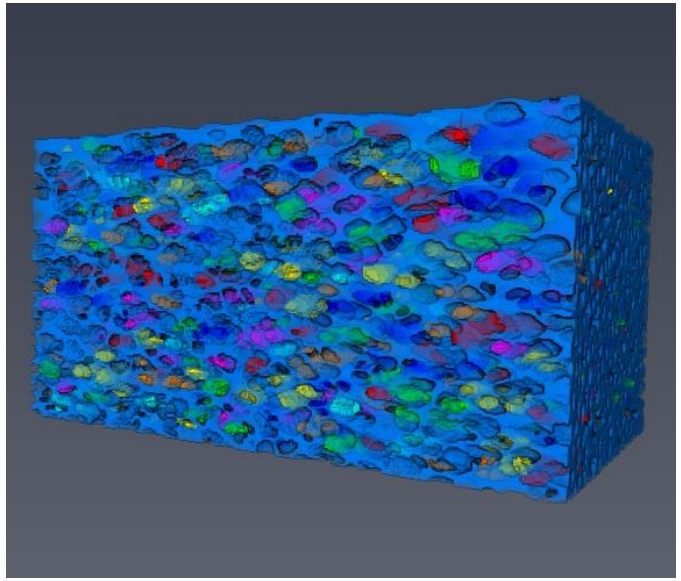
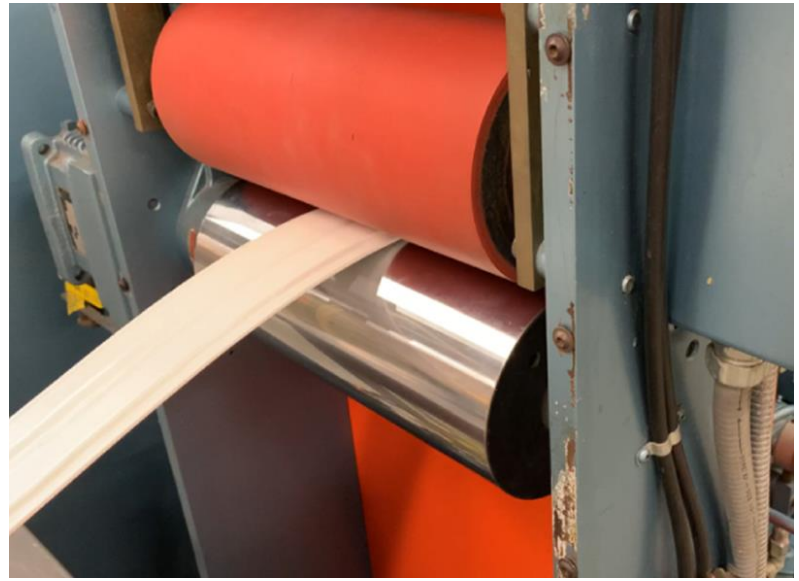
Dow Plastics Additives

Acrylic Processing Aids for PVC Foam Technology







Dow Plastics Additives / We Make Plastics Work. ***BETTER.***

November 9, 2021

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Host



Joy Gallagher
Global Marketing Director
Dow Plastics Additives &
Performance Monomers

@joyagallagher
jagallagher@dow.com

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Agenda

- Introduction to Dow Plastics Additives (DPA)
- Foam PVC Technology
- DPA Product Overview
- Updated Lab Capabilities
- Sustainability for PVC
- Conclusion
- Q&A

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Dow Plastics Additives

We Make Plastics Work. *Better*.

your key supplier &
GROWTH PARTNER



WHO
we are



WHAT
we do

Options Provider
We help to enable processing and improve functional performance of PVC and select Engineered Resins

Industry Driven
We serve the building and construction, electronics, transportation, packaging and durable goods industries



Since
1956



40+
years

Innovative Industry Leader
- Solid technical support
- Supply chain & customer service excellence
- Experienced commercial team

Global Innovation Engine
- Processing Aids
- Impact Modifiers
- MBS and Acrylic technology experience

Source: Dow 2021

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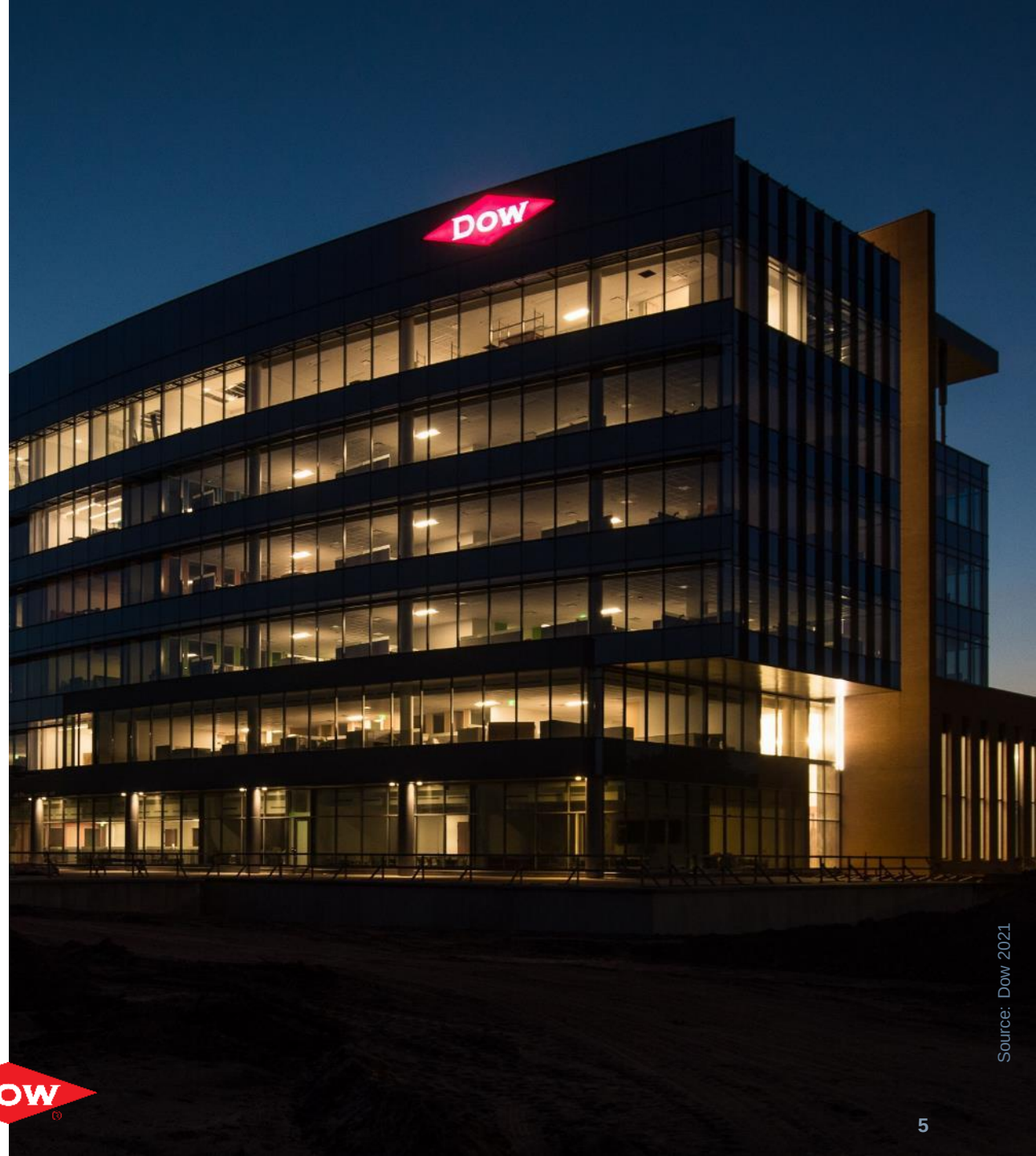
Our Vision

To be the business partner of choice for improving plastics performance sustainably.

Our Mission

We will deliver:

- Innovative and sustainable solutions for improving the processing and performance of PVC and engineering resins;
- Customized service;
- Distinct enabling technology;
- Excellence in operations and safety for the mutual prosperity of our customers, our suppliers and Dow.



Source: Dow 2021

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Around the Clock Accessibility



Global Powerhouse

Advancing manufacturing, R&D and technical experience around the world

- High class global R&D center with 100 patent families and 30 filings in last 5 years.
- Regional TS&D lab facilities.
- 4 manufacturing sites: France, Turkey, Singapore and Kentucky (US).
- Local warehousing capabilities for expedient delivery of product when you need it.
- Offering supply security through global presence.
- 68 countries served, more than 1000 ship-to customers.

Source: Dow 2021

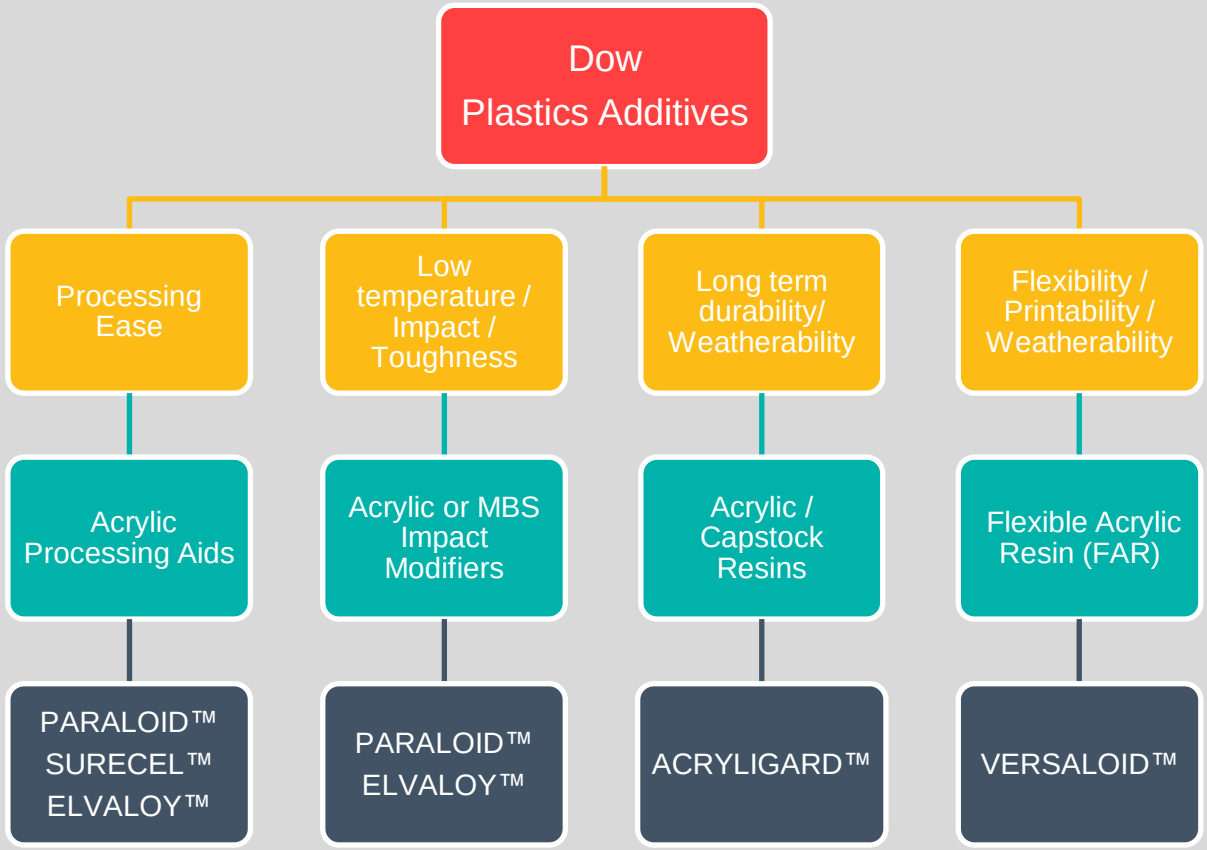
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Products You Can Depend On and Brands You Trust

Reliable Supplier

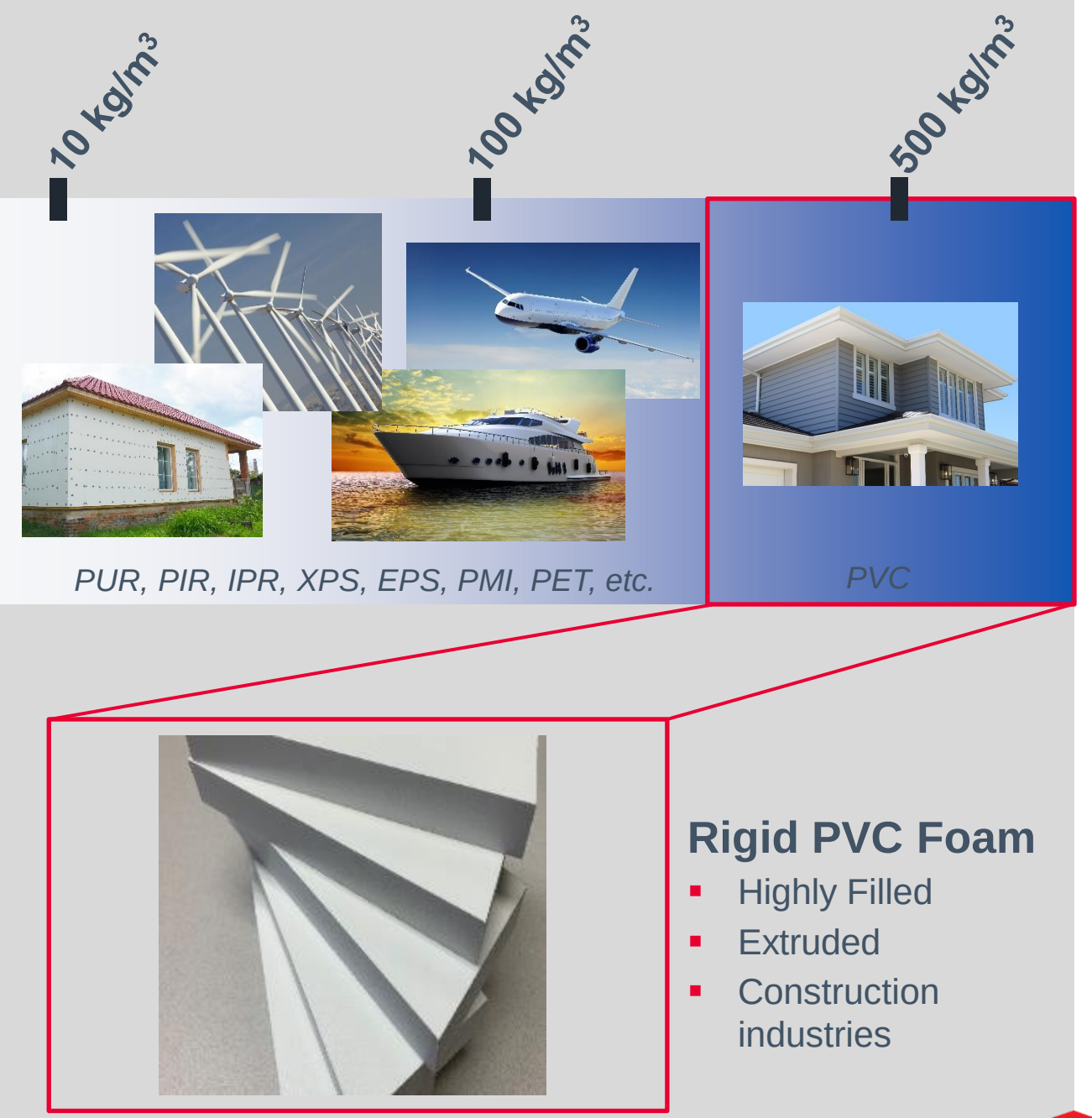
Enhancing global Acrylics and MBS supply capabilities

