3M Science. Applied to Life.™

Product Comparison Guide

3M™ Dynamar™ Polymer Processing Additives

Performance and productivity.

Proven technology from 3M, engineered for a smoother extrusion process—from start to finish.

- Improve processing and productivity
- Reduce waste and equipment downtime
- Improve surface smoothness and appearance

3M™ Dynamar™ PPAs

Optimizing performance. Improving productivity.

Common processing issues such as melt fracture, die build-up, and gel formation can be real challenges in the extrusion process. For many years, manufacturers of extruded products have depended on 3M™ Dynamar™ Polymer Processing Additives (PPAs) to reduce or eliminate these issues—and improve both product quality and production rate.

Dynamar PPAs are a family of high-performance products designed to enhance the extrusion of various thermoplastic polymers. Even at low concentration levels, Dynamar PPAs can help increase throughput and processing efficiency, even for tougher, high viscosity resins. And by reducing surface defects, Dynamar PPAs deliver a smoother, glossier final product while minimizing waste—helping manufacturers maximize profit.

How it works: The science of smooth

3M™ Dynamar™ Polymer Processing Additives function by creating a dynamic, temporary fluoropolymer coating on the die surface. The coating provides a low surface energy interface between the metal wall and the molten polymer stream. This reduces stress in the die, prevents drag and allows the melt to slip through the die more easily and without sticking—thereby eliminating melt fracture. In addition, the lowered apparent viscosity allows the polymer melt to flow more freely through the die, providing easier flow and pressure reduction.

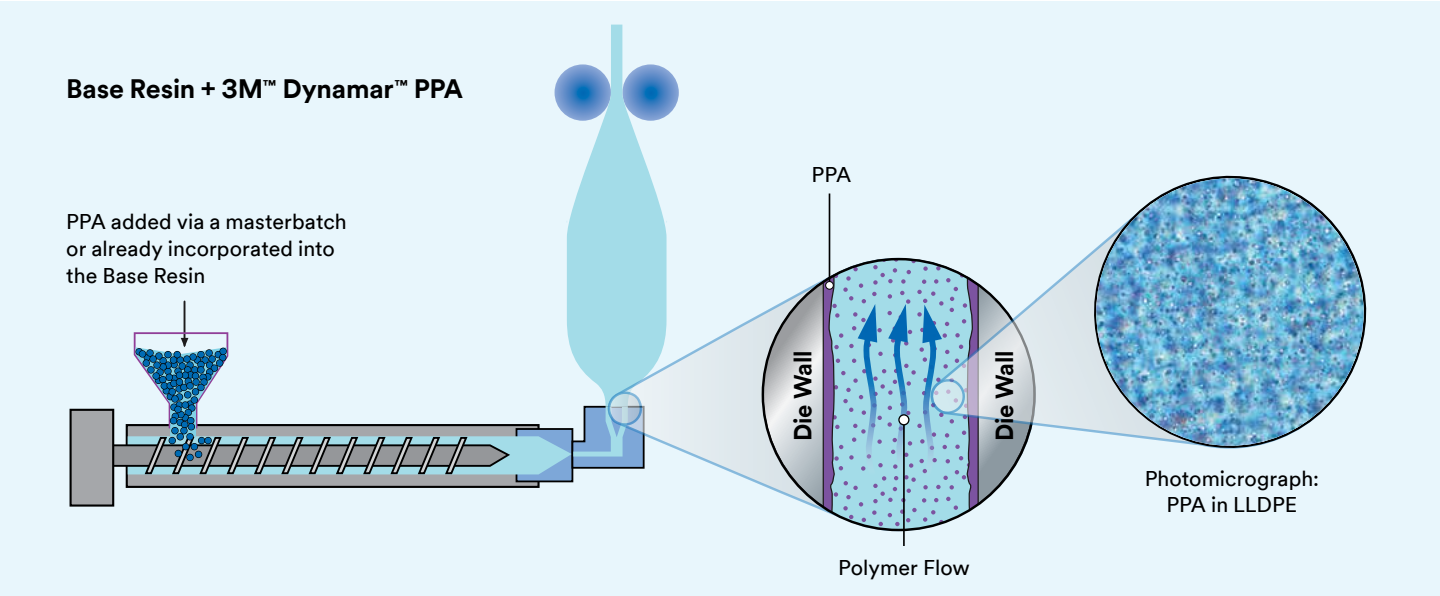
Chemical Structure

Fluoropolymers used as PPAs

The Dynamar PPA portfolio includes many additives based on fluoroelastomers or fluorothermoplastics. They are manufactured from the co-polymerization of the following monomers:

VF_2 Vinylidene fluoride	**$CH_2 = CF_2$**
HFP Hexafluoropropylene	**$CF_3CF = CF_2$**
TFE Tetrafluoroethylene	**$CF_2 = CF_2$**
Ethylene	**$CH_2 = CH_2$**

Fluoropolymers are characterized by high inertness towards chemical reactions, excellent thermal stability and low surface energy, and are mostly immiscible with other polymers.



