

Ingeo Resin

Naturally Advanced Materials

Product Guide



INGEO GRADE OVERVIEW

2000 Series – Extrusion/Thermoforming

General purpose transparent extrusion grade.

- 2003D Used as is or as part of a formulated blend on conventional extrusion equipment
- 2500HP High viscosity & designed to crystallize during processing

3000 Series – Injection Molding

Designed for injection molding applications, including high heat.

- 3001D Unlubricated, medium-flow grade
- 3052D Lubricated, medium-flow grade
- 3100HP Medium viscosity & designed for medium-flow injection molding applications
- 3251D Lubricated, ultra high flow grade
- 3260HP Designed to crystallize during processing for higher heat deflection temps in opaque applications

4000 Series – Films & Sheet

Designed for use in the production of oriented films, cardstock and graphic arts.

- 4032D High heat film
- 4043D General purpose film
- 4044D Reactive extrusion grade
- 4060D Heat seal layer for film

6000 Series – Fibers/Nonwovens

Designed for fiber processes from mono to multifilament as well as spunbond & meltblown products.

- 6060D Amorphous low melt for staple fiber/bico fiber sheath layer 3.5 Relative Viscosity (RV)
- 6100D For when lower fiber shrinkage and higher dimensional stability is required
- 6201D Continuous filament/staple for dyed fiber applications
- 6202D Staple fiber/spunbond for nonwovens, non-dyed fiber applications
- 6252D Meltblown
- 6260D Designed for meltblown fiber processing or extrusion into mechanically drawn staple fibers
- 6302D Amorphous low melt for staple fiber/bico fiber sheath layer 3.0 RV
- 6362D Higher melt flow resin designed for specialty fiber products where an amorphous structure is desired
- 6400D Monofilament/BCF/Industrial multifilament products
- 6752D Sheath polymer for spunbond applications

Extrusion/Thermoforming and Injection Molding

Physical Properties	ASTM Test Method	Grade						
		2003D	2500HP ^a	3001D	3052D	3100HP ^a	3251D	3260HP ^a
Specific Gravity	D792	1.24						
MFR (g/10min*)	D1238	6	8	22	14	24	80	65
(g/10min**)	D1238	35						
Clarity		Transparent	Opaque	Transparent		Opaque	Transparent	Opaque
Relative Viscosity [†]	D5225	4.0		3.1	3.3	3.1	2.5	
Peak Melt Temp (°C)	D3418	145-160	165-180	155-170	145-160	165-180	155-170	165-180
Glass Transition Temp (°C)	D3418	55-60	55-60	55-60	55-60	55-60	55-60	55-60

Mechanical Properties								
Tensile Yield Strength [psi (MPa)]		8,700 (60) ^a	9,500 (65.5) ^a	9,000 (62) ^a	9,000 (62) ^a	9,300 (64) ^a	9,000 (62) ^a	9,200 (63)
Tensile Strength at Break [psi (MPa)]		7,700 (53) ^a	8,300 (57)	7,800 (54) ^a	8,300 (57) ^a	8,900 (61) ^a	8,000 (55) ^a	6,500 (45) ^a
Tensile Modulus [kpsi (GPa)]		524 (3.6) ^a	680 (4.7)	540 (3.7) ^a	530 (3.7) ^a	625 (4.3) ^a	545 (3.8) ^a	650 (4.5) ^a
Tensile Elongation (%)		6 ^a	4.3 ^a	3.5 ^a	3.5 ^a	2.2 ^a	3.5 ^a	1.3 ^a
Notched Izod Impact [ft-lb/in (J/m)]	D256	0.3 (16)	0.75 (40)	0.3 (16)	0.3 (16)	0.6 (32)	0.3 (16)	0.3 (16)
Flexural Strength [psi (MPa)]	D790	12,000 (83)	18,300 (126)	15,700 (108)	15,700 (108)	15,700 (108)	15,700 (108)	15,700 (108)
Flexural Modulus [kpsi (GPa)]	D790	555 (3.8)	646 (4.36)	515 (3.6)	515 (3.6)	632 (4.36)	540 (3.7)	623 (4.3)
Heat Distortion Temp at 66 psi (°C)	E2092	55	144	55	55	149	55	151

