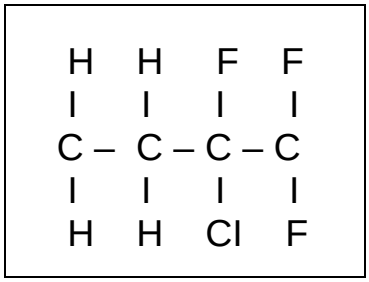
May 2005

ECTFE Halar ®



Thermoplastic High-tech Coating

- **Excellent resistance to chemicals**
- **First-rate electrical properties**
- **Superior mechanical properties**
- **Temperature proof –70℃ bis +150℃**
- **Low rate of permeation**
- **Variant for use with foodstuffs**
- **Good weatherproofness**
- **Water absorption < 0,1%**
- **Inflammable to UL94 V-0**
- **Resistant to x-rays up to 200 MRad**
- **Easily machineable**
- **High level coating thickness 400 - 1000µ**

The guidelines of DIN 29051 apply to the finishing of the articles to be coated.

Resistance to chemicals

HALAR provides an superior resistance to chemicals and an excellent diffusion barrier. It remains practically unaffected when in contact with the majority of corrosive chemicals used in industry, e.g. concentrated mineral and oxydizing acids, alkalis, metal etching products, liquid oxygen, as well as virtually all organic solvents, except the hot amines (e.g. aniline, dimethylamine).

HALAR swells when exposed to natrium and potassium compounds. The degree of swelling depends on the length of exposure and temperature.
HALAR and other fluorpolymers can also swell when in contact with certain halogenised solvents. This process does not normally its usage. When the solvent has evaporated and the surface is dry, the mechanical properties return to their original values, proving that no lasting chemical degradation has taken place.

Further information about the chemical stability of HALAR can be found in the following table 1.1 (green appendix) and 1.2 (yellow appendix).

Electrical properties

HALAR possesses a high volume and surface resisitivity and a very low loss factor. HALAR's dielectric constant is 2.6 and remains stable over a wide temperature and frequency range.

HALAR has a high dielectric strength (ASTM D149): In HALAR coatings of 1.0 mm thickness this is approx. 35 kV/mm (see Table 2).

HALAR can also be modifed to provide antistatic properties with a resistance of between 10^9 Ω und 10^6 Ω.

Table 2: Electrical properties

Electrical properties	**Testing method ASTM**	**Units**	**Value**
dieletric constant	D-150 50 Hz 10^3 Hz 10^6 Hz	1	2,6 2,5 2,5
dielectric loss factor	D-150 50 Hz 10^3 Hz 10^6 Hz	1	> 0,0009 0,0017 0,017
transverse or volume resisitivity	D-257	Ω cm	10^{15}
surface resistivity	D-257	Ω	> 10^{15}
dielectric strength	D-149 - 0,025 mm film - 1,0 mm coating	KV/mm	80 theor. value 35 prac. value
Resistance to arcing	D-495	sec.	135

Mechanical properties

HALAR is a hard, shockproof polymer, whose properties remain practically constant over a wide temperature range. Its performance at low temperatures down to -80°C, especially its resistance to impact is outstanding. Additionally HALAR displays good tensile strength and resistance to abrasion. (see table 3).

Table 3: Mechanical properties

Properties	Testing method ASTM/DIN	Units	Value
tensile strength	D-638 at point of failure yield strain	MPa MPa	50 32
elongation at failure	D-638	%	200
modulus of elasticity	D-790	MPa	1700
modulus in tension	D-638	MPa	1700
flexural strength	D-790	MPa	43
impact strength when notched IZOD	D-256	+23℃ - 40℃	Does not tear 2 – 3
hardness	D-785 53505	Rockwell Shore D	R-93 75
indentation hardness	53456	132/60 MPa	55-65
abrasion resistance	D-1242 D-1044	Armstrong cc Taber 500 U gr 1000 U gr	0,3 loss of volume 0,002 0,005
friction coefficient	ASTM D-1894		0, 7 – 0,8

Thermal properties / Inflammability / UL

HALAR is s heated uitable for constant usage at a temperature of +150℃. A short period of exposure of up to +180℃ is possible.

