SOLVAY

Progress beyond

Moving Beyond Metal for Consumer Appliances

Benefits of Utilizing Specialty Polymers

The Solvay Team

Neel Sheth

Global Marketing Manager
Consumer
Solvay Speciality Polymers

Neel Sheth is the Global Marketing Manager for Consumer Appliances. Neel has a B.S in Biotechnology and Chemistry from the State University of New York, Buffalo and an MBA in Finance and Marketing from New York University. Neel has diverse experience in the Pharmaceutical and Fine Chemical industries and joined Solvay in 2021 to drive the growth of Solvay Specialty Polymers in the Consumer Appliance segment.

Gayatri Anand

Technical Development Engineer
Consumer
Solvay Specialty Polymers

Gayatri Anand is a Technical Development Engineer for high growth market segments such as Consumer and Healthcare in North America for Solvay Specialty Polymers based in Alpharetta, Georgia. Gayatri has a B.S. in Polymer Engineering and a M.S. in Plastics Engineering from University of Massachusetts, Lowell. She joined Solvay in 2018 and supports application development, material science and provides technical customer support.

Roger Nelson

Technical Development Engineer
Consumer
Solvay Speciality Polymers

Roger Nelson is a Technical Development Engineer for Solvay Specialty Polymers based in Alpharetta, Georgia. Roger has a B.S. in Chemical Engineering from Georgia Institute of Technology and a M.S. in Chemical Engineering from The Ohio State University. He joined Solvay in 1990 and supports applications, technical and material science development for customers in the Consumer and Construction market segments in North America.

Agenda

Dilemma of metal replacement – properties and comparative performance

Benefits of utilizing specialty polymers

Real world applications case studies

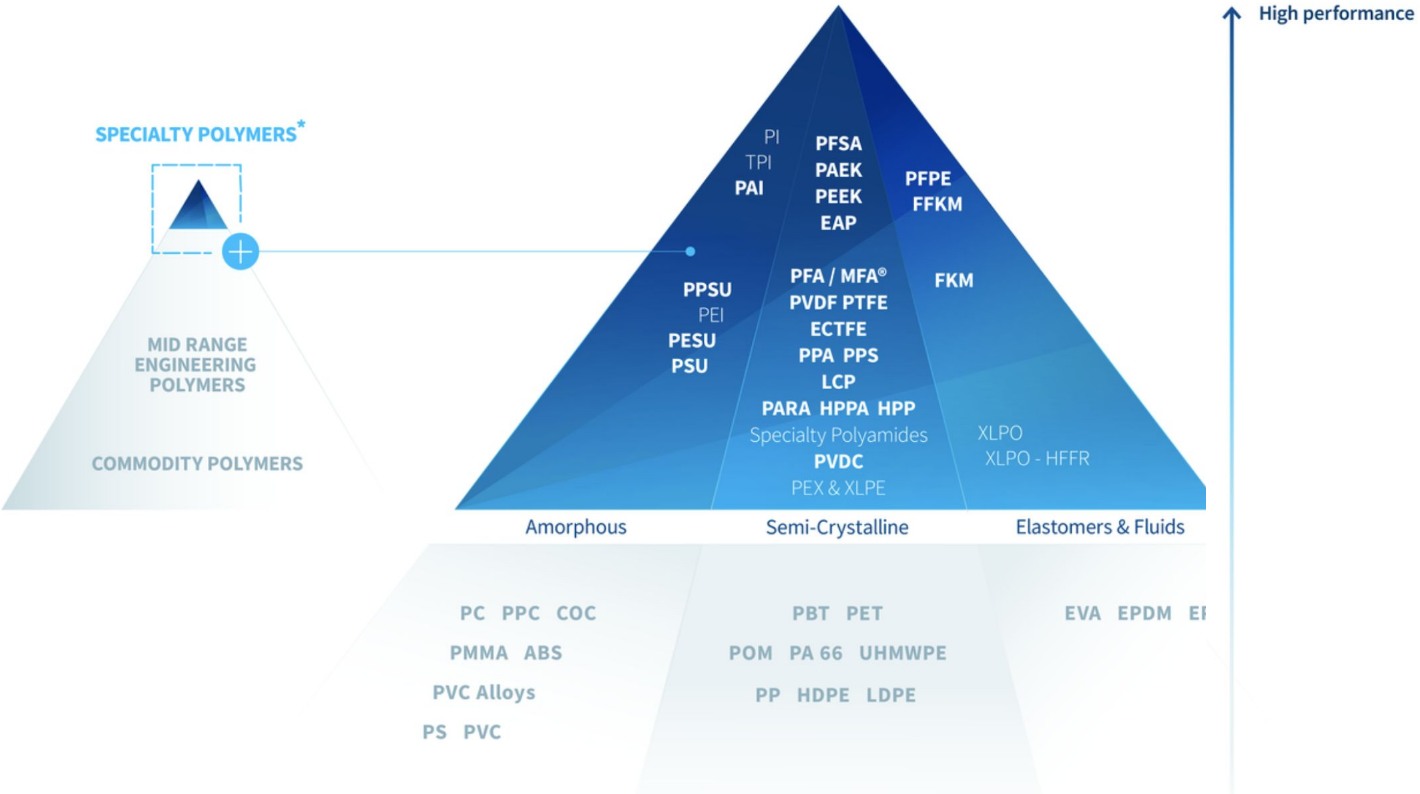
Case study 1 – Coffee machine handle
Case study 2 – Washing machine door hinge
Case study 3 - Support Brackets for Cages
Case study 4 - Vacuum cleaner
Case study 5 – Electronic instrument Chassis
Case study 6 – Air Fryer

