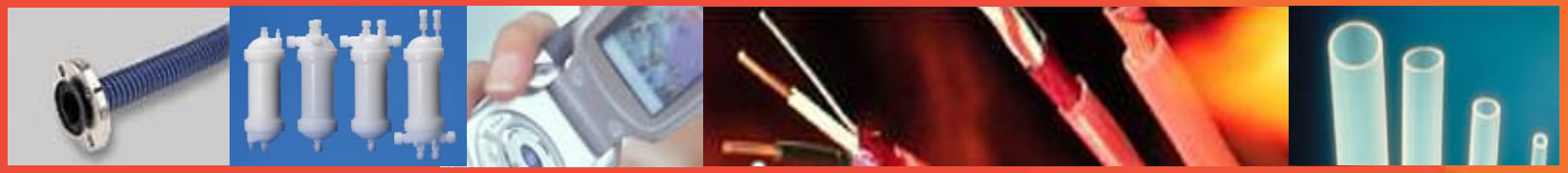
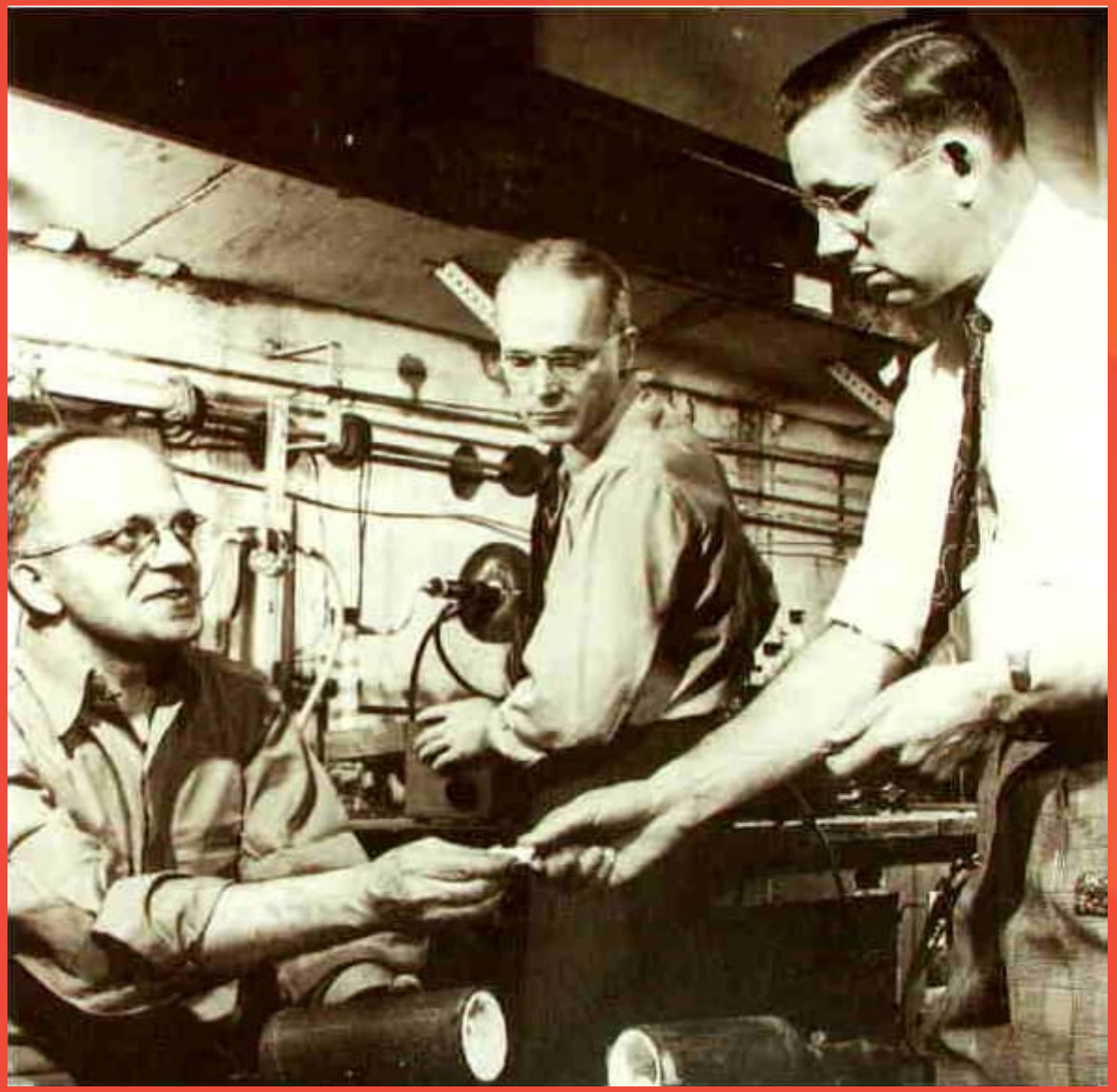
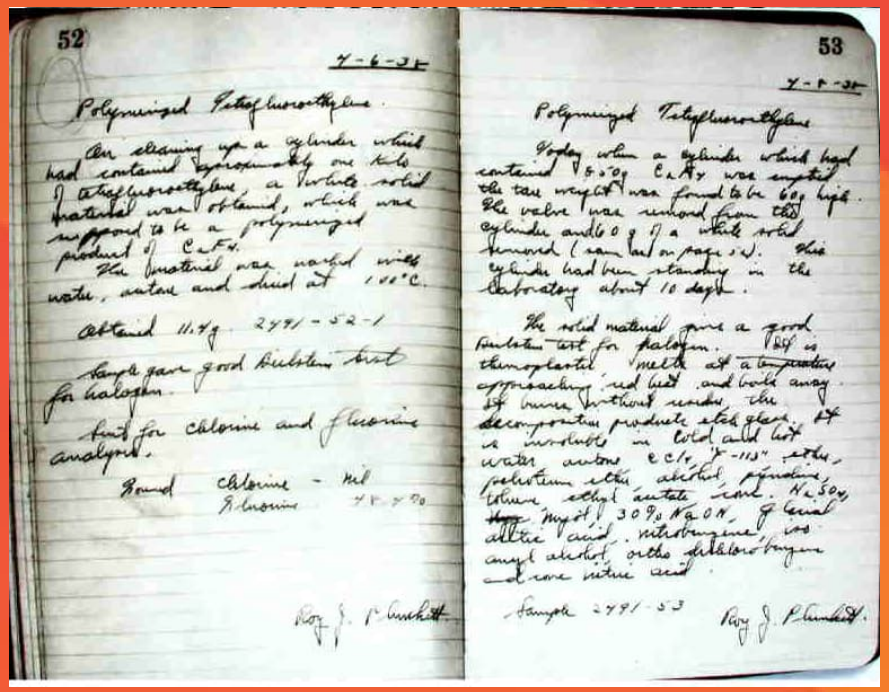
General Introduction to Chemours Fluoropolymers



ETC Meyrin-Geneva
Jeanne Driebeek

A serendipitous discovery nearly 80 years ago….





52

Polymerized Tetrafluoroethylene.

On cleaning up a cylinder which had contained approximately one kilo of tetrafluoroethylene a further solid material was obtained, which was supposed to be a polymerized product of C_2F_4.

The material was washed with water, acetone and dried at 100°C.

Obtained 11.4 g. 2791-52-1

Sample gave good Beilstein test for halogen.

Sent for chlorine and fluorine analysis.

Found Chlorine - Nil
Fluorine 78.4%

Roy J. Plunkett

53

Polymerized Tetrafluoroethylene

Today when a cylinder which had contained 5.0 g C_2F_4 was emptied the tare weight was found to be 60 g high. The valve was removed from the cylinder and 6.0 g of a white solid removed (see last on page 52). This cylinder had been standing in the laboratory about 10 days.

The solid material gave a good Beilstein test for halogen. It is thermoplastic, melts at a temperature approaching red heat and boils away at bunsen without residue. The decomposition products etch glass. It is insoluble in cold and hot water, acetone, CCl_4, P_2O_5, petroleum ether, alcohol, pyridine, toluene, ethyl acetate, conc. H_2SO_4, 30% NaOH, glacial acetic acid, nitrobenzene, ortho dichlorobenzene and conc. nitric acid.

