ACRYLIC IMPACT MODIFIERS FOR RIGID PVC COMPOUND: COMPOSITE AIM TECHNOLOGY

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PVC AUSTRALIA 2018

ARKEMA

INNOVATIVE CHEMISTRY

CONTENTS

Acrylic Impact Modifiers

- Core / Shell impact modifier design
- Modes of failure and formulation
- Arkema technology

Durastrength® Acrylic Impact Modifier (AIM) Performance

- PVC formulation and application specifics
- Durastrength® AIM product range
- Arkema composite impact modifier technology
- New Durastrength® 367

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ARKEMA PLASTICS ADDITIVES

CLEARSTRENGTH® BY ARKEMA

MBS IMPACT MODIFIERS

- Core shell based on METHYL METHACRYLATE / BUTADIENE / STYRENE
- Excellent cold impact performance
- Best balance of transparency / impact performance
- Main applications: PVC film & sheet, CPVC pipes & fittings, and engineering resins

DURASTRENGTH® BY ARKEMA

ACRYLIC IMPACT MODIFIERS

- Core-shell based only on ACRYLIC monomers
- Best balance of impact performance / weathering properties
- Main applications: PVC window profiles, pipe and fittings, fencing, siding, roofing membranes

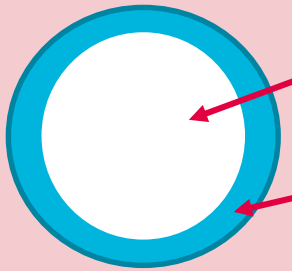
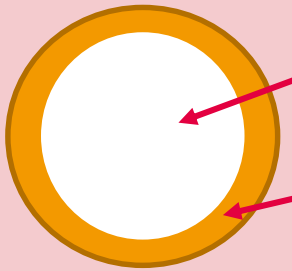
PLASTISTRENGTH® BY ARKEMA

ACRYLIC PROCESSING AID

- High molecular weight ACRYLIC copolymers
- PVC fusion promotion and rheology enhancer
- Main applications: PVC Flooring, Foam, Film & Sheet, Pipe and Profiles, Vinyl cladding, and Fence and Rail

ARKEMA INNOVATIVE CHEMISTRY

CORE / SHELL TECHNOLOGIES

Methacrylate – Butadiene – Styrene (MBS)	Acrylic Impact Modifiers (AIM)
 pBd core (Tg ~ -80°C) pMMA shell	 pBA core (Tg ~ -45°C) pMMA shell
• **Excellent low temperature impact** • **Excellent colorability** • Non-weatherable • Acceptable thermal stability	• Good low temperature impact • Good colorability • **Excellent UV stability** • **Excellent thermal stability**
CLEARSTRENGTH BY ARKEMA **MBS Impact Modifiers**	DURASTRENGTH BY ARKEMA **Acrylic Impact Modifiers**

ACRYLIC IMPACT MODIFIERS

ARKEMA CORE-SHELL TECHNOLOGY

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CLEARSTRENGTH® BY ARKEMA

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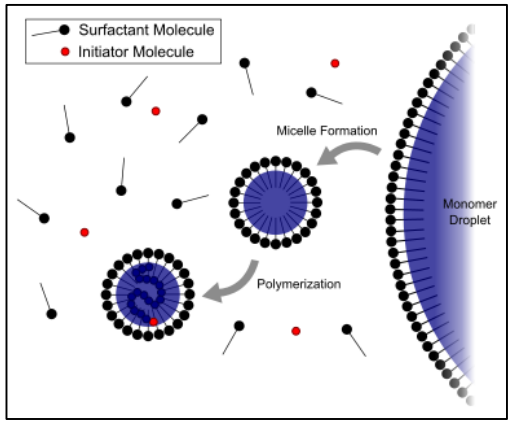
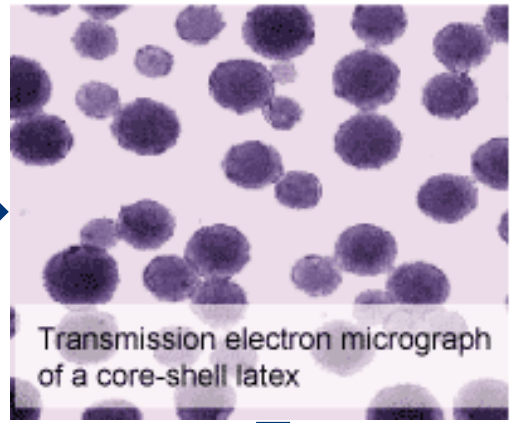
CORE/SHELL ACRYLIC IMPACT MODIFIER (AIM) SYNTHESIS, STRUCTURE, AND KEY PARAMETERS