Key factors to success

Working with Solvay

Conclusion and Q&A

Top Tier Portfolio of Specialty Polymers



*Solvay's portfolio of Specialty Polymers are indicated in bold white letters

Metals: Challenges for Consumer Appliances

Titanium
- Difficult to machine (low thermal conductivity, work hardening, vibration. deflection, comparison with Alu in aerospace industry)
- Price

Zamak
- Weak in creep resistance vs temperature (75° to 120°C)

Magnesium
- Strength, flash

Aluminum
- Health issues (powder)
- High energy consumption for extraction

Copper
- Thermal conductivity
- Oxidation

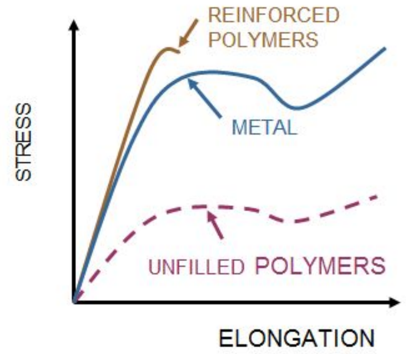
Mechanical performance

Material	Density	Strength (MPa)	E-modulus (GPa)
Steel	7.8	330	206
Aluminum	2.8	320	70
Zinc Die-casting	6.6	280	70
Magnesium	1.8	225	40
Ixef® PARA & Amodel® PPA 50% GF	1.65	280	20