Sample 2791-53

Roy J. Plunkett

„The use of Teflon™ is limited only by your imagination“

Dr. Roy Plunkett

HISTORY OF PRODUCT INTRODUCTION

TEFLON® PTFE	1938
TEFLON® FEP	1960
TEFZEL® ETFE	1970
TEFLON® PFA	1972
TEFLON® FFR	2009
ECCTREME™ ECA	2011 (currently no availability)

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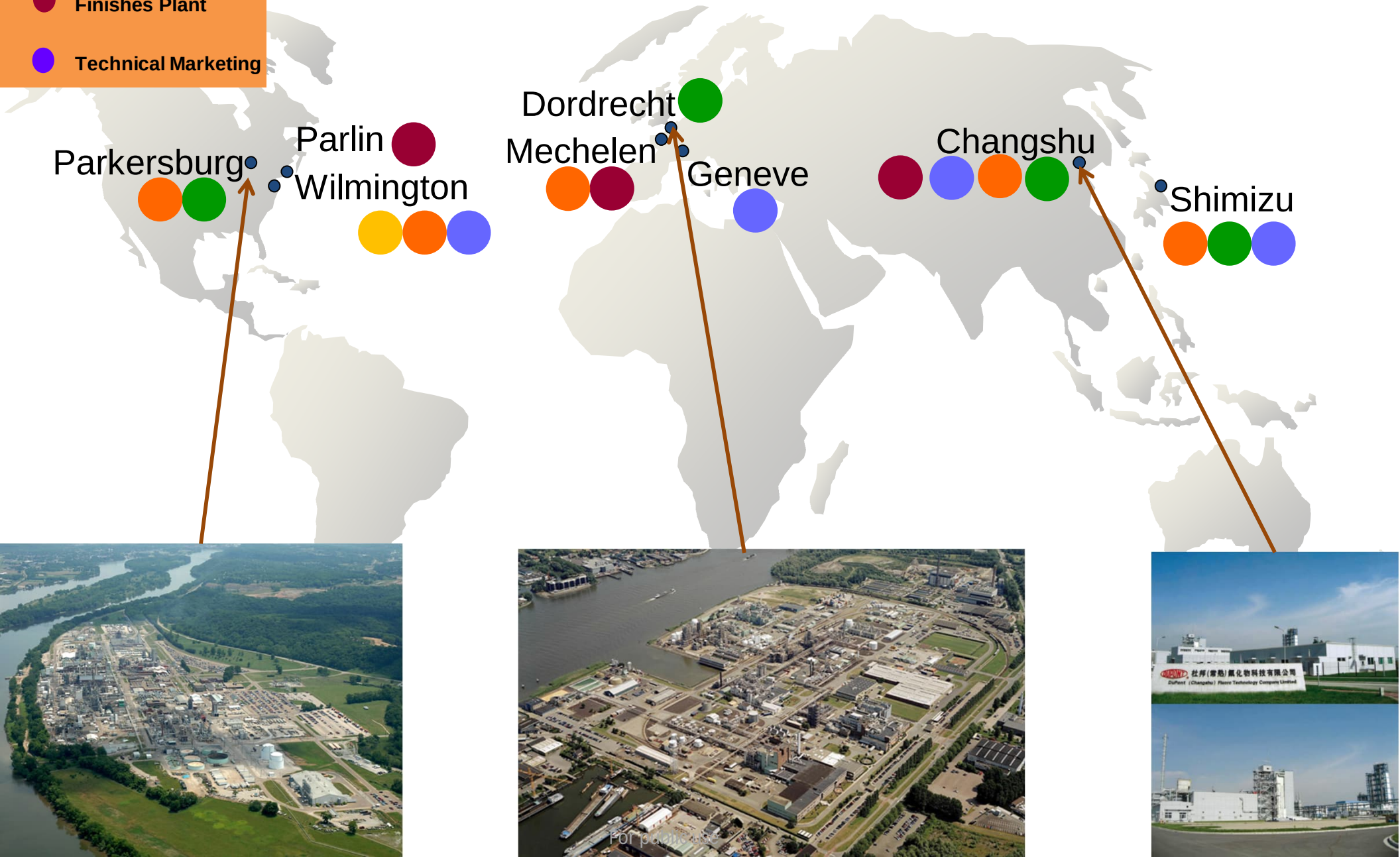
Fluoro Polymer Solutions around the World

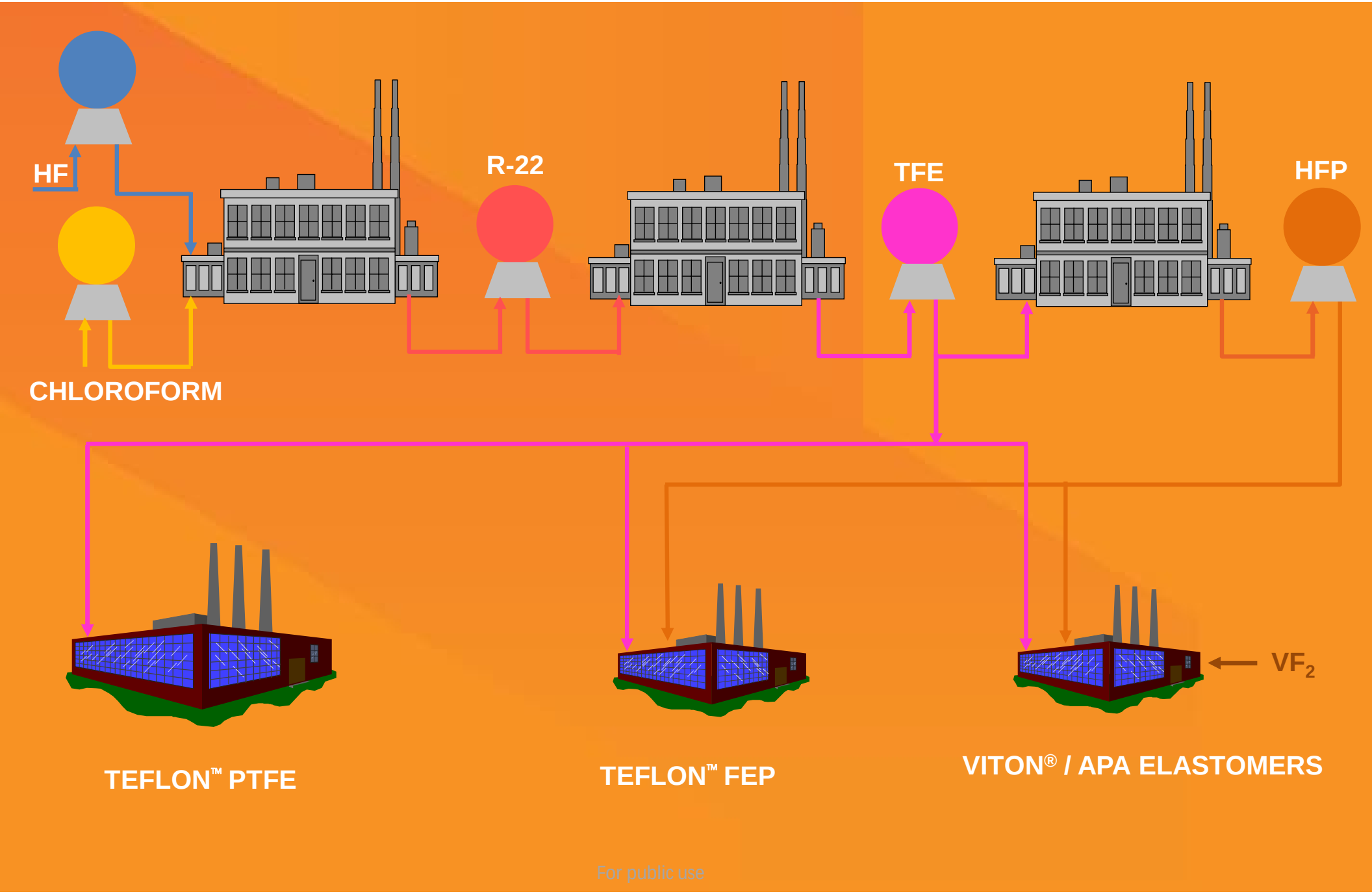
- CR&D
- FPS Research
- Polymer Plant
- Finishes Plant
- Technical Marketing