Monomers



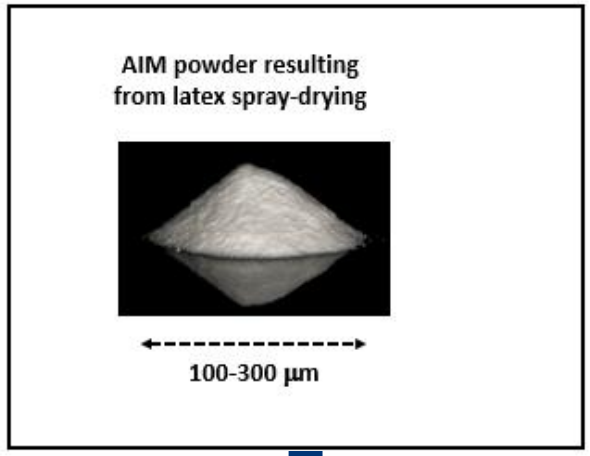
Emulsion Polymerisation

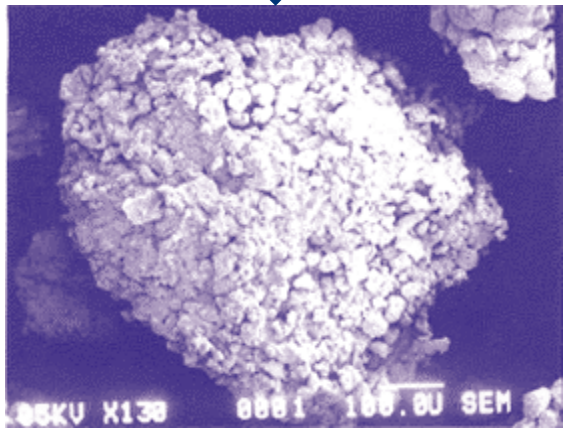
AIM Latex



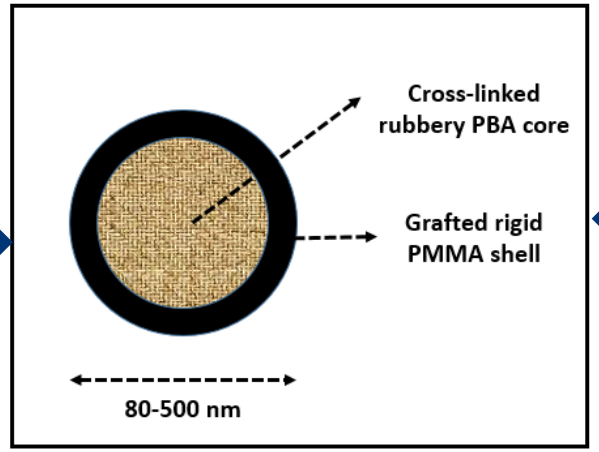
Spray-drying

AIM Powder





AIM Powder grain



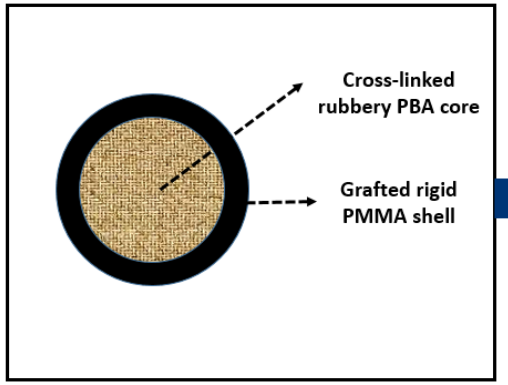
AIM CS primary particle

Key performance parameters

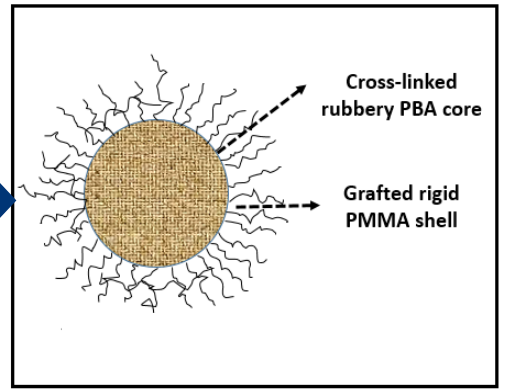
- Rubber content
- CS particle size (80-500 nm)
- Core X-linking level
- Chemistry improving PVC compatibility

CORE/SHELL VS POWDER GRAIN PARTICLES

AIM CS primary particle

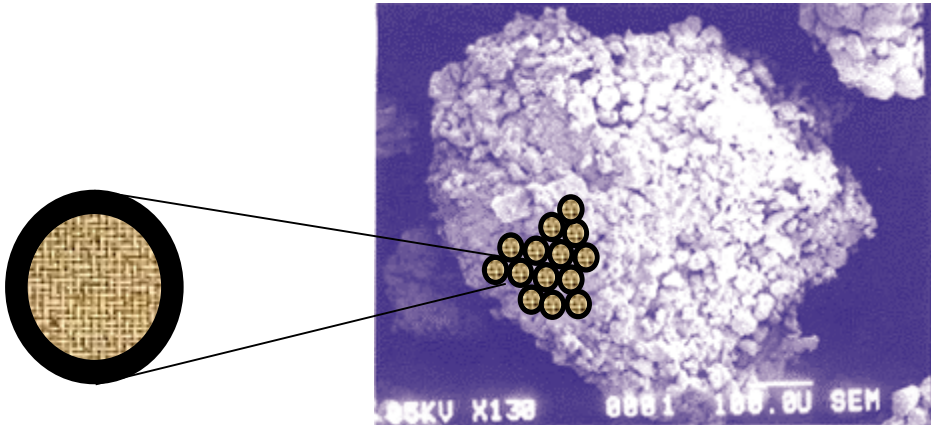


Ideal schematisation



More realistic view

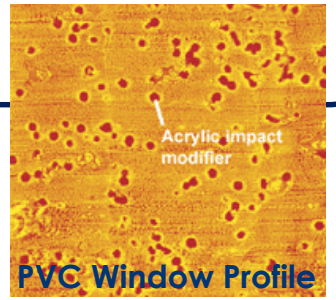
Rubber content can vary from 60 to > 90% and remain a free-flowing powder → improved shell chemistry improves anti-blocking properties



AIM CS primary particle
D50≈ 200 nm

AIM Powder grain
D50≈ 200 µm

There are about 1 billion of active AIM CS particles into a single AIM powder grain!
→ Easily released and dispersed into the PVC matrix during the extrusion step