Applications for 3M™ Dynamar™ PPAs

For many years, Dynamar PPAs have been widely used to improve processing and productivity in a variety of commercial applications—from high molecular weight, high density polyethylene (HMW-HDPE) to high viscosity resins such as linear low density polyethylene (LLDPE). Dynamar PPAs even allow for the processing of tougher resins, including metallocene grades, through narrow die configurations.

Typical extrusion processes that benefit from the use of Dynamar PPAs include:

- Blown and cast film
- Pipe extrusion
- Sheet extrusion
- Compounding
- Cable and monofilament extrusion
- Tape and fiber extrusion
- Blow molding

Most Dynamar PPAs comply with food contact regulations in a variety of countries; contact your 3M technical representative for details.

Benefits of 3M™ Dynamar™ PPAs

Dynamar PPAs offer many potential production benefits for extrusion and blown film processes, including:

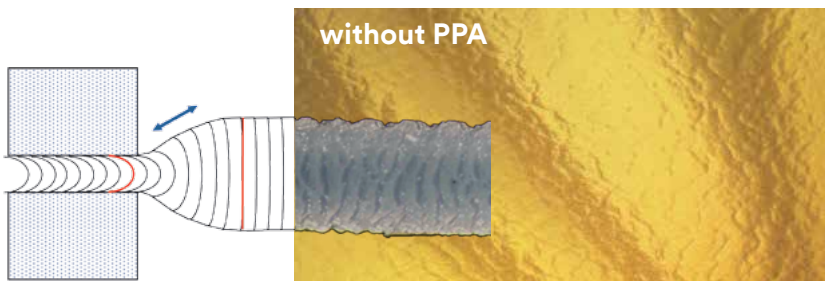
Product quality

- Elimination of melt fracture (“sharkskin”)
- Increased gloss
- Reduced surface defects
- Improved surface smoothness

Processing and productivity

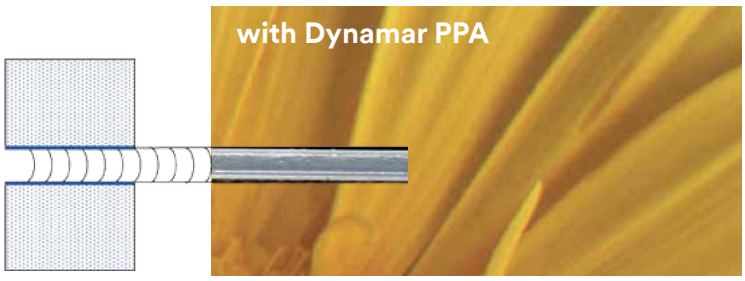
- Reduced die build-up—less downtime for maintenance
- Reduced gel formation
- Higher throughput
- Easier processing of high viscosity polymers
- Improved operation at lower processing temperatures—reduced degradation
- Lower operating pressures and amperage draw—increased output, energy savings
- Greater flexibility in die geometry
- Faster color transitions

Example: LLDPE Blown Film



Melt fracture (sharkskin) formation

One of the proposed mechanisms: Upon exiting the die, the outer layer of the melt is stretched by the elastic recovery of the polymer melt.



Elimination of melt fracture using a PPA

When the die is coated, there is slip at the wall, reducing the stresses that create melt fracture.