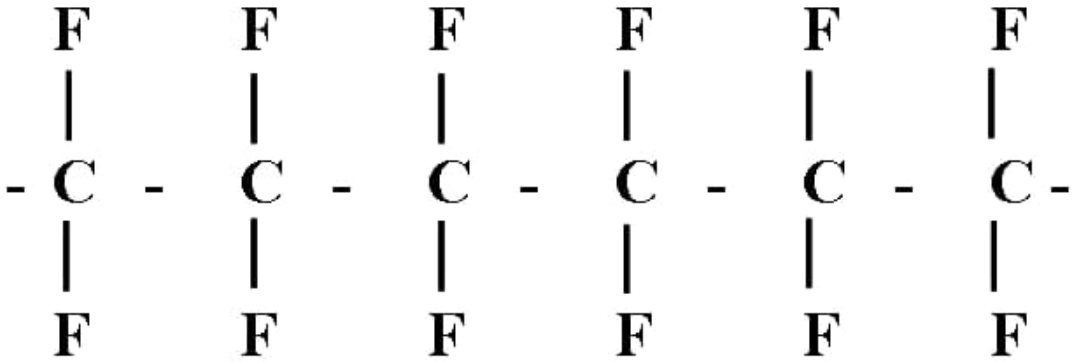
Chemours Dordrecht

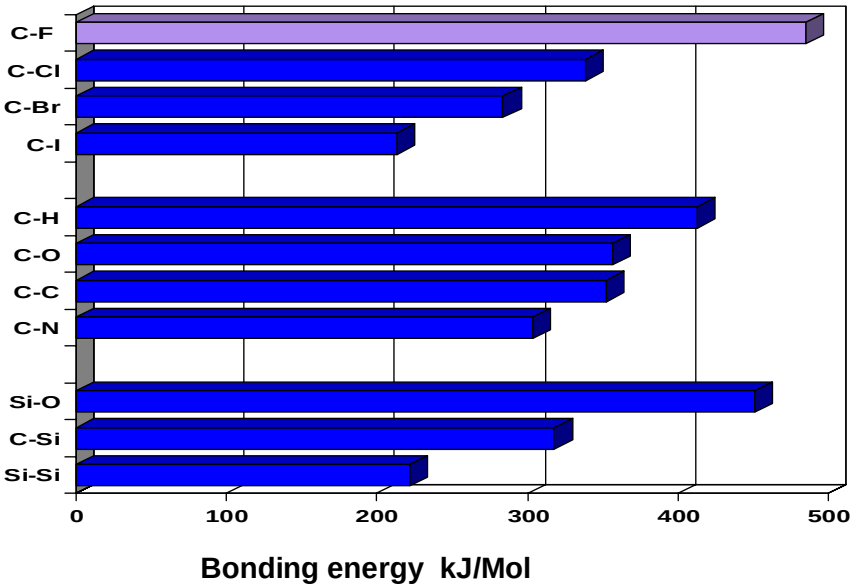
Teflon® PTFE produced at DW since 1967

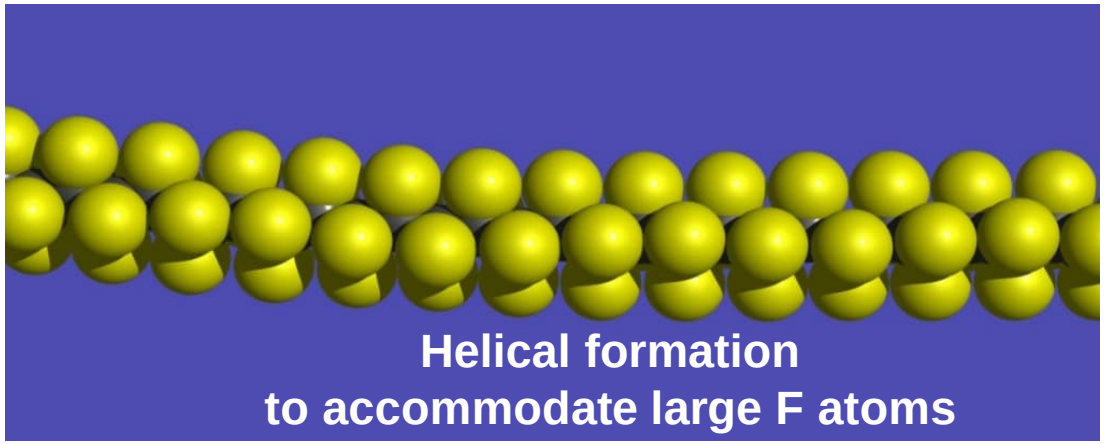
Chemours™ Fluoroproducts Dordrecht



Teflon™ PTFE







VERY Long linear chain
Tight packing of F atoms
No polarity
“Introvert”

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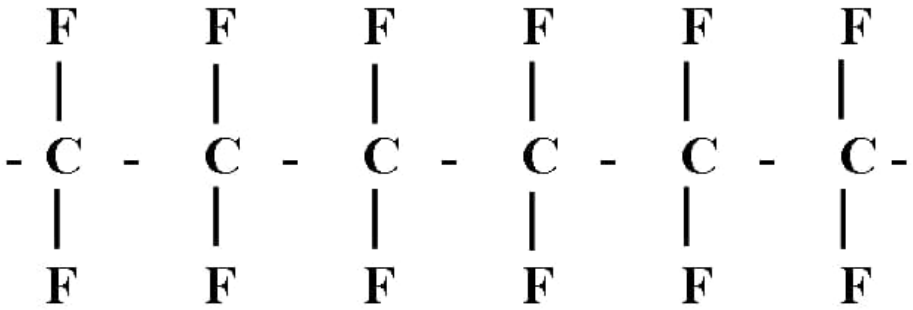
Teflon™ PTFE Fluoroplastic Outstanding Properties



Long chain
Tight packing of F atoms
No polarity
“introvert”

- Chemical Inertness
- Low extractables ; high purity
- Non-Stick ; Easy Cleaning
- Low Friction ; Self-Lubricating
- Dielectrical Properties
- Weather Resistance & Non Ageing
- Insensitive to UV
- Non-Toxic
- Wide Temperature Range resistance (- 200 °C / + 260 °C)
- Flexible over a wide range of temperature
- Non Flammable

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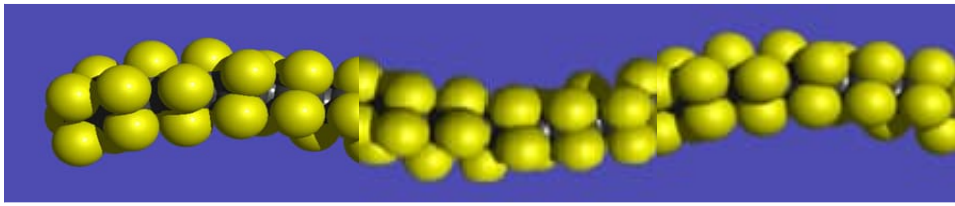
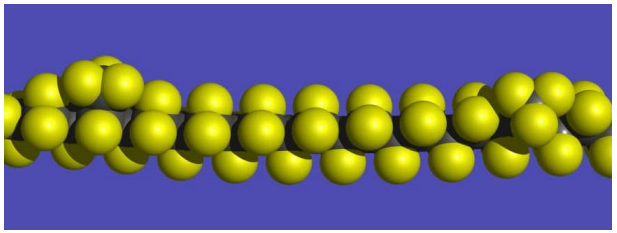
Chemours Fluoroplastic Portfolio

Teflon® PTFE $(-CF_2-CF_2-)n$
(Polytetrafluorethylene)
Discovered 1938

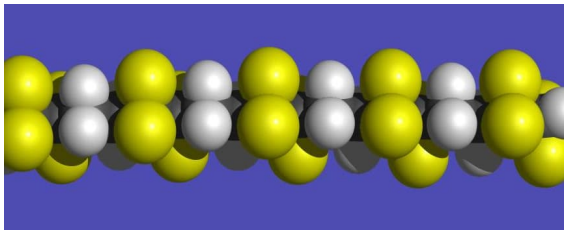


10 00 to 10 000 times shorter chains than PTFE

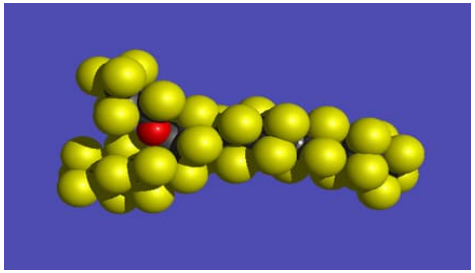
Teflon® FEP $(-(CF_2-CF_2-CF_2)_m-CFCF_3-CF_2-)_n$
(Fluorinated Ethylene Propylene)
Dvlp. 1960



Tefzel® ETFE $(-CH_2-CH_2-CF_2-CF_2-)_n$
(Ethylene Tetrafluorethylene)
Dvlp. 1970



Teflon® PFA $(-(CF_2-CF_2-CF_2)_m-FCOC_3F_7-CF_2-)_n$
(Perfluoroalkoxy)
Dvlp. 1972



In most cases, the best properties are obtained without compounding

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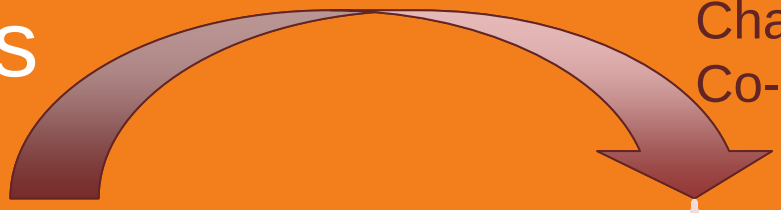
Typical Properties



Property	Units	PTFE	FEP	PFA	ETFE
Molecular Weight		10^6 - 10^7	250 - 600 x 10^3	250 - 450 x 10^3	250 - 400 x 10^3
Co-monomer Content	% Weight	< 1	10 - 12	2,8 - 4,0	20
Melting Point (ASTM D 4591)	°C	327 - 342	260	305	265
Melt Viscosity	Pa.s	10^{10} - 10^{11}	3 - 55 x 10^4	3 - 35 x 10^4	0,5 - 13 x 10^4
Melt Flow Rate(*) (ASTM D 1238)	g/10 min.	No Flow	1 - 30	1,5 - 40	*2,5 - 64*

(*) Measured at 372 °C for FEP and PFA and 297 °C for ETFE

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Thermal Properties

Property	Units	PTFE	FEP	PFA	ETFE
PEAK MELTING TEMP. (ASTM D 4591)	°C	327	260	305	265
SERVICE TEMP. (ISO 2578, 20.000 h)	°C	260	205	260	155
FLAME CLASS (UL94)		94V-0	94V-0	94V-0	94V-0
LIMITING OXYGEN INDEX (ISO 4589)	%	>95	>95	>95	30 - 32
HEAT OF COMBUSTION (ISO 1716)	MJ/kg	4,9 - 5,0	4,8 - 5,1	4,7 - 4,9	12,4 - 12,6

