



# The Next Generation of Hydrocarbon Membranes

fumion® S, ST, E and P

[www.fumatech.de](http://www.fumatech.de)



**fumatech**  
functional membranes for fuel cells

---

 **BWT** GROUP

# fumapem® S, ST, E and P

FuMA-Tech has developed the next generation of hydrocarbon membranes primarily designed for PEMFC and DMFC applications. **fumapem® S, ST, E and P** membranes and **fumion® S, ST, E and P** ionomers are based on sulfonated hydrocarbon polymers. The high-performance ionomers and membranes are approved in terms of electrochemical properties, long term stability and reliability.

**fumion® P** and **E** ionomers and **fumapem® P** and **E** membranes are based on sulfonated poly(ether ketone) polymers with an ion exchange capacity (IEC) 1.3 – 1.4 meq / g. The membranes show excellent mechanical properties, low methanol crossover and low area resistance, intended to be used in DMFC applications and other electro-membrane applications. Membranes are available in sheets and on roll, reinforcement can be optionally provided. Highly sulfonated **fumion® E** ionomer (IEC = 1.9 – 2.0 meq / g) based on sulfonated poly(ether ether ketone) is also available, intended for specific coating processes. Other IECs are available on request.

**fumapem® ST** membranes are based on sulfonated polysulfone polymers, intended to be used in PEMFC and DMFC applications. FuMA-Tech offers various versions of **fumapem® ST** membranes with different equivalent weights and thicknesses covering all customer applications:

**fumapem® ST-530** membrane with high ion exchange capacity has been designed for PEMFC applications. This membrane exhibits high proton conductivity, low hydrogen crossover and excellent chemical and mechanical stability.

**fumapem® ST-1030** membrane with low ion exchange capacity has been developed for DMFC applications. These

membranes combine low methanol crossover and low area resistance with very good dimensional stability.

**fumion® S** ionomer and **fumapem® S** membrane are based on sulfonated hydrocarbon polymers which consist exclusively of sulfone units connecting the sulfonated aromatic rings. This new class of polymers with very electron-deficient aromatic rings combines very high thermooxidative and electrochemical stability, high proton conductivity and high dimensional stability, intended for use in fuel cell applications and electrolysis. Flexible preparation routes to **fumion® S** ionomers offer various molecular structures and ion exchange capacities which allows optimal tailoring of this material to the needs of the customer. Ion exchange capacities can be varied in a wide range up to 4.5 meq / g.

In addition, **fumion® S** ionomer exhibits exceptionally high hydrothermal stability, low water-solubility and strong acidity. **fumion® S** is extraordinarily stable in aqueous environment at high temperatures up to  $T = 200\text{ }^{\circ}\text{C}$ . It does not show any excessive swelling in alcohol, even at high alcohol concentrations and elevated temperatures. **fumion® S** can be applied for any application requiring hydrothermally stable strong-acid materials, for example solid strong-acid catalysts. Up to IECs of 2.7 meq g<sup>-1</sup>, the **fumion® S** material is non-water soluble and can be provided as polymer granules, beyond IEC 2.9 meq g<sup>-1</sup> **fumion® S** is provided as water solution. **fumapem® S** membranes based on highly sulfonated **fumion® S** ionomers are provided with reinforcement, intended for PEMFC and electrolysis applications. **fumapem® S** membranes based on **fumion® S** ionomers with low IEC are ideally suited for DMFC applications.

## Key features

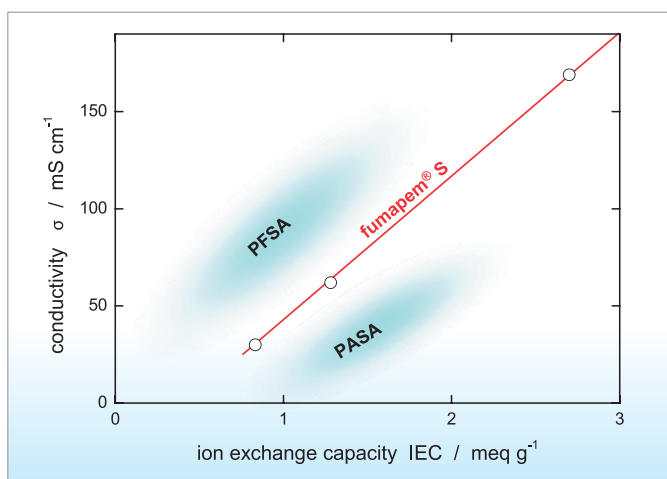
- high performance
- low area resistance
- low methanol cross-over / low hydrogen permeability
- methanol rejection (selectivity)
- high dimensional stability
- high thermooxidative and (electro-)chemical stability
- excellent hydrolytic stability