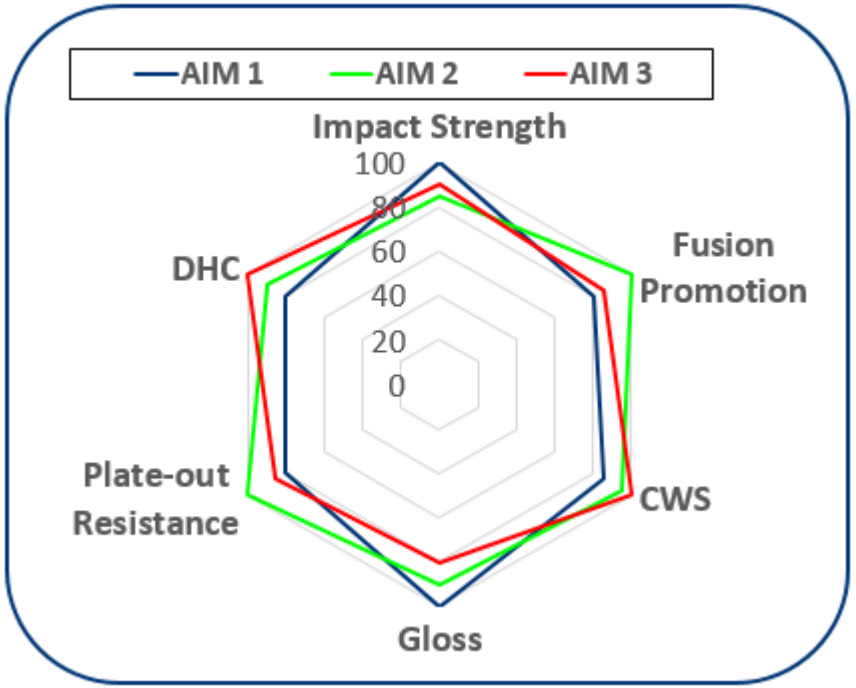
CORE/SHELL AIM SIDE EFFECTS: OTHER KEY APPLICATION PROPERTIES

- Fusion promotion
- Corner Weld Strength (CWS)
- Plate-out resistance
- Surface gloss

AIM acts as rheology modifier
(particulate system + shell processing aid effect)

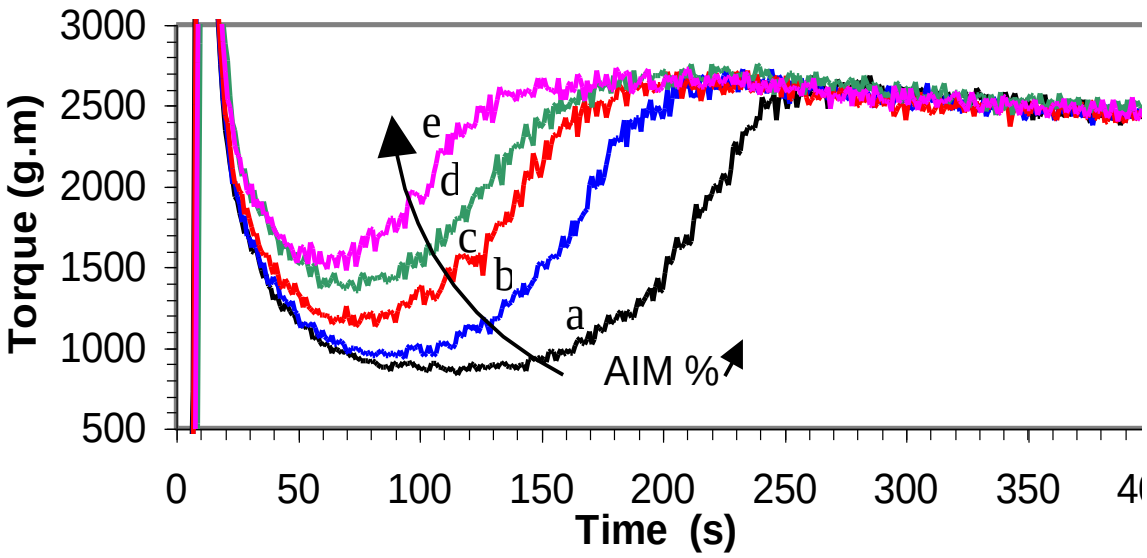
- Dehydrochlorination (DHC)
  - Small amounts of acidic species can be released without any effect on real thermo-stability of PVC profiles

These differences between AIM grades generally remain within the technical specifications…

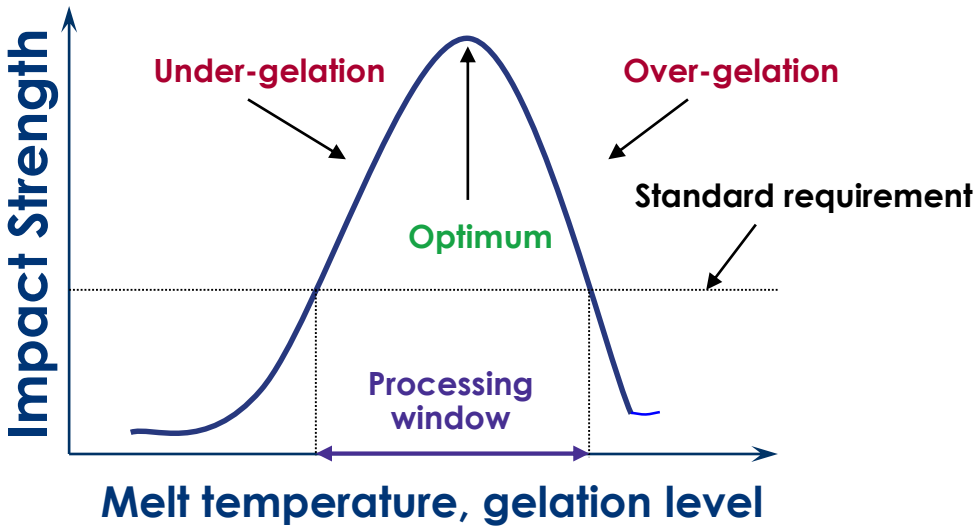


APPLICATIONS PERSPECTIVE: PROCESSING AND RHEOLOGY

- **PVC mechanical properties and melt rheology are correlated:**
  - Transition from a brittle to ductile PVC material is highly dependent on impact modifier content
  - Increasing modifier levels generally improves fusion and mechanical properties
  - Cost-efficiency gains possible due to improved fusion at higher filler loading levels while maintaining mechanical properties