- Back-integration into monomers drives downstream value and industry commitment.
- High quality supply chain best practices.
- Asset management focused on global industry demand and competitiveness.
- Pioneer of core-shell impact modifiers and acrylic processing aids.
- Leading global supplier of acrylic Impact Modifiers and Processing Aids



Source: Dow 2021

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Rigid PVC Foam

- Highly Filled
- Extruded
- Construction industries

Rigid Polymer Foams

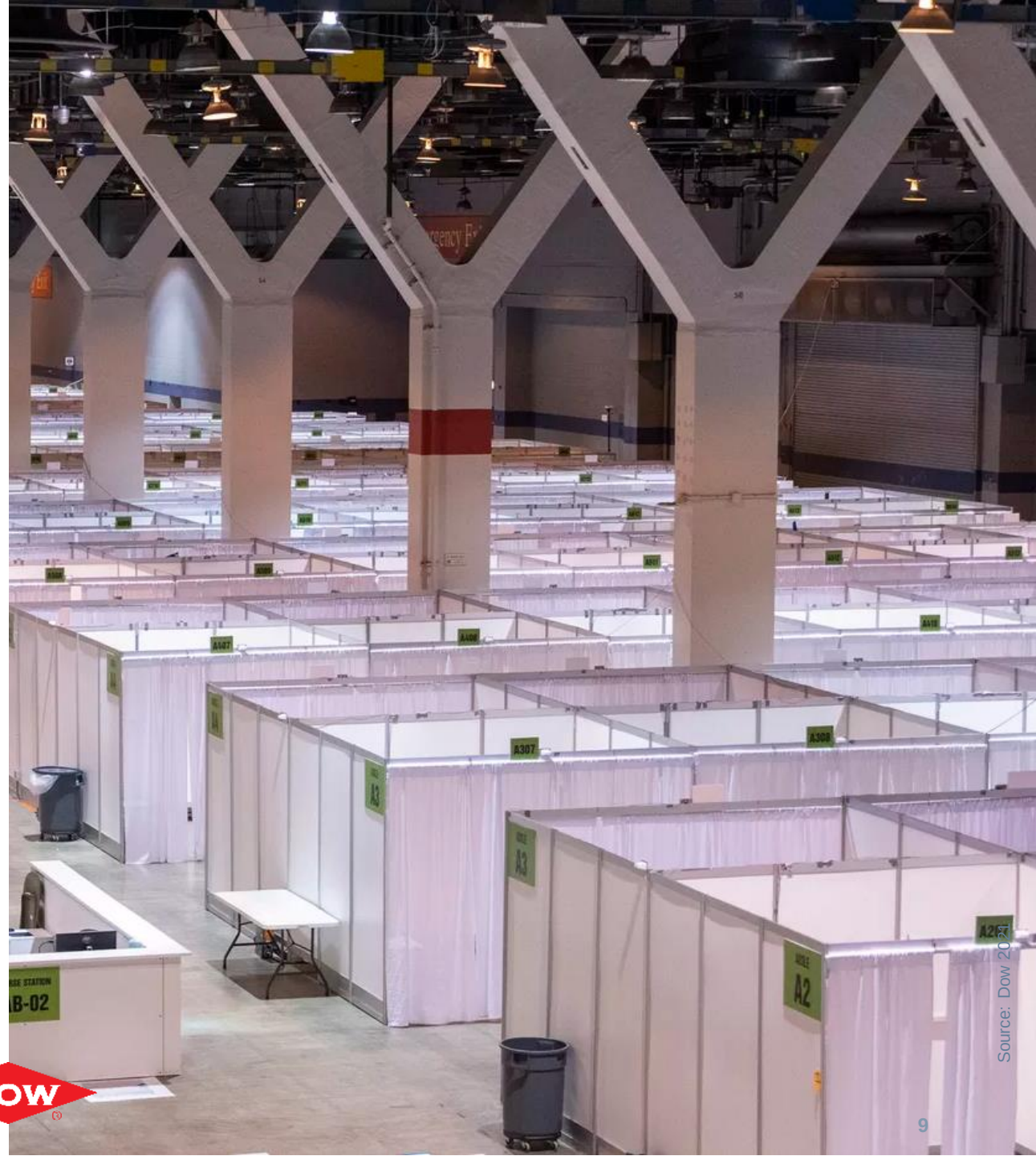
- **Chemistries:**
  - **Thermosetting:** Polyurethane (PUR), Polyisocyanurate (PIR), PVC/Polyurea Interpenetrating Network (IPN), etc.
  - **Thermoplastic:** PVC, Polyethylene terephthalate (PET), Polystyrene (EPS and XPS), Polymethacrylimide (PMI), etc.
- **Production:** Batch, Extruded
- **Densities:** 10 kg/m^3 to 500 kg/m^3 and larger
- **Applications:** Composite structural cores (Aerospace, Marine, Energy, etc.), insulation, residential construction (decks, trim, etc.), sheet

Acrylic processing aids optimized for extruded rigid PVC foam targeted for building and construction products

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Enabling the Essentials

- COVID-19 pandemic led to increased demand for PVC foam-based building materials
- At the height of the pandemic, convention centers and other public spaces were converted into temporary medical facilities and treatment centers using expanded PVC boards for antibacterial partition materials:
  - Azek VYCOM sheets at NYC Javits Center
  - 3A Composites SINTRA sheets at Chicago's McCormick Place
- Plastics Additives are essential in foam PVC products to meet stringent application requirements



Finished medical rooms at McCormick Place's emergency coronavirus hospital as it was opening in April 2020. Tyler LaRiviere / Sun-Times

Source: Dow 2021

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Presenters:



Dr. Rich Ketz
Technical Service Manager
Ph.D. Chemical Engg.
- Years with Dow: 30
- Years in Industry: 23

rketz@dow.com



Dr. Manoj Nerkar
Technical Service Manager
Ph.D. Polymer Engg.
- Years with Dow: 5
- Years in Industry: >15

mnerkar@dow.com



John Cornetta
Technical Service Manager
B.S. Chemistry
- Years with Dow: 8
- Years in Industry: 30+

jcornetta@dow.com

Source: Dow 2021

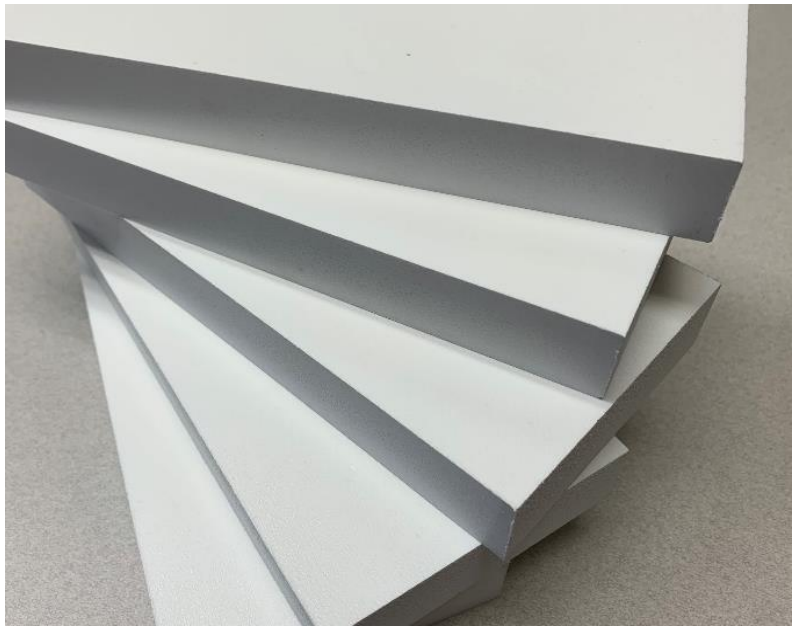
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Why Foam PVC?

Achieve properties that one can not achieve with solid rigid PVC







← ~1.5 g/cc → ~1.0 g/cc → ~0.5 g/cc →

- Raw Material Cost Reduction:
  - Density reduction from 0.55 to 0.50 g/cc can reduce RM cost by ~10%.
  - **Constraint**: Maintain physical or aesthetic properties

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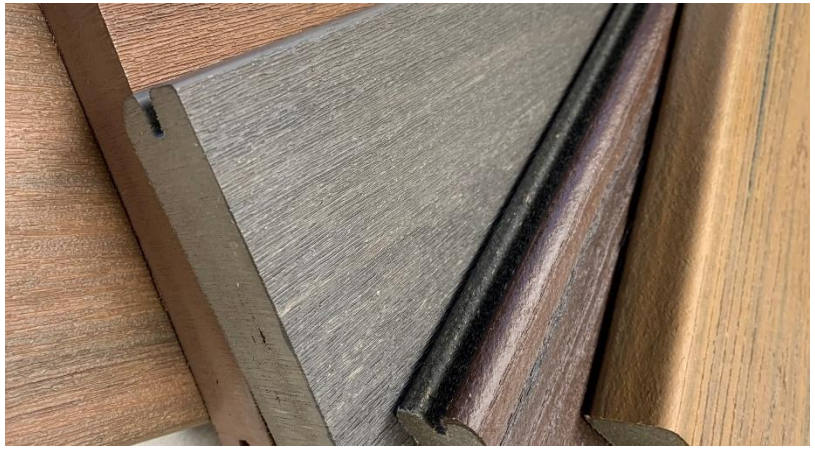
PVC Foam: Wide Range of Applications

Thick Sheet for Trim Board & Millwork

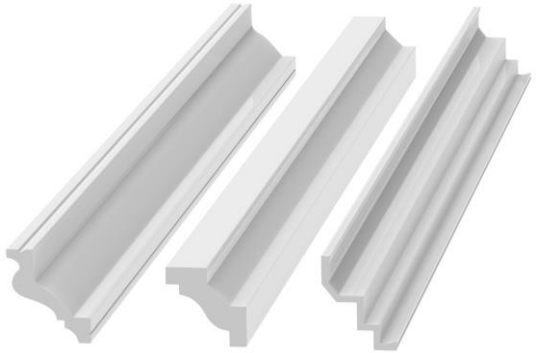




PVC Foam Core Decking



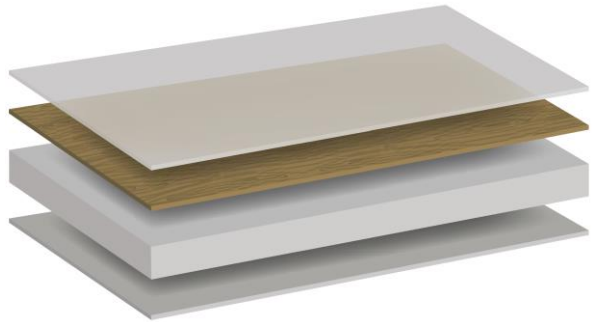
PVC Profile Moldings



Point of Display Sheet



Foam Core LVT



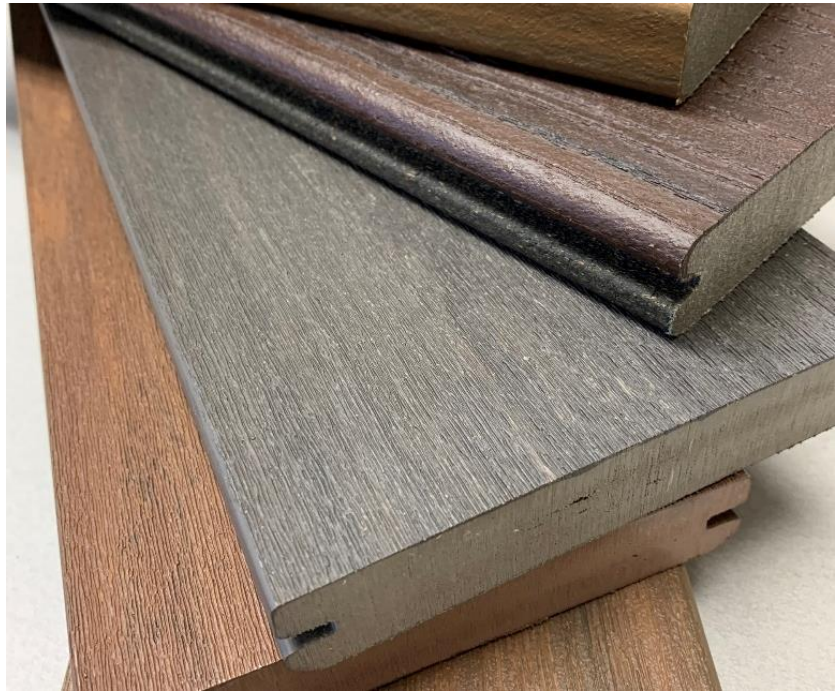
PVC Foam Core Pipe



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PVC Foam: Exterior Applications

