

Latest innovations in Additive Manufacturing: **RadiciGroup High Performance Polymers presents Radilon® Adline**

Chiara Devasini - *Marketing & Development Project Leader*

Ambra Suardi - *R&D Project Leader Scouting and Consumer goods Market*



Webinar : Latest innovations in additive manufacturing and water management

Agenda

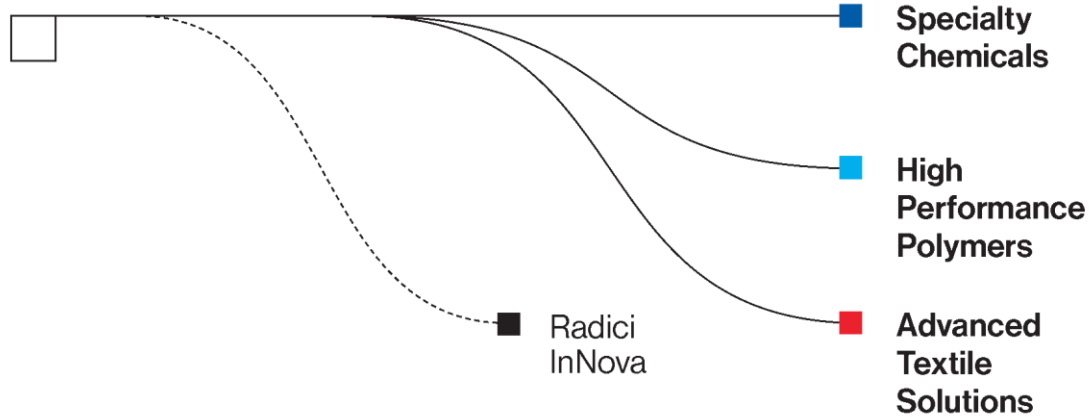


- › **RadiciGroup High Performance Polymers at a glance**
- › **Additive Manufacturing Technology**
- › Radilon® Adline new product range for Additive Manufacturing
- › Radilon® Adline future developments

RadiciGroup High Performance Polymers at a glance



RadiciGroup



RadiciGroup is one of the world's leading producers of a wide range of chemical intermediates, polyamide polymers, high performance polymers and advanced textile solutions.



RadiciGroup High Performance Polymers facts



UPSTREAM INTEGRATION

of PA6 Radilon® S, PA6.6 Radilon® A, PA6.10 Radilon® D, PA6.12 Radilon® DT and copolymers



EXPERTISE

in high performance polymers formulation and compounding, meeting the needs of the most diverse applications

RadiciGroup High Performance Polymers Innovation



Radilon® Adline printed with Ultimaker S5



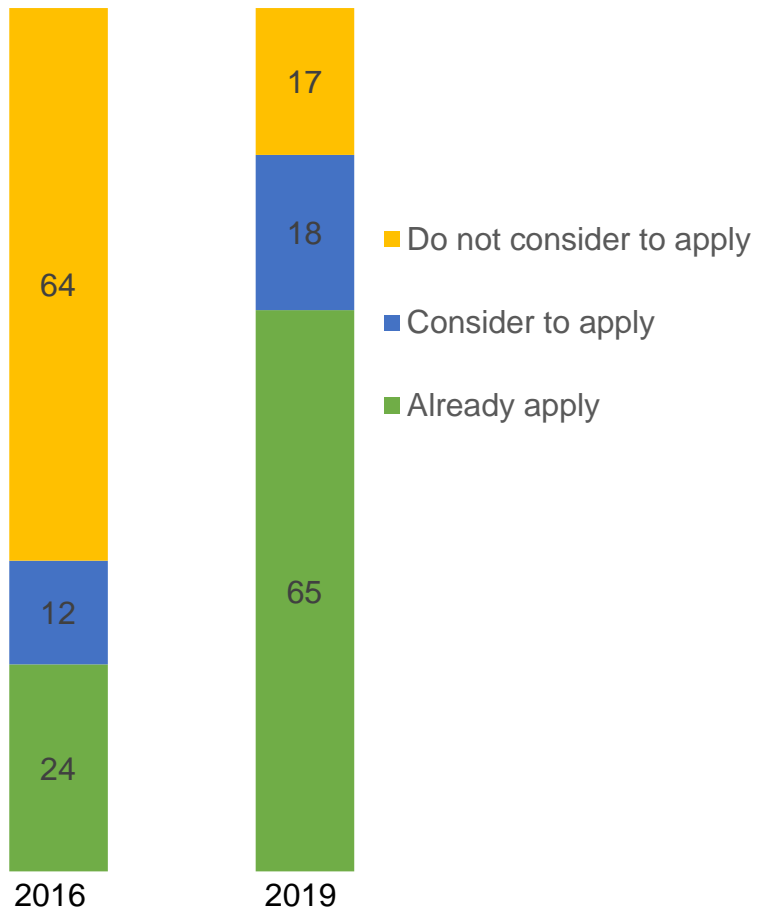
GROWTH THROUGH INNOVATION

RadiciGroup High Performance Polymers target is to develop highly innovative material solutions with additional attention to reducing their environmental impact.

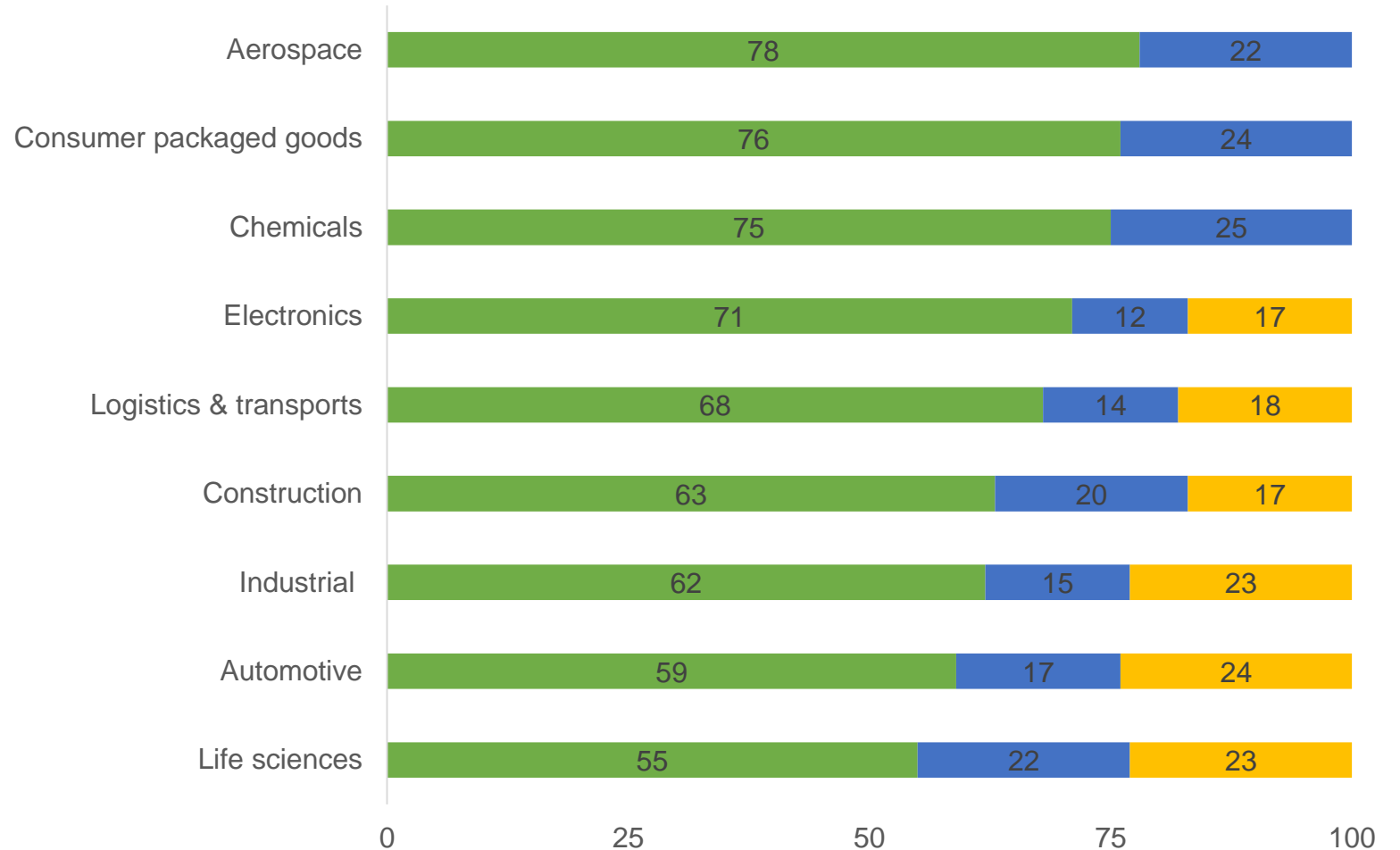
The new product range Radilon® Adline meets the needs of Additive Manufacturing technology, offering advanced and sustainable material solutions.