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Electrical Properties

Property	Units	PTFE	FEP	PFA	ETFE
RELATIVE PERMITTIVITY (ASTM D 150)	1 kHz-1 MHz	2,040	2,060	2,050	2,60
DISSIPATION FACTOR (ASTM D 150)	@ 1 MHz	0,00010	0,00058	0,00010	0,005
ARC RESISTANCE (ASTM D 495)	s	240 - 300	240 - 300	240 - 300	60 - 120
VOLUME RESISTIVITY (ASTM D 257)	W.m	> 10^{16}	> 10^{16}	> 10^{16}	> 10^{14}
SURFACE RESISTIVITY (ASTM D 257)	W	> 10^{16}	> 10^{17}	> 10^{16}	> 10^{14}

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Mechanical Properties

Property	Units	PTFE	FEP	PFA	ETFE
SPECIFIC GRAVITY (ISO 1183)		2,16	2,15	2,15	1,71
TENSILE STRENGTH (ISO 12086)	MPa	26 - 36	20 - 34	25 - 35	45 - 51
ULTIMATE ELONGATION (ISO 12086)	%	325	325	350	200 - 375
FLEXURAL MODULUS (ISO 178)	MPa	490	550 - 655	520 - 690	1000 - 1380
FLEX LIFE (ASTM D 2176) (M.I.T. 0.2 mm, 270º flex)	Cycles to failure	885.000 >90.000.000	5.000 80.000	10.000 2.000.000	5.000 80.000
IMPACT RESISTANCE 23 ºC (ASTM D 256) - 54 ºC	J/m	185 107	No break 158	No break 155	No break > 1.100
HARDNESS (ISO 868)	Shore D	D-55	D-55	D-56	D-67
COEFFICIENT OF FRICTION (dynamic, ASTM D 1894)		0,1	0,3	0,2	0,4

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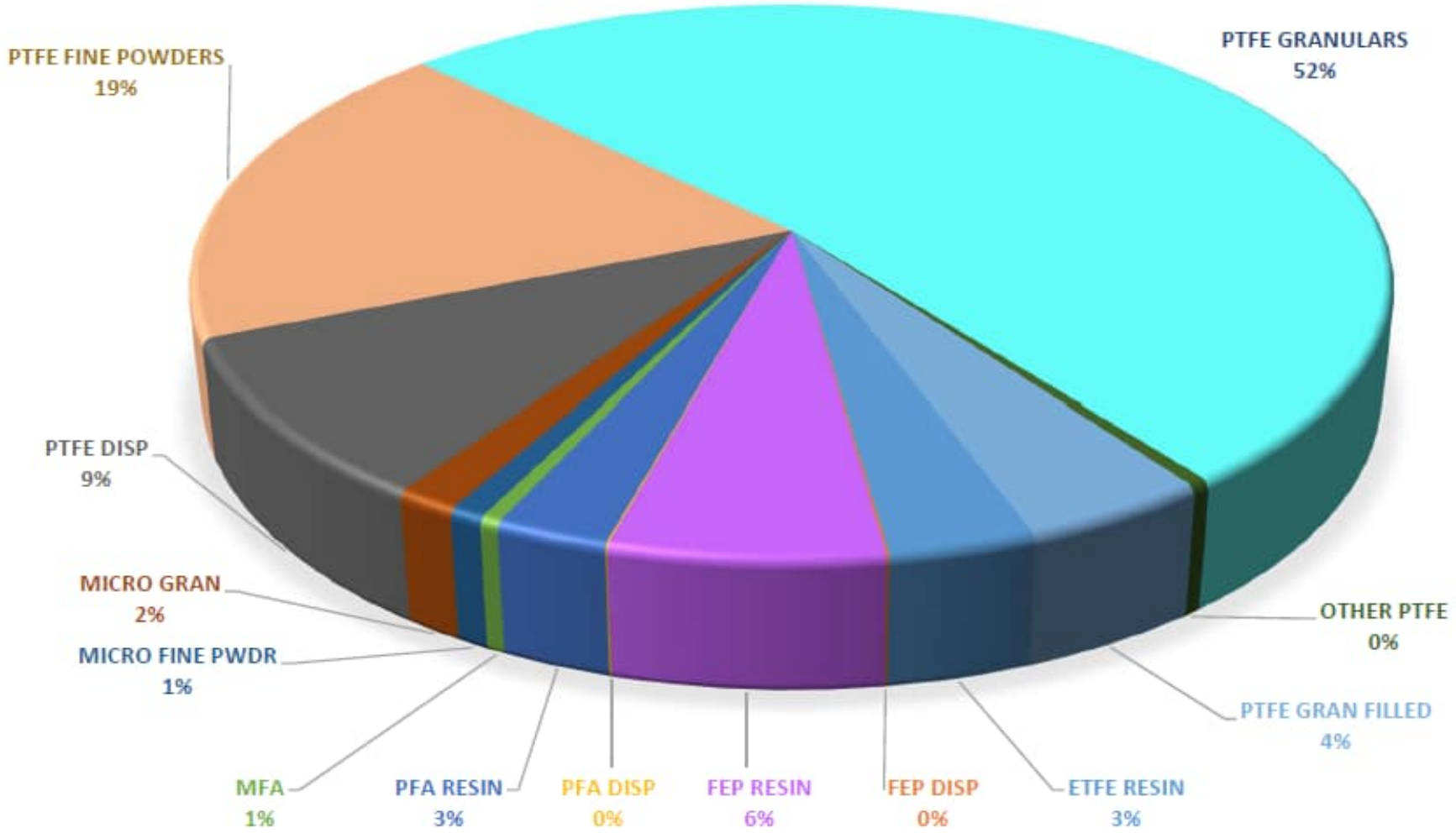
Fluoropolymers European Landscape “in-kind”



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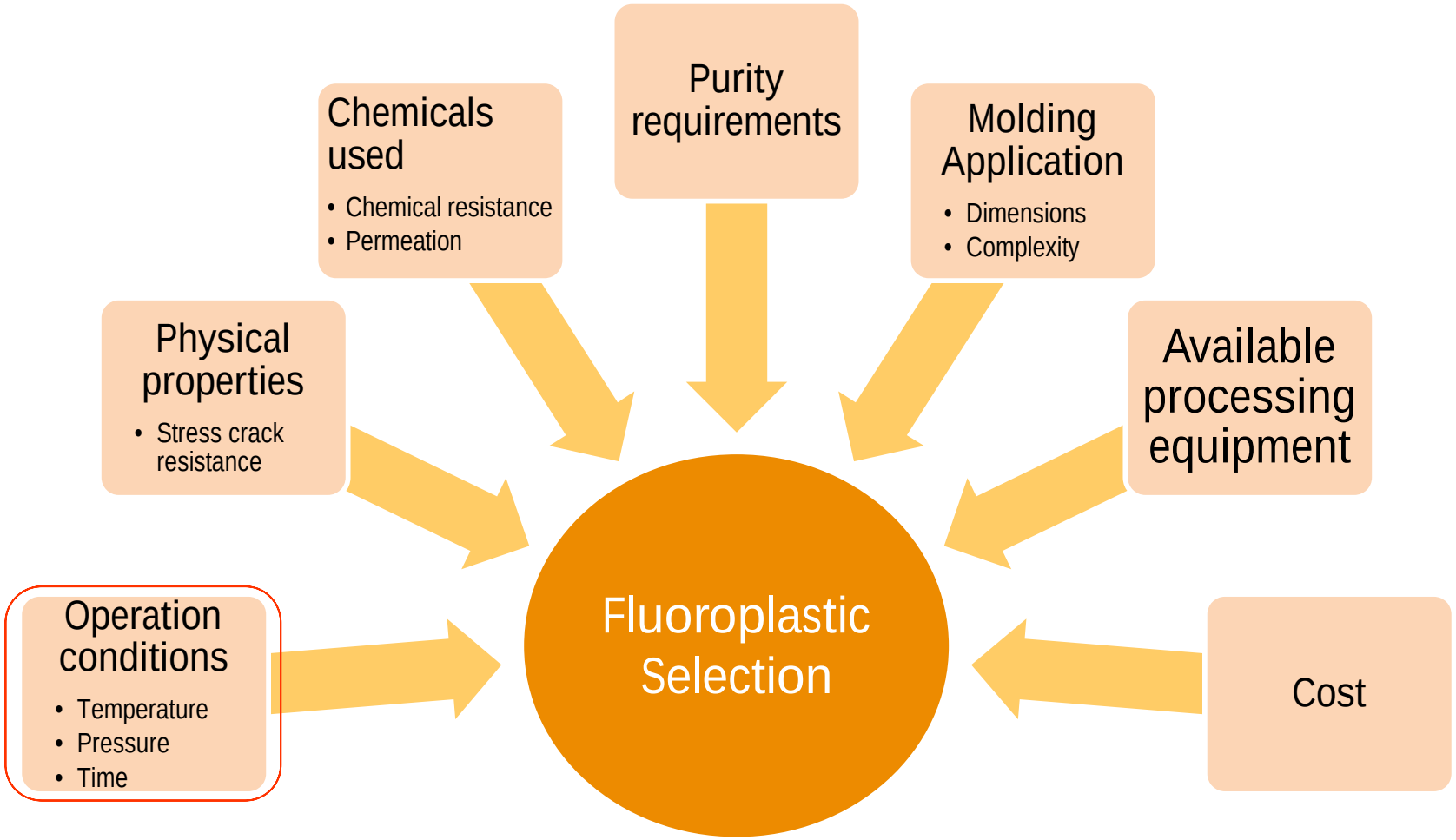
Selecting a Fluoroplastic