(a)=4.5 phr; (b) = 5.5 phr; (c)=6.5 phr; (d)=7.5 phr; (e)=8.5 phr



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DURASTRENGTH® IMPACT MODIFIER PERFORMANCE

TARGETED PERFORMANCE FOR PVC BUILDING PRODUCTS

DURASTRENGTH® BY ARKEMA

CLEARSTRENGTH® BY ARKEMA

ARKEMA INNOVATIVE CHEMISTRY

TYPICAL RIGID PVC FORMULATIONS (OPAQUE)

Function	Ingredient	Window Profile / Siding Capstock	Siding Substrate
Base Resin	PVC Resin	100	100
Heat Stability	Organotin Heat Stabilizer // *Stabilizer / lubricant one-pack*	1.0 – 1.2 (>18% Sn) // *3.5 – 4.0 (Ca/Zn or other)*	0.8 – 1.2 (6% - 12% Sn) // *3.0 – 5.0 (Ca/Zn or other)*
Internal Lubricant	Calcium Stearate (Sn only)	1.0 – 1.5	1.0 – 1.5
External Lubricant	Paraffin Wax (Sn only)	0.8 – 1.2	0.8 – 1.2
External Lubricant	PE / OPE Wax (Sn only)	0 – 0.2	0 – 0.2
Fusion Promotion Melt Strength	Process Aid (PLASTISTRENGTH® process aid)	0 – 1.0	0.3 – 2.0
Impact Resistance	***Impact Modifier (DURASTRENGTH® AIM)***	***4.5 – 6.0***	***3.5 – 5.0***
Filler	Calcium Carbonate (0.7 µm)	2.0 – 18.0	12.0 – 22.0
Pigment / UV Protection	Titanium Dioxide	3.5 – 9.5	0.5 – 1.0
Color	Pigments / Colorants	As Needed	Regrind addition

DURASTRENGTH® ACRYLIC IMPACT MODIFIER PRODUCT RANGE

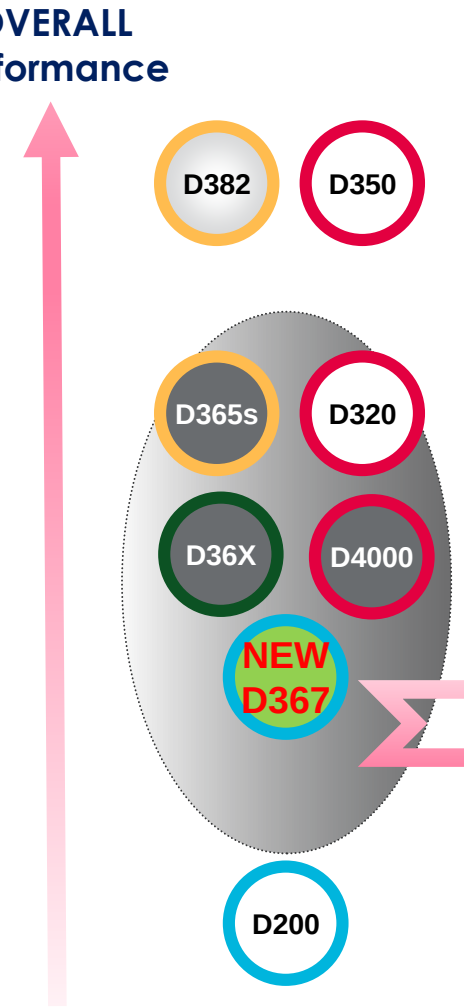
DURASTRENGTH BY ARKEMA

Highest impact requirements:
High gloss and ultimate impact strength

Standard performance AIM

New cost-efficient / high-performance alternative AIM for Rigid PVC

Injection Molding AIM - Rheology



- All stab. systems
- Ca/Zn based
- Sn-based
- Pb-based

R&D and innovation leading to dosage reduction by more than 2phr

New Arkema Technology

- Based on proprietary Arkema innovation
- Moderate performance with optimized cost
- Alternative to CPE and CPE blends,

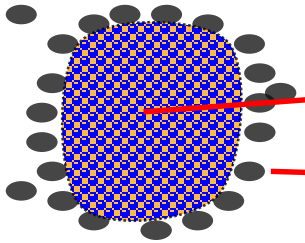
(with improved process stability), **in rigid PVC profiles and highly filled applications / substrate**

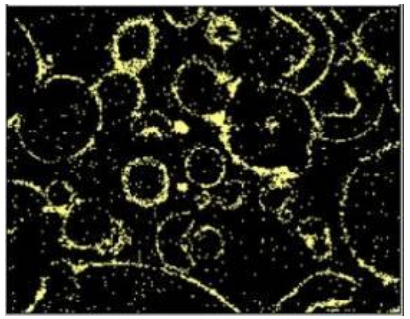
ARKEMA INNOVATIVE CHEMISTRY

ARKEMA COMPOSITE IMPACT MODIFIER TECHNOLOGY

"Outside" type

Standard AIM



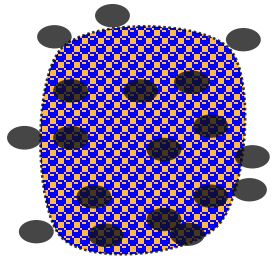


- **Fillers and impact modifier are physically blended powders**
- **Risk of segregation**
- **Heterogeneity of the mixture**