Additive Manufacturing Technology trends

Awareness about AM technologies, 2016 and 2019 (%)*

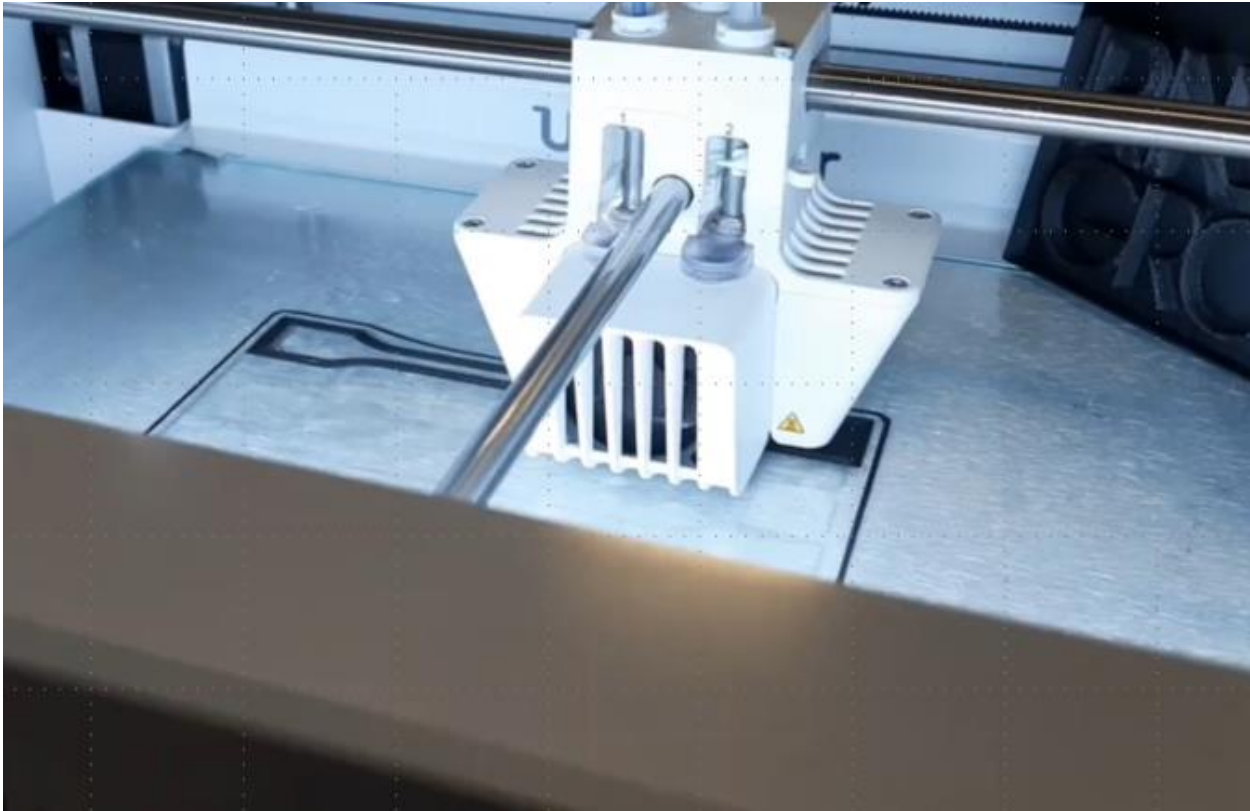


Experience of AM technology per industry 2019 (%)*



* EY Global 3D printing survey April 2019; n =900 companies

Additive Manufacturing Technology benefits



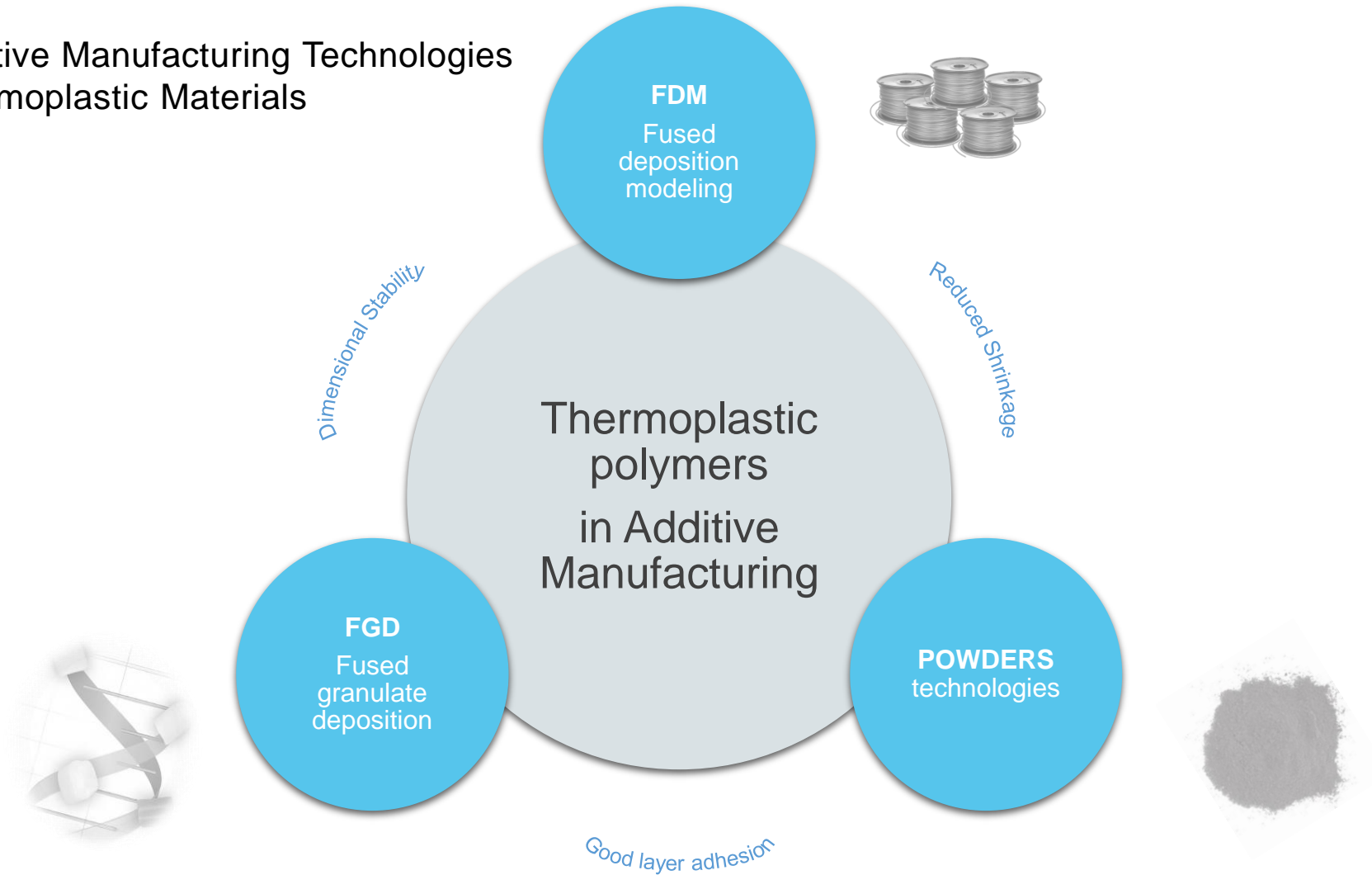
Radilon® Adline printed with Ultimaker S5

- › No fixed cost for tooling
- › Design flexibility
- › Customization & personalization
- › Prototyping - production
- › Faster time to market
- › Reduce logistic efforts

Additive Manufacturing Technologies



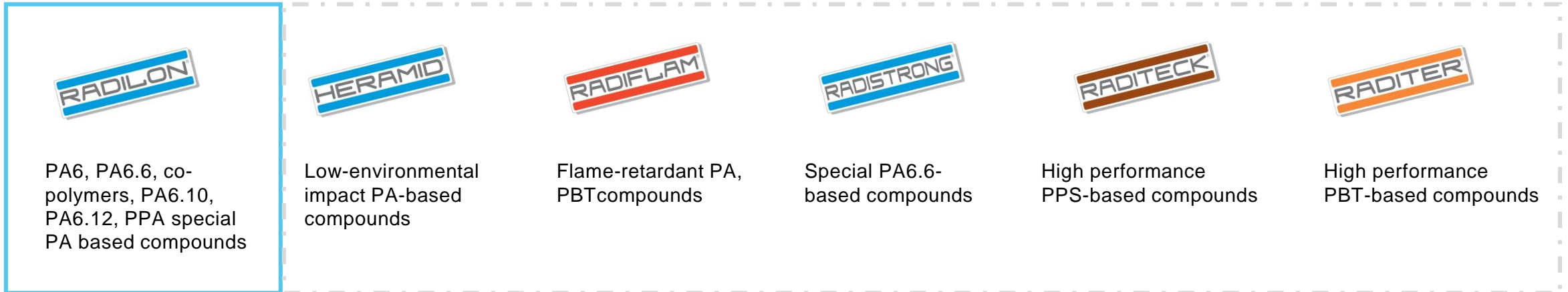
Additive Manufacturing Technologies
Thermoplastic Materials



Additive Manufacturing Technology & Materials



RadiciGroup High Performance Polymers Main Brands for injection molding and extrusion



RadiciGroup High Performance Polymers Brand for Additive Manufacturing FDM and granulate

*Radilon® Adline will be supplied in form of pellets or filaments**



Radilon® Adline CS GF10 HP BK

Polymer type

- A= PA6.6
- S= PA6
- D=PA 6.10
- CS=PA6/66

Reinforcement

- GF= glass
- CF=carbon

Special features

Colour code

- BK= black
- NAT=natural
- ...

Radilon® Adline grades

Additive Manufacturing product range | FDM and fused granulate deposition

Radilon® Adline CS



Easy printable

Radilon® Adline CS CF



Easy printable



Stiffness

Radilon® Adline MS



Special property combination

Radilon® Adline MS CF



Special property combination



Stiffness

Radilon® Adline D



Bio-based

Radilon® Adline A GF RE



Recycled

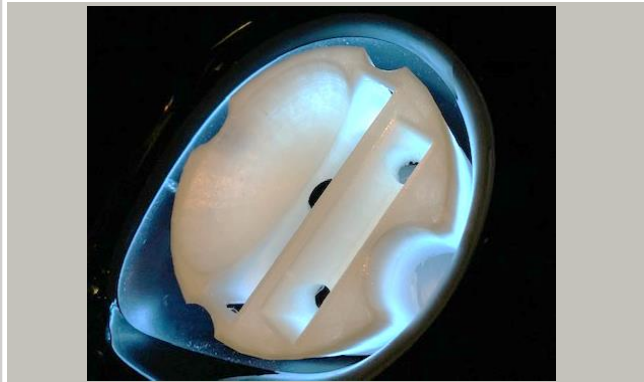


Stiffness

Radilon® Adline applications

Additive Manufacturing product range | FDM and fused granulate deposition

Test models for rapid proof of concepts and production; parts requiring high stiffness



Auto glove box in Radilon® Adline CS



Parts requiring peculiar mechanical and aesthetic features, high stiffness.



Pump in Radilon® Adline MS CF



For products manufactured using sustainable materials and recycled materials from circular economy.



Design jar in Radilon® Adline A GF RE printed from granules by eXgineering



Others

Radilon® Adline RE - recycled grade

Additive Manufacturing product range | fused granulate deposition

RadiciGroup, in order to be in front line with sustainability, environmental awareness and circularity, joined the EU Project named Car-E Service.

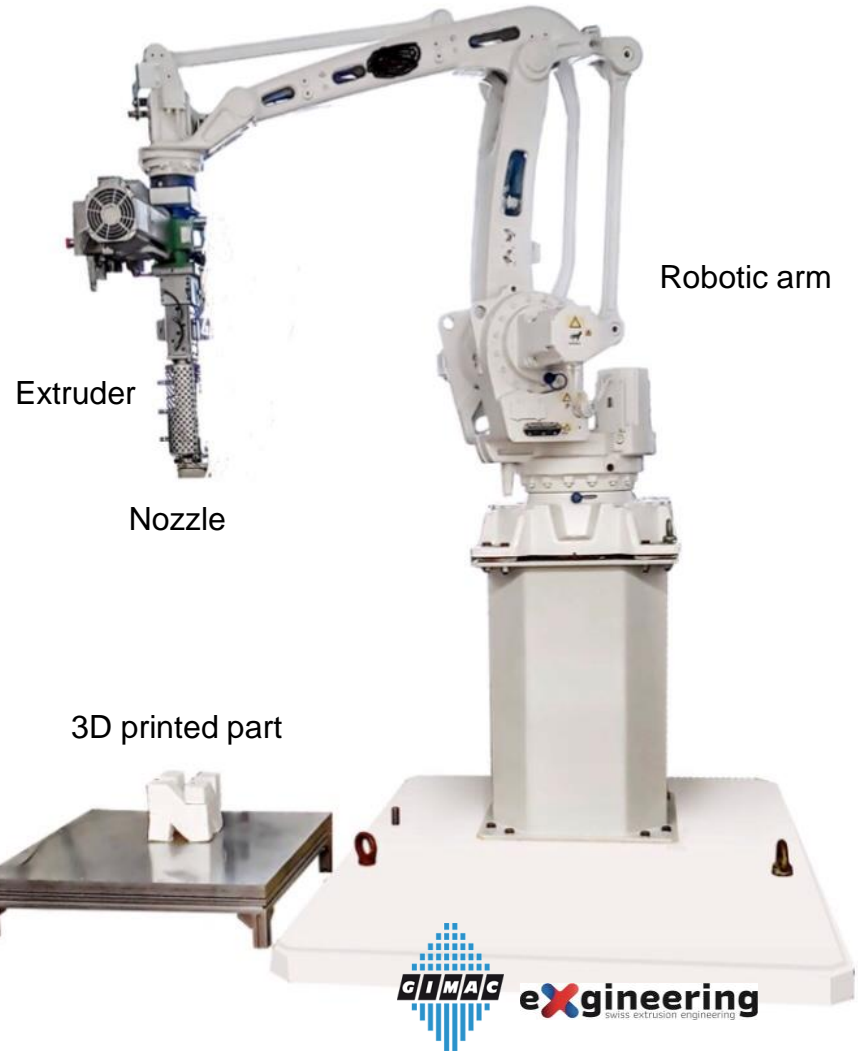
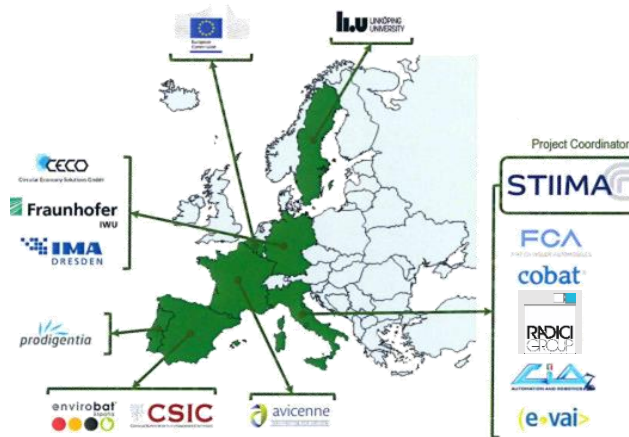
Title: Circular Economy Business Models for innovative hybrid and electric mobility through advanced re-use and re-manufacturing technologies and services.

Acronym: Car-E Service

Duration: 36 Months; **Kick Off:** 1 June 2018

Program: H2020-CIRC-2017

15 Partners



<https://www.careserviceproject.eu/>

Agenda

- › RadiciGroup High Performance Polymers at a glance
- › Additive Manufacturing Technology
- › **Radilon® Adline new product range for Additive Manufacturing**
- › **Radilon® Adline future developments**

RADILON® ADLINE CS for FDM

KEY PROPERTIES

› Easy process ability



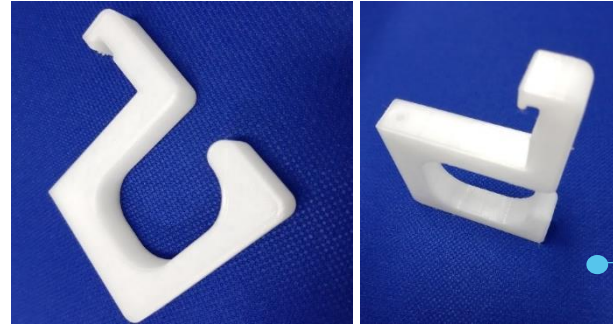
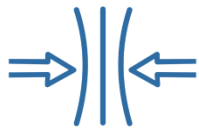
› High dimensional stability



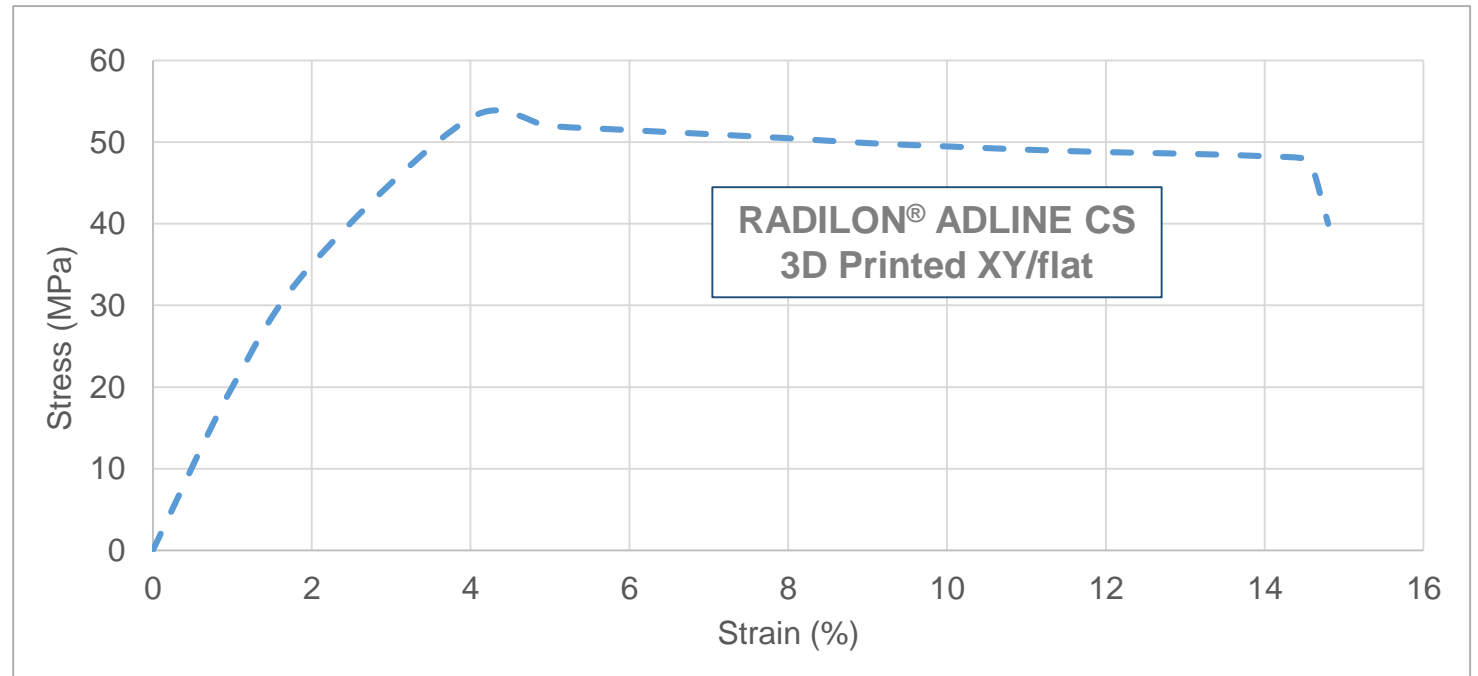
› Trasparent material

› Good surface aspect

› Ductility



*Baggage hook in
RADILON® ADLINE CS*



Tensile curve of FDM printed RADILON® ADLINE CS

RADILON® ADLINE and COVID-19 Emergency: a Case History



Protective face shields in **RADILON® ADLINE CS**



RADILON® ADLINE MS for FDM

KEY PROPERTIES

› Compression resistance



› Right compromise between stiffness and toughness

› Low water absorption



› Good surface aspect and color stability

› Heat and chemical resistance



*Pump in **RADILON® ADLINE MS**
printed with the collaboration of
Perlon and Ultimaker*