There are several variables to consider when selecting a fluoroplastic



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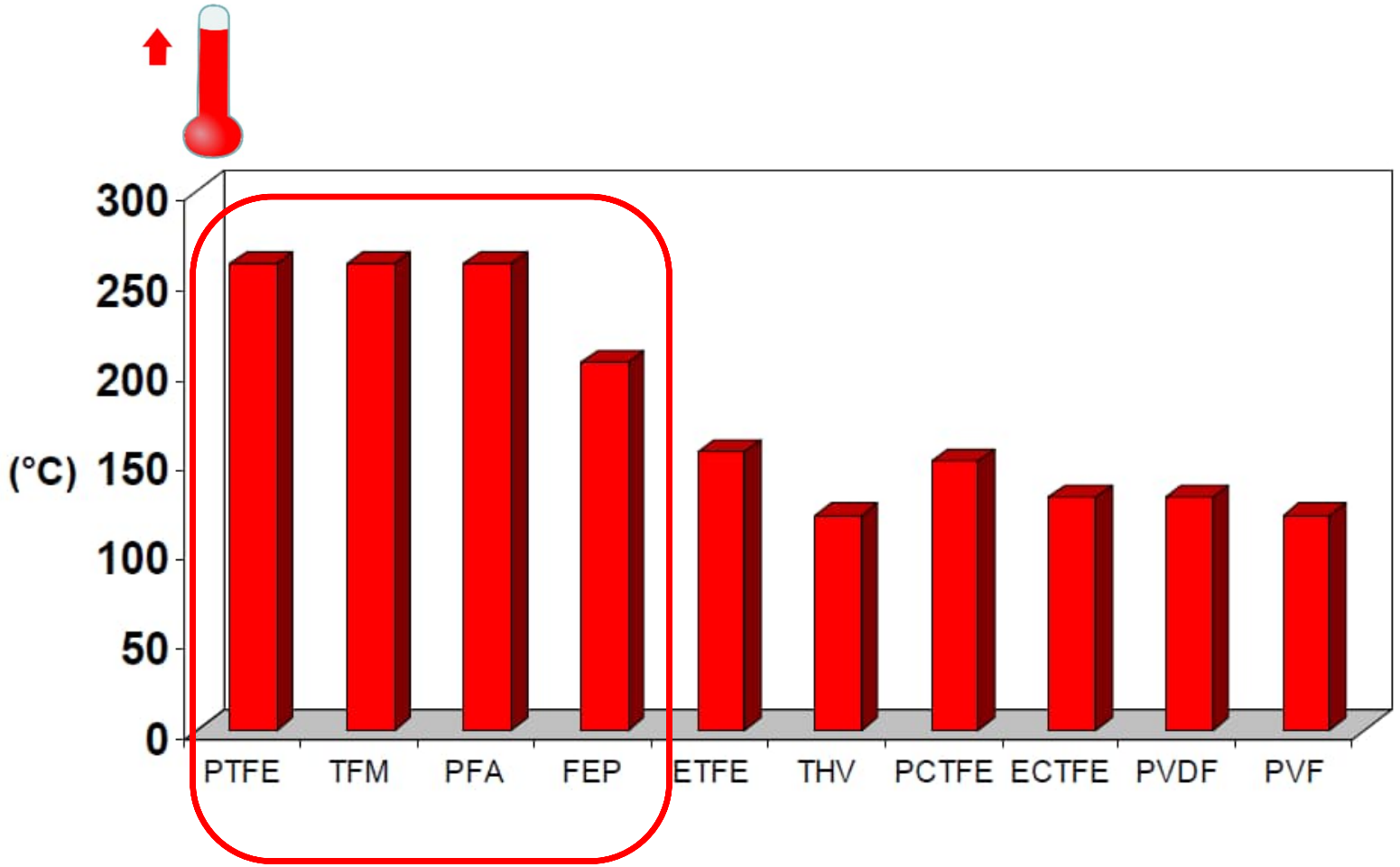
Continiuous Service Temperatures of fully and partially fluorinated resins



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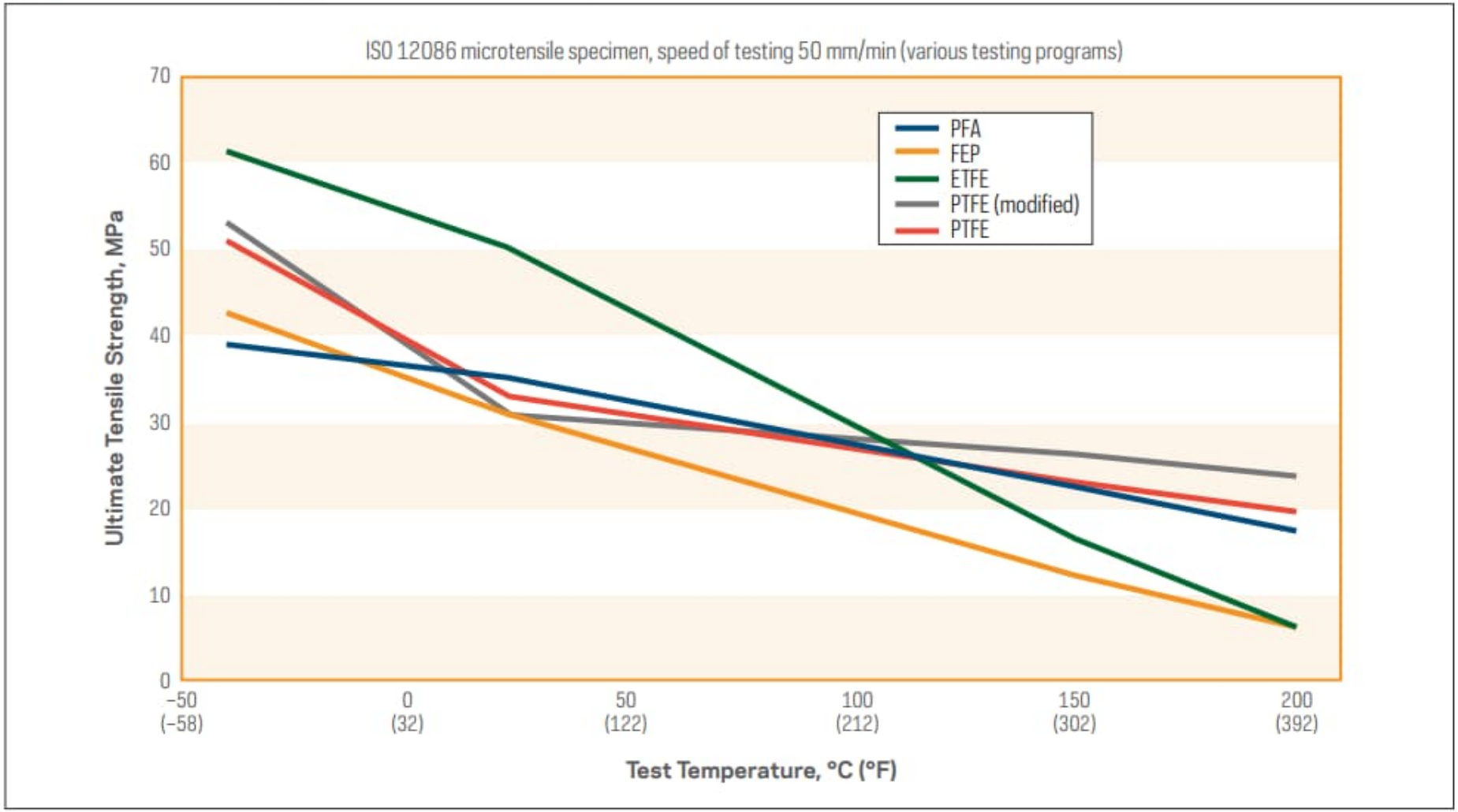
Selecting a Fluoroplastic