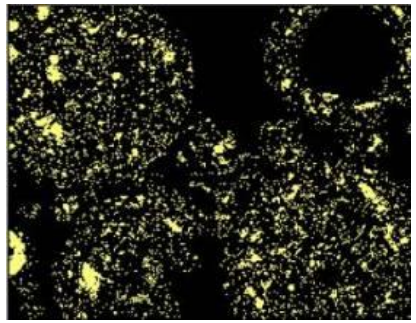
Performance with optimized cost-efficiency

"Inside" type

Patented technology



Innovative association
of highly efficient AIM
& inorganic additive



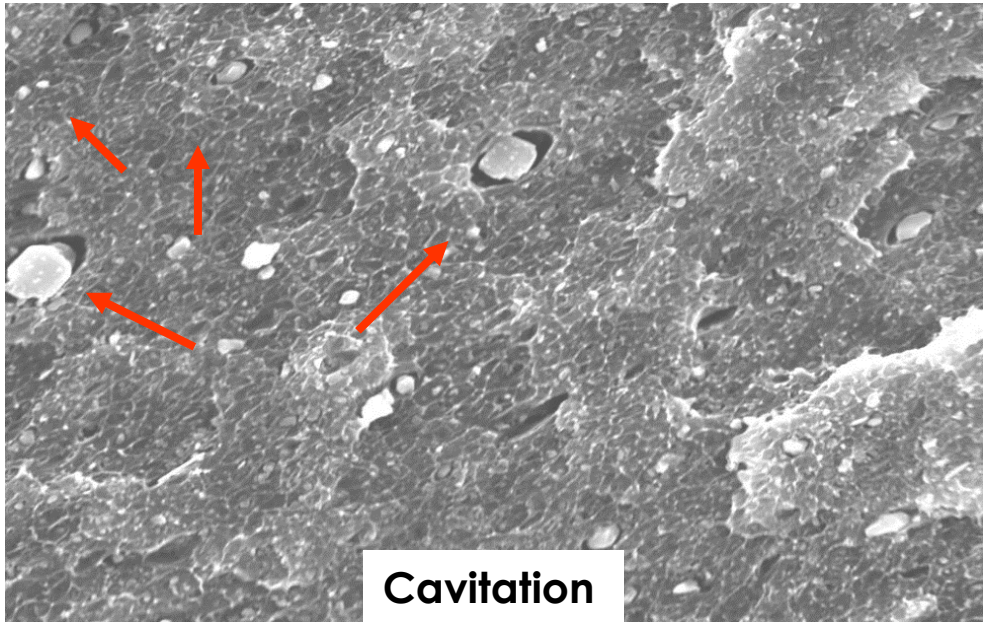
Why encapsulation ?

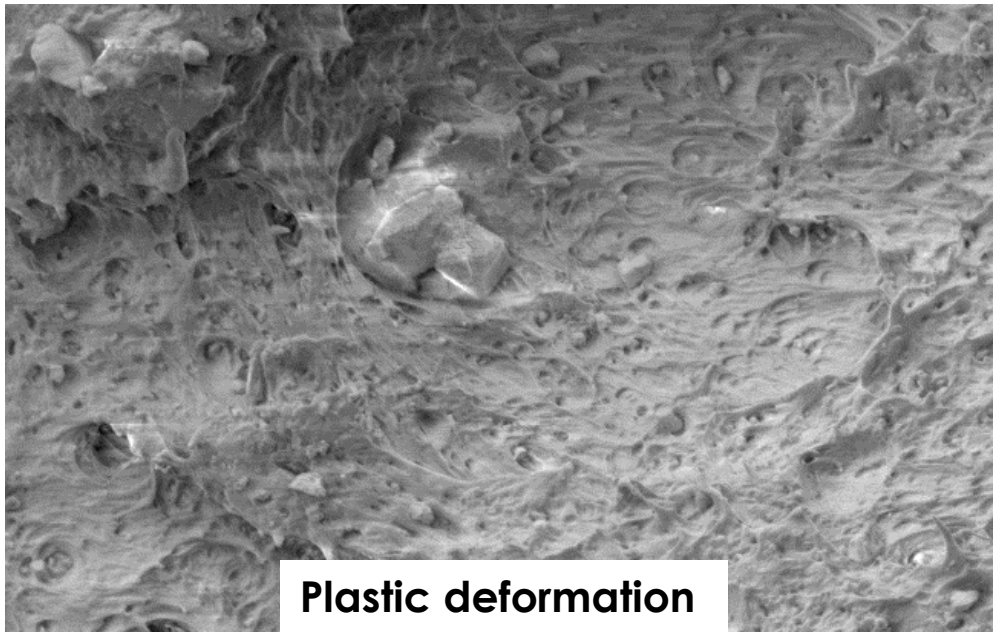
- **No segregation**
- **Homogeneity of the mixture**
- **Excellent flowability and powder properties**
- **Mineral/Rubber synergy : larger energy dissipation** (cavitation and shear yielding)
- **Minimal abrasion on metal tooling**
- **High reward with optimized cost**

ARKEMA COMPOSITE IMPACT MODIFIER TECHNOLOGY

Example of mineral / AIM synergy

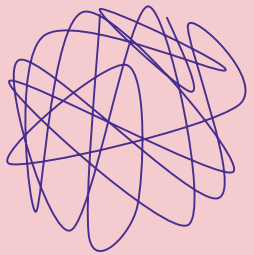
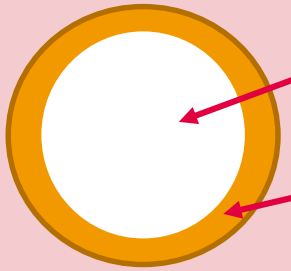
SEM Morphology investigations after impact testing (ductile break)