* 210°C/2.16kg [†] 190°C/2.16kg ^a ASTM D638 [†] 1.0 g/dL in chloroform at 30°C [‡] nucleated, crystallized properties. non-impact modified

Fibers/Nonwovens

Physical Properties	ASTM Test Method	Grade									
		6060D	6100D	6201D	6202D	6252D	6260D	6302D	6362D	6400D	6752D
Specific Gravity	D792	1.24									
Relative Viscosity [*]	D5225	3.3	3.1	3.1	3.1	2.5	2.5	3.0	2.5	4.0	3.3
MFR g/10 min (210°C, 2.16kg)	D1238	8	24	15-30	15-30	70-85	65	15-20	70-85	6	15
Melt Density (230°C)		1.08									
Crystalline Melt Temp (°C)	D3418	125-135	165-180	155-170	155-170	155-170	165-180	125-135	125-135	160-170	145-160
Glass Transition Temp (°C)	D3418	55-60									

* 1.0 g/dL in chloroform at 30°C

INGEO GRADE OVERVIEW (CONT.)

7000 Series – Injection Stretch Blow Molding

Designed for use in injection stretch blow molded (ISBM) bottle applications.

- 7001D General purpose ISBM bottle grade
- 7032D Heat-set ISBM bottle grade

8000 Series – Foam

Designed for expanded foam sheet.

- 8052D Expanded foam sheet

3D Series – 3D Printing

Developed for those manufacturing monofilament for use in 3D printers.

- 3D850 Fast crystallizing, low color grade designed for 3D printing monofilaments -- recommended for investment casting
- 3D870 High heat & impact resistance grade 3D printing monofilament used in industrial applications

Technical data sheets are available for each Ingeo resin grade

Films & Sheet

Physical Properties	ASTM Test Method	Grade			
		4032D	4043D	4044D	4060D
Specific Gravity	D792	1.24			
Melt Density (g/cc)		1.08 @ 230 °C			
Glass Transition Temp.	D3418	55 -60 °C			
MFR* (g/10 min)	D1238	7	6	6	10
Relative Viscosity*	D5225	4.0			3.4
Morphology		Semi-crystalline			Amorphous
Peak Melt Temp (°C)	D3418	155-170°C	145-160°C	145-160°C	NA
Oxygen	D3985	650 - 700 cc-mil/m2-24-hr-atm			
Carbon Dioxide	Internal	2700 - 3000 cc-mil/m2-24-hr-atm			
Water Vapor	F1249	350 - 400 g-mil/m2-24-hr			

* 210°C/2.16kg

▲ 1.0 g/dL in chloroform at 30°C

Injection Stretch Blow Molding

Physical Properties	ASTM Test Method	Grade	
		7001D	7032D
Specific Gravity	D792	1.24	
Clarity	D1746	Transparent	
Relative Viscosity*	D5225	4.0	
Peak Melt Temp (°C)	D3418	145-160	155-170
Glass Transition Temp (°C)	D3418	55-60	
Oxygen	D3985	650 - 700 cc-mil/m2-24-hr-atm	
Carbon Dioxide	Internal	2700 - 3000 cc-mil/m2-24-hr-atm	
Water Vapor	F1249	350 - 400 g-mil/m2-24-hr	

* 1.0 g/dL in chloroform at 30°C

3D Printing

Physical Properties	ASTM Test Method	Grade	
		3D850 ¹ (Amorphous)	3D870 ^{1,2} (Crystalline)
Specific Gravity	D792	1.24	1.24
Peak Melt Temp	D3418	165-180	170-180
Glass Transition Temp (°C)	D3418	55-60	55-60
MFR* (g/10 min)	D1238	7-9	

Mechanical Properties			
Tensile Strength [psi (MPa)]	D638	8,847 (61)	5,802 (40)
Tensile Modulus [kpsi (GPa)]	D256	491 (3,387)	416 (2,865)
Tensile Elongation (%)	D638	2.3	1.6
Notched Izod Impact [ft-lb (J/m)]	D256	.58 (31)	4.37 (233)
Flexural Strength [psi (MPa)]	D790	15,229 (105)	10,588 (73)
Flexural Modulus [kpsi (GPa)]	D790	459 (3,167)	350 (2,414)

* 210°C/2.16kg

1 Orientation: See the technical data sheets on these grades for more detailed descriptions of XY build orientations.

2 3D printed part / 100% in-fill, annealed at 110°C/20 min

WHAT IS INGEO?