PERLON
The Filament Company

Ultimaker



*Industrial gear and cup holder in
RADILON® ADLINE MS*



RADILON® ADLINE

Carbon fiber reinforced grades for FDM

KEY PROPERTIES

› High modulus and strength



› Fatigue and compression resistance

› Low water absorption



› Good surface aspect

› Heat and chemical resistance



Pieces in **RADILON® ADLINE CS CF10**
HP printed with the collaboration of
Perlon and Ultimaker

PERLON®
The Filament Company

Ultimaker

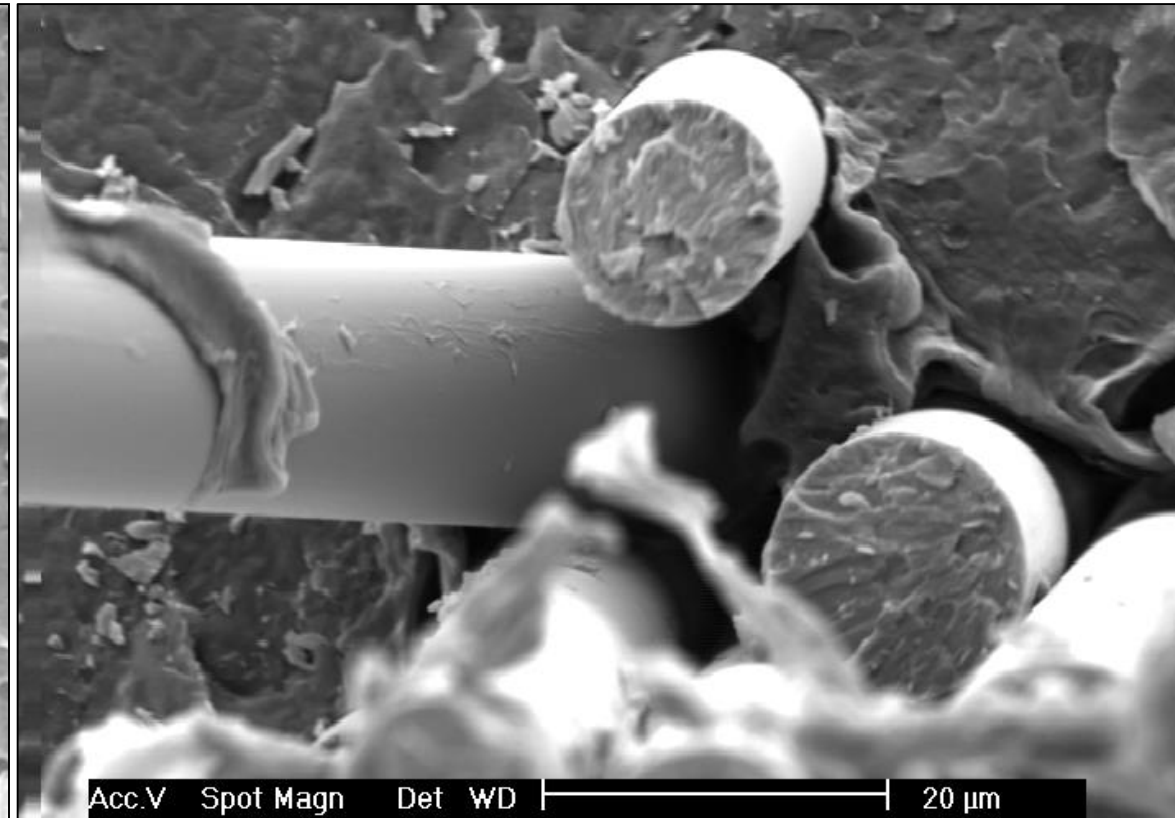
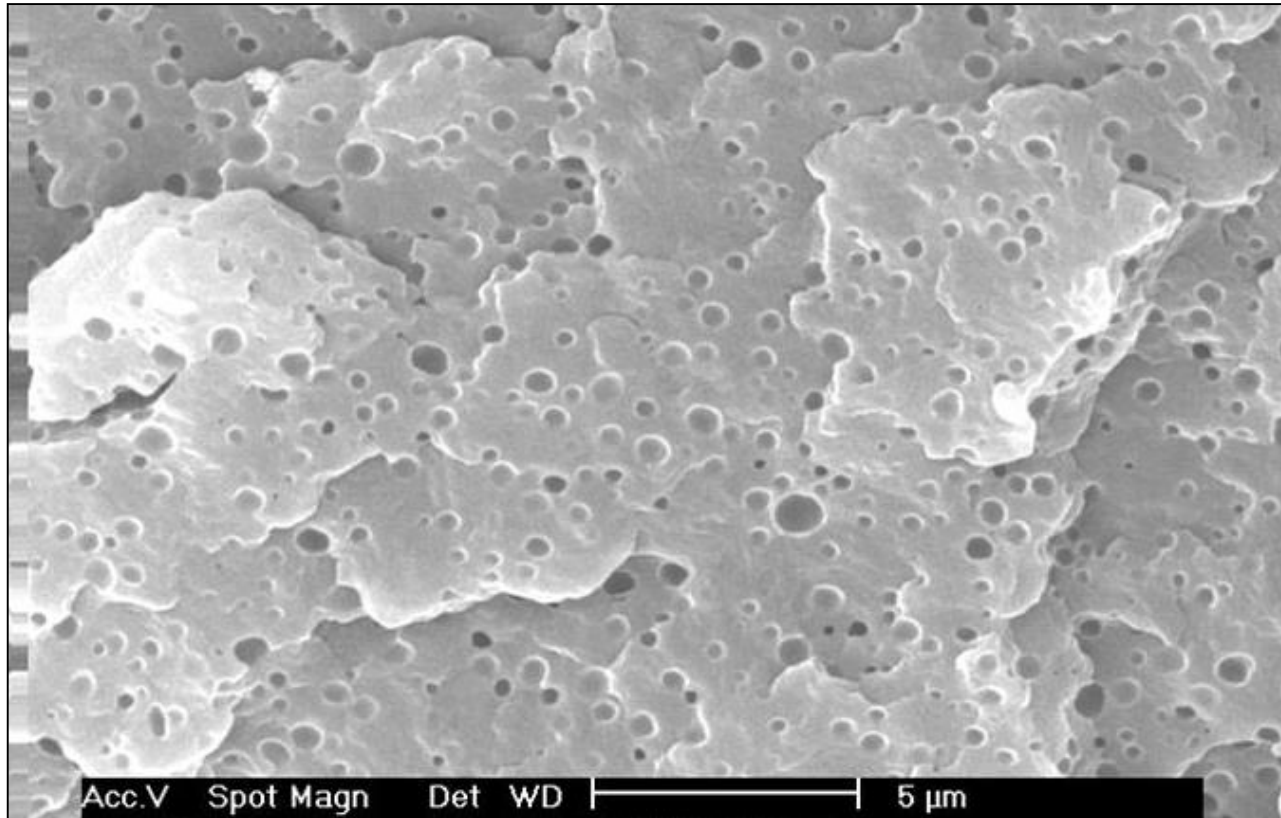


Cup holder and baggage hook in
RADILON® ADLINE MS CF10

RADILON® ADLINE

Carbon fiber reinforced grades for FDM

Compound structure tuned to minimize warping and maximize layer adhesion



RADILON® ADLINE D for FDM

KEY PROPERTIES

› Bio-based (64% renewable source polymer)