- Dewetting of inorganic/PVC interfaces leads to cavitation that promotes shear yielding
- Larger energy dissipation

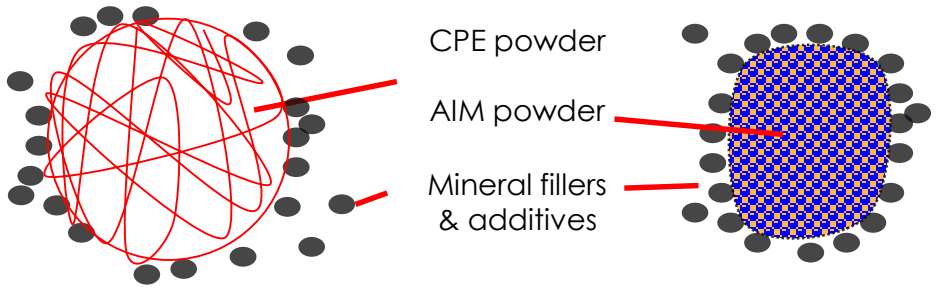
IMPACT MODIFIER TECHNOLOGY COMPARISON

Chlorinated polyethylene (CPE)	Acrylic Impact Modifiers (AIM)
 No defined core-shell particle (Tg ~ -10°C) Poor powder properties	 pBA core (Tg ~ -45°C) pMMA shell
• Poorer UV Stability • Shrinkage (swelling) • Lower environmental resistance • Plate-out deposit • **Melt flowability** *CPE no longer has improved welding strength as a technical advantage in current grades	• **Excellent UV stability** • **Good thermal stability** • **Best-in-class impact performance** • **Improved plate-out resistance** • **Higher melt strength development** • **Broad process window**

CPE SOLUTIONS: NEAT CPE AND CPE BLENDS

CPE and CPE blends

- Today CPE is used in combination with AIM products or with high loading levels of fillers and inorganic content



- Today's CPE materials: more caking / blocking CPE ⇔ requires more mineral fillers

➔ Extra cost : minimum extra dosage of AIM to maintain properties

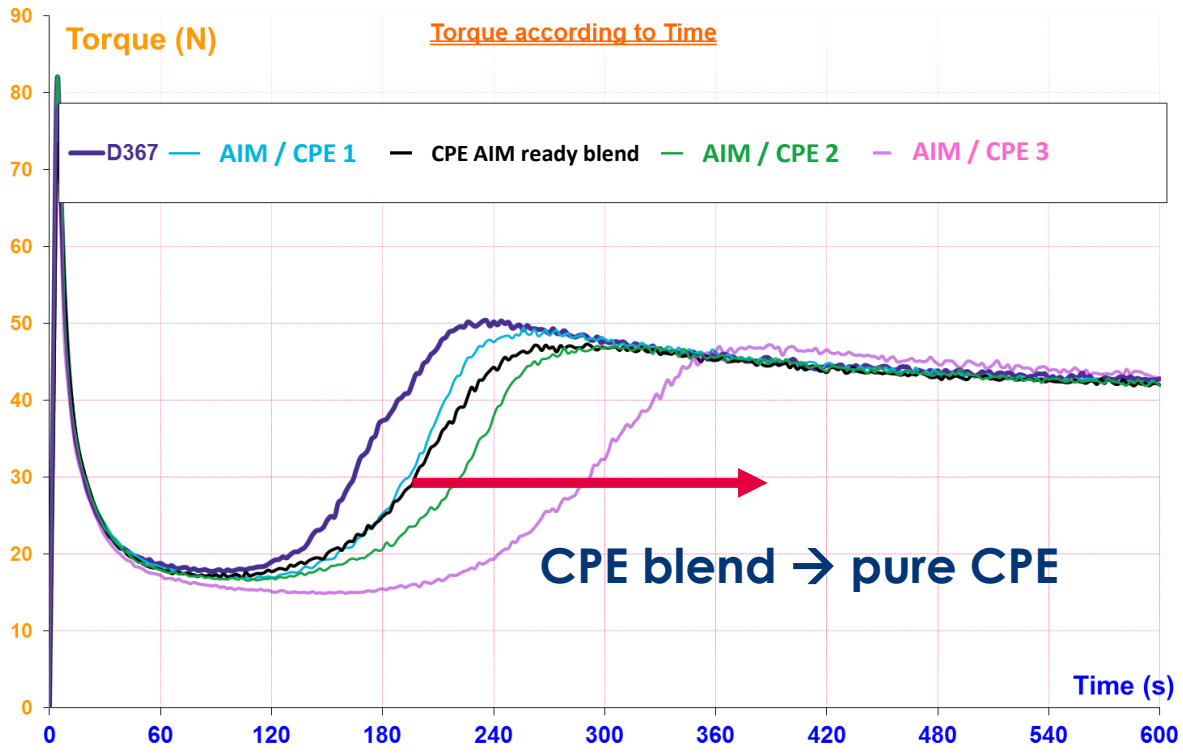
➔ More complex to handle : physical mixture of multiple IM components

➔ Unstable processing : heterogeneous modifier & PVC blend

➔ Poorer weatherability / UV resistance vs. AIM products

NEW DURASTRENGTH® 367

Focusing on Fusion



DURASTRENGTH® 367

- Faster fusion than CPE/AIM blends regardless the AIM ratio
- Same observation vs CPE/AIM ready blend