+ Moisture
+ Temperature

Polymers vs Metal: Performance Overview

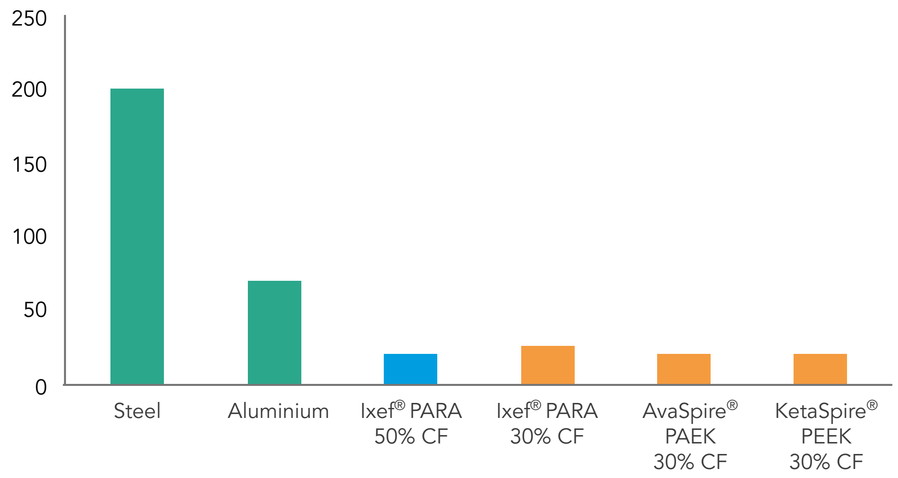
	Attributes	Metal	Polymers
Sustainability & Design	Weight (density)	–	+
	Design freedom	–	+
Properties	Isotropic properties	+	–
	Strength/stiffness	+	–
	Fatigue behavior	-	–
	Properties temperature /time dependent	+	–
	Chemical resistance (+ corrosion)	–	+
	Thermal conductivity / insulation	–	+
	Electrical conductivity / insulation	–	+
	Electromagnetic shielding	+	–
	Friction/wear	+ /–	+ /–
	Transparency	–	+
Post processing	Secondary operations (if needed)	–	+
	Dimensional stability/tolerances	+	–
Cost elements	Fluctuating market price	–	+
	Cost	+/–	+/–
Market specific elements	Food contact	+/–	+/–
	Biocompatibility	+/–	+/–

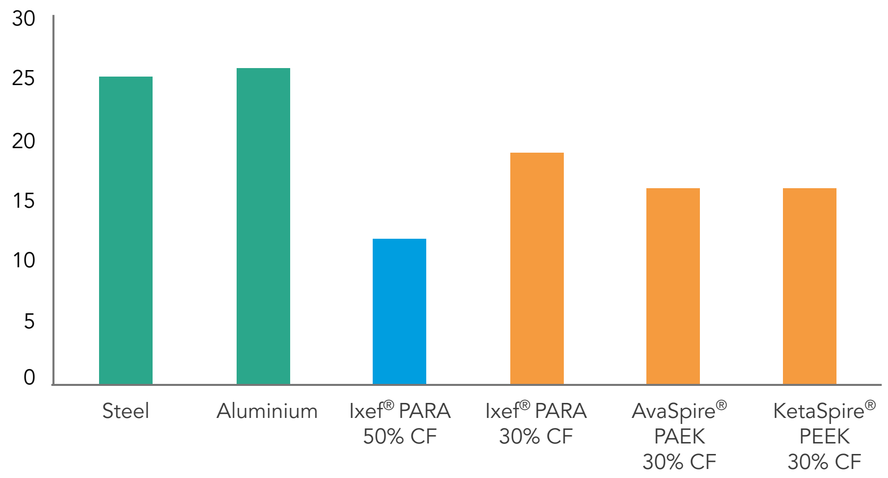


Solvay Polymers for Metal Replacement

Material	Polymer Type	Description	Specific Gravity (gm/cm^3)	Strength (Mpa)	E-modulus (Gpa)	Melting Pt. (°C)
Udel® PSU GF	Polysulfone	High Temperature Amorphous Aromatic Sulfone	1.4	97	6	N/A
AMODEL® PPA	Polyphthalamide	High Temperature Semi-crystalline Aromatic Polyamide	1.56	263	17.2	313
IXEF® PARA	Polyarylamide	High Modulus Semi-crystalline Aromatic Polyamide	1.64	280	20.0	237
OMNIX® HPPA	High Performance Polyamide	Hot Water Moldable Semi-crystalline High Performance Polyamide	1.59	245	17	260
KETASPIRE® PEEK GF	PolyEther EtherKetone	Ultra-Performance Semi-crystalline Polyketone	1.53	174	11.2	343
AVASPIRE® PAEK GF	PolyAryl EtherKetone	Ultra-Performance Semi-crystalline Modified Polyketone	1.52	162	10.4	340