Properties of 3M™ Dynamar™ Polymer Processing Additives

Typical Physical Properties (Not for specification purposes)

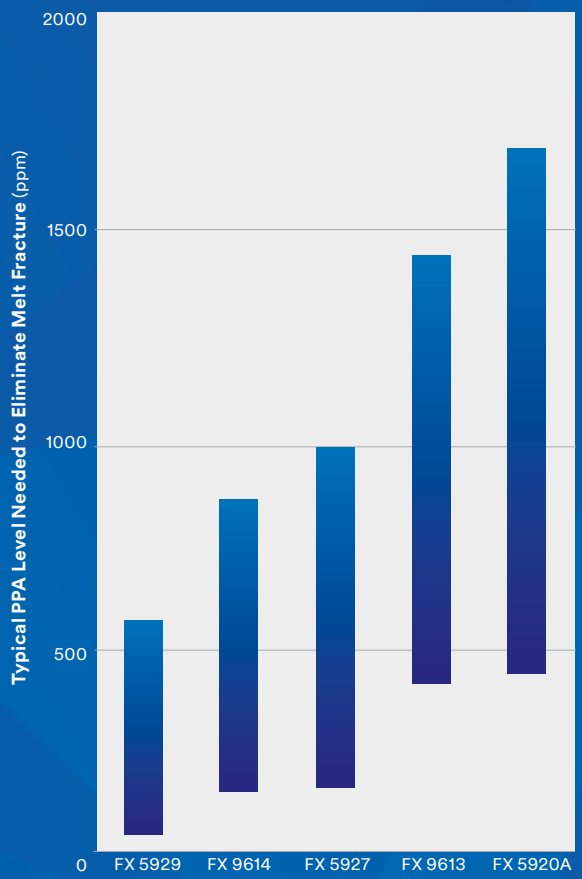
	FX 5920A	FX 5927	FX 5929	FX 9613	FX 9614	FX 5911	FX 5912
Physical Form	free flowing powder	free flowing powder	free flowing powder	free flowing powder	free flowing powder	free flowing powder	free flowing powder
Color	white to off white	white to off white	white to off white	off white	off white	clear to off white	clear to off white
Active Ingredients, %	97	96	95	90	90	100	100
Inorganic Additives, %	3	4	5	10	10	N/A	N/A
Particle Size	< 10 mesh	< 10 mesh	< 10 mesh	< 10 mesh	< 10 mesh	98% < 2400 µm	98% < 2400 µm
Bulk Density, g/cm³	0.7	0.7	0.85	0.9	0.7	–	–
Specific Gravity, g/cm³	–	–	–	–	–	1.9 – 1.96	1.9 – 1.96
Melting Point, °C	–	–	–	–	–	110 – 126	110 – 126
Melt Flow Index, g/10 min (265°C, 5 kg)	–	–	–	–	–	5 – 14	15 – 25
Typical Use Level, ppm	400 – 1500	200 – 1000	100 – 700	400 – 1400	200 – 800	100 – 1000	100 – 1000
European Food Contact	+	+	+	+	+	+	+
FDA Food Contact	+	+	+	+	+	+	–

Selecting the right PPA for your application

PPA selection and usage levels are determined largely by the specific process and related parameters. Typically, the polymer type, rheology and processing temperatures will be important considerations in the choice of PPA type.

Typical use levels range from 50 to 1000 ppm. In any given process, the total additive package needs to be taken into account in order to avoid or minimize potential interactions which could affect the performance of the PPA. Selection of the PPA also depends on the target benefit, such as melt fracture elimination, pressure reduction or die build-up reduction. 3M Technical Service experts will work with you to help you overcome your toughest processing challenges, and can help you select the optimal grade of 3M™ Dynamar™ PPA for your application.

Relative 3M™ Dynamar™ PPA Performance in Blown Film



Blown film extrusion

High performance polyolefins, such as LLDPE and mLLDPE, provide exceptional film characteristics; however, they can also be difficult to process. Common issues include melt fracture (also known as sharkskin), die build-up, gel formation, bubble instability and surface defects. 3M™ Dynamar™ PPAs have proven to be an effective solution for the majority of these processing problems.

A typical LLDPE resin formulation containing antiblock additives can benefit from the use of a synergist containing PPA, such as 3M™ Dynamar™ FX 5920A or FX 5927 (at a loading range of 300 to 1000 ppm). This PPA series has been engineered for improved efficiency and reduced interaction with inorganic additives.

In the extrusion of HDPE blown film, pressure and die build-up are often the most critical issues. For an HDPE resin formulated with high titanium dioxide content (e.g. synthetic paper), 3M™ Dynamar™ FX 9613 and FX 5911 would be recommended for evaluation.