Pure CPE, CPE/AIM blends and ready blends

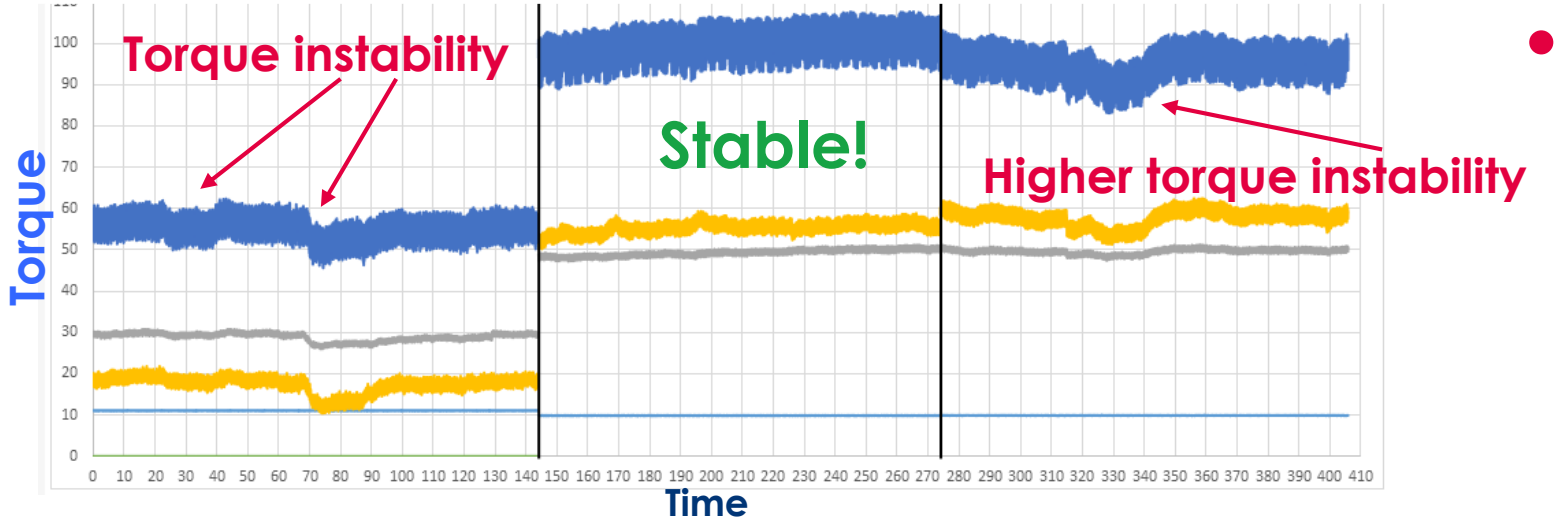
- Different fusion speed = f(source) for CPE quality
  ⇔ **different CPE product**
- Faster fusion requires higher modifier dosage ⇔ **extra cost**
- Same CPE source gives larger fusion fluctuations than DURASTRENGTH® acrylic impact modifier
- **Pure CPE even slower (incomplete) fusion**

Lab. Scale extrusion - Window Profile Ca/Zn
5,5phr of IM and 8 phr of CaCo3 fillers
50/50 AIM/CPE ratio

NEW DURASTRENGTH® 367

Focusing on process stability : 3h lab-scale extrusion

Lab-scale Extrusion Measurements



CPE | Durastrength® AIM | CPE ready blend

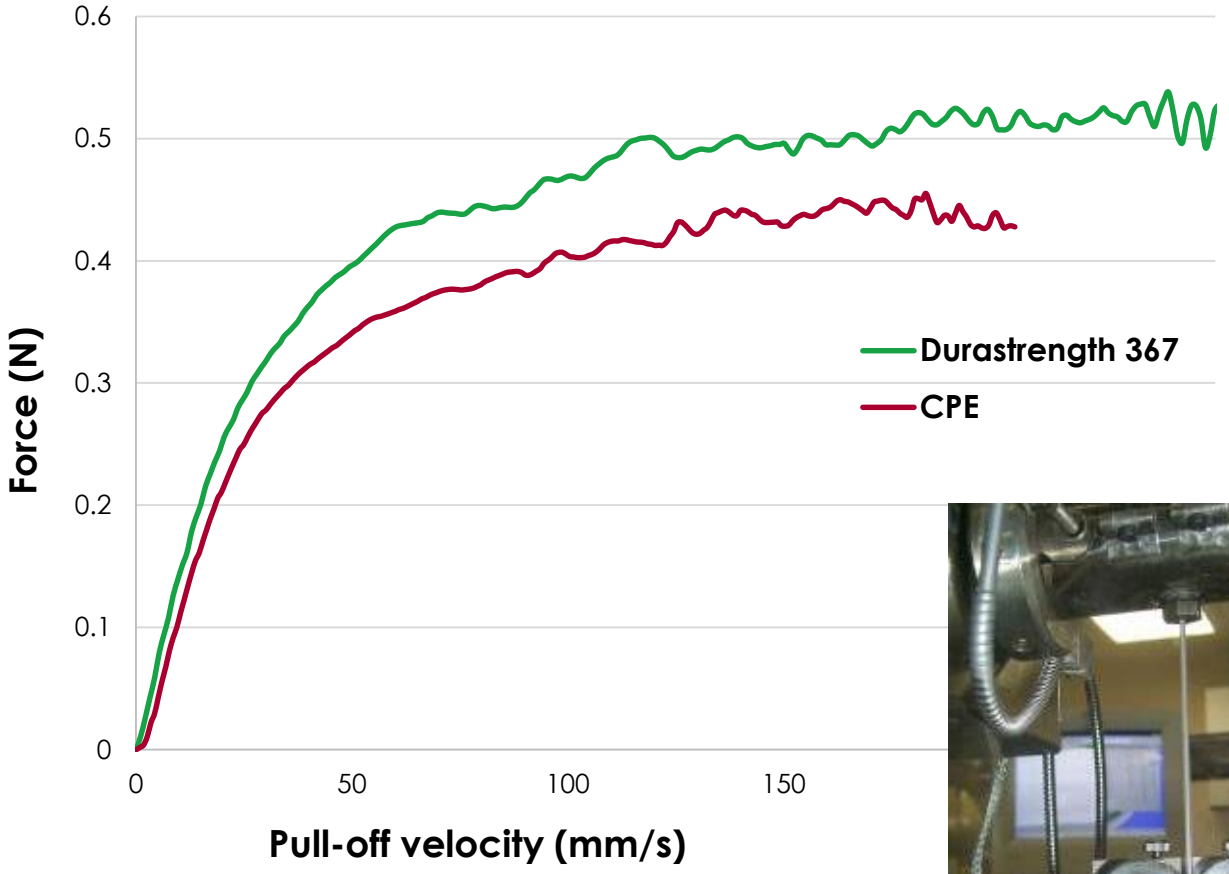
- **CPE and CPE blends lead to instability:**
  - ⇔ poor homogeneity
  - ⇔ risk of segregation
  - ⇔ poor quality stability
- **Durastrength® AIM provides processing stability**