There are several variables to consider when selecting a fluoroplastic

Figure 1. Tensile Strength as a Function of Temperature



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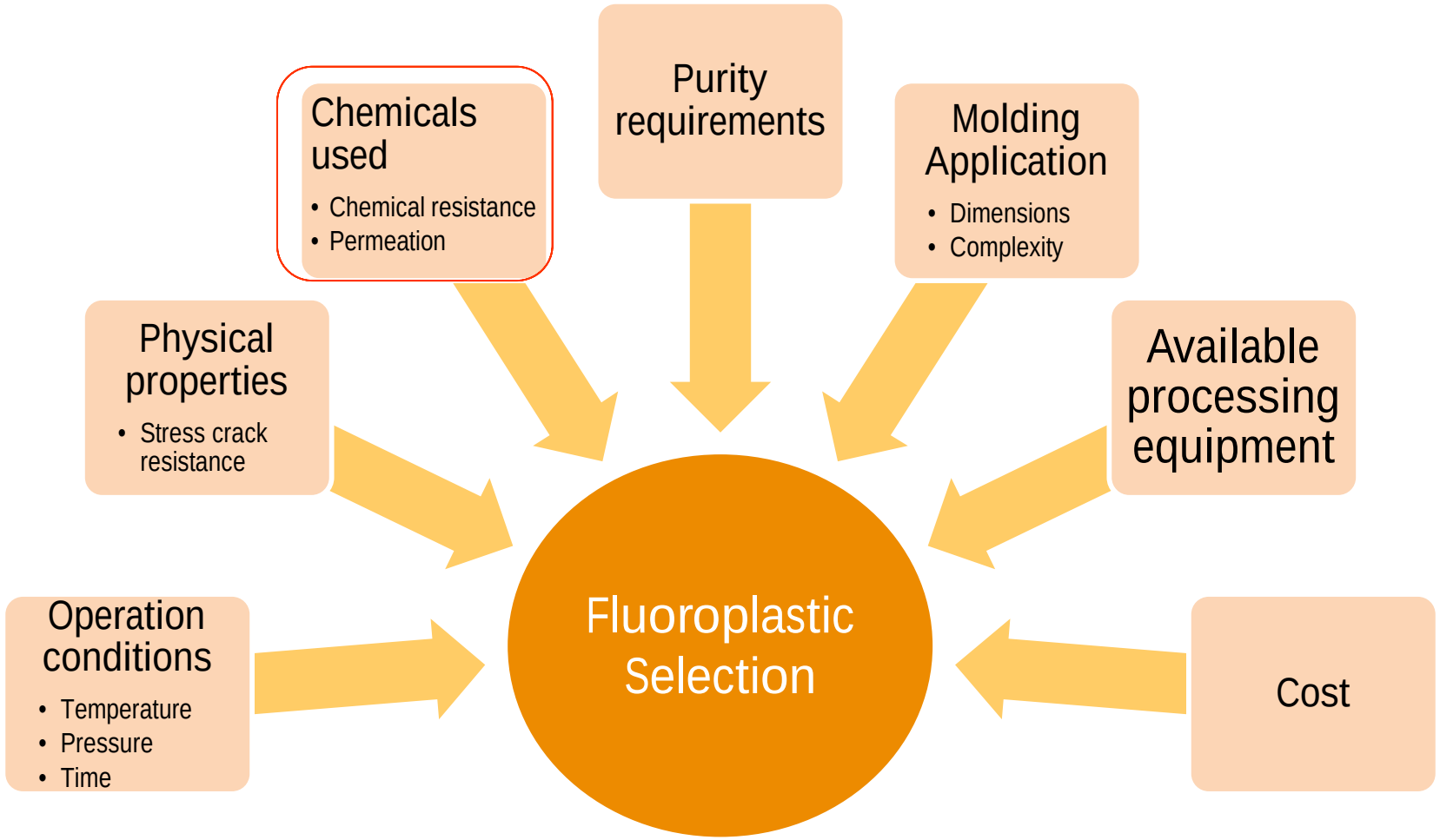
Selecting a Fluoroplastic

There are several variables to consider when selecting a fluoroplastic



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Chemical Resistance

Teflon FEP fluoropolymer resins are essentially chemically inert. Up to the highest use temperature of 200°C (392°F), very few chemicals are known to react chemically with these resins. Those that do include molten alkali metals, fluorine, and a few fluorochemicals such as chlorine trifluoride, ClF_3, or oxygen difluoride, OF_2, which readily liberate free fluorine at elevated temperatures.

Similar statements for PTFE & PFA up to 260 °C and ETFE up to 150 °C
UNSTRAINED

NOTE : chemical resistance does not relate to permeation resistance !

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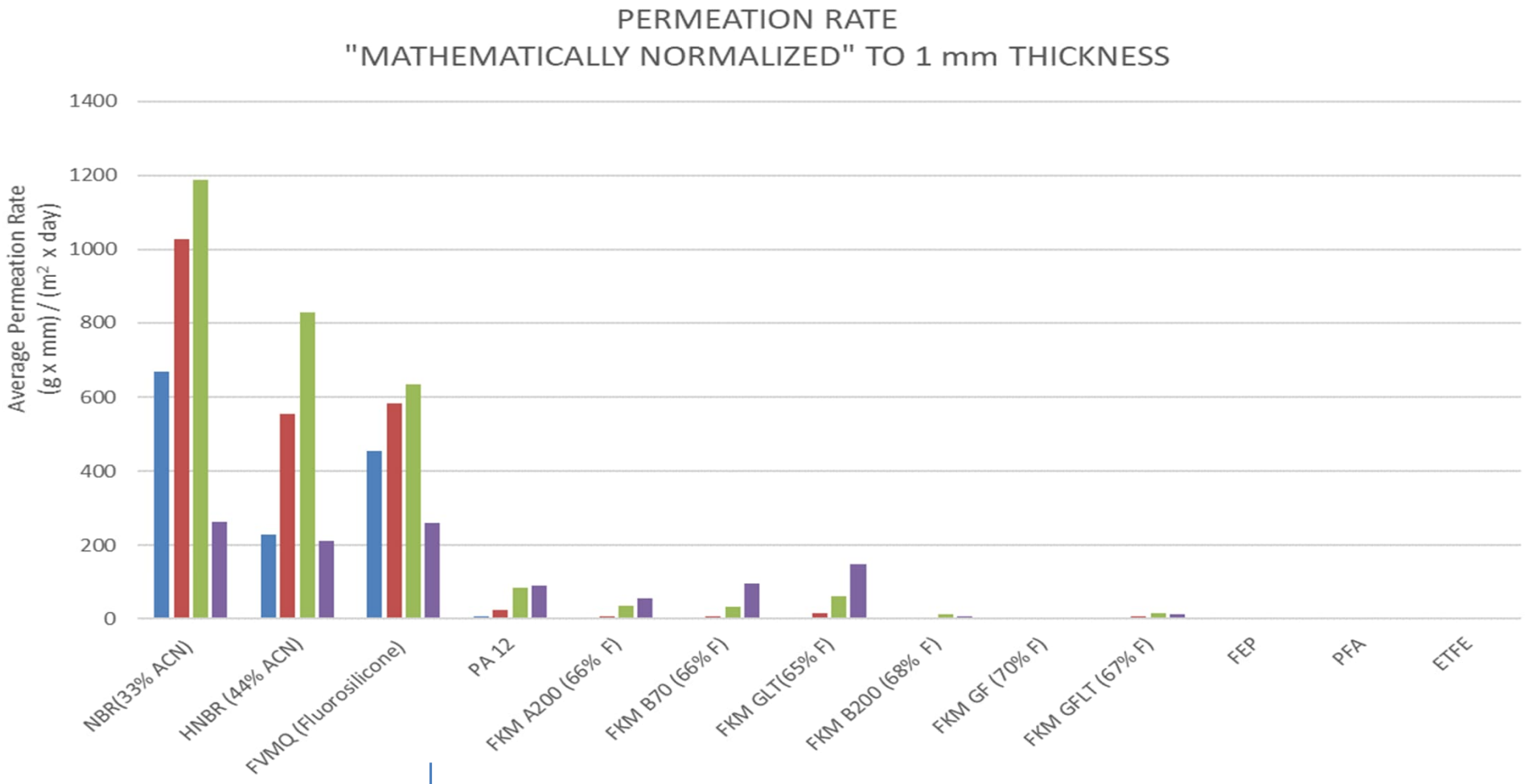
Permeation