HALAR takes on a brownish colour when exposed for a longer time to the temperatures given above.

HALAR's nonflammability is one of its excellent properties. When exposed to fire HALAR carbonises while most of the other fluoroplastics melt and drip. The carbonisation process stops immediately the flames are removed.

HALAR has been assessed as UL94-VO material by Underwriters Laboratories (UL) als UL94-VO Material.

Production of fumes in case of fire is lower with HALAR than with most other thermoplastics.

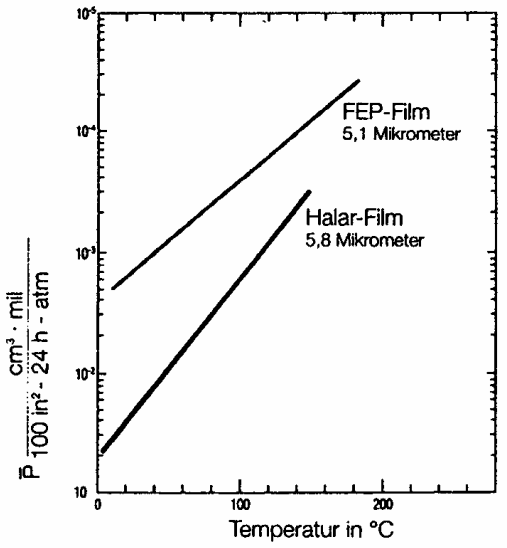
Table 4: General thermal properties of HALAR			
Properties	**ASTM method**	**Unit**	**Value**
coefficient of linear expansion	D-696 -30℃ bis +30℃	1	5 X 10^{-5}
thermal conductivity	40℃ 40℃	Joule/m h℃ Kcal/m h℃	556 0,13
Resistance to thermal deformation under pressure 4,6 kp/cm^2 18,6 kp/ cm^2		℃ ℃	115 76
Melting point	DSC	℃	245
embrittlement at low temperatures	D-746	℃	-80
max. constant usage temperature without strain.		℃ ℃	150 180 momentary
nonflammability	D-635	UL 94 vertical 0,18 mm	V-0 does not drip does not burn
inflammability L0I (limit oxygen index)	D 2863	$\%0_2$	60

Permeation / Diffusion barrier

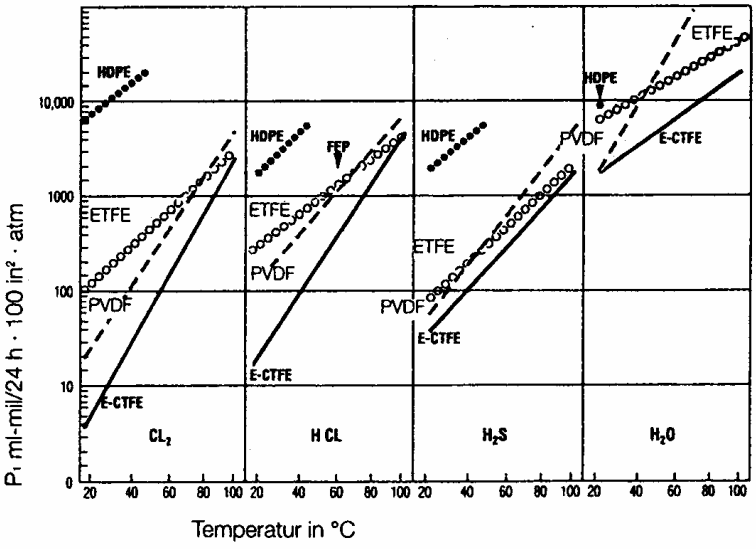
HALAR displays a very low permeability to steam and oxygen, as well as various other gases. Absorption of humidity is less than 0,1 %. HALAR can only be sterilised to a limited extent.