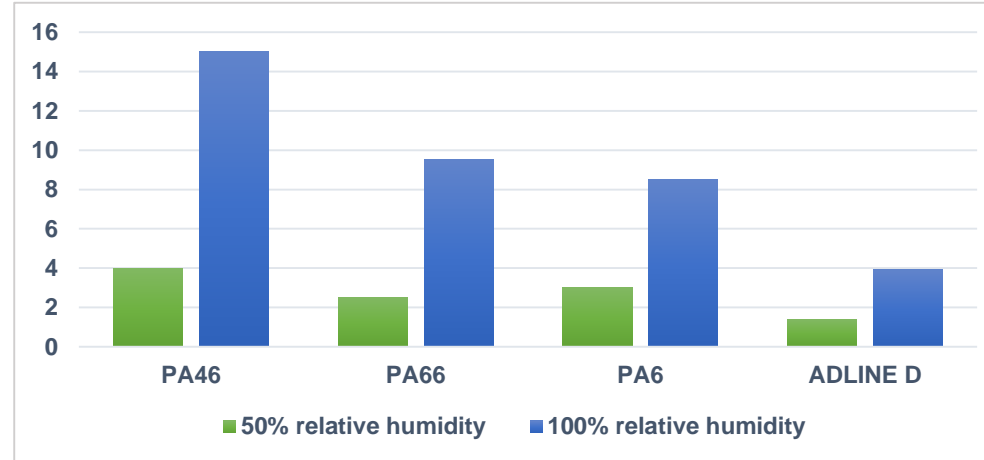


› Low water absorption

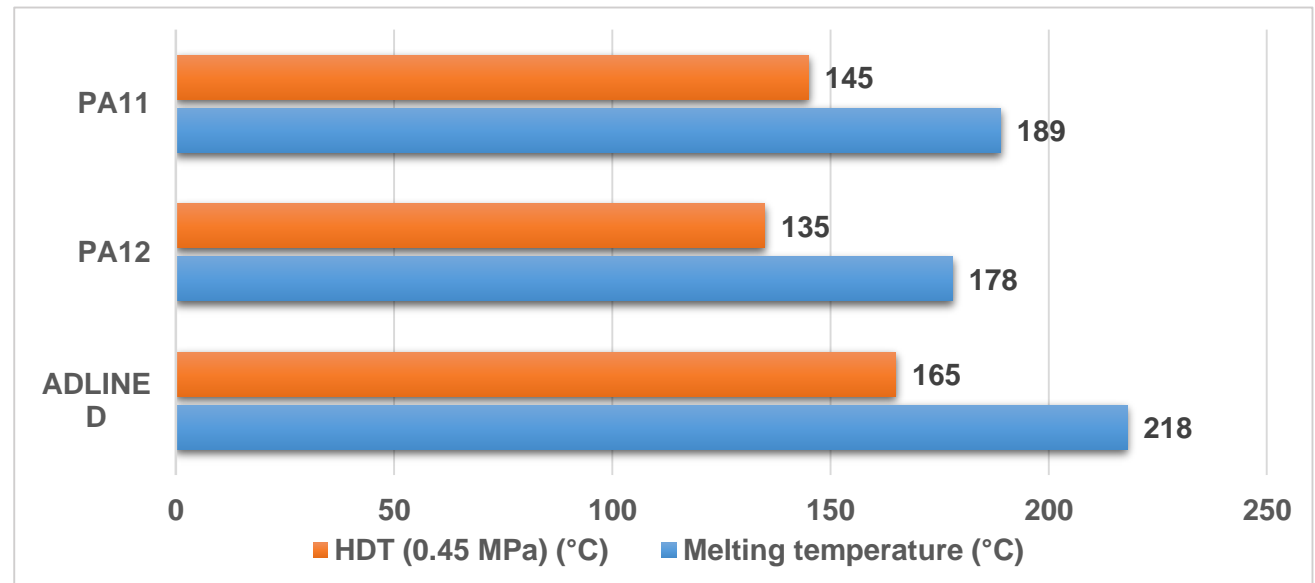


› High chemical and thermal resistance

› Excellent hydrolysis resistance and dimensional stability

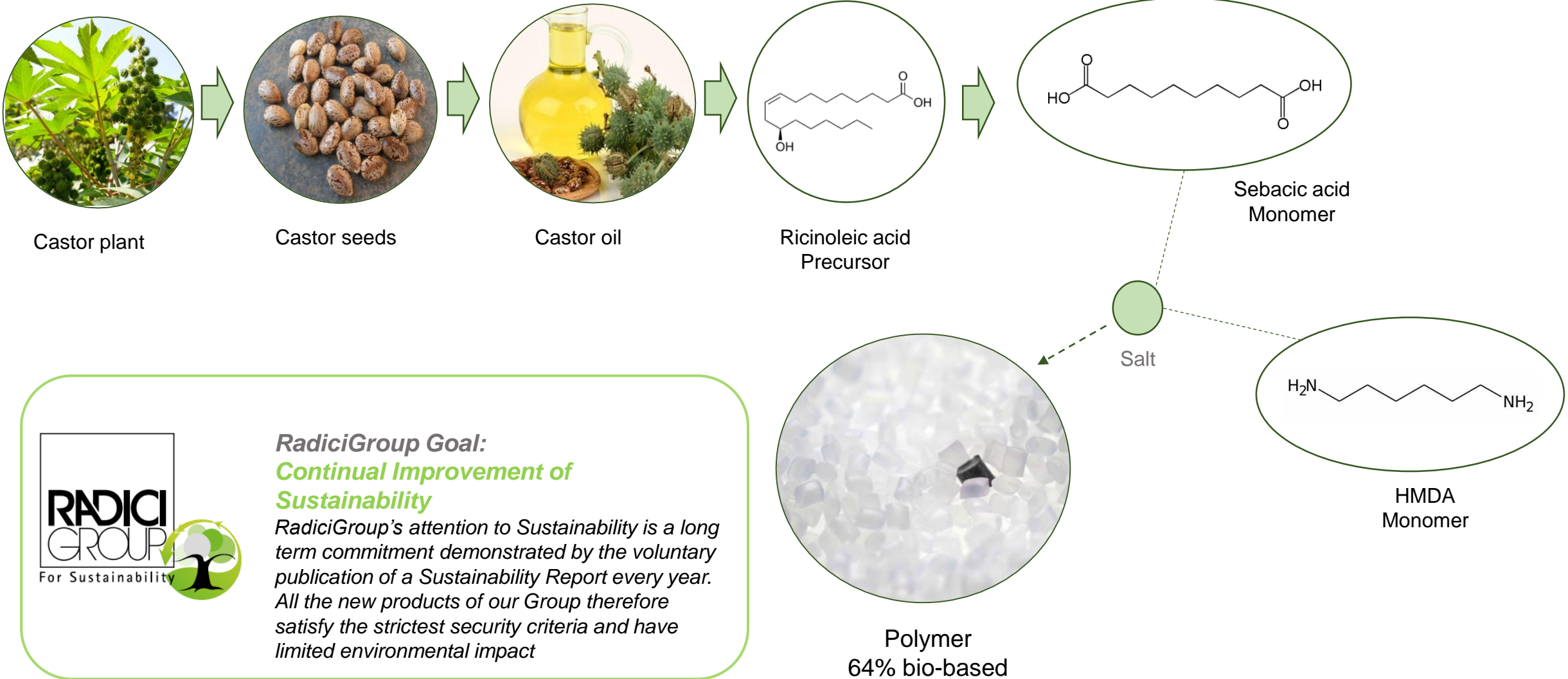


Moisture absorption of **RADILON® ADLINE D** and other polyamides



Thermal data of **RADILON® ADLINE D** in comparison to typical polyamides used in Additive Manufacturing

RADILON® ADLINE D: Sustainability



RadiciGroup Goal:
Continual Improvement of Sustainability

RadiciGroup's attention to Sustainability is a long term commitment demonstrated by the voluntary publication of a Sustainability Report every year. All the new products of our Group therefore satisfy the strictest security criteria and have limited environmental impact

RADILON® ADLINE RE GF30 BK

Recycled grades for FGF



KEY PROPERTIES

› Reduced global and warming potential



› Less consumption of energy

› High modulus and strength

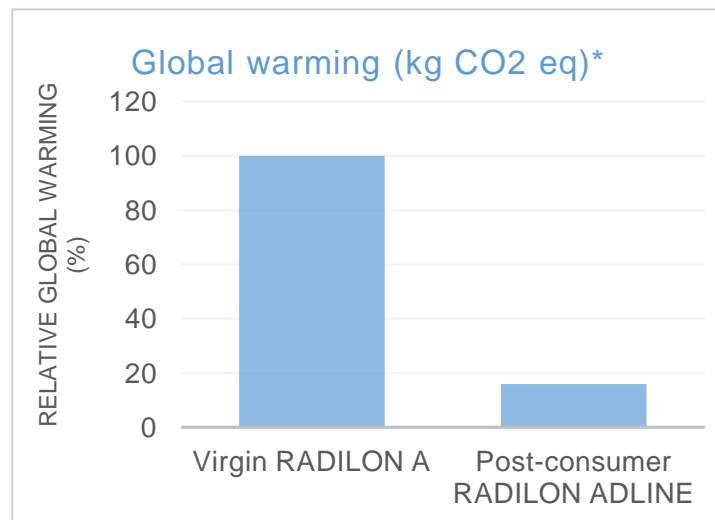
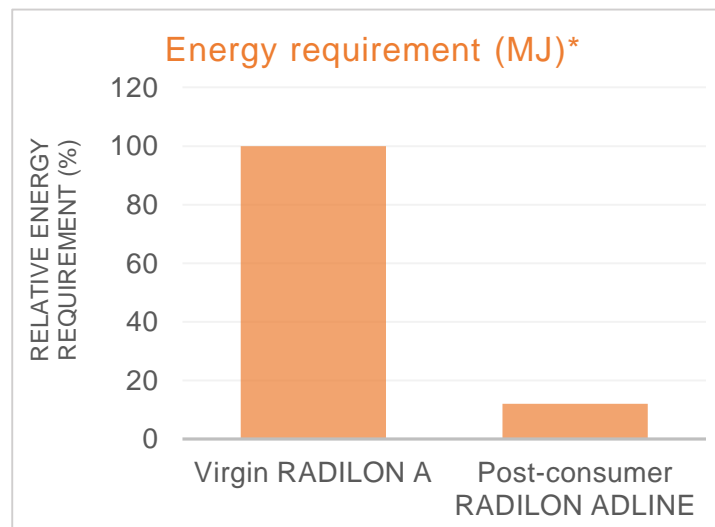


› Fatigue and compression resistance

› Heat and chemical resistance



Designer vase in experimental post-consumer RADILON® ADLINE developed with the collaboration of eXngineering and CAR-E Service

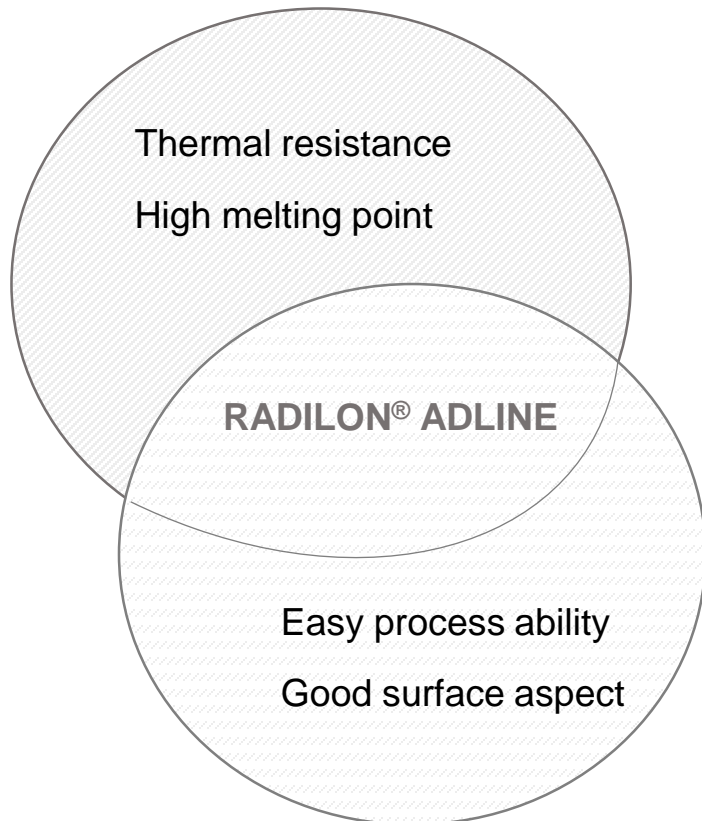


*In agreement with ISO 14040 Life Cycle Assessment standard



RADILON® ADLINE: Future Developments

High temperature RADILON® ADLINE



Focus on Sustainability

- ✓ **100% bio-based** RADILON® ADLINE
- ✓ **Recycled** RADILON® ADLINE grades: further developments



Partnership

Close collaboration with printer manufacturers to develop RADILON® ADLINE portfolio



3D printed pump in experimental RADILON® ADLINE under development with the collaboration of 3ntr



HIGH PERFORMANCE POLYMERS

Chiara.Devasini@radicigroup.com

Ambra.Suardi@radicigroup.com

Thank you



Key drivers in metal to polymer replacement in water management

Paolo Rossi - *Appliance & Water management Segment Leader*



HIGH PERFORMANCE
POLYMERS

Webinar : Latest innovations in additive manufacturing and water management

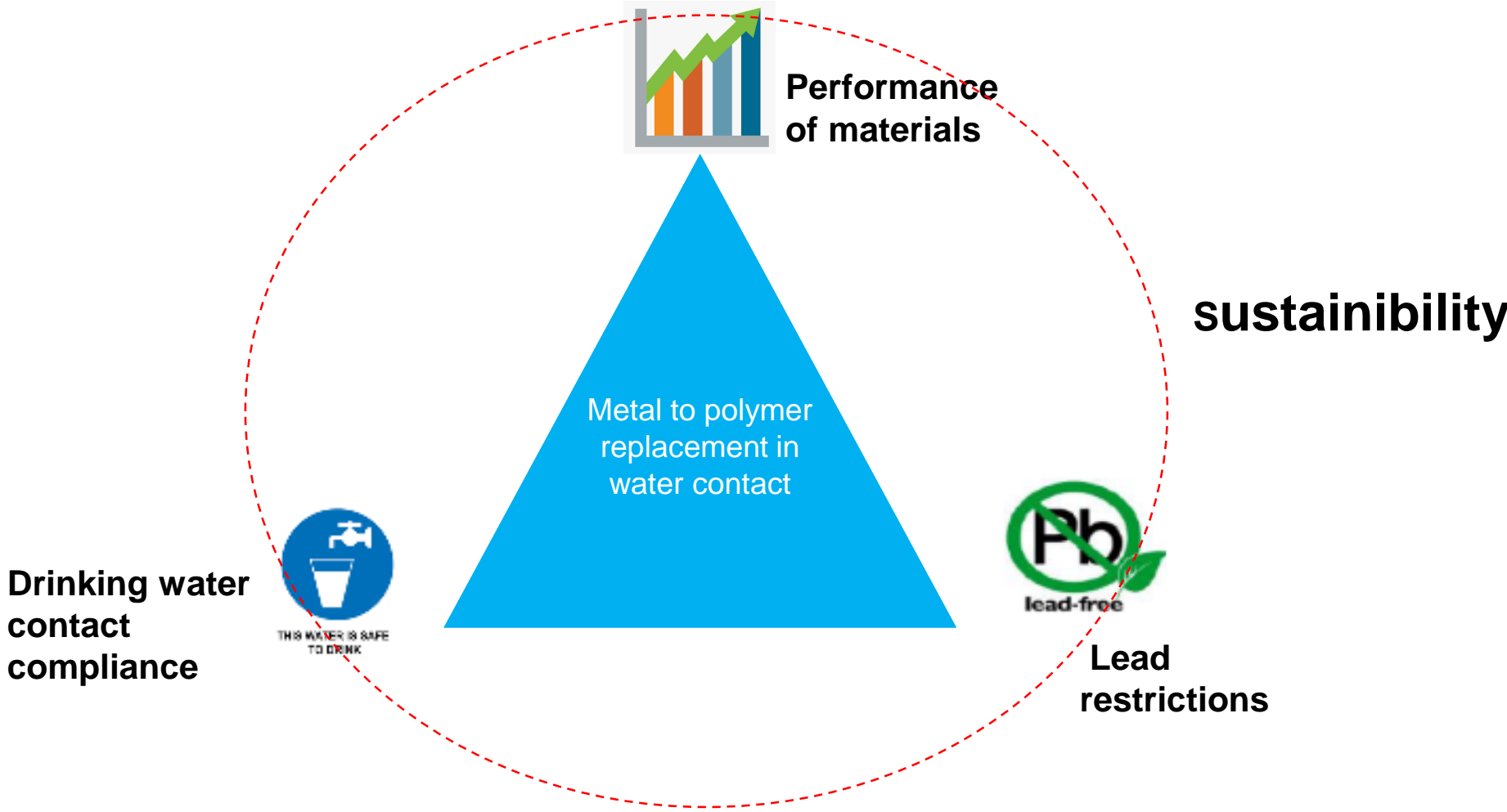
«Water drops»

- › Key Market Drivers in metal to polymer replacement in Water Management
- › Metal to Polymers replacement examples in Water Management
- › Designing with CAE
- › Water Management case study