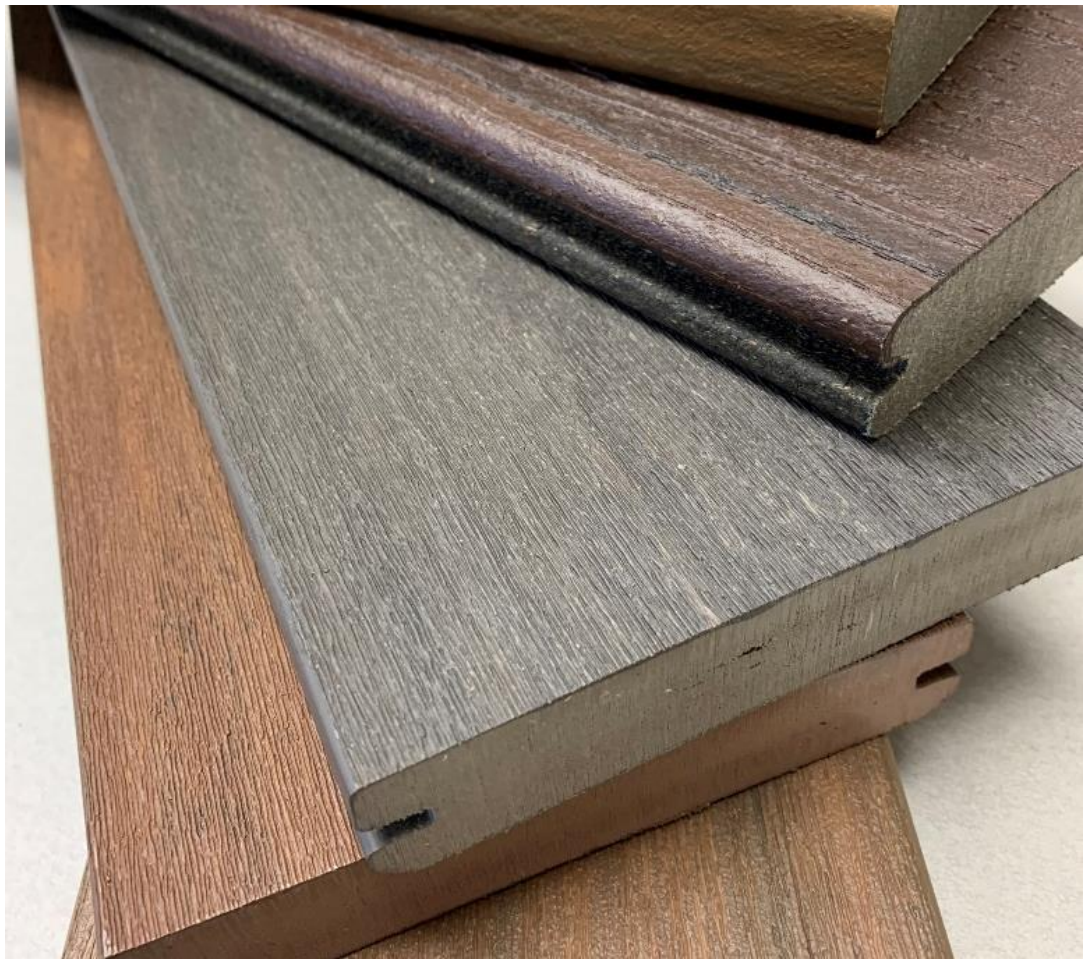




Deck Boards
Capped

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Typical PVC Foam: Deck Board and Fascia Applications

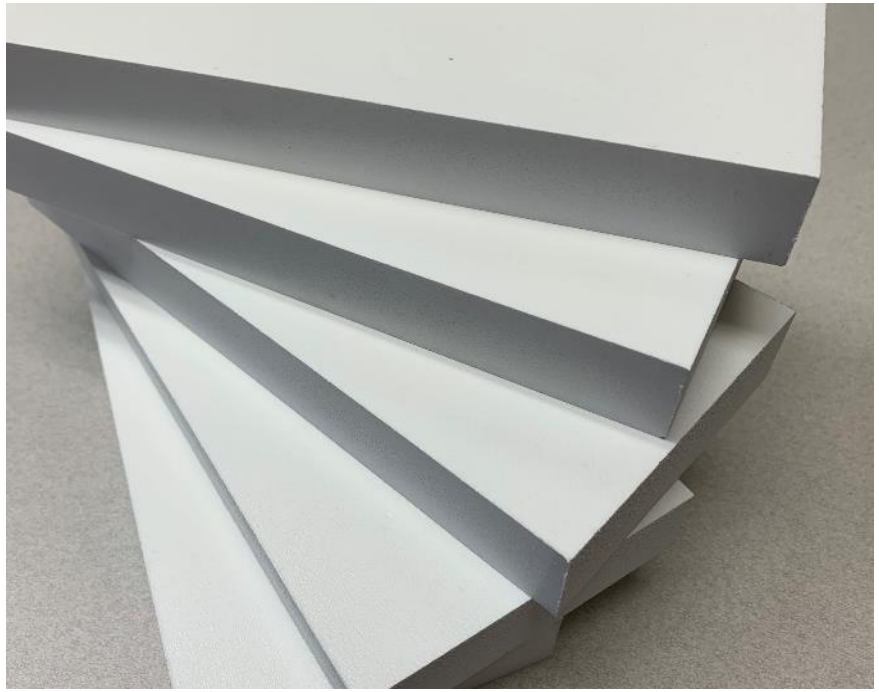


	Deck Board
PVC (K-58)	100
Processing Type	Capped with co-extruded Celuka
Sn Stabilizers	1.0 – 2.0
Lubricants (internal / external)	1.5 – 3.0
Fillers (CaCO3, TiO2, Talc, etc.)	20 – 40
Acrylic Processing Aids	5 – 10
Regrind/Recycle (%)	10 – 30
Chemical blowing Agent	0.5 -1.0

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PVC Foam: Exterior Applications





Trim Boards
Free foam white or can be painted

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PVC Foam Formulations (PHR): Trim Board Applications

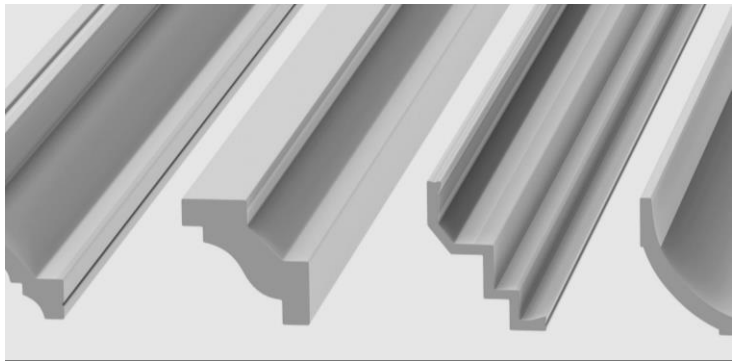


	Trim Board
PVC (K-58)	100
Processing Type	Free foam or Celuka
Sn Stabilizers	1.5 – 2.7
Lubricants (int./ext.)	1.5 – 4.0
Fillers (CaCO3, TiO2, Talc, etc.)	10 – 25
Acrylic Processing Aids	4 – 12
Regrind/Recycle (%)	5 – 25
Chemical blowing Agent	0.5 -1.0

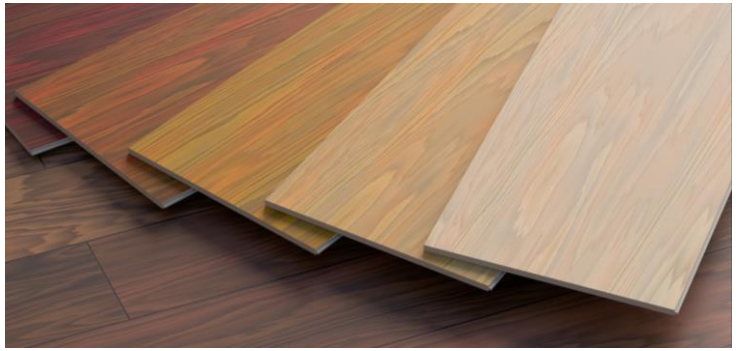
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PVC Foam: Interior Applications

PVC Moldings and Trim



LVT Flooring

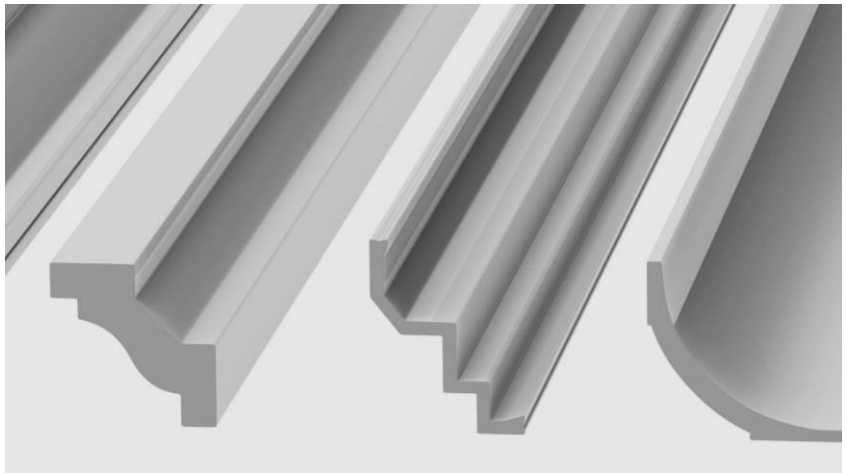


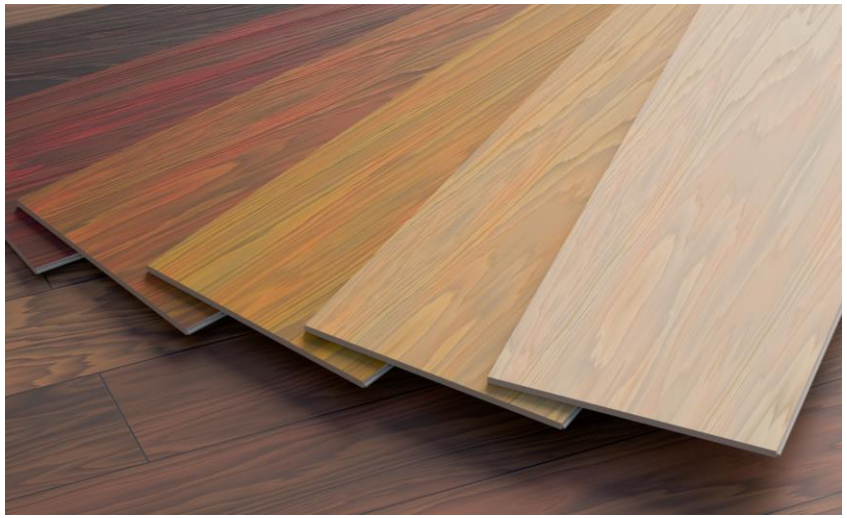


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PVC Foam (PHR): Applications and Formulations

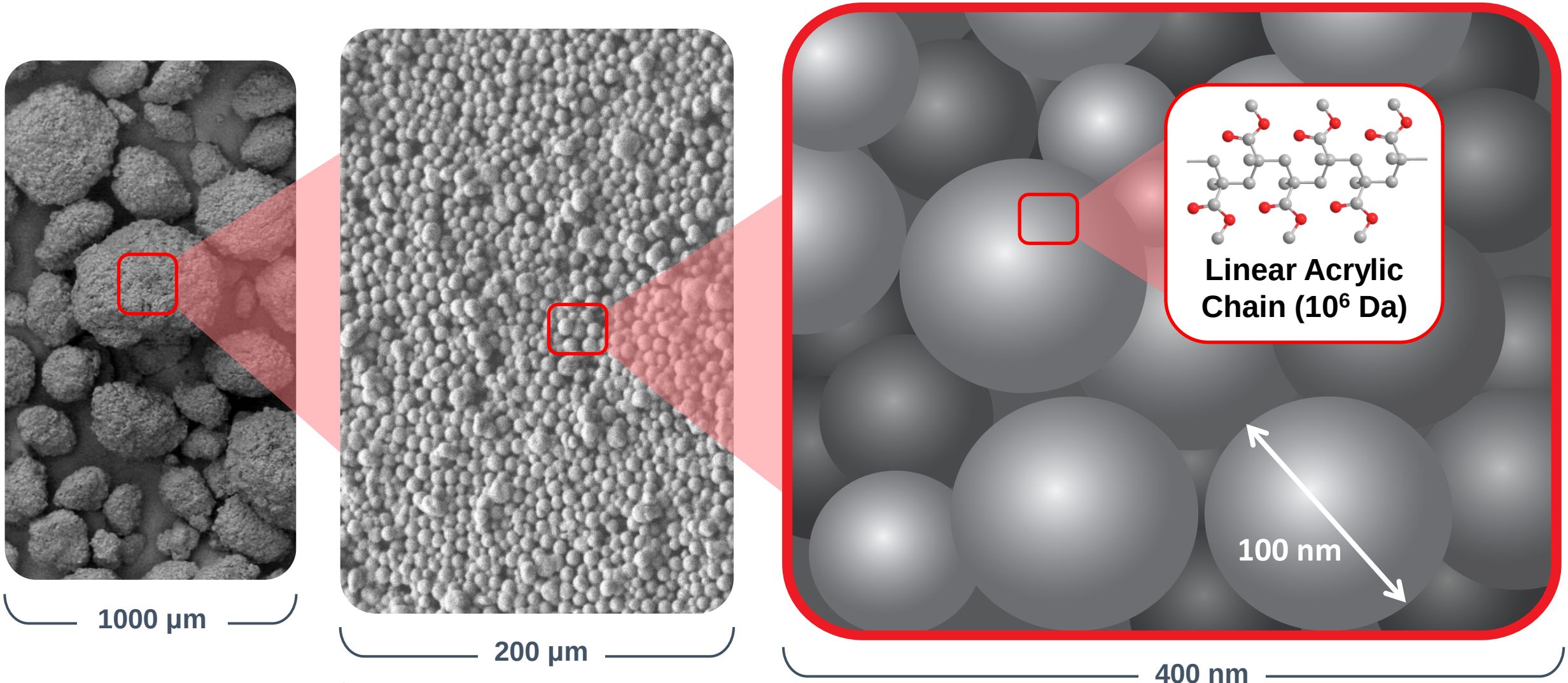
	Profiles	LVT Flooring
PVC	100 (K-58)	100 (K-62)
Processing Type	Celuka	Free foam, laminated
Stabilizers	1.0 – 2.0 (Sn)	4-8 (Ca. Zn.)
Lubricants (internal / external)	1.5 – 3.0	1 – 4
Fillers (CaCO3, TiO2, Talc, etc.)	10 – 20	100 – 300
Acrylic Processing Aids	3 – 8	2 – 10
Regrind / Recycle (%)	5 – 10	20 – 40
Chemical blowing Agent	0.5 -1.0	0.5 - 1.0