Mechanical Performances

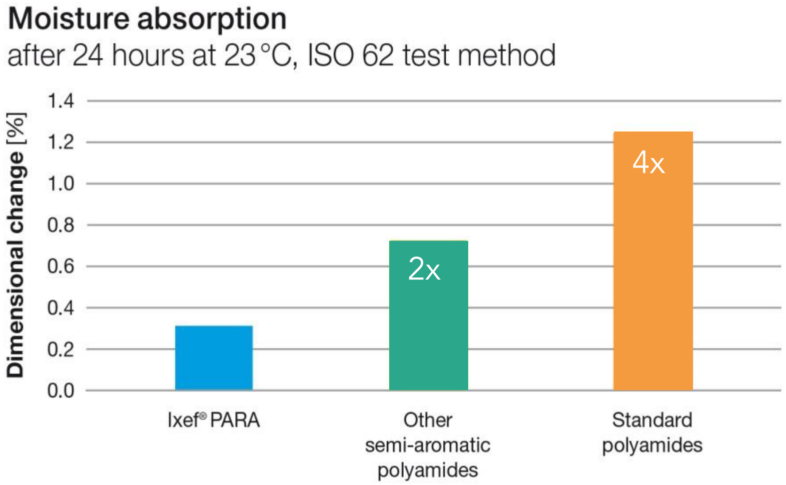


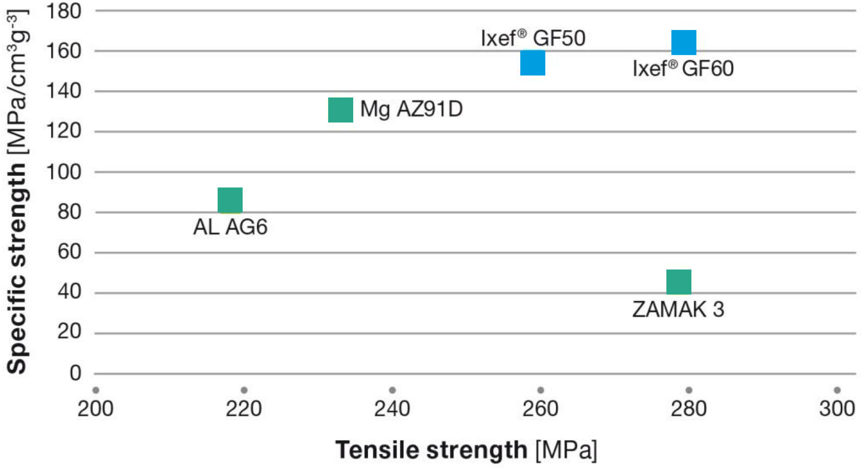


Ixef® PARA: strength and aesthetics for metal replacement

- Very low moisture absorption vs. other polyamides

- High tensile strength and modulus (exceeds PEEK)
- Low creep and low CLTE (similar to Aluminum)





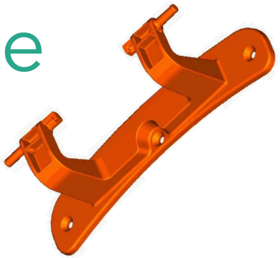
Case Study 1
Coffee Machine

Die-cast Zinc alloy replacement for coffee machine handles

Ixef® PARA
replaced
Zinc Die-cast part

- Removed all die-casting steps
- Ixef® PARA was painted to appear just as the zinc part
- Elimination of die-casting resulted in significant savings

Case Study 2
Washing machine door hinge



250,000 Parts	Ixef®	Aluminium Alloy
Material Cost ($)	*52,000*	*40,500*
Capital Investment ($)	165,000	860,000
Machinery	100,000	830,000
Tooling	65,000	30,000
Operating Cost ($)	16,500	121,500
Casting		40,500
Finishing		81,000
Total Cost ($)	233,500	1,022,500
Cost Per Part ($)	*0.94*	*4.08*

