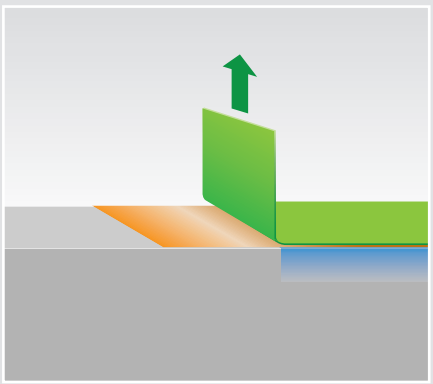
Three physical effects have a significant impact on the bond between adhesives or paints and the component. Fluorination can enhance these effects:

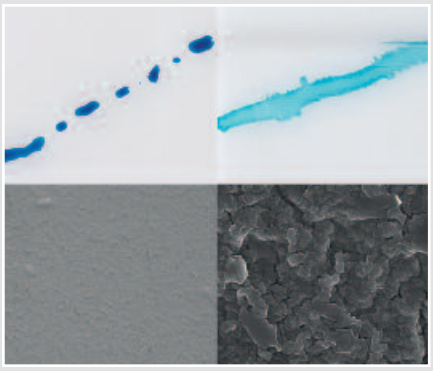
- **Wetting**
- **Film formation**
- **Adhesion**

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

Examples of treated products

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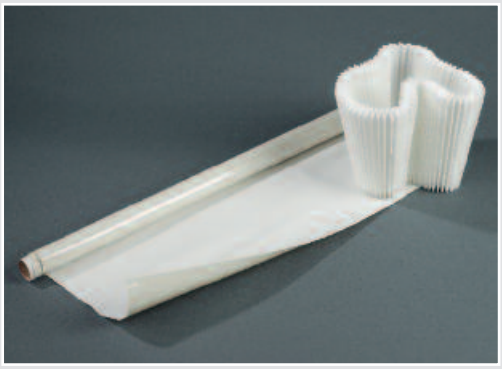
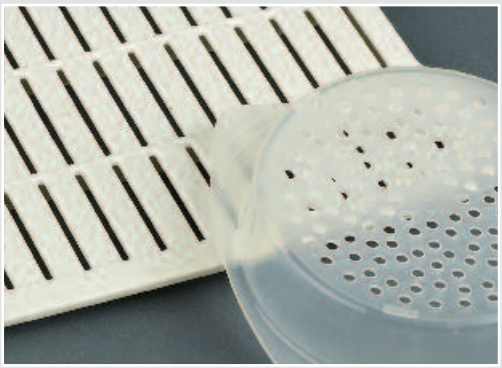


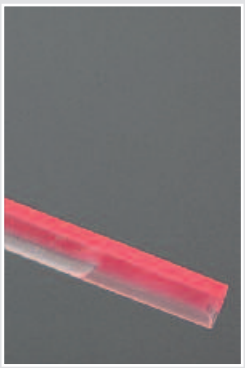
Hydrophilic filter material



Faster-drying appliances

Non-fluorinated	Fluorinated
	

Capillary effect of filter material

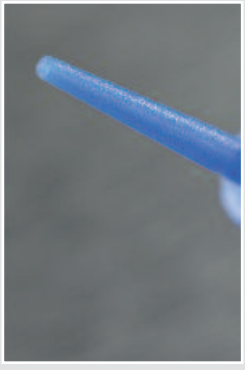
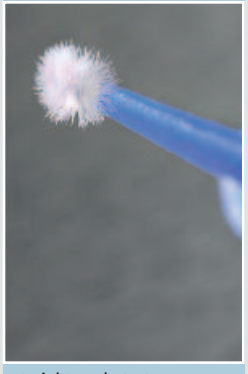
Dripping behaviour of PS tubes

Enhanced print adhesion

Perfect paint layers in critical areas

Non-fluorinated	Fluorinated
	

Grid-cut testing of paint adhesion to substrate

Adhesion of flocking material to substrate

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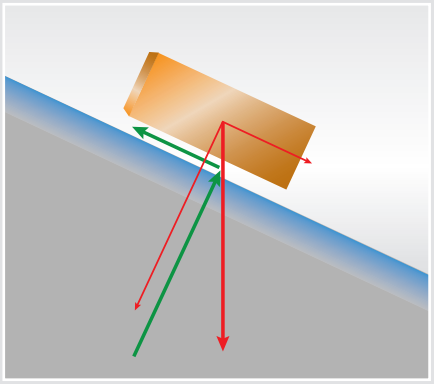
Anti-friction fluorination

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

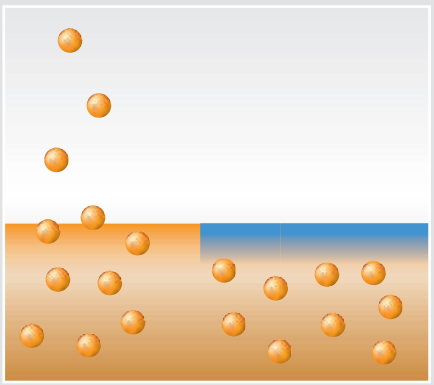
Intensive fluorination causes the fluorine atoms to be embedded in the surface. Stickiness and static and dynamic friction are significantly reduced. This effect is enhanced by the inherent increase in surface roughness while the rubber-specific properties remain unaffected.

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.