Key market drivers in metal to polymer replacement in water management



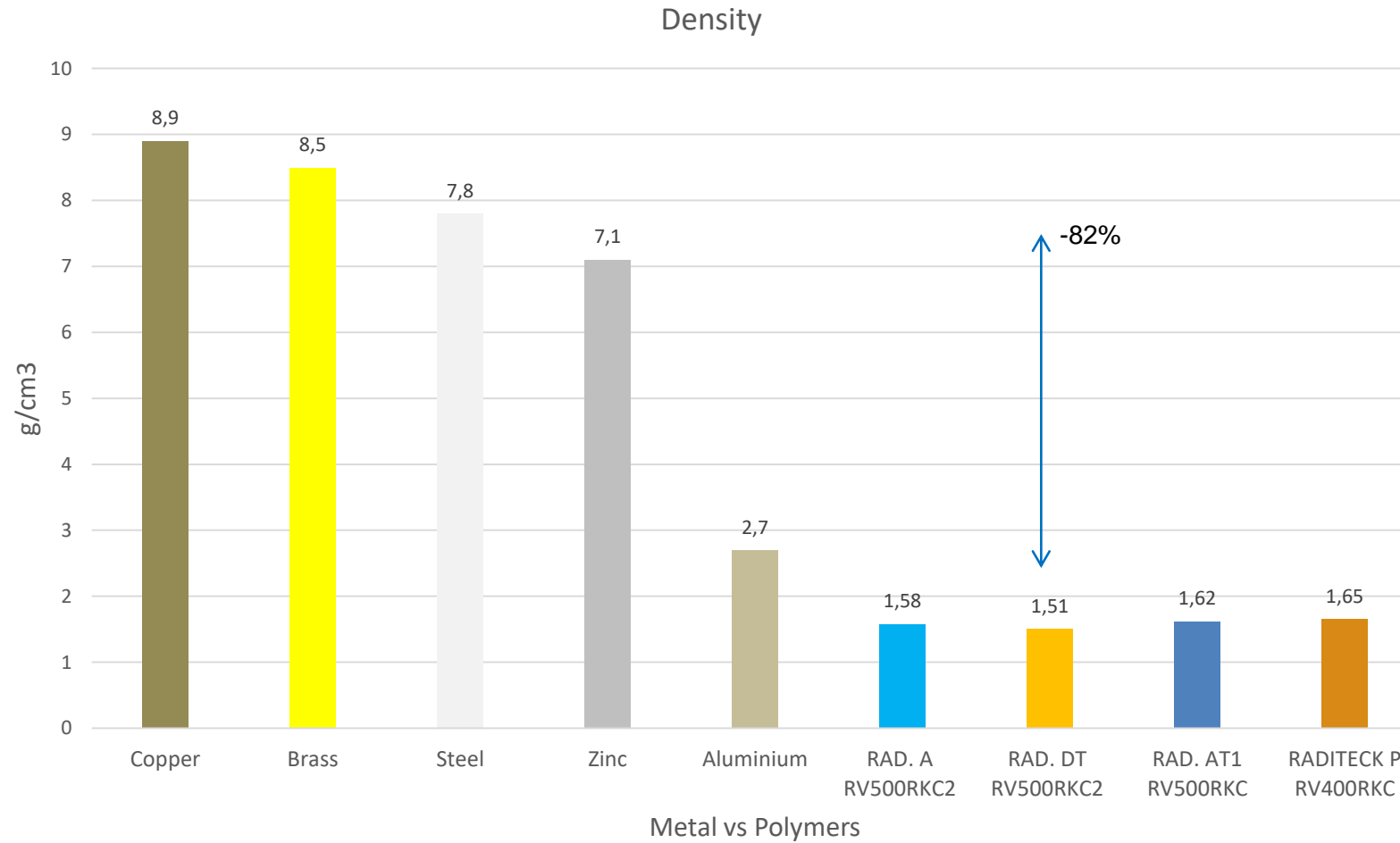
Key market drivers in metal to polymer replacement in water management



Polymer performance

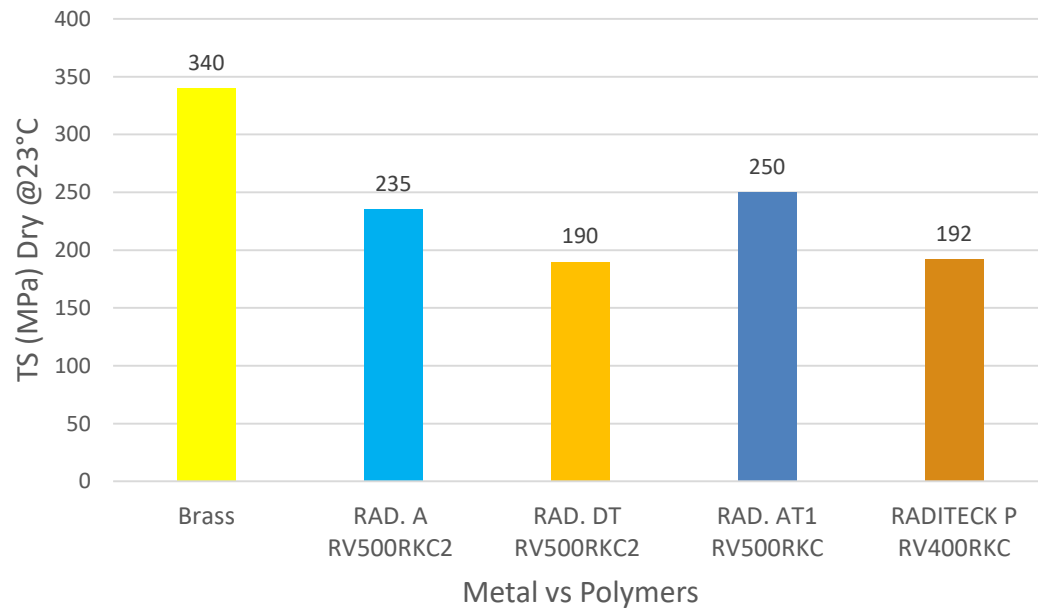


Polymer properties vs metals

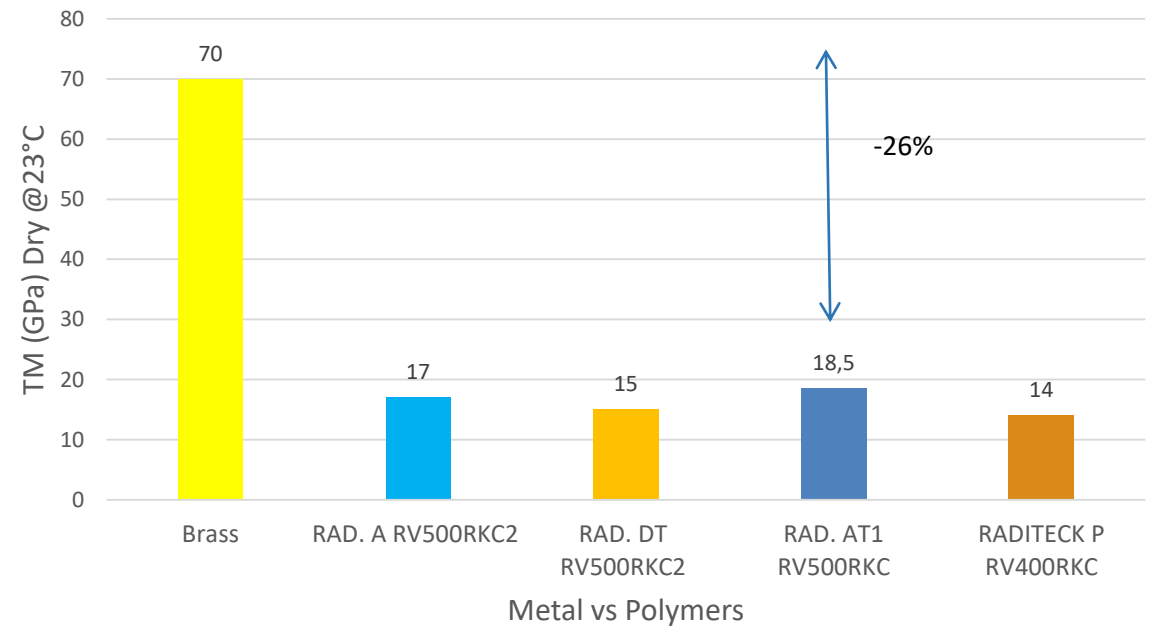


Polymer properties vs brass

Tensile Strength

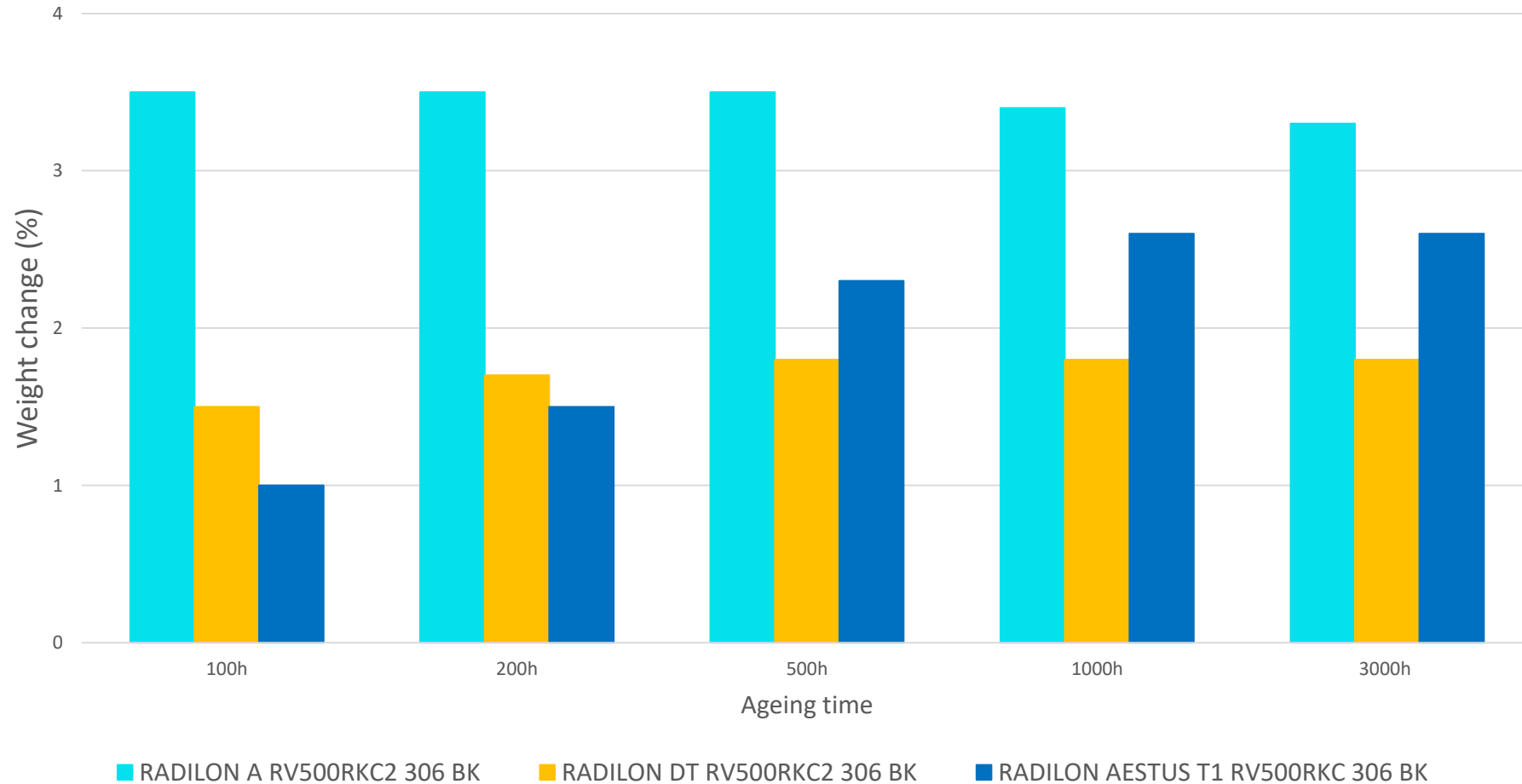


Tensile Modulus

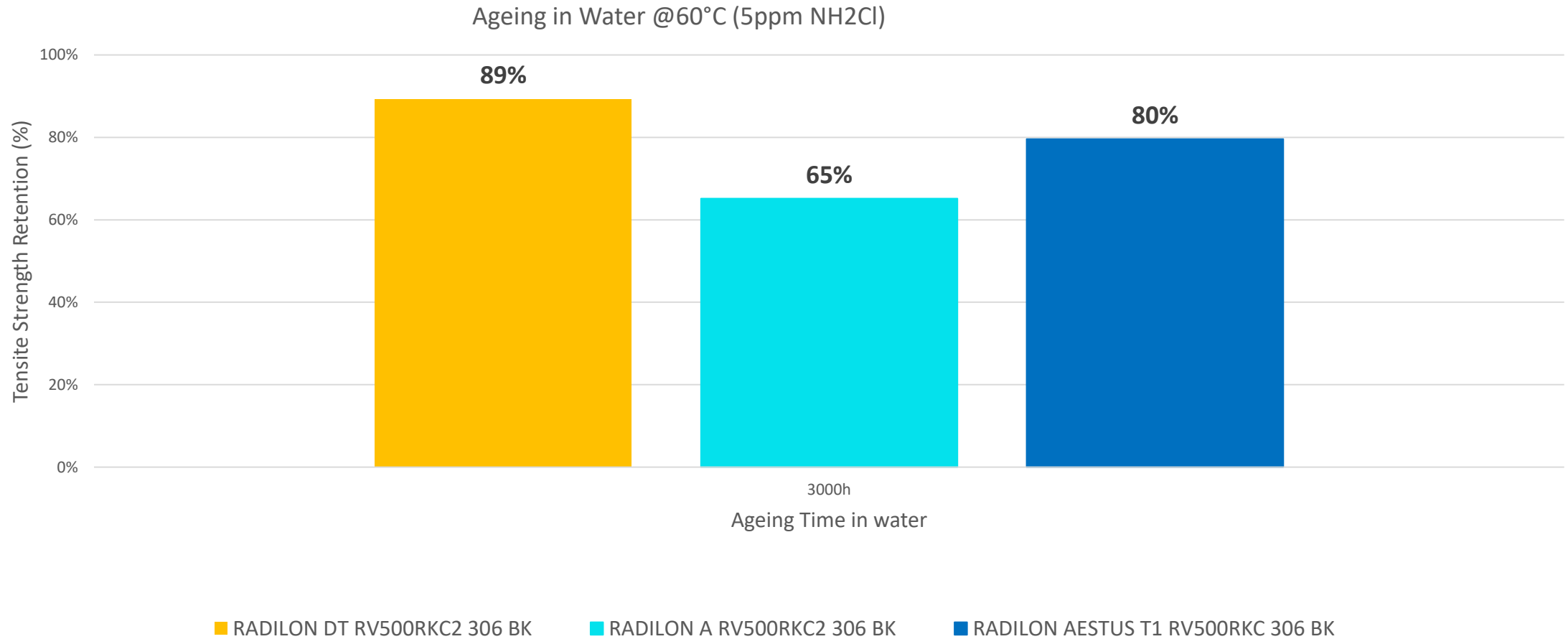


Polymer performance in water

Weight Change after ageing in water @60°C (5ppm NH₂Cl)