Recommended Products

Formulations without Antiblocking Additives
▶ FX 9613 ▶ FX 5920A

Formulations with Antiblocking Additives
▶ FX 5920A ▶ FX 9613 ▶ FX 9614
▶ FX 5927 ▶ FX 5929

LLDPE Formulations with HALS
▶ FX 9613 ▶ FX 9614 ▶ FX 5920A

HDPE Formulations with Pigments (e.g. TiO_2, Carbon Black)
▶ FX 9613 ▶ FX 5911

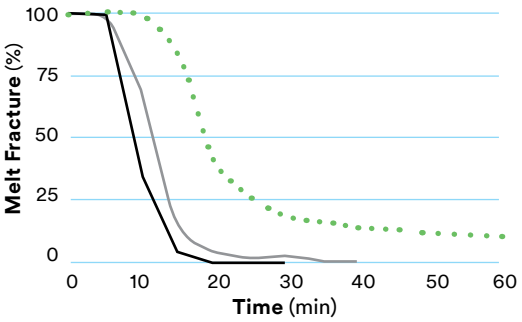
Blown Film Line Evaluations

PPA1 *Foundation Product* FX 5920A

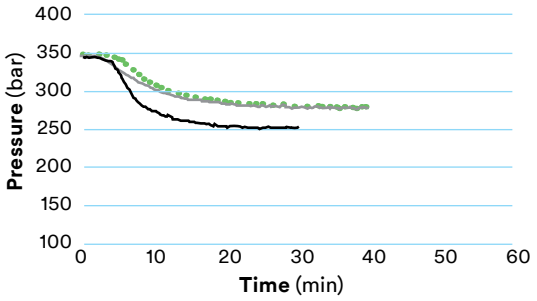
PPA2 *Improved Efficiency Product* FX 9613 and FX 9614

PPA3 *High Efficiency Product* FX 5927 and FX 5929

C4 LLDPE: Melt Fracture Elimination[1]

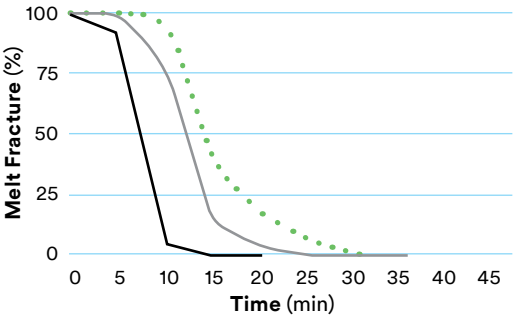


C4 LLDPE: Pressure Reduction[1]

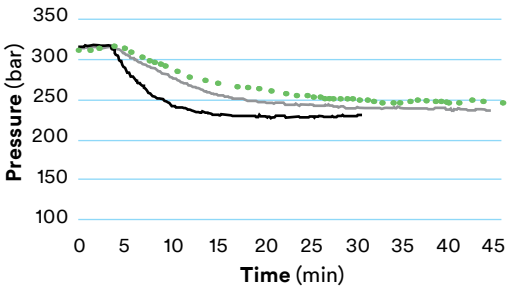


[1] LLDPE: C4, MFI: 0.7, Density: 0.925, 1000 Slip, 2000 ppm Antiblock, 400 ppm PPA

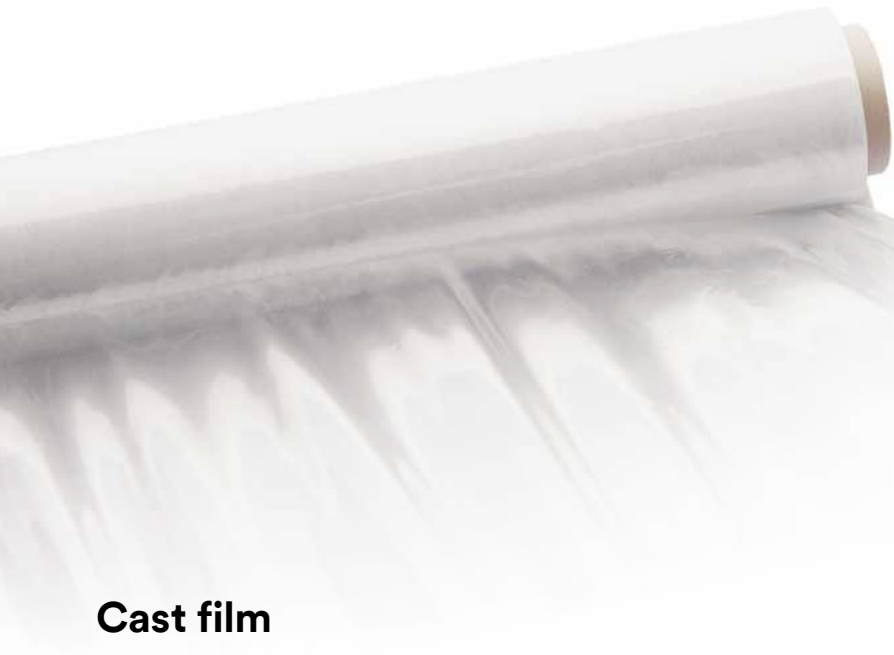
C6 mLLDPE: Melt Fracture Elimination[2]