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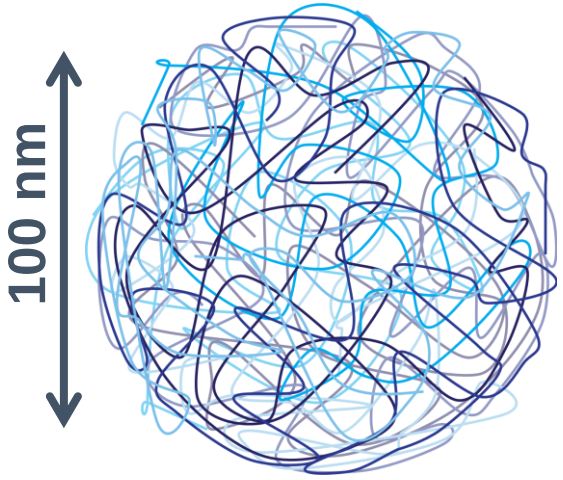
Powder Product: Powder Grains Consist of Acrylic Polymer Nanoparticles

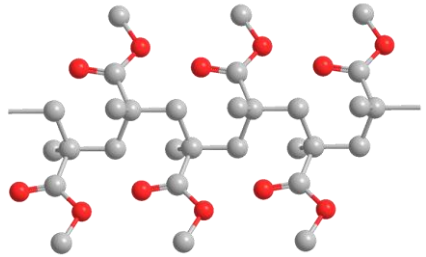


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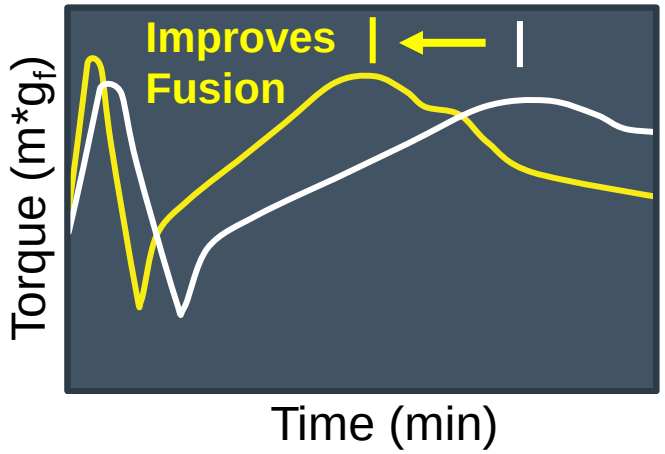
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Attributes of Acrylics: Promote Fusion, Enhance Rheology



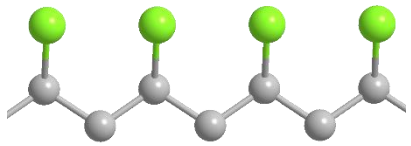


Linear Acrylic Chain
(10^6 to 10^7 Da)

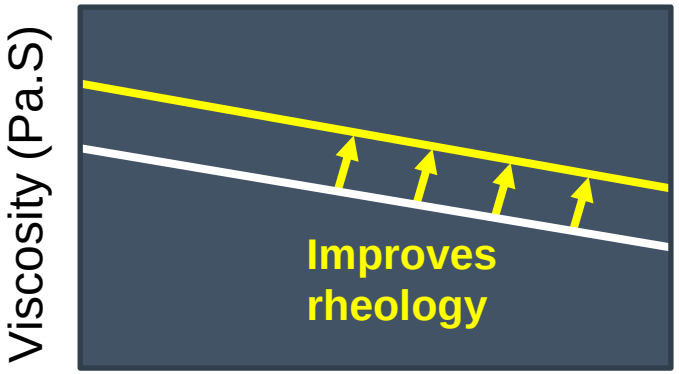


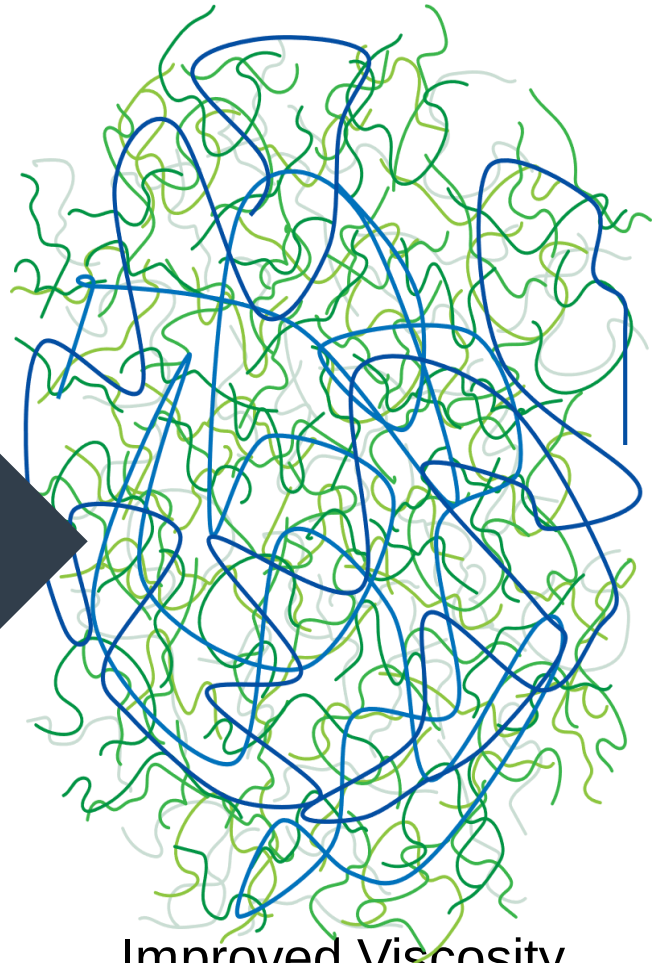
Component Powder Blend → Melt Process (Fusion) → Polymer Alloy





PVC Chain
(10^4 Da)



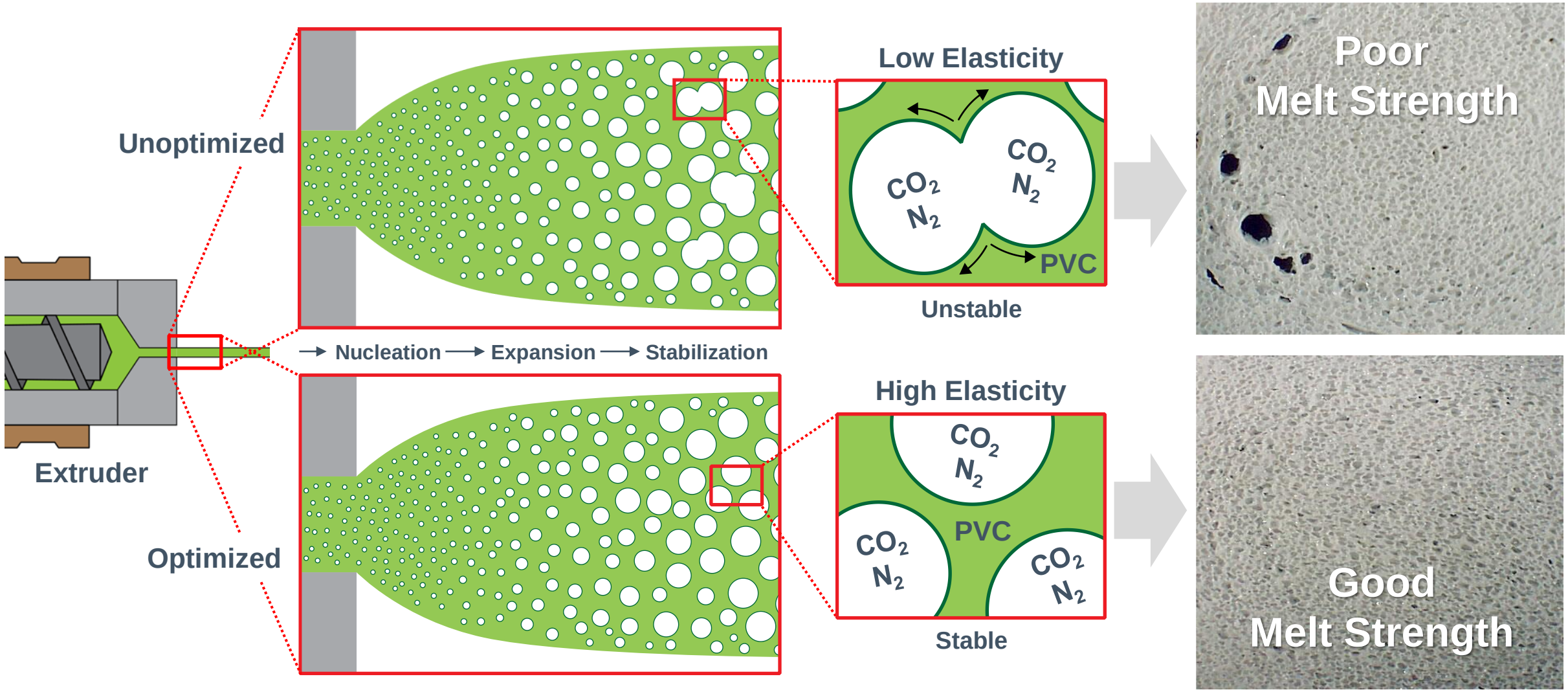


Improved Viscosity,
Elasticity, Melt Strength

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Foam Processing Aids: High Molecular Weight Improved Melt Strength, Elasticity



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Dow Product Portfolio

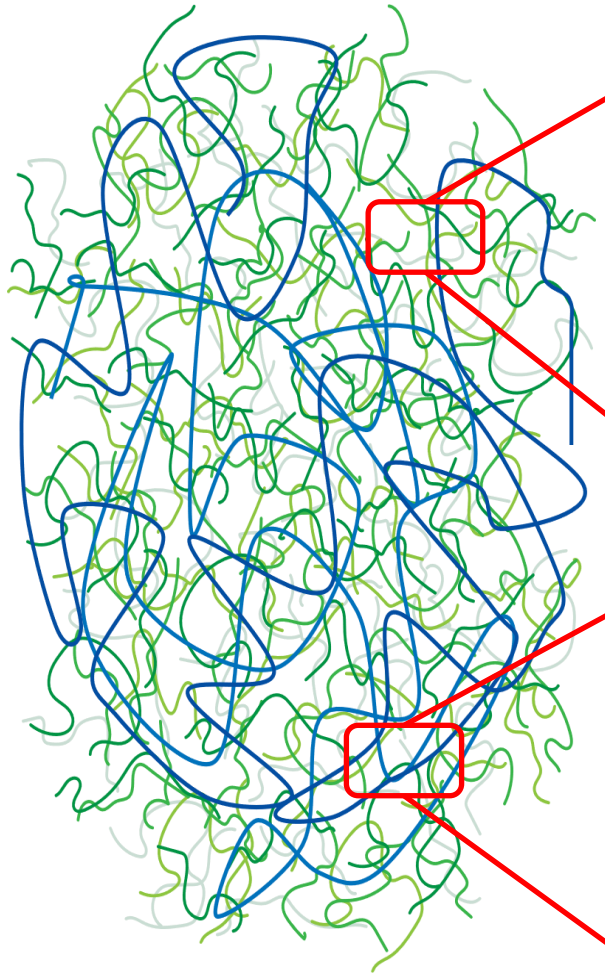
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Dow Processing Aids Suite: For All PVC Foaming Needs

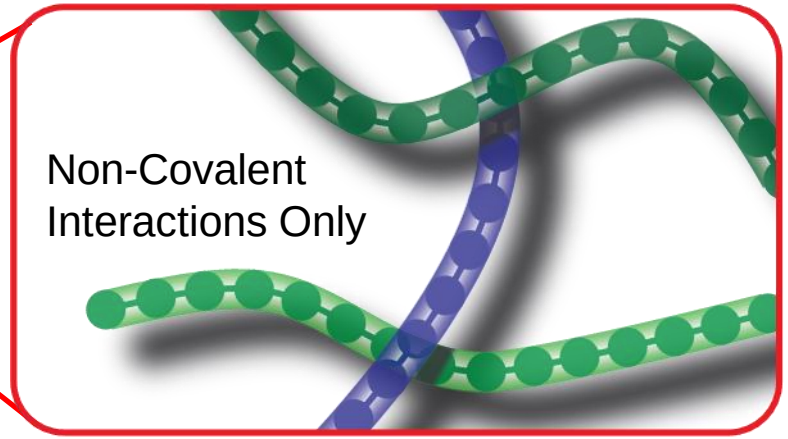
Processing Aids	Relative Mw (vs. K-400)	Function	Key Advantages
PARALOID™ K-175	-	Lubricating PA: PVC melt to hot metal release	Reduced plate-out, longer run times
PARALOID™ K-415 / K-416	= / +	Melt Strength and Lubricating	Balanced property combination for foam core pipes
PARALOID™ K-445	+	Melt Strength & Elasticity (entanglement)	Very robust processing window
SURECEL™ 467	++		Wide processing window, higher efficiency and expansion
SURECEL™ 488	+++		BEST efficiency and expansion
SURECEL™ T-60	+, plus functionalized	Melt Strength & Elasticity (entanglement and reactive)	Less cell rupture, lower density, better cell structure