Table 5: Permeations

Oxygen permeation



Permeation of various polymers



Contact with foodstuffs

HALAR type 8014 complies with the requirements of Food-Additive Regulations, use B, set down in 21 C.F.R. 176.170 ©, Tab. 2.

Weatherproofness

HALAR displays very little change in its properties and appearance when used outdoors. Concentrated weather tests have proved a considerable stability of the polymer. Essential properties are scarcely affected even after 1000 hours in weather-ometer with xenon light.

Resistance to radiation

HALAR is one of the polymers most resistant to radiation, e.g.HALAR retains its good properties even after cobalt 60 radiation of 200 Mrad.

Long-term reactions

HALAR's life-expectancy by constant use at 150℃ is approximately 20 years (limitation: 50% tensile strength, however, still fulfilling its prime function).
HALAR produces many times smoother microsurfaces than, for example PVDF, PVC, PP and is water repellent.
The degree of crystallinity and thus the mechanical and thermal properties remain permanently stable.

Application

Substrate-preparation:
- degreasing
- corundium blasting, scale of cleanness Sa3

Priming:
Coating is carried out by electrostatic powder spraying on to the primer coat heated to 360℃ - 390℃. There are two different priming syst ems available:

- thermoplastic primer coat, black or
- thermoset primer coat, green/brown

Coating
- fusing of several coats at a substrate temperature of +360℃ to +390℃.
- a thickness of 100 - 200my can be applied at each coating. This means that 4 – 6 coats must be separately fused, in order to achieve the standard layer thickness for pretection against chemicals.

Retouching of suspension points
- re-melting, where necessary with the addition of HALAR

Quality control
- measurement of layer thickness with Fischer Dualscope
- Pinhole testing with Fischer poroscope 2,5 – 25 kV

Essential specifications of HALAR 6014

Property	Unit	6014
Mechanical properties		
Hardness	Shore D	75
tensile strength	MPa	32
tensile strength at break	MPa	45
elongation at tear	%	325
flexural module	MPa	1520
impact strength Izod, with notch, +23℃	J/m	kein Br uch
Izod, with notch, -40℃	J /m	48
Elelctrical properties		
dielectric strength		
coating 800 µ	kV/mm	34,6
dielectric constant	1	
at 10^3 Hz		2,45
at 10^6 Hz		2,57
loss factor	1	
at 10^3 Hz		0,0017
at 10^6 Hz		0,017
Resistance to chemicals		
Sulphuric acid 98 %		no effects of corrosion
Concentrated hydrochloric acid		no effects of corrosion
Hydrofluoric acid		no effects of corrosion
Sodium hydroxide, 50 %		no effects of corrosion
Inflammability		
Oxygn index, 1,6 mm		min. 52
UL 94 vertical, 0,18 mm		94 V-O
Nonflammability and dischagre of smoke (fumes?)		i.O.
Thermal properties		
Melting point	℃	245
max. temperature for usage	℃	-70/+150
Other specifications		
Resistance to radiation	MRad	200
weatherproofness		good
Specific gravity	gr/cm^3	1,68±0,05
Absorption of humidity	%	<0,1
Application		
Fusing temperature	℃	+260 bis +300

Eposint AG / K. Gantenbein/ua

Table 1.1 Resistance to chemicals

Effect on properties

***1** There was no evidence of tears due to strain(tension) on the 2.29mm test objects in any of the experiments according to ASTM D1693.

***2 Key**:U = unimportant
A = reduction by 25-50%
B = reduction by 50-75%
C = reduction by >75%

***3** This data is based on 11 day tests on 2.29mm thick test objects (//with strain/tension tears). The loss in weight was measured within 15 minutes after removal from the testing fluid. The test objects were then wrapped in foil and sealed in glass jars to minimise the release of solvent. The tests for tension followed within 24 hours after their removal (test objects
according to ASTM D1693)

***4** HALAR contains application additives, which darken in colour when exposed for longer periods to certain highly concentrated acids (e.g. sulphuric and nitric acid.)