C6 mLLDPE: Pressure Reduction[2]



[2] mLLDPE: C6, MFI: 1.2, Density: 0.920, 200 ppm Dynamar PPA, No Antiblock



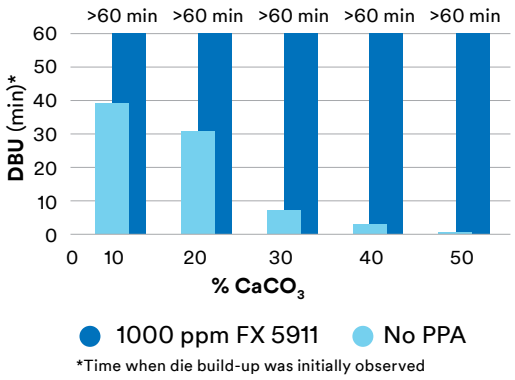
Cast film

2 Higher processing temperatures and/or shear rates are typically employed in cast film extrusion. Consequently, die build-up can be an issue, resulting in film defects and requiring frequent machine downtime for die cleaning.

The addition of small amounts of 3M™ Dynamar™ FX 9613, typically at lower loadings than used for blown film, will delay the onset of deposition at the die exit. Levels of 300 ppm or lower can provide significant productivity improvements.

In breathable films and other special applications with high loadings of inorganic fillers, higher torque loading and rapid deposit formation at the die lip can affect product quality and output. To resolve these issues, the most suitable choice is 3M™ Dynamar™ FX 5911 at concentrations of up to 1000 ppm.

Reduction of Die Build-Up



*Time when die build-up was initially observed

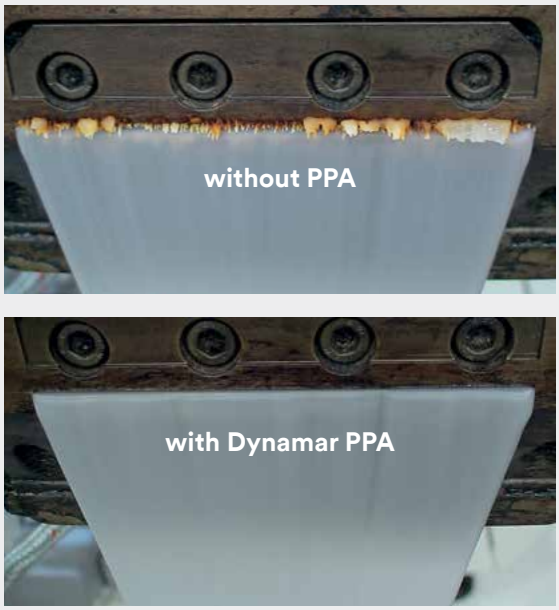
Recommended Products

Transparent LLDPE
- FX 9613

LLDPE with High Inorganics Content
- FX 9613
- FX 5911

PP Raffia, Tapes
- FX 9613
- FX 5911

BOPP
- FX 9613



Reduction of die build-up in cast film extrusion

Reduction of interfacial instability in multilayer film (mLLDPE / MDPE / mLLDPE)

As part of our in-house testing, we use a capillary rheometer to evaluate the influence of Dynamar PPA on shear stress reduction.

Multilayer film extrusion

3 In both blown and cast films, multilayer film architecture can give rise to unique processing issues. Many materials and formulations are used to impart barrier properties, provide inter-layer adhesion and reduce costs. However, the differences in layer thickness, rheology and polymer type can cause the layers to meet at conflicting rates of speed—resulting in turbulence at the interface and disrupting the optical clarity. This phenomenon is known as “interfacial instability,” and is especially problematic for food packaging (e.g. meat and poultry barrier films) where optical clarity is a key criterion.