Total Savings in Ixef® PARA= $3.14/part or $787,000 Total

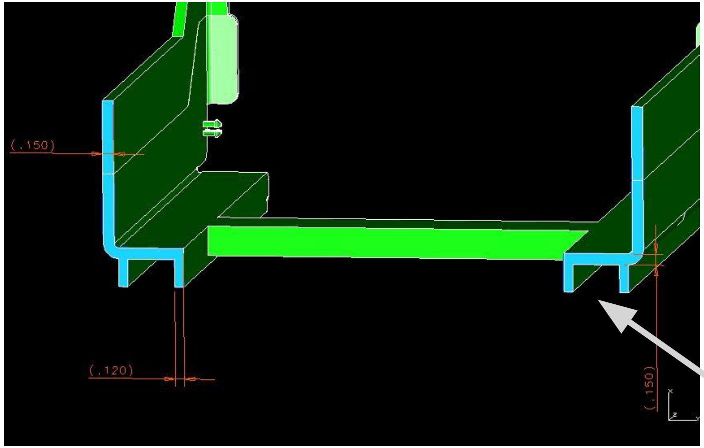
Case Study 3
Support Bracket for Cage Racks

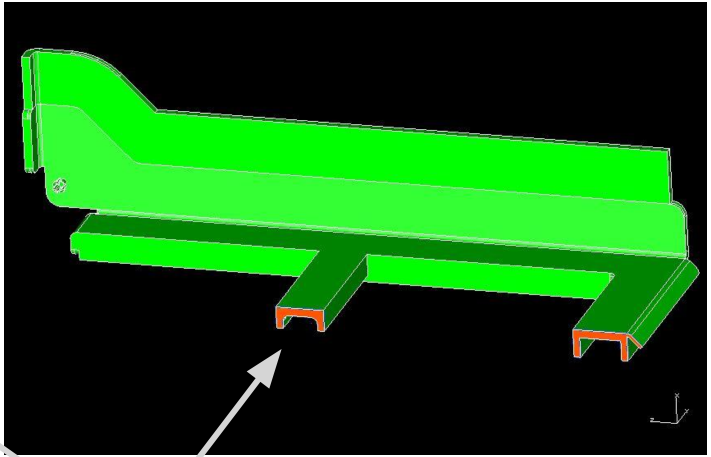
Replacing metal: the importance of redesign

Current Metal Design - Model View

Replacing metal: the results of redesign

High-performance Polymer Bracket Design
Details of Design Changes: Nominal Walls





Rigidity = Modulus (E) x Moment of Inertia (I)

For equivalency $(E \times I)_{Plastic} = (E \times I)_{Metal}$

$I_{Plastic} = (E_{Metal}/E_{Plastic}) \times I_{Metal} = 10 \times I_{Metal}$

"U" channel configuration

Results of changing design to Polymers

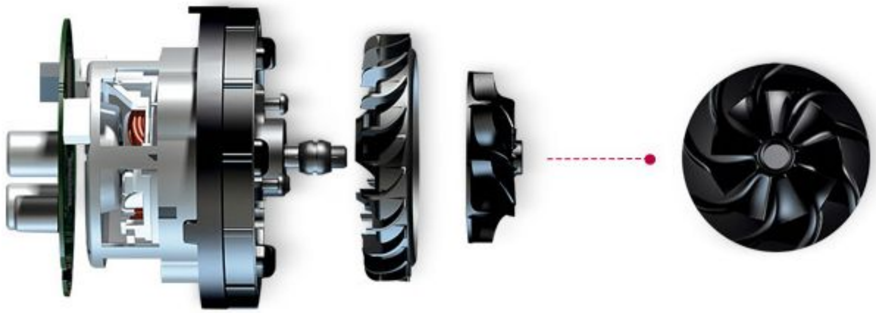
Comparison of Stainless Steel Bracket Design to High-performance Polymer Bracket Design

Part	Predicted deflection under 10 lb. load (in.)	Part Volume (in^3)	Material Density (lbs/in^3)	Part Weight (lbs. & grams)
SS Design	0.005	3.513	0.285	1.00 (454)
High-performance Polymer Design (Amodel® PPA)	0.008	16.205	0.050	0.81 (368)