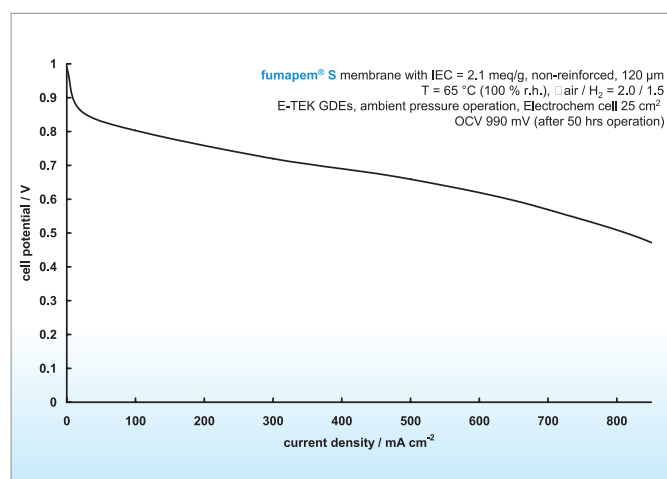
About **fumion® S** ionomer and **fumapem® S** membrane:

- excellent hydrolytic stability (stable up to  $T = 200\text{ °C}$  in water environment)
- outstanding (electro-)chemical stability
- high thermal and thermooxidative stability
- low methanol crossover and high selectivity (preferential uptake of water)
- strong acidity of the sulfonic acid group (due to electron-withdrawing groups)
- high proton conductivity and high catalytic activity as solid strong-acid catalyst
- constant and uniform solvent swelling irrespective of temperature and alcohol content
- transparent and colorless
- water-soluble ionomer with IEC  $> 3.0\text{ meq g}^{-1}$
- water-insoluble ionomer with IEC up to  $3.0\text{ meq g}^{-1}$

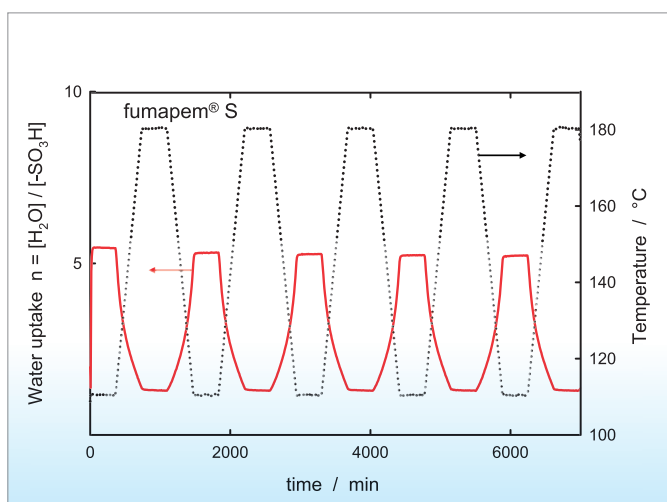
**Conductivity versus IEC** measured in water at  $T = 20\text{ °C}$



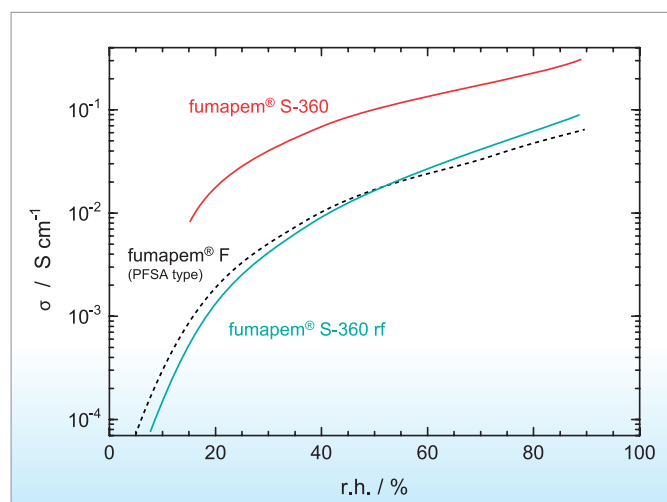
Performance of single cell test with **fumapem® S** membrane