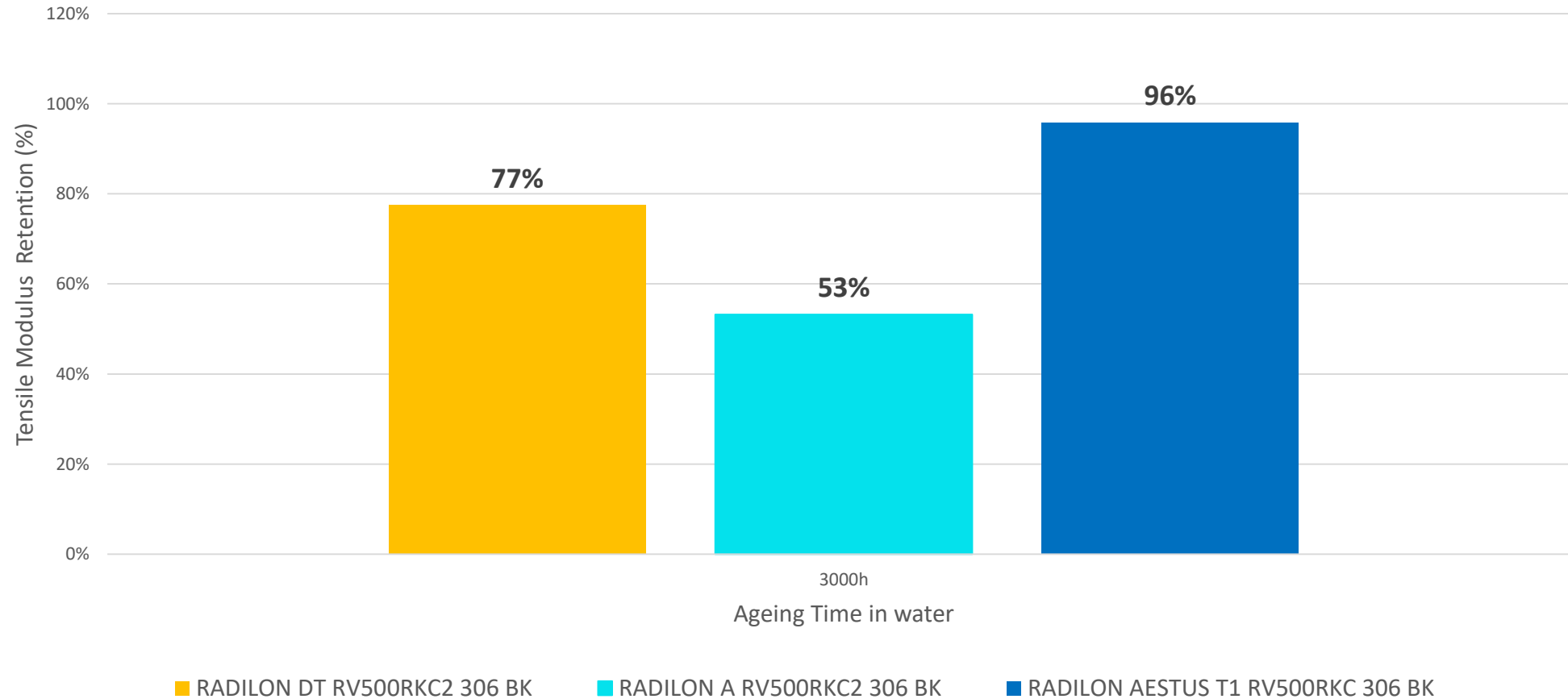


Polymer performance in water



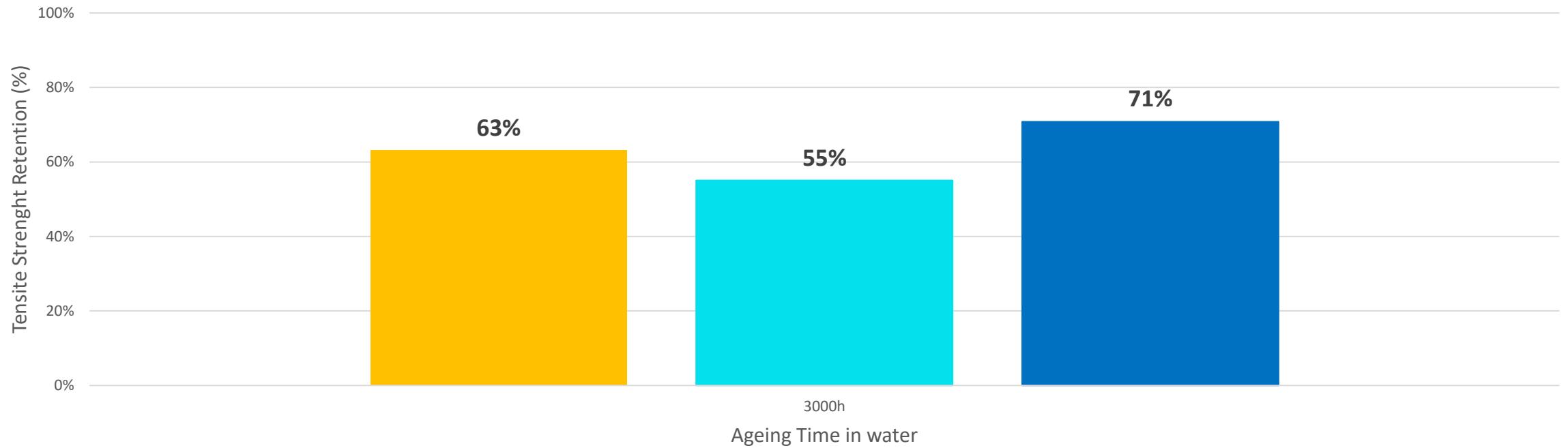
Polymer performance in water

Ageing in Water @60°C (5ppm NH₂Cl)



Polymer performance in water

Ageing in Water @90°C (5ppm NH₂Cl)