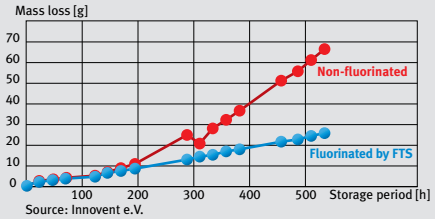
Surface barrier fluorination

Less permeation, diffusion and migration



Non-fluorinated Fluorinated

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

Examples of treated products

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O-rings are easy to separate and install

Non-sticking profiled seals

Non-fluorinated	Fluorinated
	

Rubber doesn't stick – without talcum or silicone oil

Soiling behaviour of silicone

Diffusion-proof containers for chemicals

Diffusion-proof dispensers

Non-fluorinated	Fluorinated
	

Adhesion of a label with and without the effect of diffusing contents

Diffusion of ingredients

The FTS service offering
for surface finishing

FTS is specialised in fluorination with 25 years experience in the field. Our high level of competence is based on our highly qualified personnel and our equipment fleet, which is maintained to the latest technological standards by our in-house plant engineering department. Regular participation in research projects ensures that we keep abreast of state-of-the-art technology, and underlines our position as a development leader.

Process development

FTS changes the properties of plastics in such a way that specified functions are achieved in an optimal manner: adhesion, sliding, wetting and barrier formation are optimised. The components' dimensions and physical properties remain unchanged. FTS identifies the possibilities and also the limits of the fluorination process.

Tests and pre-production series

Each new treatment is subject to a series of tests, adjusting it to the product and defining the optimal parameters that are then saved as the formula. Our customers are welcome to participate in the testing process and to verify the new impact of the component in its intended use. The parameters used can be repeated reliably and will later be applied in series production.

Series production

FTS can fluorinate small and medium production series, even if parts are highly diverse:

- Bulk material from 1 mm in size
- Components in racks and transport units up 1.800 mm in size
- Web material up to a width of 2.100 mm

Service

Our customers from many industries appreciate our quick and uncomplicated communication. FTS offers any service you may need:

- Analytical investigations
- Individual, customised packaging
- Storage of intermediate and finished products
- Just-in-time delivery on call
- Quick and uncomplicated order processing
- Individual labelling and identification

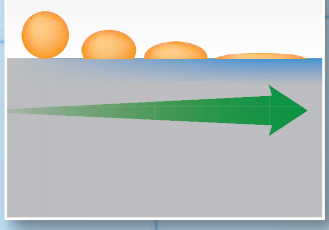
Quality management

We are certified according to DIN EN ISO 9001:2008 by the TÜV CERT certification office of TÜV Hessen, certificate no. 73 100 145.

- We apply defined parameter sets. These are defined together with the customer according to the product and its use during sample evaluation and are stored as a formula in the PLC.
- The process of fluorination is fully automated. Deviations from target values are identified and signalled. The entire procedure is documented.
- Surface tension is measured using test ink according to DIN ISO 8296.
- Initial-sample test reports and test certificates are generated upon request.

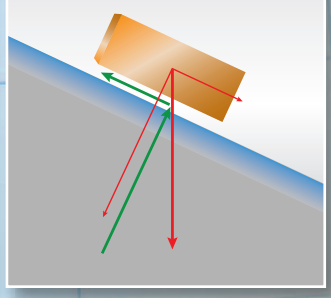
Wettability fluorination

Improved surface wettability



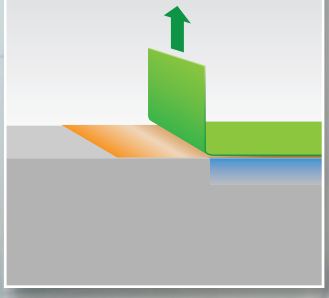
Anti-friction fluorination

Reduced friction and stickiness



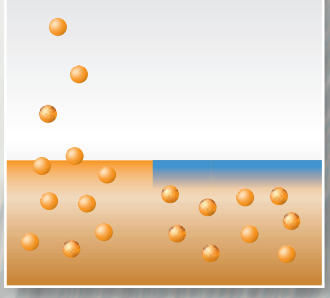
Adhesion fluorination

Better bonding and adhesion



Surface barrier fluorination

Less permeation, diffusion and migration



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Benefits of gas-phase fluorination

- **Long-term stability**
  Depending on the material, the effects achieved on the surface remain stable for several months.
- **Even application with no geometric constraints**
  Even deep grooves, undercuts or cavities with small openings are pre-treated consistently. All exposed surfaces have identical properties.
- **Reproducibility**
  The fully automated procedure facilitates easy control and monitoring of influencing factors, allowing the exact result to be replicated later on.
- **Low temperatures**
  The treatment is performed at low temperatures that doesn't affect the plastic material. Local temperature peaks are avoided.
- **Antibacterial effect**
  Fluorination has an antibacterial effect for a limited period.

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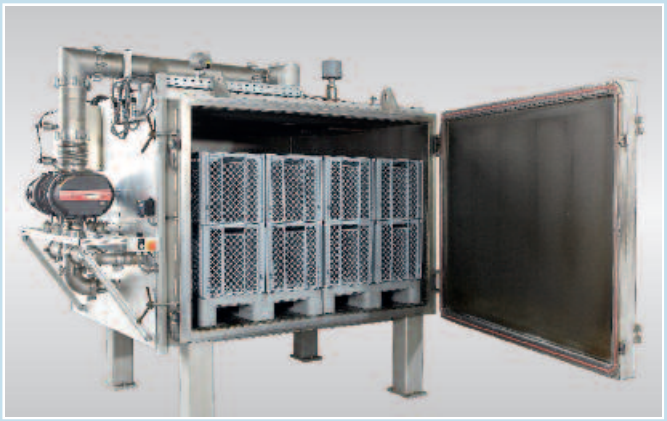

FTS has focussed on the development and manufacture of fluorination systems and fluorination services for more than 20 years. Realised projects, memberships in trade associations, cooperation with universities and research institutes, as well as many patents, are proof of FTS' expertise. We are member 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. Please feel free to inquire.

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.

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