Fuel C mixture permeations rates through various polymers and elastomers

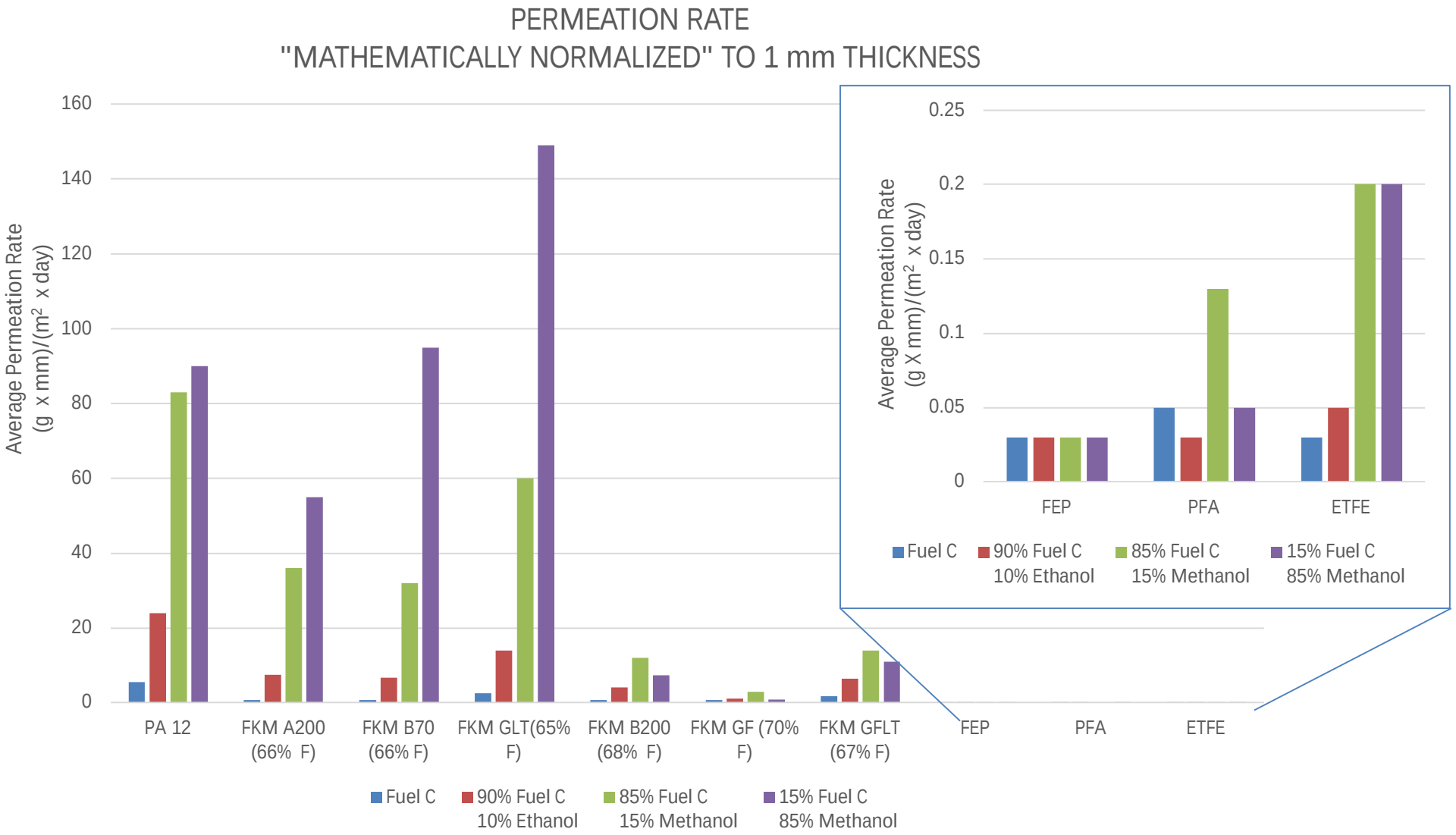


23 ºC - 21 days ←

→ 23 ºC - 28 days

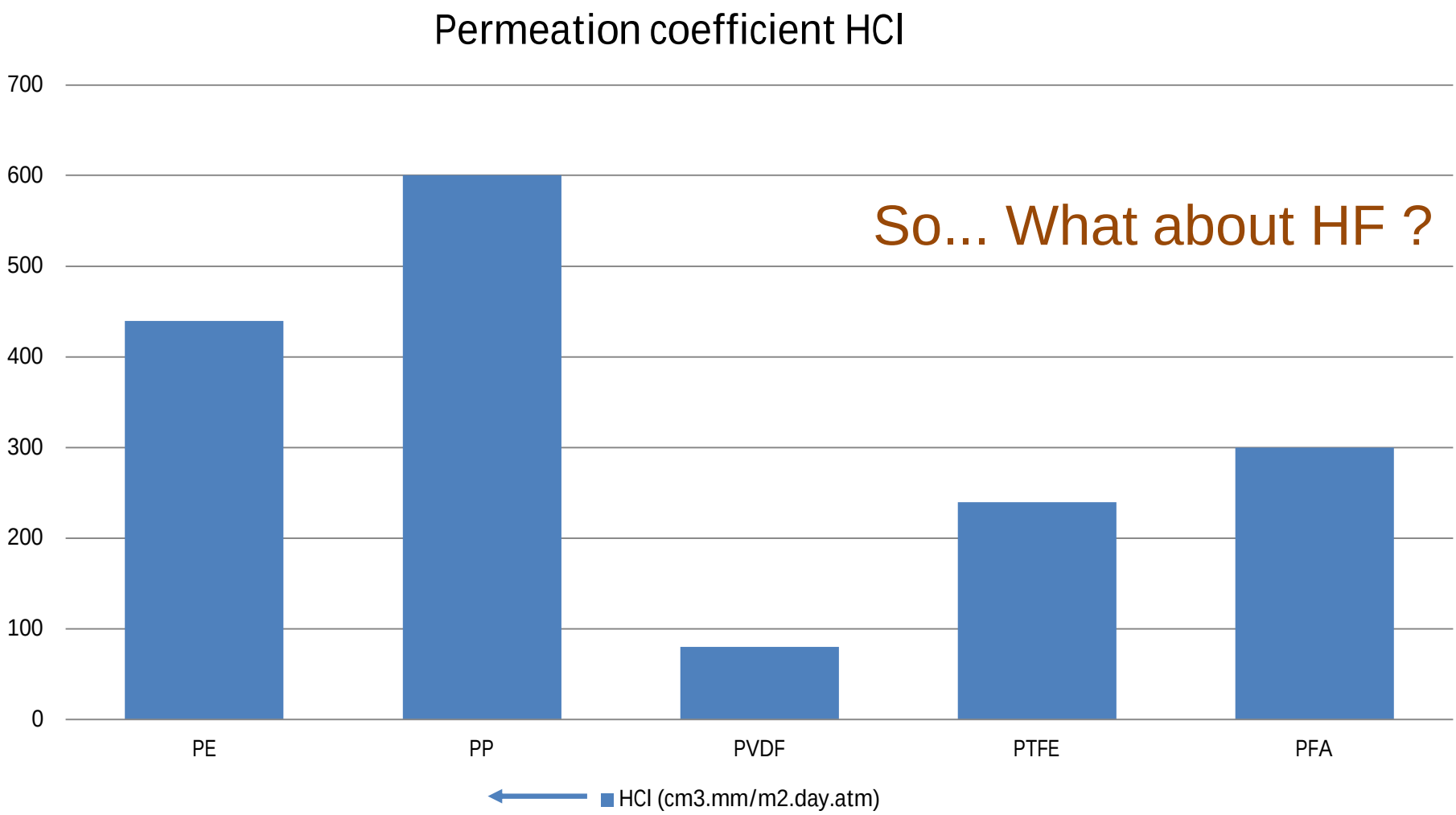
«MATHEMATICALLY NORMALIZED» : initial measurements on various thicknesses

Fuel C mixture permeations rates through various polymers and elastomers



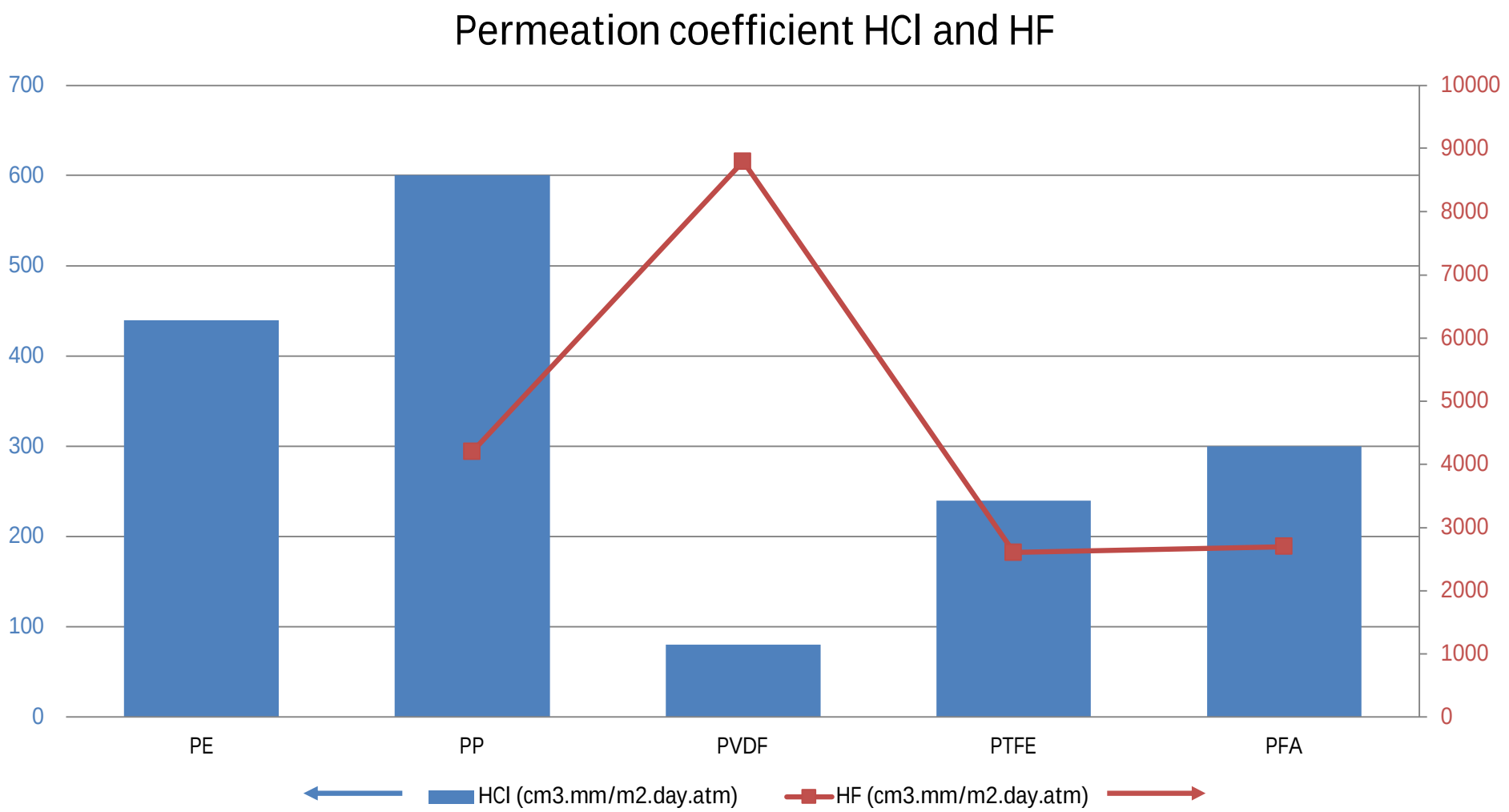
23 ºC - 28 days

Permeation coefficient HCl through different polymers (literature study)



Source
CT Associates, Inc - G Van Schooneveld et al (2011), Presented at the CMP and Ultrapure Conference Sponsored by Levitronix.