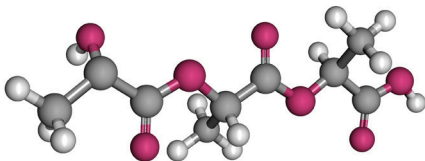
Back in 1989, we had a big, crazy idea. What if we could turn greenhouse gases like carbon dioxide into products? We got to work, looking to plants for inspiration. It took a lot of hard thinking and some real innovation, but today Ingeo polymers are valued for their unique properties and found in products like coffee capsules, yogurt cups, cutlery, diapers & electronics.

How is Ingeo made?

Nature looks at greenhouse gases, like atmospheric carbon, as a feedstock, a raw material. It's what trees, plants, and coral reefs, are built from. At NatureWorks, we're doing the same thing – using our best technologies to turn greenhouse gases into a portfolio of polylactic acid (PLA) performance materials called Ingeo.

Today, we use plants like corn, cassava, sugar cane or beets to capture and sequester CO₂ transforming it into long-chain sugar molecules. Carbon is captured in these plant resources, sequestered from the atmosphere during plant photosynthesis and stored as plant starches. NatureWorks uses dextrose derived from these starches as the starting point for Ingeo.

Through a process of fermentation, separation and polymerization, the carbon and other elements in these natural sugars are transformed into a family of Ingeo PLA pellets that are shipped around the world to our customers and partners who transform them into a wide-range of innovative products. Our R&D team is currently assessing new technology to skip plants and use microorganisms to directly convert greenhouse gases into lactic acid.

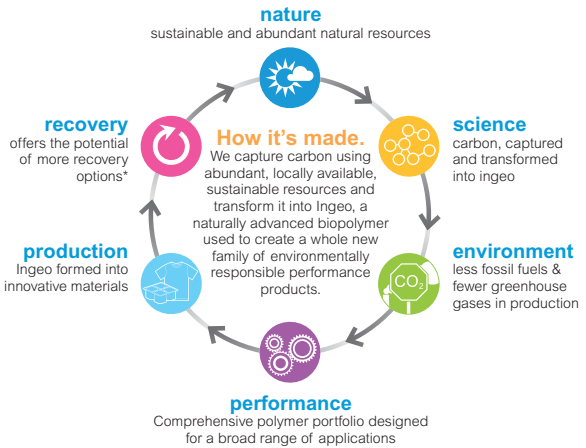


INGEO BENEFITS

NatureWorks specific expertise is working with customers to find the right mix of performance, cost, and when relevant, environmental credentials where Ingeo provides the optimum solution. One plastic cannot meet every functional performance need.

For example, the inherent stiffness of Ingeo makes it ideal for form-fill-seal yogurt cups and the new trend toward transparent cups. In markets such as foodservice, Ingeo-based products are 3rd party certified compostable, and enable food waste diversion from landfills.

Made from renewable resources, the manufacture of NatureWorks' Ingeo polymer emits fewer greenhouse gasses (GHGs) than the comparable manufacture of all common petrochemical-based plastic and consumes less energy to manufacture when compared to those plastics.



*complete Ingeo eco-profile - www.natureworkslc.com

INGEO REGULATORY AFFAIRS COMPLIANCE INFORMATION

NatureWorks has a fundamental duty to all those that use our products, and for the environment in which we live today and in the future. This duty is the basis for our Product Stewardship philosophy, by which we assess the health and environmental information on our products and their intended use. Our job is to maintain an effective product stewardship program to ensure that customers involved with our product receive sufficient information and training to store, use, and dispose of our product with no harm to human health or the environment.

Several resources are available on our website, including SDS and general information regarding food contact, chemical inventory, compostability, biobased content, etc. The information is available for download.

For specific information, contact your NatureWorks representative and/or the regulatory department at sdsinquiry@natureworkslc.com.



naturally advanced polymers

Interested in learning more about Ingeo resins?

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