Chemical	Temp °C	Weight increase, %	Effect on elasticity of elongation	Effect on elongation at tear
Mineral acids (*4)				
sulphuric acid 78%	23	<0.1	U	U
	121	<0.1	U	U
Hydrochloric acid 37%	23	<0.1	U	U
	75-105	0.1	U	U
Hydrochlori acid 60%	23	<0.1	U	U
Chlorosulfone acid 60%	23	0.1	U	U
Oxydising acids				
Nitric acid 70%	23	<0.1	U	U
	121	0.8	A	C
Chromic acid	23	<0.1	U	U
	111	0.4	U	U
Nitrohydrochloric acid	23	0.1	U	U
	75-105	0.5	U	U
Anorganic salts				
Ferrous chloride 25%	23	0.1	U	U
	1 03	0.1	U	U
Zinc chloride 25%	23	<0.1	U	U
	104	<0.1	U	U
Copper chloride 25%	23	<0.1	U	U
	1 03	<0.1	U	U
Anorganic alkalis				
Sodium hydroxide 50%	23	<0.1	U	U
	121	<0.1	U	U
Ammomnium hrdroxide 28%	23	<0.1	U	U
	66	0.2	U	U
Halogens				
Bromine	23	1.4	U	U
Solvents				
Aliphatic compounds	23	0.1	U	U
Hexane	54	1.4	A	U
(solvents)				
Chemical	**Temp**	**Weight**	**Effect on**	**Effect on**

Effect on properties		°C	increase, %	elasticity of elongation	elongation at tear
	Isooctane	23	<0.1	U	U
		116	3.3	A	U
	Aromatic compounds				
	Benzene	23	0.6	U	U
		74	7.0	C	U
	Methylbenzene	23	0.6	U	U
		110	8.5	C	U
	Ketones				
	Acetone	23	0.1	U	U
		52	4.0	B	U
	methylethylketone	23	1.0	U	U
		79	6.0	C	U
	Methylisobutylketone	23	0.5	A	U
		115	9.0	C	U
	Acids				
	Acetic acid pure	23	0.2	U	U
		110	3.5	C	U
	Ester				
	Ethylacetate	23	0.2	U	U
		71	6.5	B	U
	Butylacetate	23	0.2	U	U
		121	10.5	C	U
	Dimethylphatat	23	<0.1	U	U
		121	3.5	A	U
	Amines				
	Diethylamine	23	0.2	U	U
		118	?	?	?
	Aniline	23	<0.1	U	U
		121	?	?	?
	Standard plastic solvents				
	Dimethylformamide	73	2.0	A	U
		250	7.5	C	U
	Dimethylsulfoxide	73	0.1	U	U
		250	3.0	U	U

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Chemical	Temp °C	Weight increase, %	Effect on elasticity of elongation	Effect on elongation at tear
(solvents)				
Functional aromatic compounds				
Aniline	23	<0.1	U	U
	121	1.4	A	U
Benzaldehyde	23	0.2	U	U
	121	10.4	C	U
Chlorbenzol	23	0.9	C	U
	121	19.5	U	U
Dimethylphtalate	23	<0.1	U	U
	121	3.5	A	U
Nitrobenzol	23	0.2	U	U
	121	11.5	C	U
Chlofied solvents				
Chloroform	23	4.5	A	U
Methylenchloride	23	8.0	B	U
	40	9.0	C	U
Trichlorethylene	23	5.0	B	U
	85	16.5	C	U
Perchlorethylene	23	1.0	U	U
	121	29.0	C	U
Dichlorethylene	23	1.0	C	U
	85	9.5	U	U
R113	23	0.4	U	U
	49	2.0	U	U
chlorbenzol	23	0.9	A	U
	121	19.5	C	U
Alcohols				
methanol	23	0.1	U	U
	60	0.4	A	U
buthanol	23	0.1	U	U
	118	2.0	A	U
Ethers				
ethylether	23	0.9	U	U
dioxane	23	0.9	U	U
	102	16.0	C	U
Propylenoxide	23	6.0	C	U
tetrahydrofurane	23	4.5	B	U
	63	11.0	C	U