**Hydrothermal stability** determined in water atmosphere  $p(\text{H}_2\text{O}) = 1\text{ atm}$



**Conductivity of fumapem® S-360 membrane versus relative humidity** determined in FuMA-Tech MK3 conductivity cell



	<b>fumion® S-360</b>	<b>fumion® S-340</b>	<b>fumion® S-220</b>
appearance	white powder	white powder	off-white powder
solubility	water insoluble	water soluble	water soluble
IEC	meq g <sup>-1</sup> 2.7	2.9	4.5
density	g cm <sup>-3</sup> 1.6 – 1.7	1.5 – 1.6	1.7 – 1.8
glass transition	°C no Tg	280 – 300 °C	no Tg
thermal decomposition	°C > 350	> 340	> 350

## Physical and chemical data

		fumapem® E-730	fumapem® ST-1030	fumapem® P-730	fumapem® ST-530	fumapem® S-360 rf	
application		DMFC	DMFC	DMFC	PEMFC	PEMFC	
reinforcement		optional	-	-	-	reinforced	
IEC	meq g-1	1.4	0.99	1.42	1.84	1.9	
EW	g eq-1	740	1010	704	545	520	
thickness (dry)	µm	30	30	30	30	60 – 70	
uptake in	H <sub>2</sub> O at 25 °C a)	wt %	27	15	27	45	60
	H <sub>2</sub> O / MeOH at 25 °C a)	wt %	58	33	51	144	64
	MeOH at 25 °C a)	wt %	38	29	27	-	46
dimensional swelling in	H <sub>2</sub> O at 25 °C b)	%	7	2	6	15	3
	H <sub>2</sub> O / MeOH at 25 °C b)	%	11	9	14	33	4
	MeOH at 25 °C b)	%	11	10	8	-	3
conductivity c)	mS cm-1	16	20	15	120	120	
area resistance c)	Ω cm2	0.18	0.15	0.20	0.025	0.058	
methanol permeation d)	Mol h-1 m-2	15	13	15	-	-	
Young's modulus at 23 °C / 50 % r.h. e)	MPa	> 1400	> 1300	> 2000	1100	1000	
yield strength at 23 °C / 50 % r.h. e)	MPa	40 – 45	40 – 45	55 – 60	30 – 35	-	
tensile strength at 23 °C / 50 % r.h. e)	MPa	60 – 65	45 – 50	55 – 60	30	45 – 50	
elongation at break at 23 °C / 50 % r.h. e)	%	> 200	> 100	> 80	> 140	30	
density (dry)	g cm-3	1.2 – 1.3	1.3 – 1.4	1.2 – 1.3	1.3 – 1.4	1.5 – 1.6	
molecular weight Mw	g mol-1	> 50.000	> 50.000	> 90.000	> 50.000	> 100.000	
start of thermal decomposition f)	°C	> 200	> 250	> 300	> 250	> 350	
glass transition temperature Tg g)	°C	209	205	300 – 310	210	no Tg	

a) reference membrane dried over P2O5 in vacuo.

b) reference membrane dried at room temperature and 50 % r.h.

c) in H-form at T = 25 °C in H<sub>2</sub>O.

d) determined in a concentration cell (1.0 M methanol versus deionized water at T = 50 °C).

e) according to DIN EN ISO 527-1.

f) in H-form and dry state using TGA (heating rate 2 K min<sup>-1</sup>).

g) in H-form and dry state using DMA (heating rate 2 K min<sup>-1</sup>), maximum of tanδ.



## The company

Focussing on water as the basis of all forms of life, and energy as the basis for a higher quality of life, FuMA-Tech “Functional Membranes and Plant Technology” combines the important tasks of providing energy and water. The company is engaged in the field of fuel cell technology and membrane separation technology, particularly for the treatment of aqueous solutions.

FuMA-Tech draws its particular strengths as a leading producer of ion-exchange membranes from its membership in the BWT Best Water Technology - Group.

FuMA-Tech is committed to develop new products that will accelerate progress in polymer electrolyte fuel cells.

The company is both competent and competitive as a leading supplier of polymers and membranes for manufacturing of membrane electrode assemblies.

The high performance membranes are the heart of a proton exchange membrane (PEM) fuel cell stack.

FuMA-Tech produces and develops

- polyelectrolytes (**fumion**<sup>®</sup> ionomers),
  - proton conductive membranes (**fumapem**<sup>®</sup> membranes) and
  - separation membranes (**fumasep**<sup>®</sup> membranes)
- based on proprietary technology and designed for high precision mass manufacturing.