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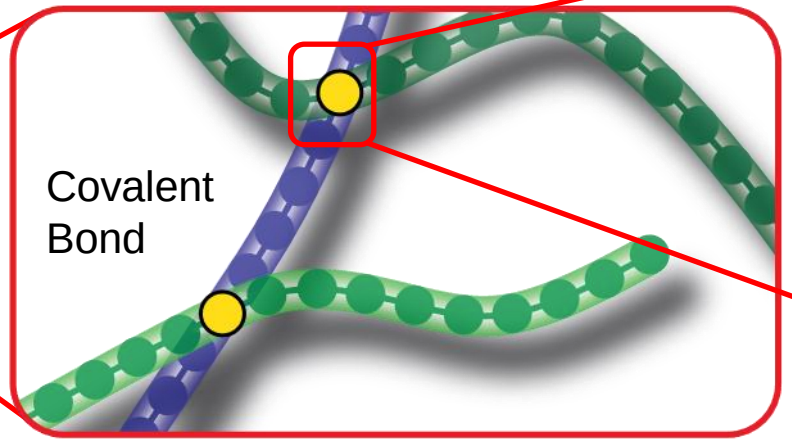
Product Modes of Action: Entanglement Only or Entanglement + Reaction



Conventional UHMW Foam PA



Reactive Foam PA

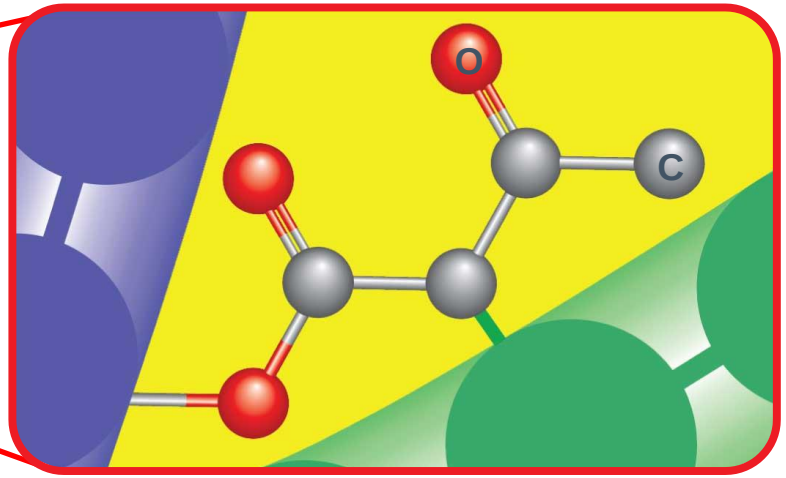


PVC repeat unit

Acrylic repeat unit

Bond

Beta-Diketoester Functional Acrylic Chain Reacts with PVC*



P. Van Rheenen et al. US8722250B2, **2014**

* M. Tong et al., *Int. J. Mol. Sci.* **2011**, 12, 1756-1766.

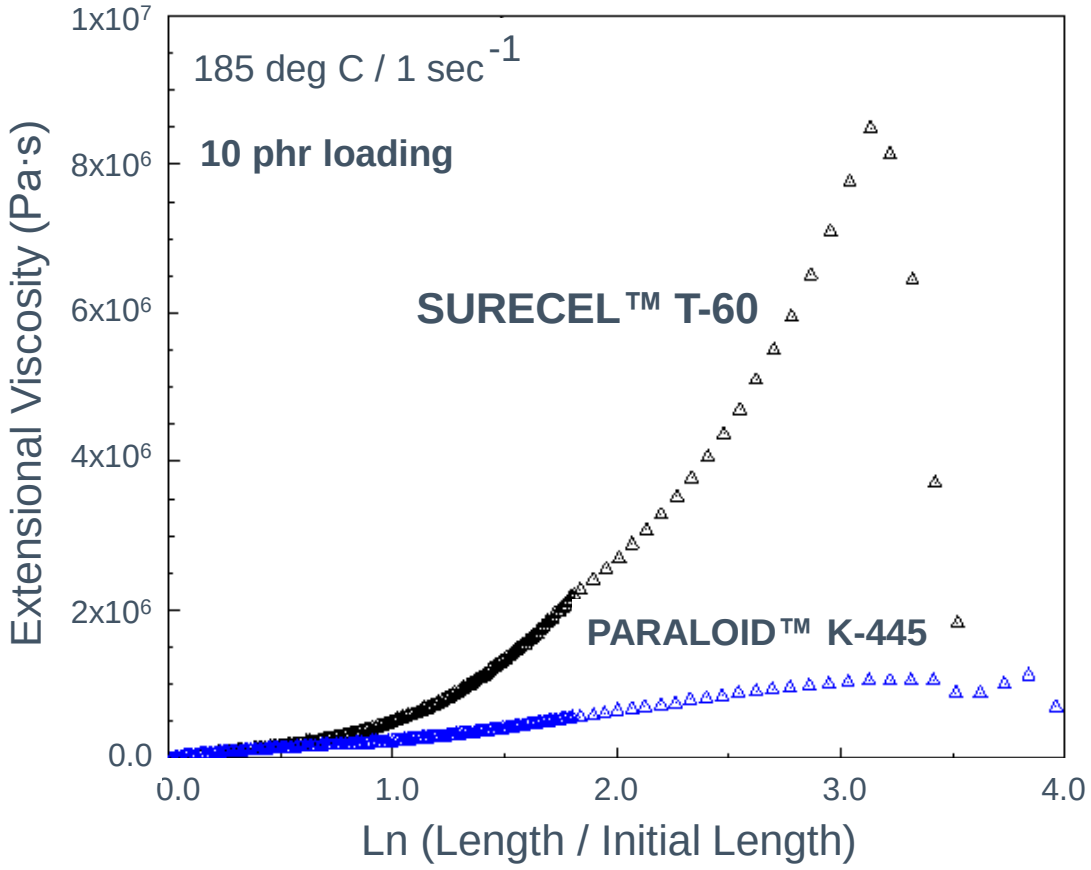
B. Staniszewski et al., *Chem. Papers,* **2009**, 63, 212–216.

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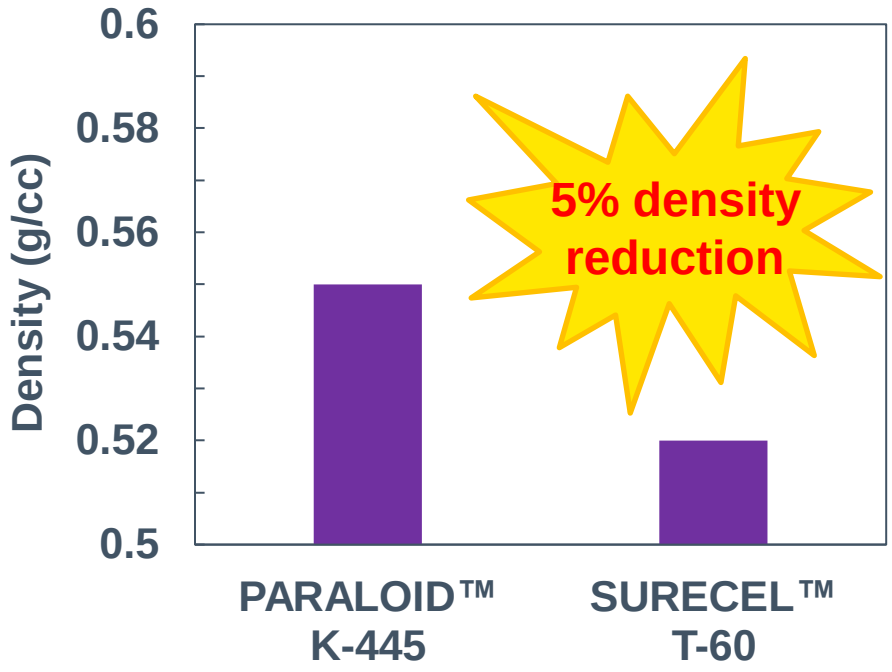
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SURECEL™ T-60 Processing Aid: Chemical Grafting Increases Extension Viscosity

Reduces Cell Rupture for maximum gas capture and improved cell structure.



Foam sheet extrusion at 10phr of Processing Aid and Fixed CBA

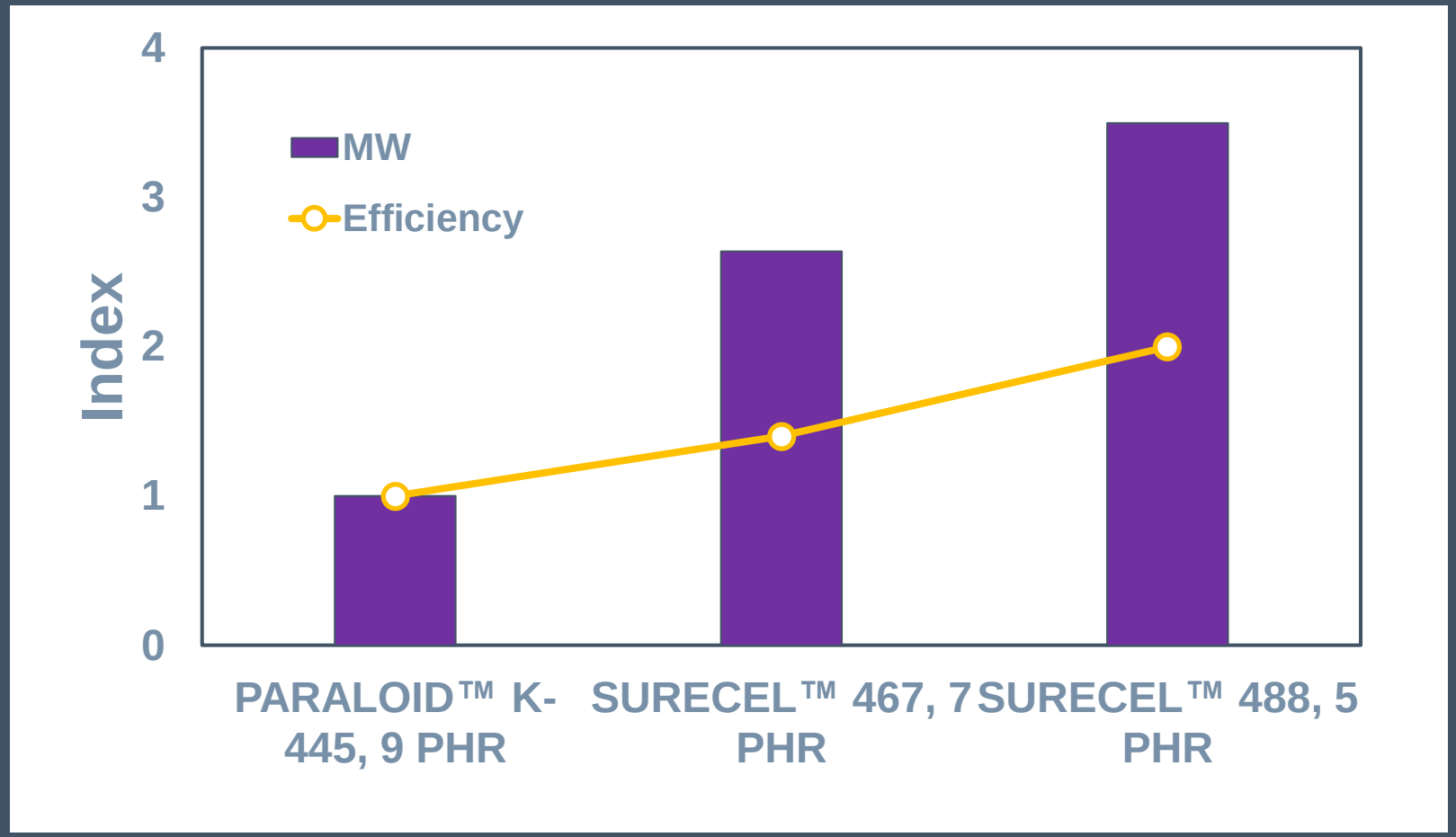


SURECEL™ T-60 also improves cell structure and limits large voids.

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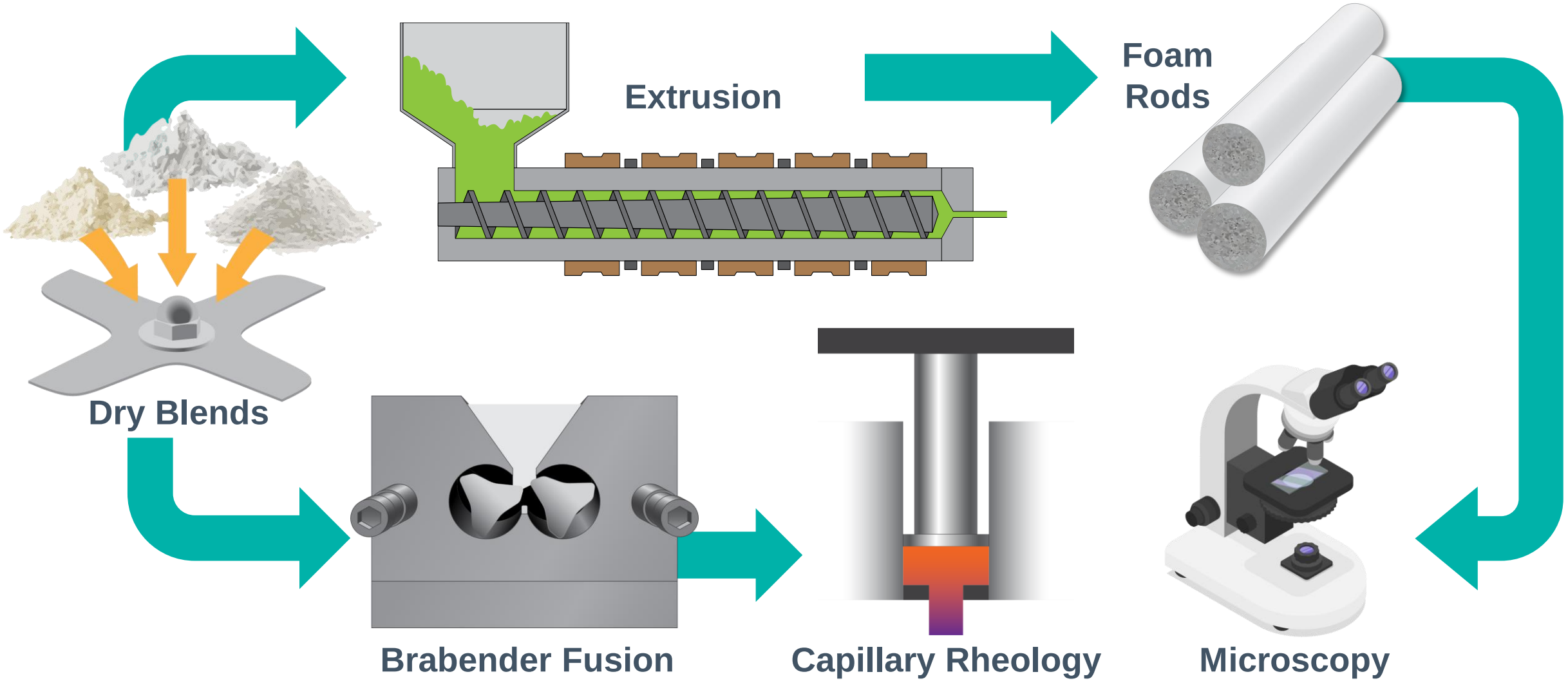
Case Study:

Comparison of PARALOID™ K-445, SURECEL™ 467, SURECEL™ 488 Processing Aids



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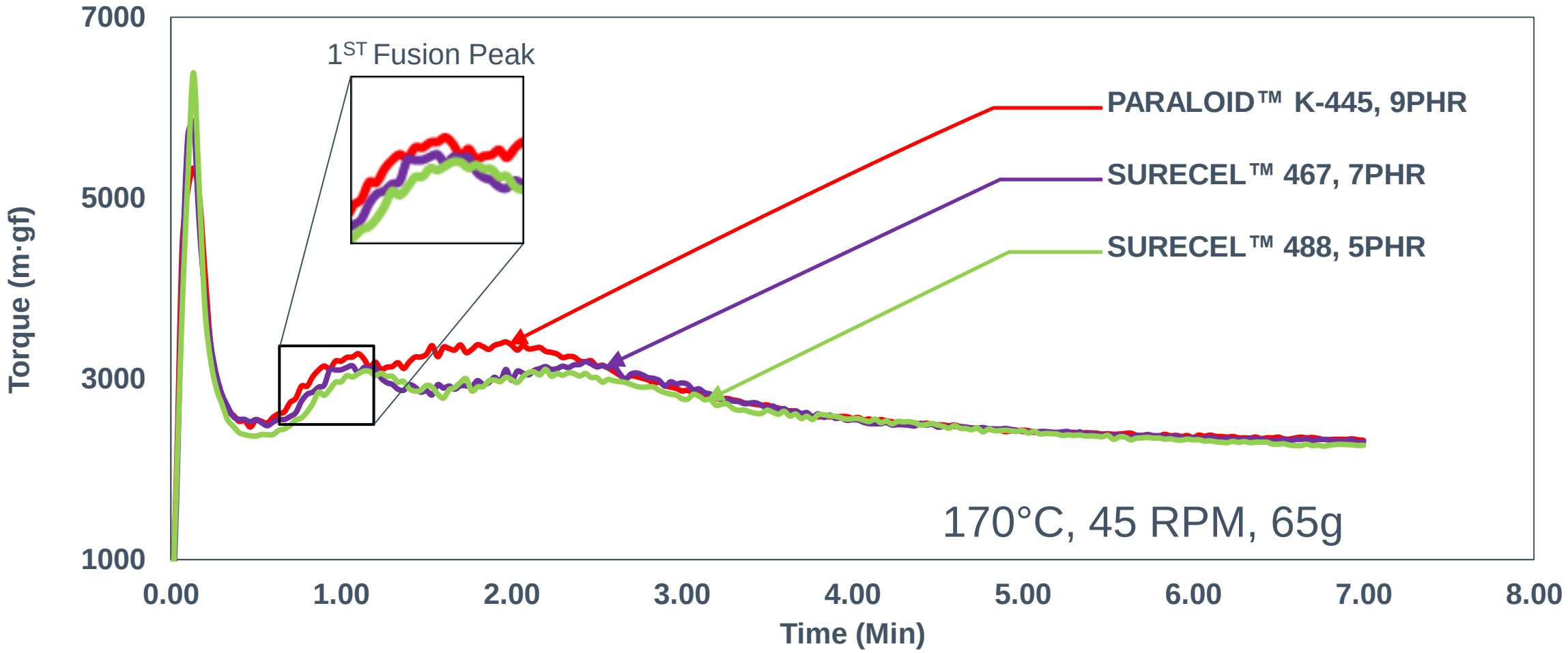
Workflow: Evaluation of Foam Formulations and Process in State of Art Labs



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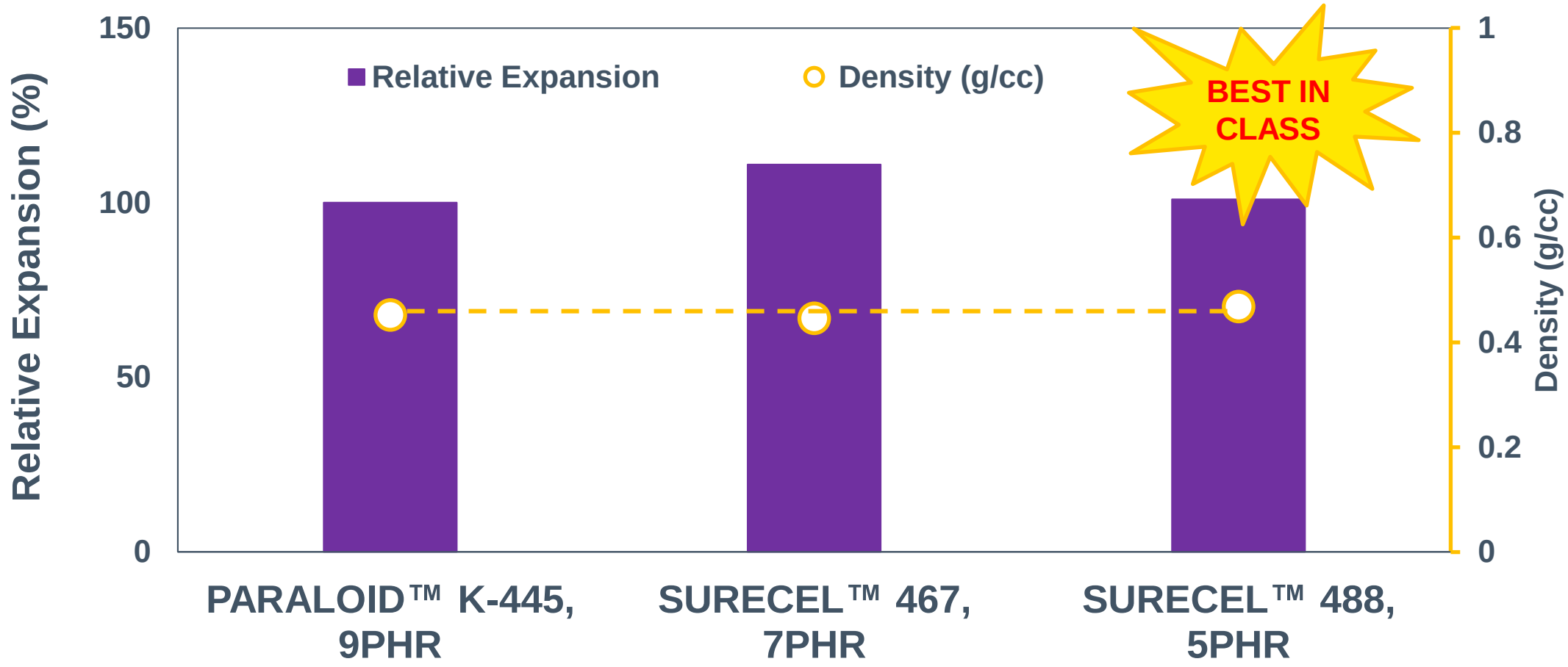
Similar Fusion Characteristics: Offers Drop-in Replacement



Similar fusion characteristics were observed with UHMW PA at lower level

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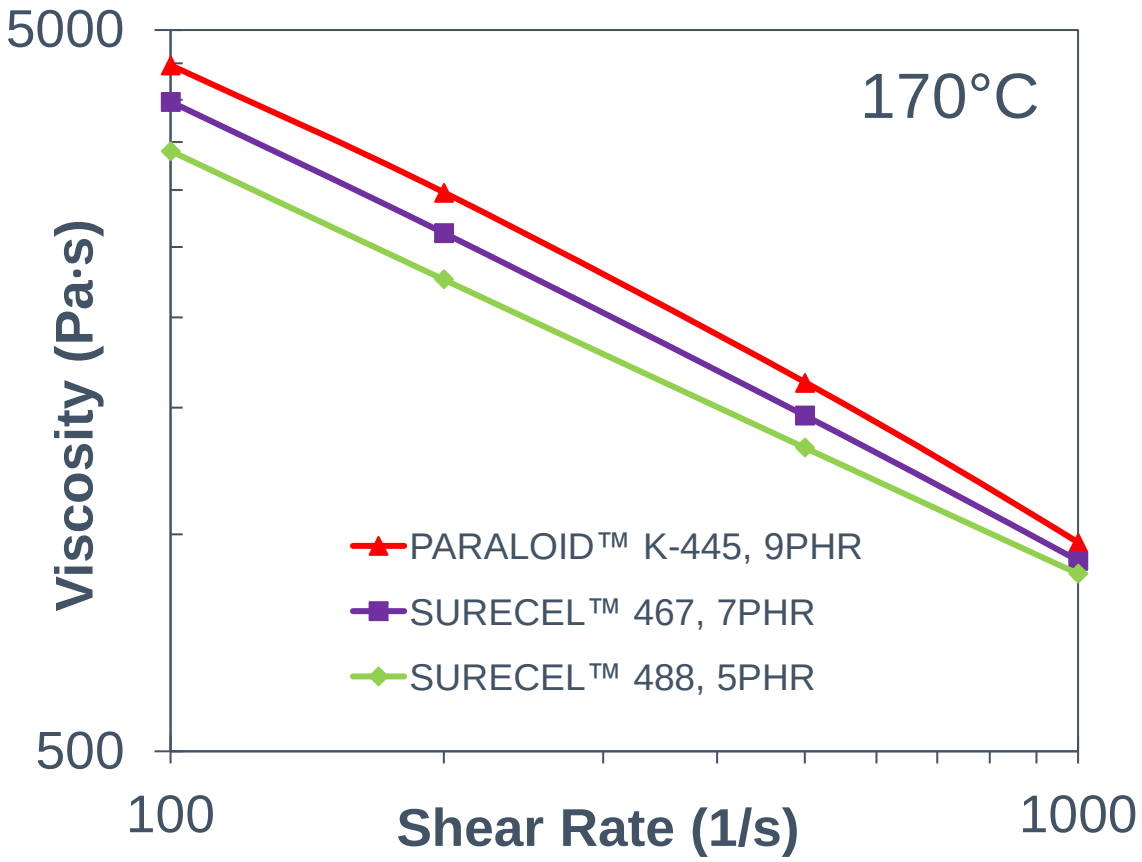
Density, Expansion: SURECEL™ 488 is ~ 50% efficient than PARALOID™ K-445



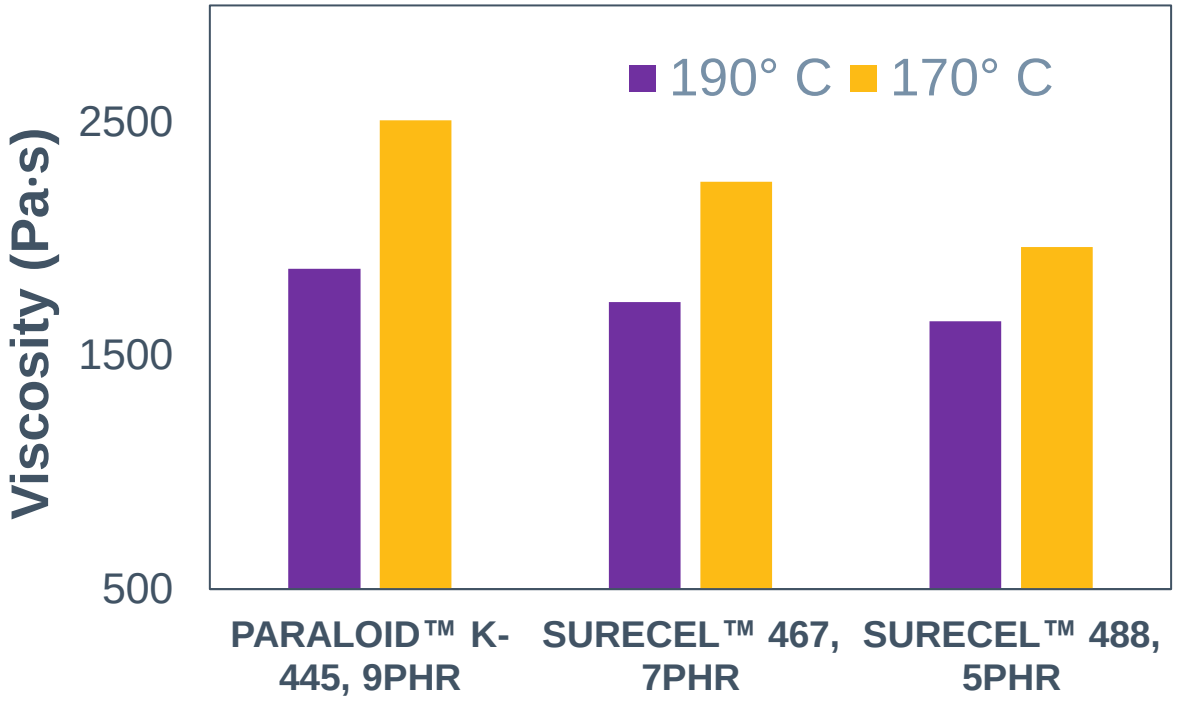
Similar foaming performance was observed with UHMW PA at lower level

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Melt Rheology: Higher Efficiency Does Not Affect Melt Viscosity