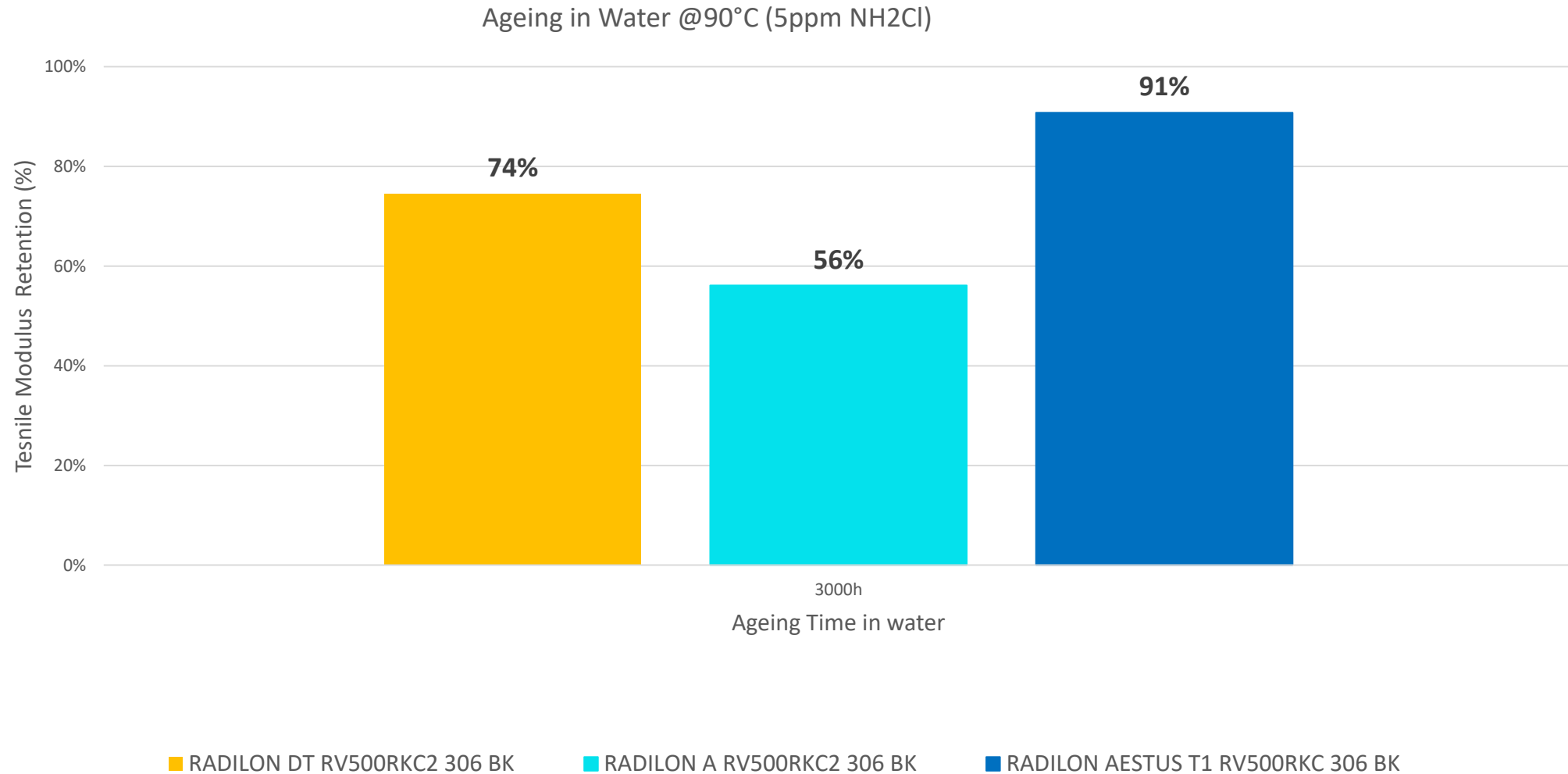


■ RADILON DT RV500RKC2 306 BK

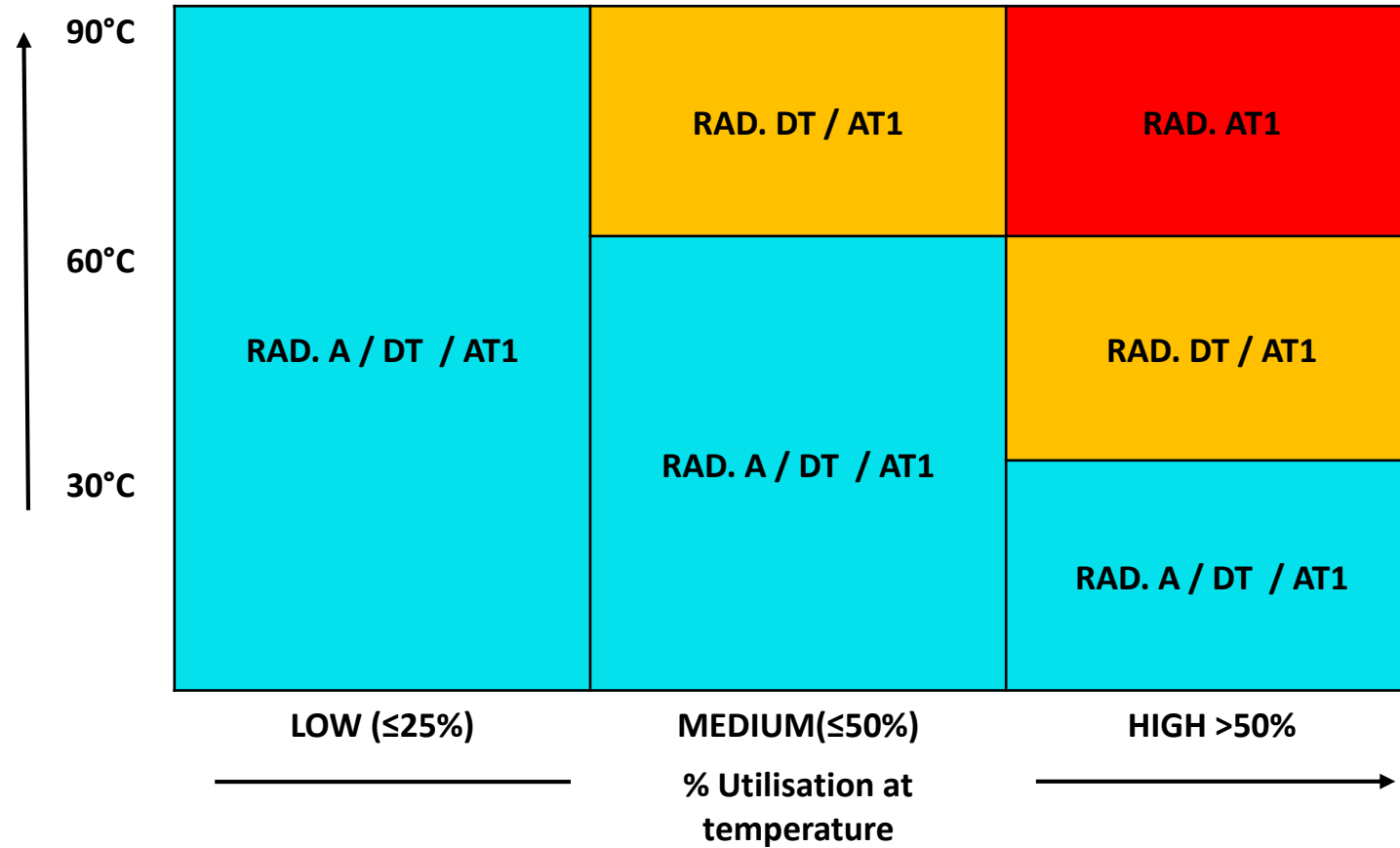
■ RADILON A RV500RKC2 306 BK

■ RADILON AESTUS T1 RV500RKC 306 BK

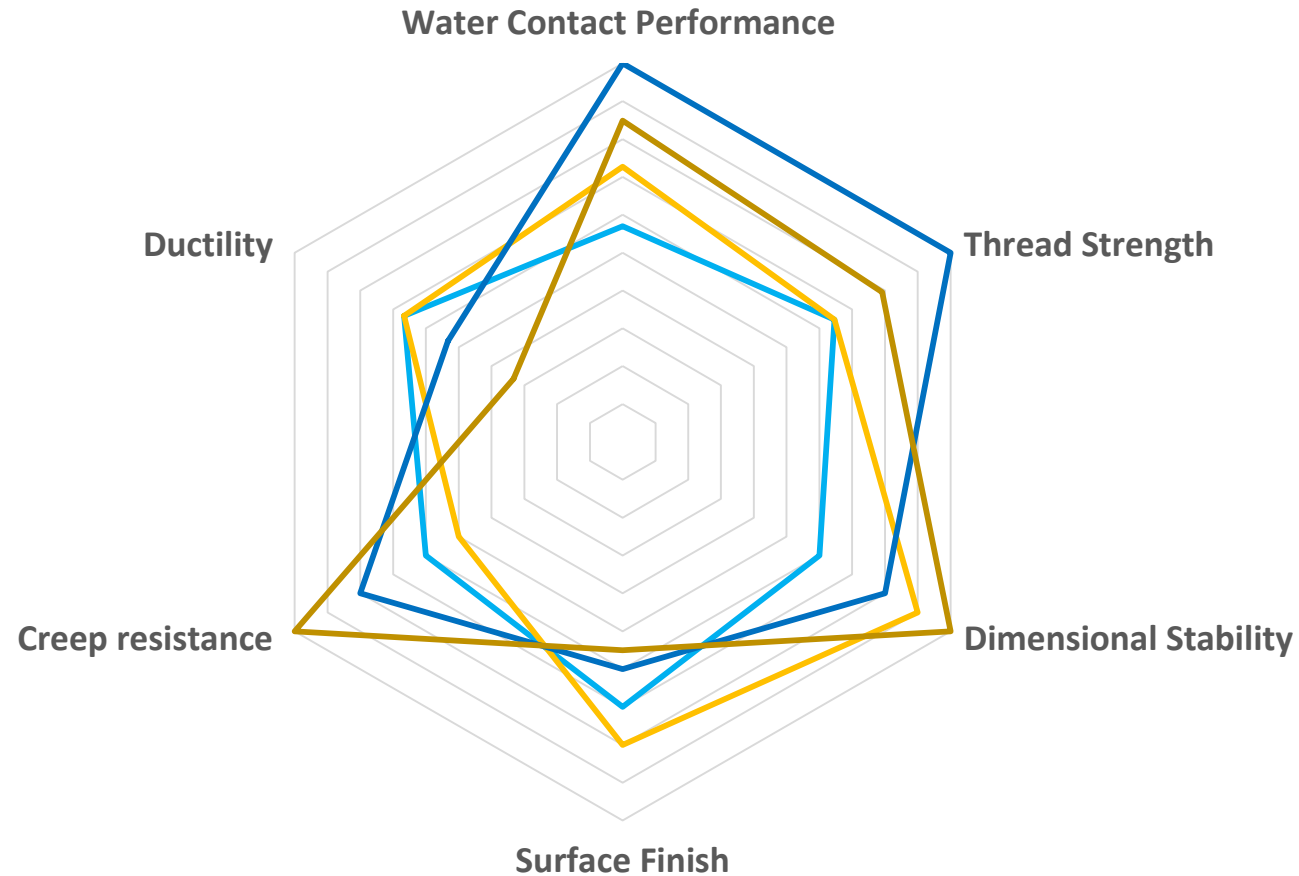
Polymer performance in water



Positioning polymer performance in water



Positioning polymer performance in water



— RADILON® A

— RADILON® DT

— RADILON® AESTUS T1

— RADITECK®

Global lead restrictions



Global lead restrictions

Different lead restrictions in the world:

- › EU Standards for Drinking Water (98/83/EC) from 12-2013 have reduce lead content = 0.010 mg/l (10 ppb)
- › The more stringent pass/fail criteria for certification to the NFS 61 standard will require the maximum amount of lead leaching to be reduced from 5 micrograms (μg) to 1 μg for plumbing endpoint devices that dispense drinking water such as faucets, and from 3 μg to 0.5 μg for other plumbing components such as connector hoses and small shut-off valves.

Lead restrictions

Polymers Benefits Vs Brass :

- › No corrosion
- › No heavy metal contamination coming from polymers
- › Polymer contribute in the reduction of lead content in water systems



= Safer drinking water !

Drinking water contact material compliance

























**THIS WATER IS SAFE
TO DRINK**


Drinking water certifications


Nation	Standard	Tests required
UK	WRAS (BS6920)	Microbial growth, organoleptic & chemical properties
DE	KTW	Organoleptic properties , migration tests
DE	W270	Microbial growth
FR	ACS	Migration tests & cytotoxicity
USA	NSF 61	Migration tests & site audit

Drinking water certifications


GRADE	POLYMER	COLOUR	FILLERS		KTW		W270	NSF61	WRAS	ACS
RADILON® A RV300RKC2 306 BK	PA 6.6	Black	GF30							
RADILON® A RV300RKC2 106 NT	PA 6.6	Natural	GF30							
RADILON® A RV500RKC2 306 BK	PA 6.6	Black	GF50							
RADILON® A RV500RKC2 106 NT	PA 6.6	Natural	GF50							
RADILON® A RCM4010RKC 306BK	PA 6.6	Black	GF10 M30							


 Cold water certificate, 23°C

 Warm water certificate, 60°C

 Hot water certificate, 85°C



























 Approval pending


 Microbial growth test certificate


 Positive list compliancy


RADICI HPP will have RAD A Range approved according to new KTW-BWGL by Q1-2021

Drinking water certifications


GRADE	POLYMER	COLOUR	FILLERS		KTW		W270	NSF61	WRAS	ACS
RADILON® DT CV300RKC2 306 BK	PA 612	Black	GB30							
RADILON® DT CV300RKC2 106 NT	PA 612	Natural	GB30							
RADILON® DT RV300RKC2 306 BK	PA 6.12	Black	GF30							
RADILON® DT RV300RKC2 106 NT	PA 6.12	Natural	GF30							
RADILON® DT RV500RKC2 306 BK	PA 6.12	Black	GF50							
RADILON® DT RV500RKC2 106 NT	PA 6.12	Natural	GF50							


 Cold water certificate, 23°C

 Warm water certificate, 60°C

 Hot water certificate, 85°C





































 Approval pending


 Microbial growth test certificate


 Positive list compliancy


RADICI HPP will have RAD DT Range approved according to new KTW-BWGL by Q1-2021

Drinking water certifications


GRADE	POLYMER	COLOUR	FILLERS		KTW		W270	NSF61	WRAS	ACS
RADILON® Aestus T1 RV300RKC 306 BK	PPA	Black	GF30							
RADILON® Aestus T1 RV300RKC 106 NT	PPA	Natural	GF30							
RADILON® Aestus T1 RV400RKC 306 BK	PPA	Black	GF40							
RADILON® Aestus T1 RV400RKC 106 NT	PPA	Natural	GF40							
RADILON® Aestus T1 RV500RKC 306BK	PPA	Black	GF50							
RADILON® Aestus T1 RV500RKC 106NT	PPA	Natural	GF50							


 Cold water certificate, 23°C

 Warm water certificate, 60°C

 Hot water certificate, 85°C

 Approval pending

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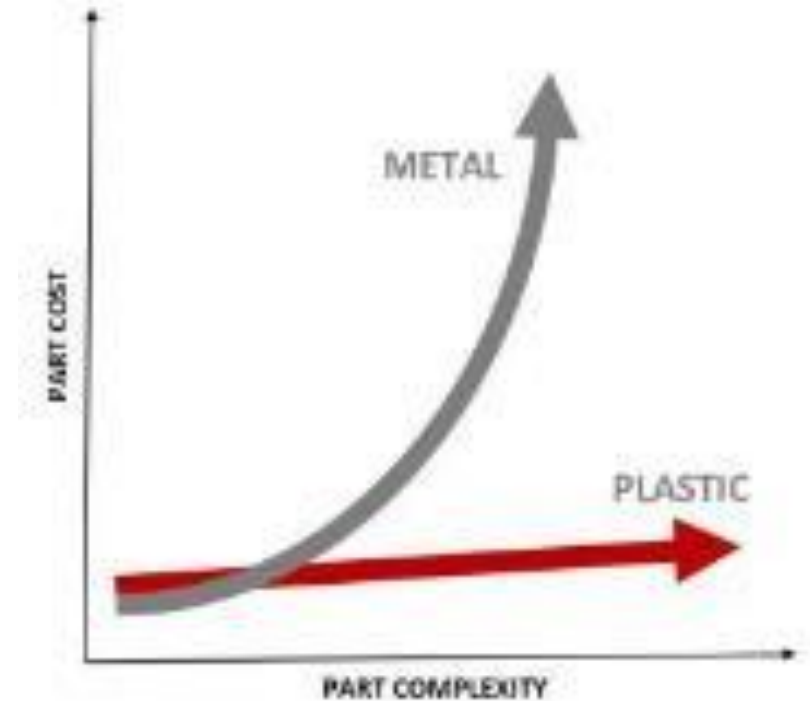
Metal to polymer replacement sustainability



Metal to polymer replacement sustainability

Polymers Benefits related to sustainability Vs Brass :

- › Lower environmental impact (up to less 50% on GWP)
- › Lower production costs (depending on system)
- › Lower density (up to 80% less)
- › Less processing steps
- › Better design freedom (integration & feasibility of complex parts)
- › Better tolerances without post treatment or reworking
- › Higher tooling life
- › Stable vs Brass volatile pricing



Metal to polymers replacement examples in water management



Water distribution: water meter housing & other wm components



Metal to Polymers replacement benefits:

- ❖ *Lighter (up to max 80% lighter than Brass)*
 - ✓ *Easier to install (less injuries)*
 - ✓ *Lower transport costs*
- ❖ *Lead free*
- ❖ *Lower CO2 Footprint (PA vs Brass)*
- ❖ *System Cost reduction*
- ❖ *Recyclable material end of life*

Material grades typically specified:

Radilon® A RV500RKC2 (PA66-GF50) - Radilon® DT RV500RKC2 (PA612-GF50) –Radilon® DT CV300RKC2 (PA612-GB30) - Radilon® Aestus T1 RV500RKC (PPA-GF50)

Water distribution: water meter box & lid



Metal to Polymers replacement benefits:

- ❖ *Lighter (up to 70% lighter than cast iron)*
 - ✓ *Easier to install/use (less injuries)*
 - ✓ *Lower transport costs*
- ❖ *Shape retention upon load & heat (Vs PP)*
- ❖ *No corrosion (rust free)*
- ❖ *Noise pollution reduction (lower density than cast iron)*
- ❖ *Theft prevention (no scrap value)*
- ❖ *Lower CO2 Footprint (PA Vs cast iron)*
- ❖ *System Cost reduction*
- ❖ *Recyclable material end of life*

Material grades typically specified:

Radilon® A RV300RKC (PA66-GF30)- Heramid® A NER GF030/1 K (PA66 –GF30 recycled grade)

Plumbing: cap fittings



Metal to Polymers replacement benefits:

- ❖ *Lighter (up to 80% lighter than brass)*
 - ✓ *Easier to install/use (less injuries)*
 - ✓ *Lower transport costs*
- ❖ *Part Colourability without extra steps*
- ❖ *Lower CO2 Footprint (PA Vs brass)*
- ❖ *System Cost reduction*
- ❖ *Recyclable material end of life*

Material grades typically specified:

Radilon® A RV300RKC 106NT (PA66-GF30) - Radilon® S RV300RKC2 *all colours (PA6-GF30 new development grades)*

Plumbing: innercore fittings



Metal to Polymers replacement benefits:

- ❖ *Lighter (up to 80% lighter than brass)*
 - ✓ *Easier to install/use (less injuries)*
 - ✓ *Lower transport costs*
- ❖ *Part Colourability without extra processing steps*
- ❖ *Lower CO2 Footprint (PA Vs brass)*
- ❖ *System Cost reduction*
- ❖ *Recyclable material end of life*

Material grades typically specified:

Radilon® Aestus T1 RV500RKC (PPA-GF50) – Raditeck® P HSX100KC 1706 NT (PPS-GF10 new development grade)

Heating: boiler hydraulic group or other components



Metal to Polymers replacement benefits:

- ❖ *Lighter (up to 80% lighter than brass)*
 - ✓ *Easier to install/use (less injuries)*
 - ✓ *Lower transport costs*
- ❖ *Lower CO2 Footprint (PA Vs brass or copper)*
- ❖ *Part Colourability without extra processing steps*
- ❖ *Lead free*
- ❖ *System Cost reduction (less parts – integration of components possible)*
- ❖ *Recyclable material end of life*

Material grades typically specified:

SL : Radilon® A RV300RKC 306BK (PA66-GF30) - SL/HL: Radilon® A RV300RKC2 306BK (PA66-GF30), Radilon® Aestus T1 RV400RKC 306BK (PPA-GF40)- HL: Radilon® A RV300RG 3900BK (PA66-GF30)

Sanitary: mixer cartridge component



Main Typical requirements:

- › Operating Temperature 20-60°C
- › Resistance to hydrolisis with disinfectants & cleaning agents up to 90°C
- › High Dimensional stability
- › Resistance to wear after Life Cycle test (100k hrs)
- › KTW/W270 ,WRAS , ACS, NSF 61, Drinking Water approvals

Material grades typically specified:

Radilon® A RV300RKC2 (PA66 –GF30) - Radilon® DT RV300RKC2(PA612-GF30) - Radilon® Aestus T1 RV400RKC (PPA-GF40)

Large appliances: electrovalves housing



Metal to Polymers replacement benefits:

- ❖ *Lighter (up to 80% lighter than brass)*
 - ✓ *Easier to install/use (less injuries)*
 - ✓ *Lower transport costs*
- ❖ *Lower CO2 Footprint (Vs brass /PA66)*
- ❖ *Part Colourability without extra processing steps*
- ❖ *Lead free*
- ❖ *System Cost reduction (less parts – integration of components possible)*
- ❖ *Recyclable material end of life*

Material grades typically specified:

Radilon® A RV300RKC2 (PA66-GF30) - Radilon® DT RV300RKC2 (PA612-GF30)