Permeation coefficient HCl and HF through different polymers (literature study)



Source :
CT Associates, Inc - G Van Schooneveld et al (2011), Presented at the CMP and Ultrapure Conference Sponsored by Levitronix.

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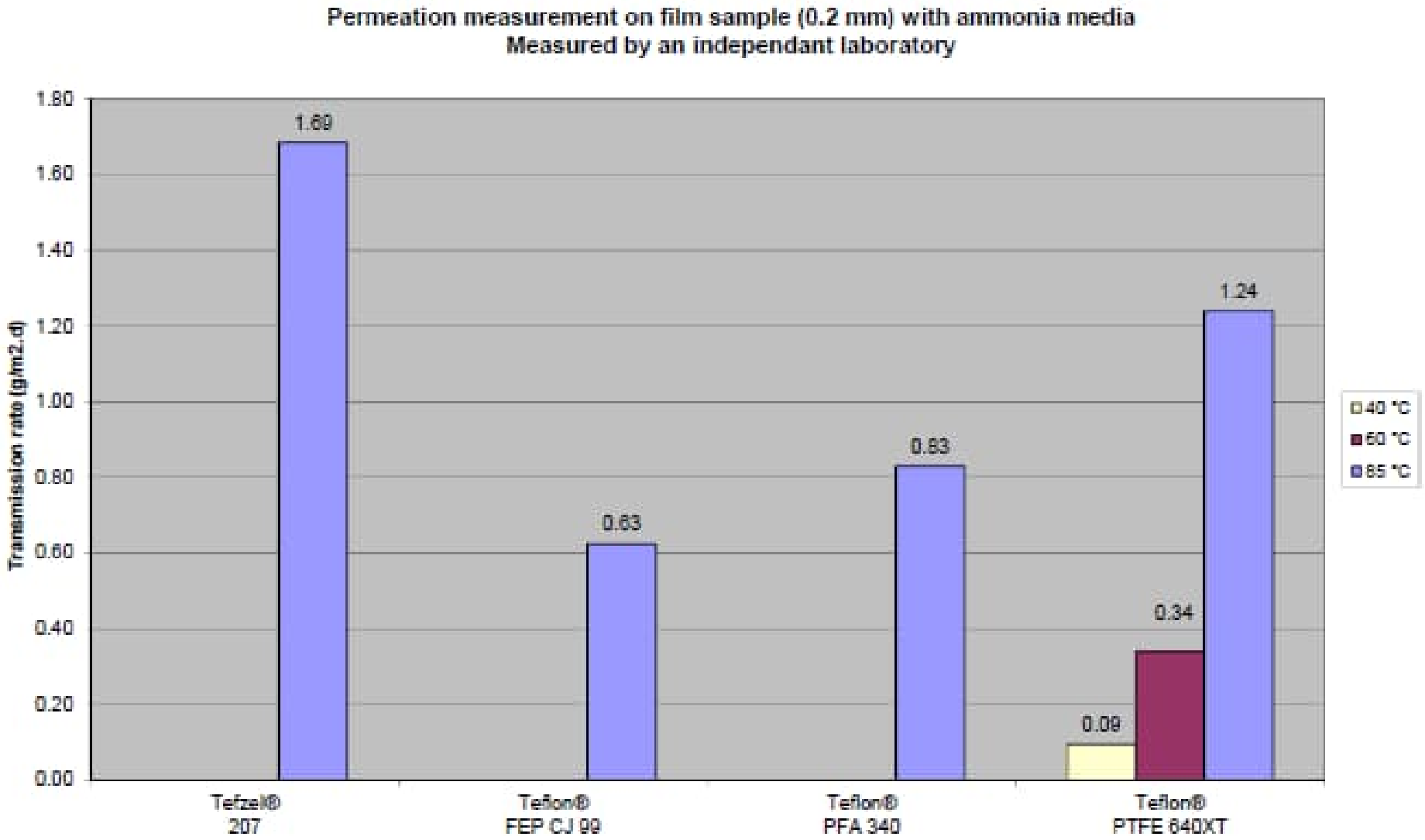
Ammonia permeations through various Fluoropolymers



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Source :
Chemours ETC - WR5143

If zero permeation is the goal, do not select a polymer

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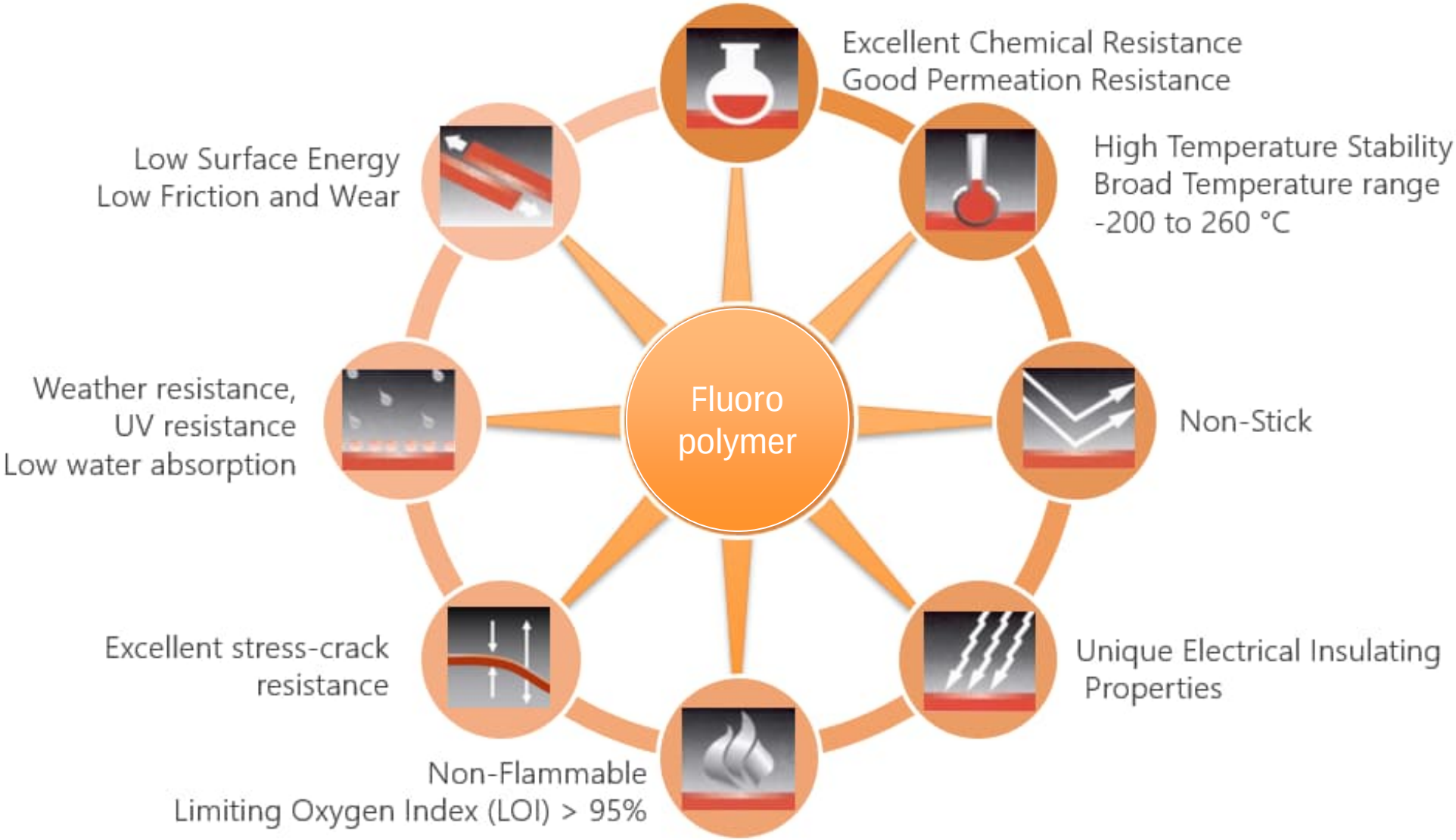
Summary : There is never a single reason to select a fluoropolymer



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