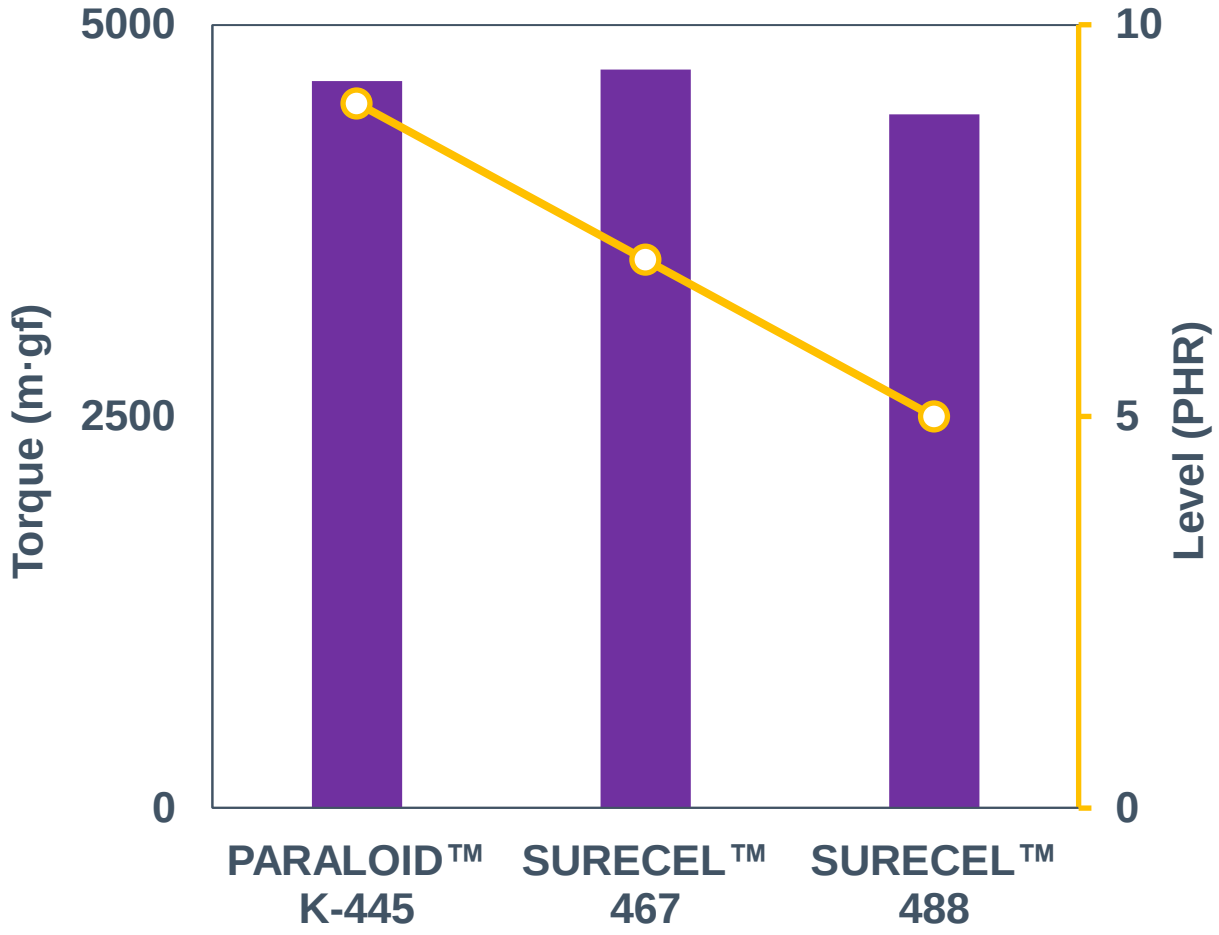
Avg. Viscosity in shear range 100-1000 (1/s)

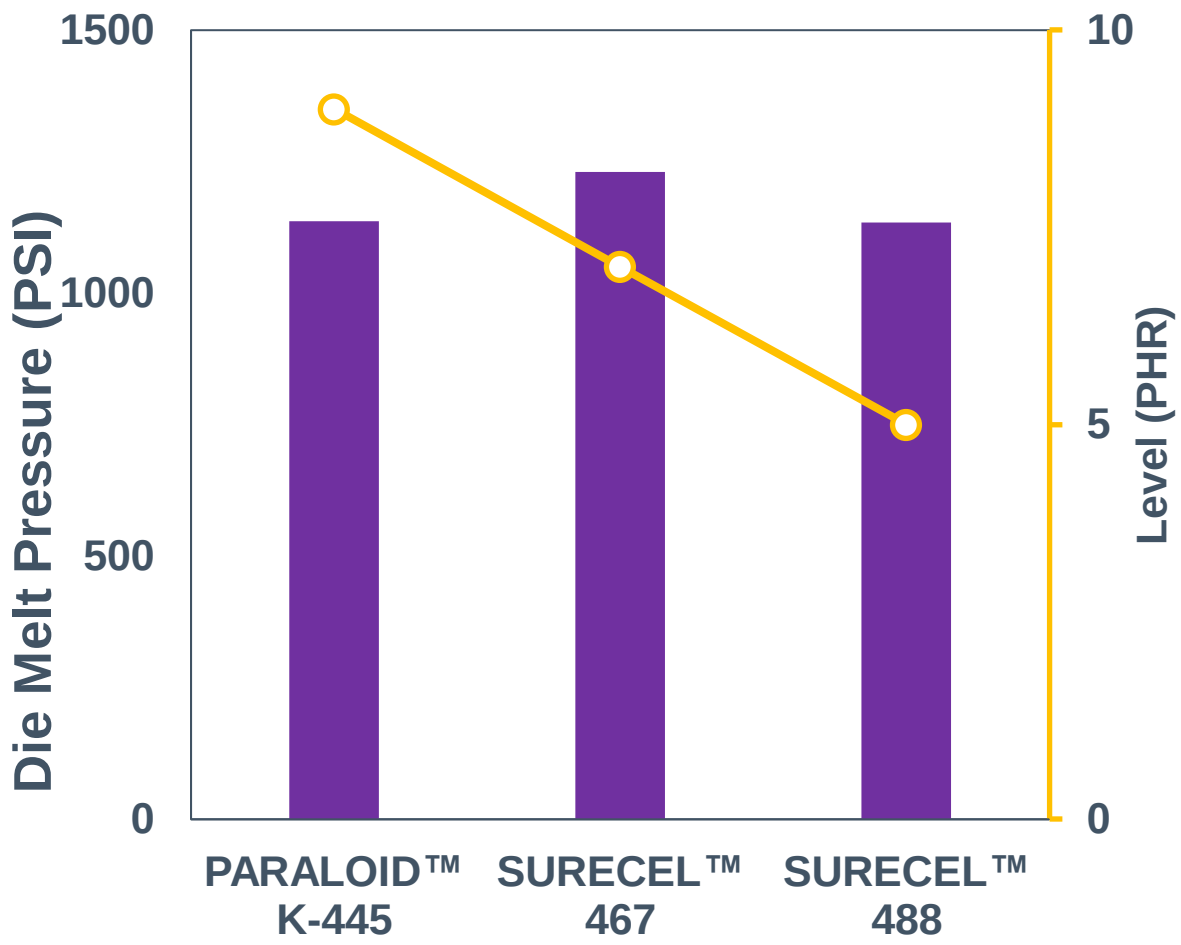


UHMW PA shows similar or better melt flow

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Robust Processing: Optimized Loadings of Acrylic Maintains Melt Processing

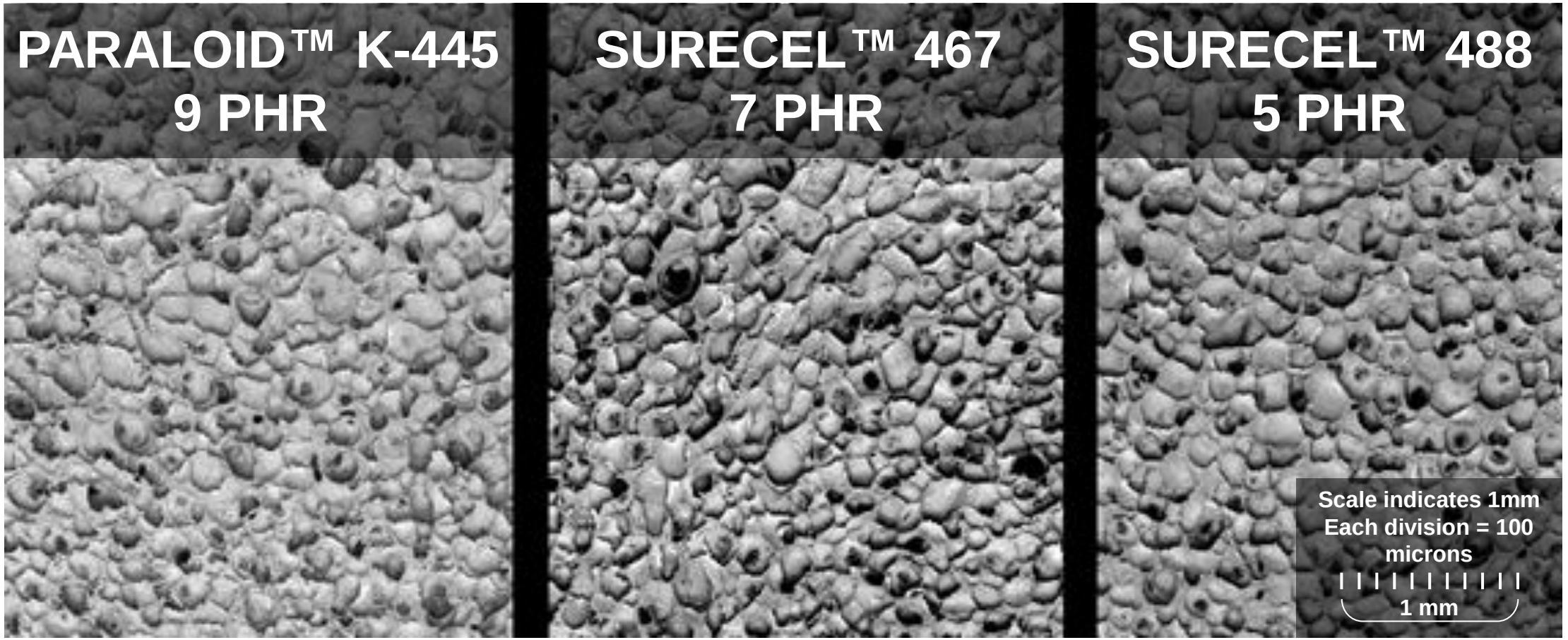




No substantial difference was observed in torque, pressure and melt temp

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Cell Morphology: Uniform Cell Structure at Lower Acrylic Levels



UHMW PA maintained cell morphology at lower loading level

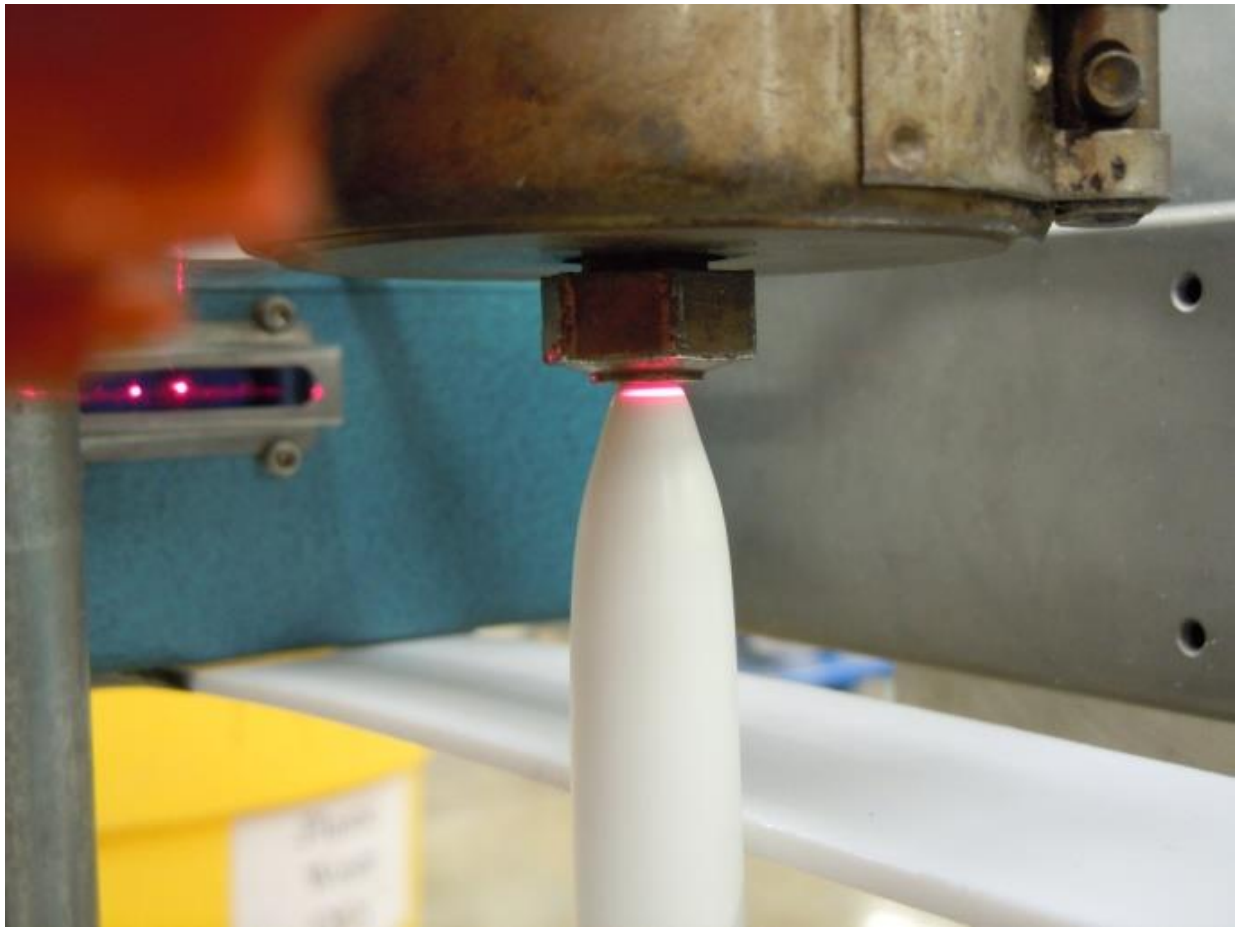
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New Lab Capabilities