Case Study 4
Vacuum cleaner

Ketaspire® PEEK/Avaspire® PAEK replaced Metal impeller

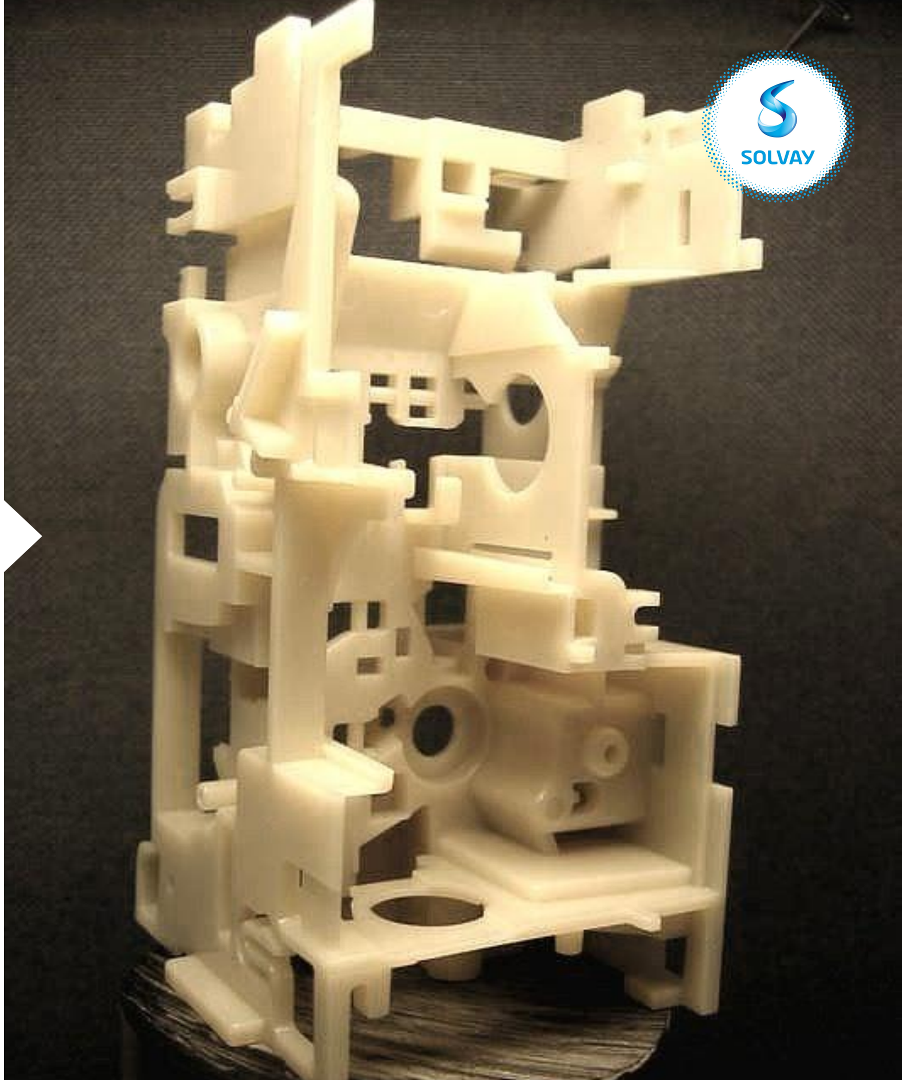
- Heat dissipation management
- Weight reduction
- Increased battery range and suction power



Case Study 5
Electric Instrument Chassis

Benefits of Udel® GF PSU

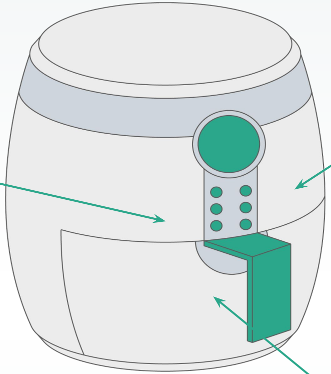
- Eliminate machining
- No corrosion
- 50 % weight reduction
- Low noise and vibration
- Easier manufacturing



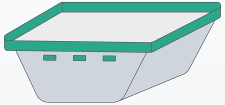
Case study 6
Air Fryer functional integration

Oil collector

Ominx® HPPA
- High stiffness
- high heat resistance
- oil resistance
- high rigidity
- low moisture pick up
- ease of processing