Lab. Scale extrusion - Window Profile Ca/Zn
5,5phr of AIM and 8 phr of CaCo3 fillers

NEW DURASTRENGTH® 367

Focusing on melt fracture resistance

- Melt fracture resistance influenced by type of impact modifier in the formulation
- DURASTRENGTH® 367 shows improved melt fracture resistance versus CPE-based PVC formulations
- Typically, melt fracture resistance is decreased with higher $CaCO_3$ content – Durastrength® 367 helps maintain higher overall melt strength

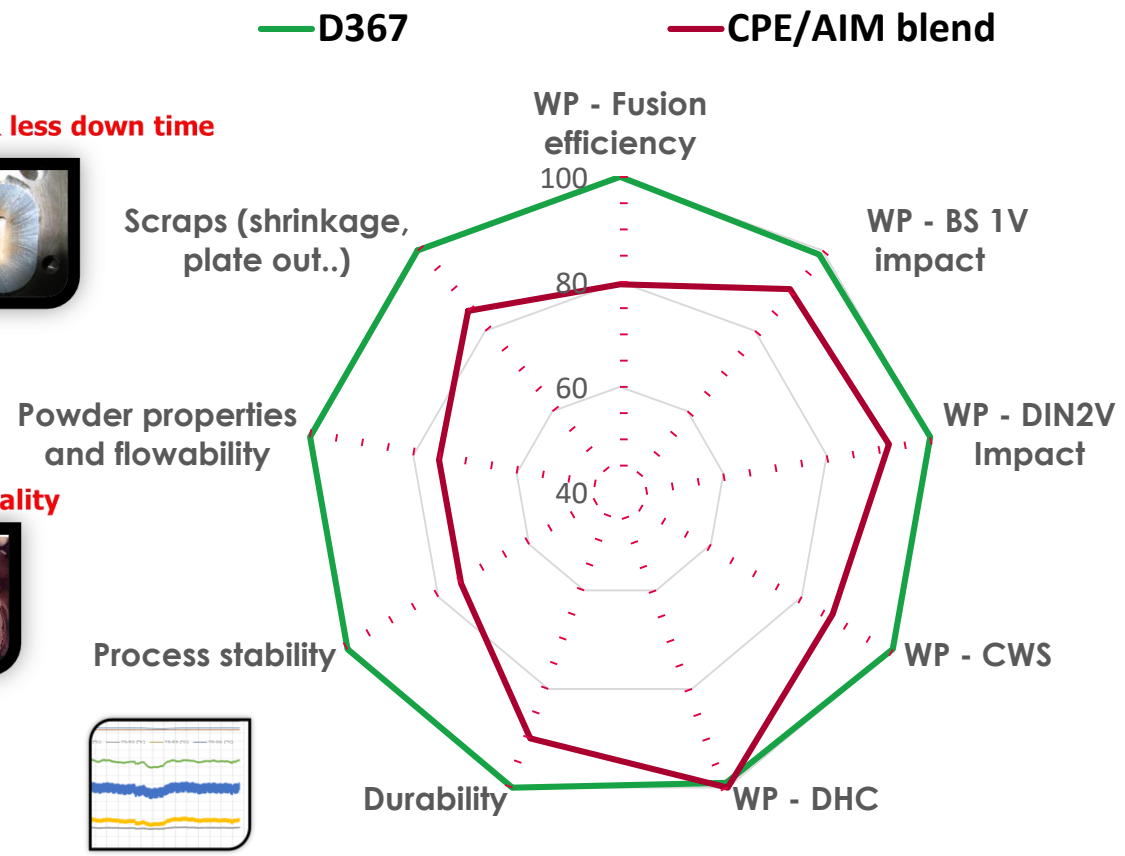


NEW DURASTRENGTH® 367 – IMPROVED TECHNICAL SOLUTION VS. CPE

PVC Window Profile & Siding application perspective

Better quality & less down time

Stable dry blend quality



DURASTRENGTH® 367 vs CPE / CPE blends

- Improved flowability and powder properties
- Same improved, stable processing conditions offered by Durastrength® products
- Improved melt fracture resistance
- Acrylic technology offers improved UV resistance
- Faster fusion
- Similar notched impact resistance
- DURASTRENGTH® quality consistency
- Global production in North America and Europe

Performance & Savings
without processing inconsistencies and lot-to-lot variability attached to CPE and CPE blends

THANK YOU!

Technical Support
ARKEMA Coating Resins
Plastic Additives

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