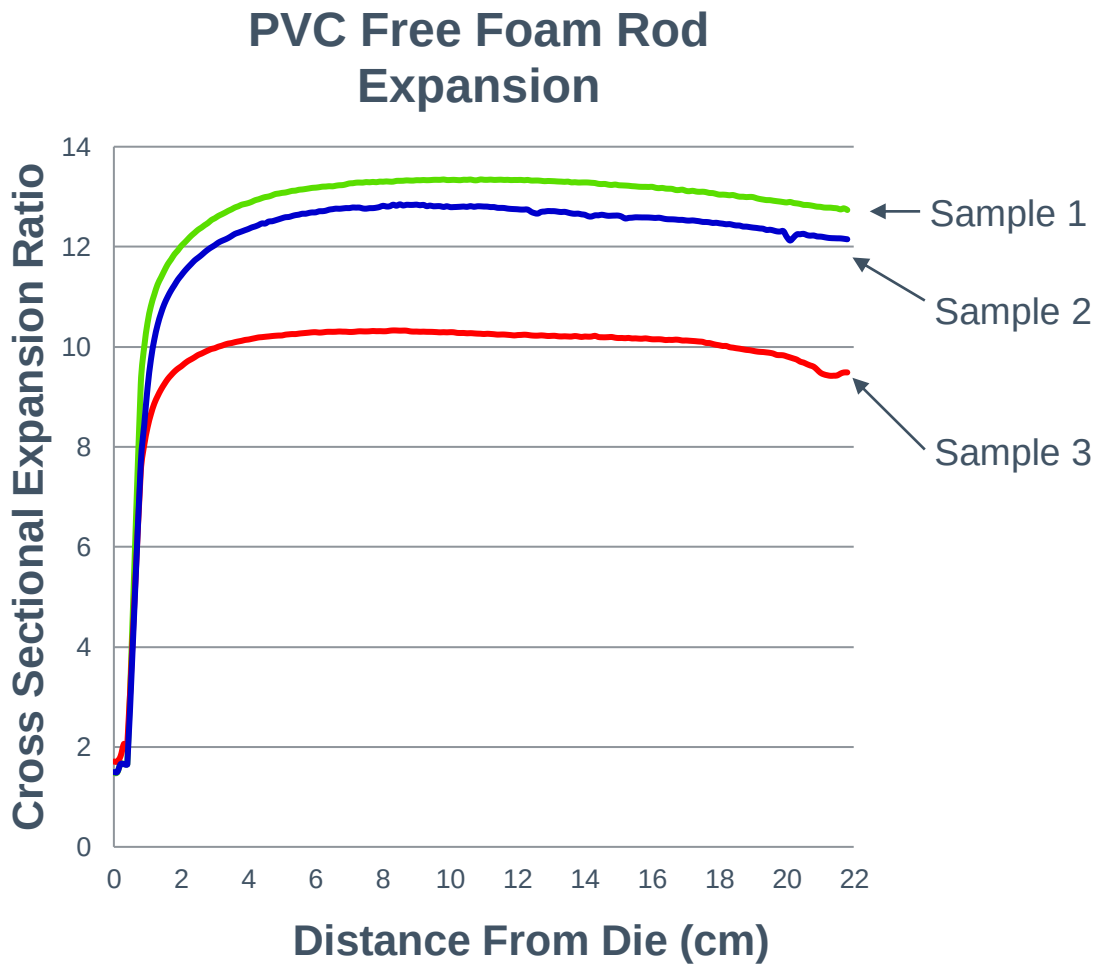
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DPA Foam Study Capabilities: Differentiation of Expansion Rate and Density

- Ladder studies for PA or additive levels



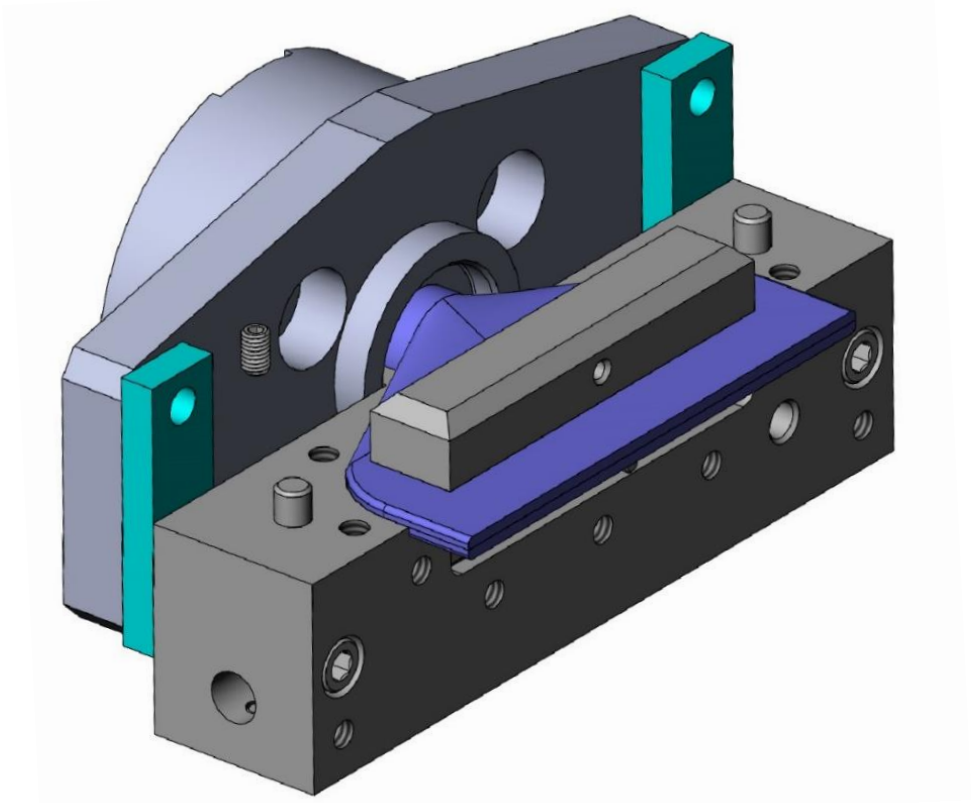
P. Van Rheenen et al. WO2013095876A1, **2013**

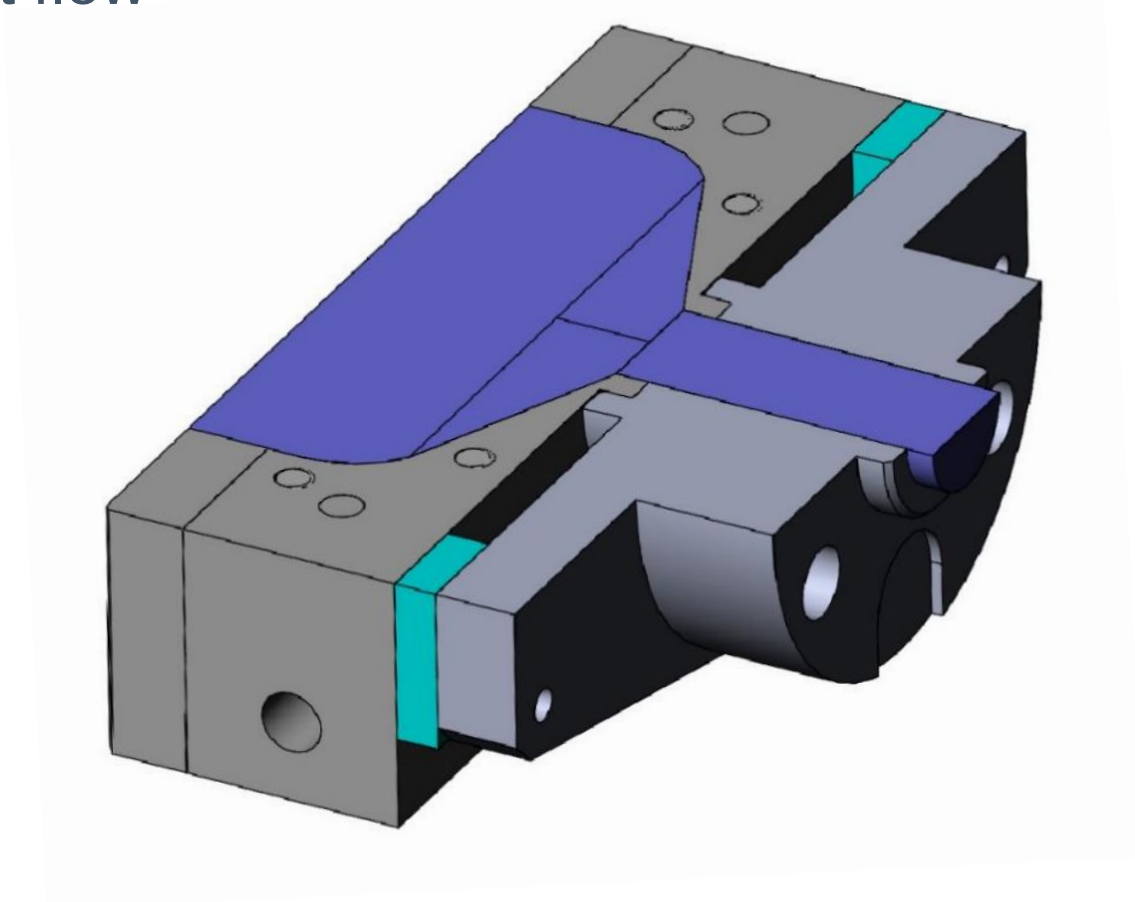


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CAD Die Design: For Lab Free Foam Testing

Designed to simulate production scale melt flow





Free foam PVC die for Leistritz 27mm twin screw extruder

The graphic representations are presented here for illustrative purposes only and should not be construed as product specifications

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New Pilot Foam Line: Scale up, Predictability, Testing

Picture will be replaced by video



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Sustainability: Recycle, Rework, Regrind PVC







vinyl INSTITUTE

- ~9MM MT of virgin PVC consumed in NAR in 2019
- In 2019 approx. 500,000 MT of PVC were recycled by >100 PVC recyclers
- Majority of recyclates are from **industrial** or **pre-consumer** recycling

Regrind/Rework: In-House scrap. Trimmings, off spec, returned product etc.

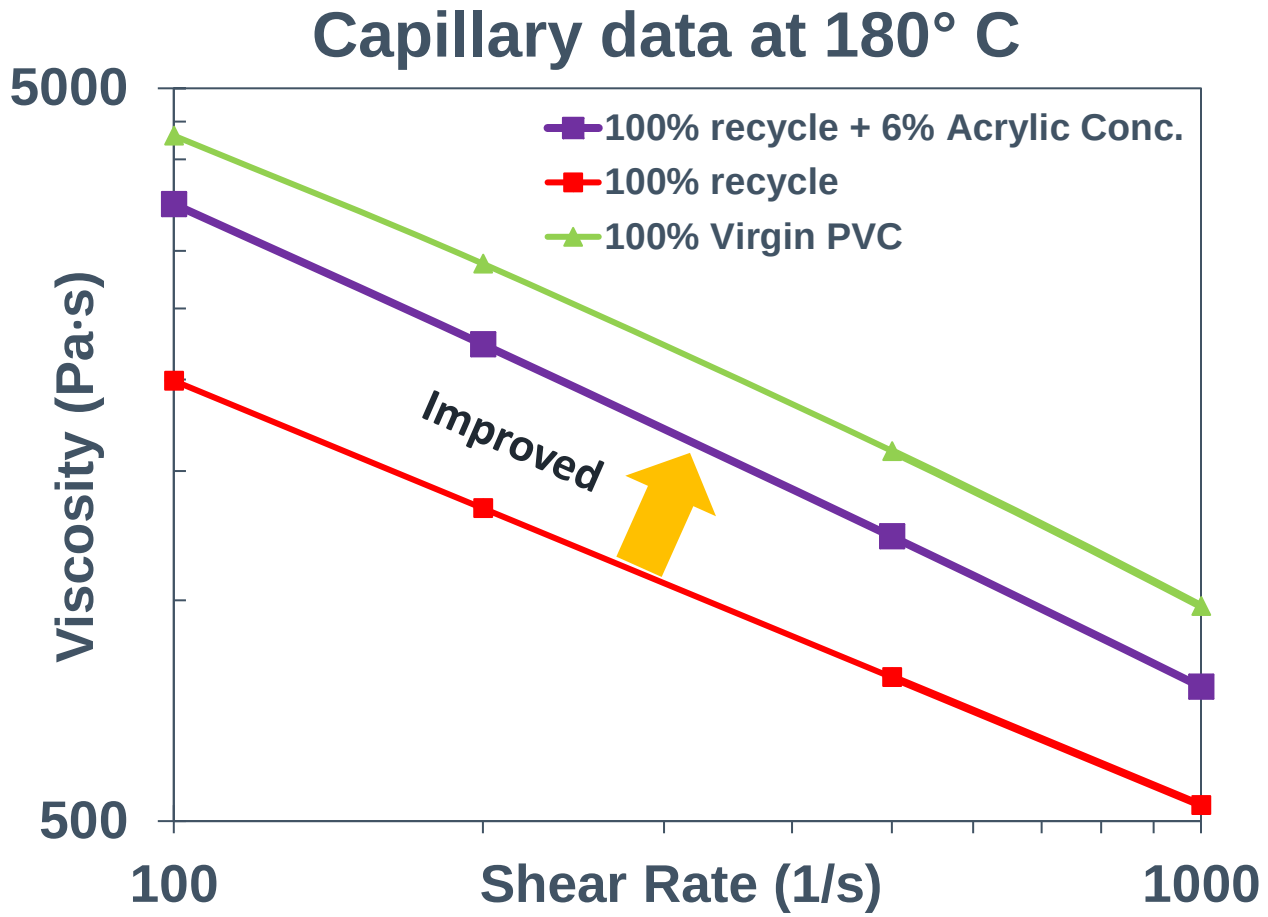
Recycle: Outside materials with potential variability. Pipe, window, card stock etc.

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Sustainability: Dow's Acrylic One Pack solution in Pellet form

Acrylic Processing Aids can improve processability of recycled PVC





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Conclusion and Q&A

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In conclusion…

- Polymer foams play a critical role in our world in a broad range of applications ranging from building and construction to durable goods to marine and transportation.
- PVC foam in particular continues to see growing demand due to PVC's performance attributes vs. cost balance
- In order to achieve this, however, PVC compounders and manufacturers need the right processing aids in their formulations.
- Our team here at Dow Plastics Additives has decades of experience in this area and we offer a broad range of solutions to meet your needs.
- Contact us to see how we can help you achieve your objectives!



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Source: Dow 2021

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