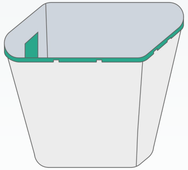
Fryer basket

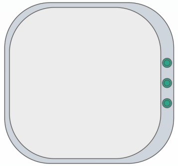


Amodel® PPA
- Temperature resistance up to 220°C
- oil, hot water, steam resistance
- dishwasher resistance
- passes drop tests
- food approvals
- cost down effect from metal

Body and Structure Ring

Ryton® PPS
- temperature resistance up to 220°C
- chemical resistance to hot oil, water and steam
- cost efficient injection molding
- functional integration
- easy to assemble
- high stiffness





Key Factors to Success

- Apply team approach
- Use flow analysis and stress analysis
  to validate functionality and moldability
- MUST evaluate optimal polymeric design
- Select the right polymer for the job

Well-Designed Part Made from the Correct Polymer
Can Outperform a Metal Part

Broad solutions portfolio

SOLVAY

	Amodel® PPA	Ixef® PARA	Omnix® HPPA	Kalix® HPPA	Ryton® PPS	Xydar® LCP	Xencor™ PARA, HPPA PPA, PPS	Udel® PSU	Veradel® PESU	Radel® PPSU	KetaSpire® AvaSpire PEEK, PEAK	Solef® PVDF
Chemistry	✓	✓	✓	✓	✓	✓	✓				✓	
Stiffness				✓			✓			✓	✓	
Creep	✓				✓	✓	✓				✓	
Inherently V-0					✓	✓	✓		✓	✓	✓	✓
Aesthetics		✓					✓	✓	✓	✓		
High colorability	✓	✓	✓	✓			✓	✓	✓	✓		
Transparency								✓	✓	✓		
Water & Steam	✓				✓	✓	✓	✓	✓	✓	✓	✓
Temperature	✓				✓	✓	✓		✓	✓	✓	
F&W							✓				✓	✓
Food Contact	✓	✓	✓		✓			✓	✓	✓	✓	✓
Injection molding	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Extrusion		✓			✓			✓	✓	✓	✓	✓

Customer Excellence through Application Engineering

We are your partner in the commercial journey providing added value with specialty polymers

Our expertise

- Wide and differentiated portfolio of specialty polymers
- Consumer market expertise
- Clearly laid out life cycle view

Solution proposal	Prototyping	Mold Design, Definition and Testing	Part processing Support	Field follow up and Support
Material solutions that enhance the overall value for the customer	Virtual: expertise in Software based quick overview of application performance Physical testing	Mold and part design review Implementation of specific customer testing procedures	On-site support during processing (molding, extrusion) trials Direct support to molders and processors	QC review and failure analysis (fractography, IR, etc)

A balanced presence to better serve our customers

2020 figures

SOLVAY

NORTH AMERICA

- 28% of net sales
- 39 industrial sites
- 24% of Group employees
- 7 major R&I centers

EUROPE

- 29% of net sales
- 40 industrial sites
- 48% of Group employees
- 8 major R&I centers

LATIN AMERICA

- 11% of net sales
- 7 industrial sites
- 10% of Group employees
- 1 major R&I center

ASIA PACIFIC
& Rest of the world*

- 32% of net sales
- 24 industrial sites
- 18% of Group employees
- 4 major R&I centers

*includes Middle-East and Africa

Solvay Today

We are a science company whose technologies bring benefits to many aspects of daily life.

Our innovative solutions contribute to safer, cleaner, and more sustainable products found in homes, food and consumer goods, planes, cars, batteries, smart devices, health care applications, water and air purification systems.

Our Group seeks to create sustainable shared value for all, notably through its Solvay One Planet plan crafted around three pillars: protecting the climate, preserving resources and fostering better life.

- **€8.9bn** Net sales
- **€1.9bn** Underlying EBITDA
- **52%** Net sales from sustainable solutions
- **+23,000** Employees
- **64** Countries
- **110** Industrial sites

*2020 figures

Questions?

Progress beyond

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