<b>fumion</b> <sup>®</sup>	ionomer resin as granular polymer, in solution form or in dispersion
<b>fumion</b> <sup>®</sup> FF	granular perfluorosulfonyl fluoride resin for extrusion
<b>fumapem</b> <sup>®</sup> F	perfluorosulfonic acid membranes for PEMFC
<b>fumapem</b> <sup>®</sup> AM	polybenzimidazole membranes for high temperature PEMFC
<b>fumapem</b> <sup>®</sup> ST	hydrocarbon membranes for DMFC and PEMFC
<b>fumapem</b> <sup>®</sup> P,E	hydrocarbon membranes for DMFC
<b>fumapem</b> <sup>®</sup> FAA	anion-exchange membrane for alkaline FC
<b>fumasep</b> <sup>®</sup> FAP	anion-exchange membrane for redox flow batteries
<b>fumasep</b> <sup>®</sup> FBM	bipolar membrane
<b>fumasep</b> <sup>®</sup> HF	hollow fibre cartridge for gas humidification
<b>fumasep</b> <sup>®</sup>	ion-exchange membranes for humidifier, electro dialysis and electrolysis
<b>fumea</b> <sup>®</sup>	catalyst coated membranes for water electrolysis

# BWT – The Water Company

The Best Water Technology Group was formed in 1990 and today is Europe's leading water technology company. The goal of our 2,700 employees in 80 subsidiaries and associates is to provide private, industrial, business, hotel, hospital and municipal customers with innovative, ecological and efficient technologies that deliver maximum safety, hygiene and health in their daily contact with the elixir of life, water.

BWT offers state-of-the-art water treatment technologies and services for drinking water, pharma water, process water, heating water, boiler water, cooling water and water for air-conditioning systems as well as swimming pool water. For the technological superiority in all areas of water treatment, the international BWT innovation centers continuously research, develop and optimize processes for filtration, filter media, ion exchange systems for demineralization, softening, decarbonisation, membrane technologies (microfiltration, ultrafiltration, nanofiltration, reverse osmosis), pure steam generators, high purity water distills UV systems, ozone generators, ion exchange membranes, electrolysis systems, electro dialysis, electrodeionisation, chlorine dioxide generators and metering pumps which are used throughout the world to achieve excellent water quality.

Tens of thousands of service employees, plumbers, planners, architects and sanitation experts constitute the BWT water partner network. Whether at the entrance of the water pipe into a building (at the "Point of Entry") or at the tapping point ("Point

of Use"), BWT products "made in Europe" have proven their quality million times. With new table water filters for preparing tea or coffee, filters for optimizing water for coffee machines, water filters for baking and steam ovens and vending machines, under-the-sink particle-filters as well as micro-filters, water dispensers, reverse osmosis and UV devices BWT also offers compact and innovative products for end consumers for best water quality.

With unique high efficiency membranes for fuel cells and batteries BWT is working for a cleaner energy supply of the 21<sup>st</sup> century.

Employees in Research & Development work on new processes and materials using state-of-the-art methodologies targeting to develop ecological, at the same time efficient products. The reduction of energy consumption of products and minimization of CO<sub>2</sub>-emissions forms a key issue for new and further development. Ecological, economical and social responsibility and the employment of state-of-the-art technologies as well as permanent product evolution contribute significantly to growing the company and the reputation of the market-leading regional brands BWT, HOH, Permo and Christ Aqua as well as Christ Aqua Pharma & Biotech.

BWT – The Water Company - is our vision to provide our customers and partners with the best products, systems and technologies and services in all areas of water treatment.

Our Vision:

**BWT – The Leading International Water Technology Group.**

**For further information:**

**FuMA-Tech Gesellschaft für funktionelle Membranen und Anlagentechnologie mbH**  
Am Grubenstollen 11  
D-66386 St. Ingbert  
Tel.: +49/6894/9265-0  
Fax: +49/6894/926599  
E-Mail: office@fumatech.de

**FuMA-Tech Gesellschaft für funktionelle Membranen und Anlagentechnologie mbH**  
Steinbeisstraße 41 – 43  
D-71665 Vaihingen Enz  
Tel.: +49/7042/97024-0  
Fax: +49/7042/9702499  
E-Mail: office@fumatech.de

**BWT Aktiengesellschaft**  
Walter-Simmer-Straße 4  
A-5310 Mondsee  
Tel.: +43/6232/5011-0  
Fax: +43/6232/4058  
E-Mail: office@bwt-group.com  
www.bwt-group.com



**fumatech**  
functional membranes for fuel cells

[www.fumatech.de](http://www.fumatech.de)

**BWT GROUP**