Small appliances: coffee machine pump housing



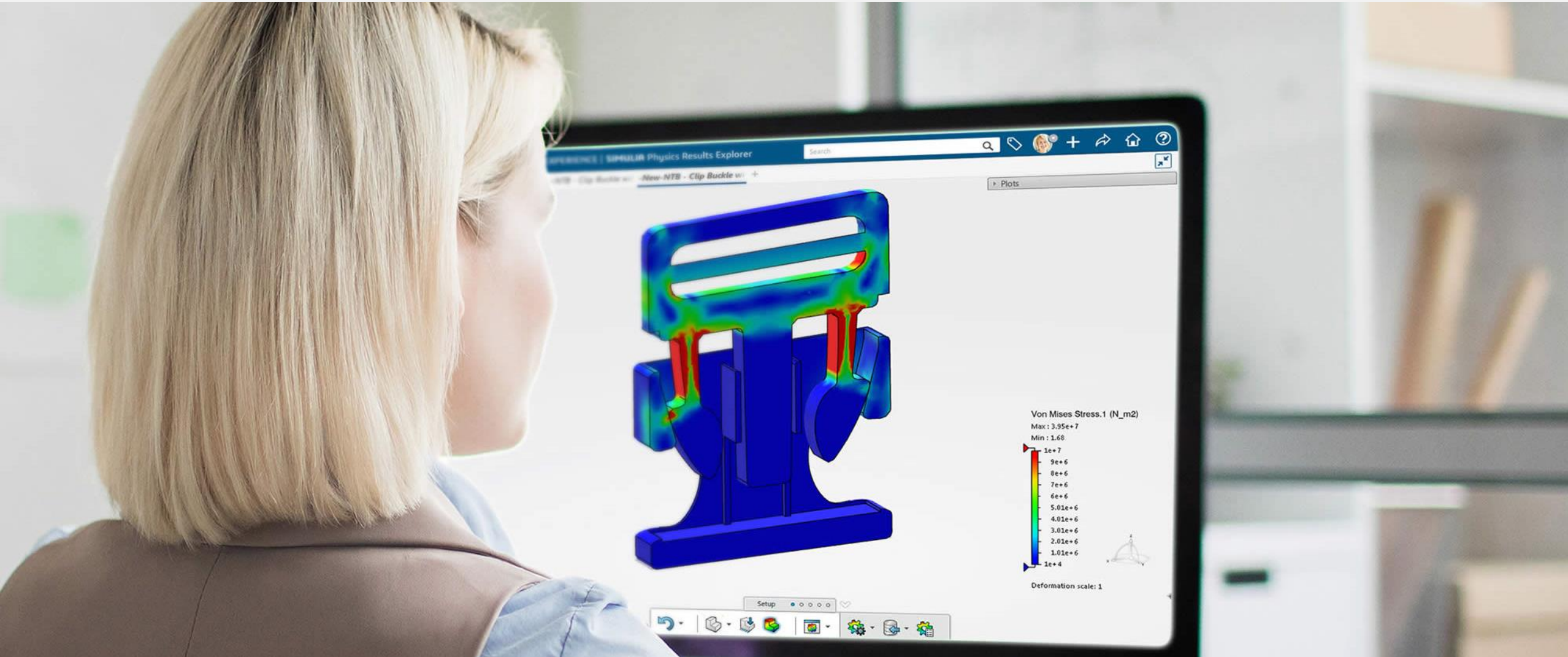
Main Typical requirements:

- › Water and Food Approvals (23°C up to 60°C)
- › Hydrolysis resistance up to 85°C
- › Excellent dimensional stability

Material grades typically specified:

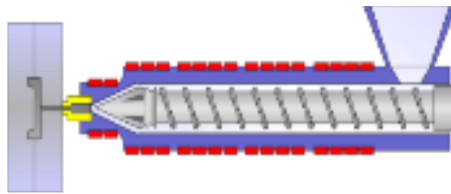
Radilon® A RV500RKC2 (PA66-GF50) - Radistrong® Aroma RV500RKC2 (Special PA –GF50 development grade)
- Radilon® Aestus T1 RV400RKC (PPA –GF40)

Designing with CAE



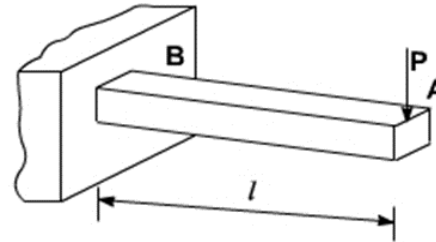
Designing with CAE

Process



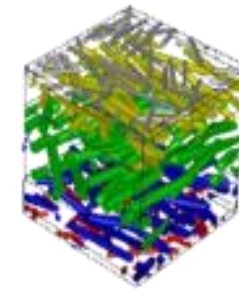
- › Injection molding
- › Flow, Packing, Cooling, Warpage
- › Prevision of process-related output and defects

Structural



- › Static non linear, contact
- › Stiffness, strength, failure
- › Dynamic, Impact, Vibrations
- › Thermal and thermo-mechanical

Integrated



- › From Process to Structure
- › Anisotropic behavior, GF orientation, welding lines
- › Multi-scale material model

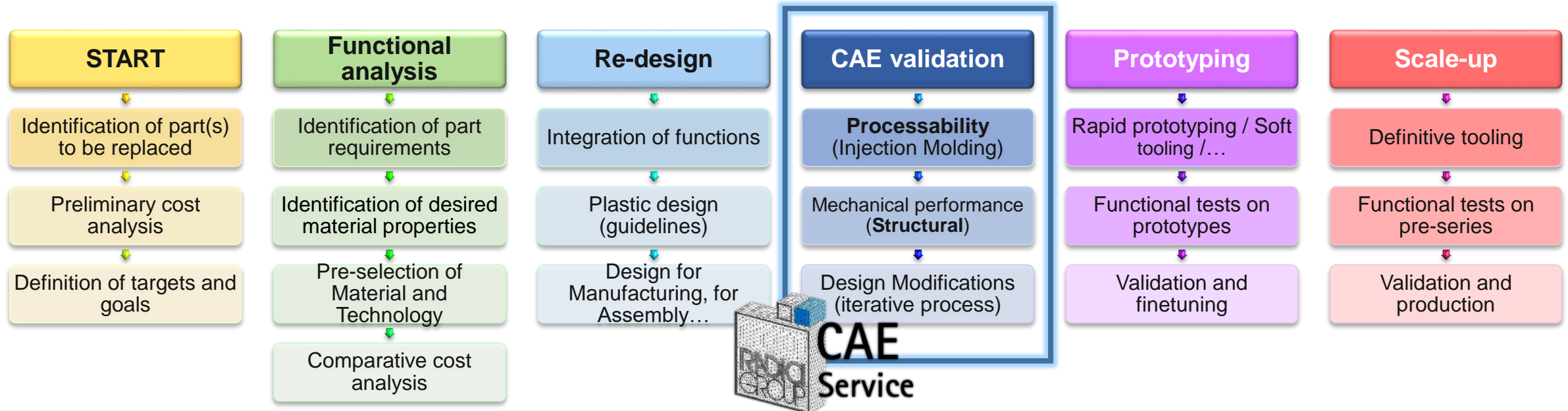
Metal Replacement – Key concept

› Change **MATERIAL**, maintain **FUNCTIONALITY**, gain **ADVANTAGES**

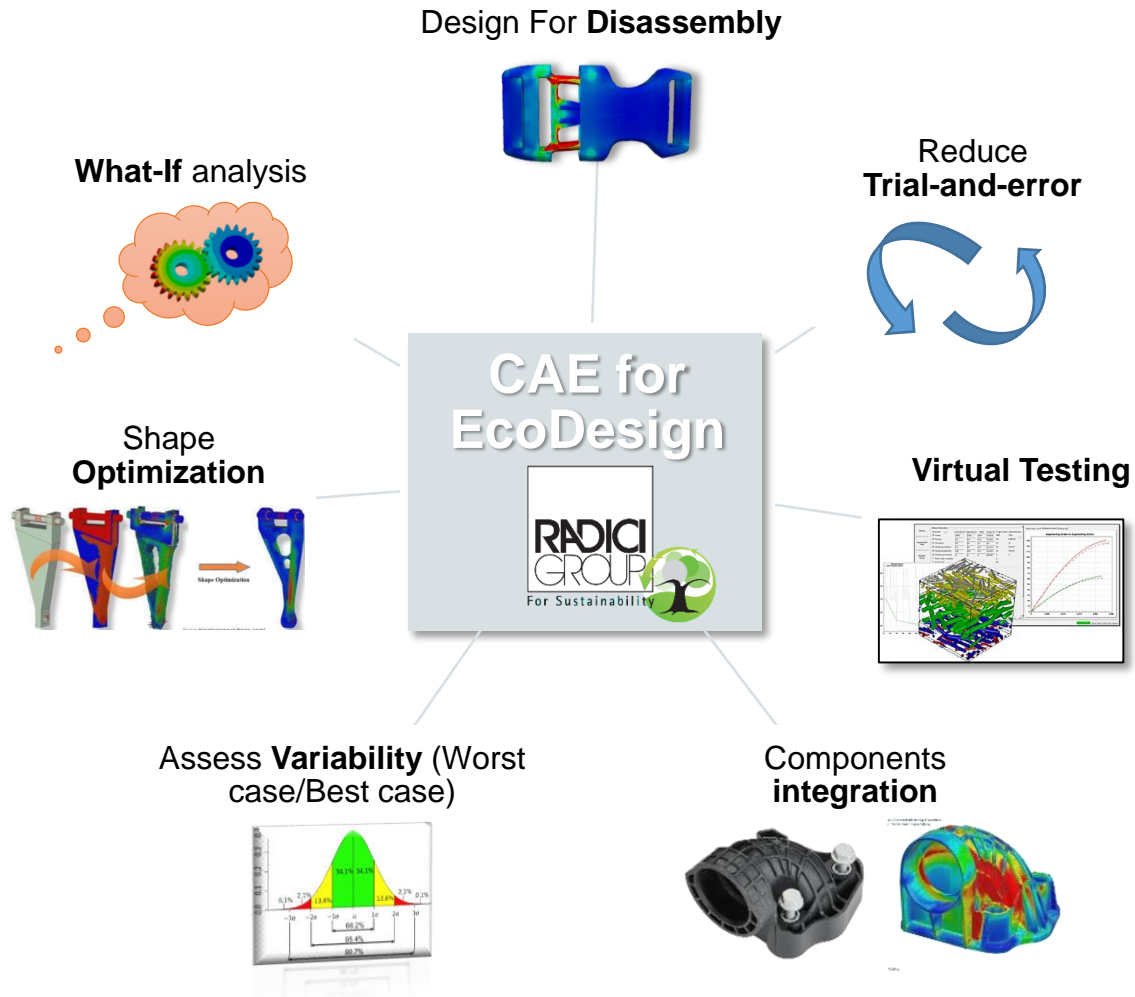
“Metal to **HighPerformance polymer**”

Not a “volume refilling” but a **re-engineering process!**

- ✓ **Weight** reduction
- ✓ Form design **freedom**
- ✓ **Integration** of functions
- ✓ Reduction of **post-manufacturing**
- Aesthetics**, color
- ✓ Total **cost** of part (*≠ cost per kg!!!*)



CAE for EcoDesign

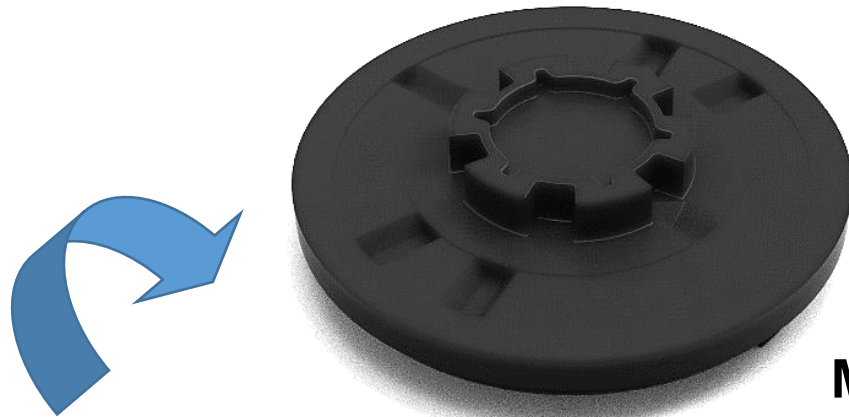


- › **Design for Disassembly**: be able to easily dismantle the item at end-of-life, making easy to recover recyclable parts
- › **Trial-and-error minimized**, saving time and material for disruptive trials and prototyping
- › **Formulation** of new materials made quicker by use of multi-scale **virtual testing**
- › Possible to reduce the number of components by **integrating** in few multi-functional parts
- › Assessing **variability** which is intrinsic in recycled materials, evaluating best/worst cases
- › **Optimize** the shape of items by fully exploiting the potential of materials
- › Explore **alternative solutions** (what-if?)

Water Management Case Study



Case Study: Water meter diaphragm



Material: RADILON® DT RV300RKC2 (PA612 - GF30)

Application: Diaphragm of water meter

*The component lies between the water meter housing (brass) and a steel ferrule screwed onto it. It bears an internal pressure in different load cases, up to **40 bar** at a temperature up to **90°C** (peak load) Furthermore, it needs to be able to withstand a long-term pressure of **10 bar** at **70°C** for up to **10⁵ h** (creep load).*



Main conclusions

- › Rad. A, Rad. DT, Rad. Aestus have good chemical & hydrolisis resistance
- › Rad. A, Rad. DT, Rad. Aestus and polymers in general have lower mechanical proprieties than metals which can compensated with geometry modifications of parts.
- › Rad A, Rad DT, Rad Aestus can contribute to safer drinking water systems (lead free)
- › Polymers have significant lower environmental impact than metals
- › CAE support enables to re-design robust polymers components taking advantage of all possible benefits offered by high performance polymers (incl.EcoDesign)



HIGH PERFORMANCE POLYMERS

paolo.rossi@radicigroup.com





HIGH PERFORMANCE POLYMERS

Q&A TIME