Interfacial instability is a complex problem; individual film layers, for example, may benefit from different PPA chemistries or concentrations. As a starting point, consider the recommended 3M™ Dynamar™ PPA products for the given resin and process (e.g. blow molding LLDPE with antiblock). 3M technical specialists can help you evaluate which layers require PPA addition and determine the appropriate concentration for your application.

Die build-up in HDPE pipes

Recommended Products

High Pressure Pipes

▶ FX 5911 ▶ FX 9613 ▶ FX 9614

Cross-linked Pipes

▶ FX 5911 ▶ FX 5920A
▶ FX 9613 ▶ FX 9614

Corrugated Pipes

▶ FX 5911 ▶ FX 9613

Long term aging data

Tests conducted by independent institutes, on pipes manufactured under real production circumstances, reveal that Dynamar PPA has no effect on the long-term hydrostatic strength (LTHS) properties of the pipe.

Pipe extrusion

Plastic pipe offers a versatile and reliable alternative to conventional construction materials such as metal, concrete and clay composites. A wide variety of polymers (including HDPE, MDPE, LLDPE, LDPE, PP and PVC) are used for applications such as gas and water high pressure pipes, floor heating, drainage, irrigation and sewage systems.

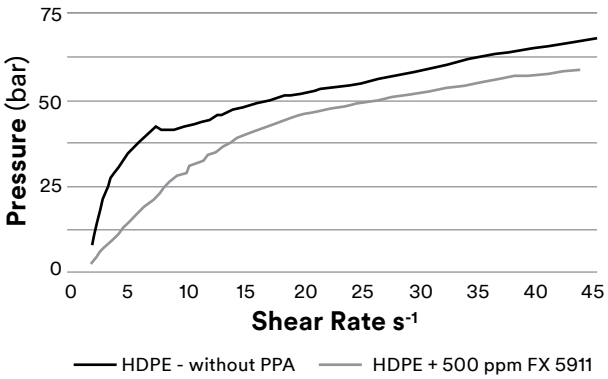
Typical processing issues relate to overall pipe dimensions, the rheological behavior of the polymer, and the presence of other additives such as carbon black and pigments. These issues include head pressure, die deposit and surface defects—all of which can benefit from the addition of 3M™ Dynamar™ PPAs at levels from 250 ppm up to 1000 ppm.

The addition of Dynamar PPAs can improve quality and overall productivity in the manufacture of high pressure pipe, cross-linked pipe for floor heating, drainage and sewage pipes.

- Reduction of die build-up
- Reduction of back pressure
- Reduction in processing temperatures
- Higher output
- Improved surface appearance

Pressure reduction in HDPE Pipe extrusion

Capillary rheometry is a tool used to demonstrate the possible processing enhancements that can be achieved by addition of a 3M™ Dynamar™ PPA.



Other extrusion processes

5 Any continuous extrusion process with shear rates of up to 2000 sec^{-1} may be influenced by PPA. Depending on the given formulation and processes, typical extrusion benefits provided by 3M™ Dynamar™ PPA include:

- Reduction of die build-up
- Pressure reduction
- Faster color transitions
- Energy savings
- Better surface quality

Recommended Products

Sheet Extrusion
- FX 5911
- FX 5912
- FX 9613
- FX 9614

LDPE, HDPE & PP Artificial Grass
- FX 5911
- FX 9613

PP Carpet Backing
- FX 5911

Cable Extrusion
- FX 5912

Polyamide Black Compounds
- FX 5914
- FX 5911

Wood Plastic Composites (WPC)
- FX 5911

Other Engineering Resins
- FX 5911

Support from start to finish

3M™ Dynamar™ Polymer Processing Additives are supported by global sales, technical and customer service resources, with fully-staffed technical service laboratories in the U.S., Europe and Asia. Contact us today to learn how we can help you solve your toughest processing challenges—and smooth your way to higher profits.

Technical papers and knowledge base

Our technical specialists have developed a library of resources exploring how Dynamar PPAs function with various polymers, additives and processing conditions. These technical papers cover topics such as the mechanism of Dynamar PPAs; their effects on avariety of physical and optical properties; reduction in melt fracture and die build-up; the influence of compounding and extrusion parameters; and interactions with various materials and additives.

To download these technical papers, view videos and more, visit our website: **www.3M.com/PPAs**

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