



naturally advanced materials from NatureWorks

# Naturally Advancing Ingeo Material Properties for Durable Applications



## There are some things you should be able to take for granted...

...and when it comes to materials, for us at NatureWorks, that means the basics like heat performance, physical and mechanical properties, and processing ease – and with commercial products of course, delivered at competitive costing and from a reliable, world-scale supply base.

Our new Ingeo formulations take things like “high heat” performance as a given, and move beyond that to offer a comprehensive suite of properties, which in most cases exceed ABS.

Unlike legacy polymer blend approaches where PLA was alloyed or compounded with a petroleum-based polymer to get requisite properties, albeit at low biobased content, these new Ingeo formulations derive their functionality from the crystallization enabled by combining NatureWorks newly commercialized polymer chemistries with our twenty plus years in developing formulation technology. The resulting renewably-sourced carbon content in the Ingeo formulation is approximately 90%.

For rapid response, we have local supply chains activated in North America, Europe, and Asia Pacific. Interested in seeing how you can outperform ABS with high biobased content using our new Ingeo formulations? We'd love to hear from you at [durables@natureworkslc.com](mailto:durables@natureworkslc.com).



## Made Responsibly

The base biopolymer in our Ingeo formulation is made by fermenting the carbon in greenhouse gases into lactic acid, a safe material naturally present in our bodies and in many of our foods – then transforming that building block into a performance thermoplastic with physical characteristics and performance tailored injection molding.

Our biopolymers are USDA BioPreferred certified as 100% biobased, have no BPA, no phthalates, no styrene, and have undergone a rigorous 3rd party assessment for health and human safety by the Cradle-to-Cradle Product Innovation Institute. Each of our base biopolymers is Silver Certified ([www.c2ccertified.org](http://www.c2ccertified.org)).



# Typical Material & Application Properties

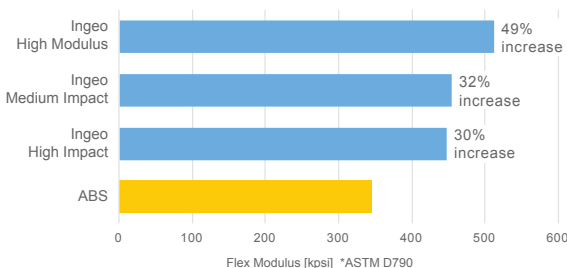
	PLA	INJECTION MOLDING GRADES ABS	INGEO INJECTION MOLDING FORMULATION		INGEO PROFILE EXTRUSION FORMULATION High Modulus (821-56-2)	ASTM Method
			Medium Impact (884-41-1)	High Impact (884-41-2)		
Bio-Content (%)	100	0	89	88	76	6866
Specific Gravity (g/cm <sup>3</sup> )	1.24	1.04	1.22	1.21	1.24	D792
Specular Gloss (60°/20° geometry)	125 / 112	89 / 68	72 / 48	73 / 47	77 / 56	D792
Tensile Modulus, kpsi (MPa)	494 (3,400)	336 (2,316)	414 (2,850)	414 (2,850)	454 (3,125)	D638
Tensile Yield Strength, psi (MPa)	9,300 (64)	5,600 (39)	5,400 (37)	5,500 (38)	4,940 (33)	D638
Tensile Elongation at Break (%)	3.6	5.5	32	21	38	D638
Notched Izod Impact, ft-lb/in (J/m)	0.4 (21)	5.19 (277)	2.6 (139)	8.3 (443)	6.6 (352)	D256
Flexural Strength, kpsi (MPa)	16.4 (113)	9.9 (68)	9.5 (66)	9.4 (65)	8.6 (59)	D790
Flexural Modulus, kpsi (MPa)	528 (3,640)	345 (2,381)	455 (3,140)	448 (3,100)	513 (3,550)	D790
Heat Distortion Temp @ 66 psi (°C)	55	87	92	77	85	D648

## Modulus & Impact

Three new formulated Ingeo offerings take for granted significantly higher heat performance, and build off that high heat foundation\* to offer a range of improved impact and modulus performance.

Two formulations offer a medium and high impact properties with high bio content. This makes them ideal for injection molding applications – particularly those currently in ABS that require high heat performance with high impact and/or high modulus. Additionally, a high modulus Ingeo formulation for profile extrusion applications maintains excellent impact performance, while its high stiffness simultaneously offers opportunities for downgauging and materials savings.

## Up to 50% higher flex modulus over ABS offers downgauging potential



## HEAT-STABLE FOUNDATION\*

Each of these Ingeo formulations have significantly faster crystallization kinetics than PLA resins currently in the market place. The rapid crystallization rate allows for the molding of crystalline parts at competitive cycle times with high heat distortion temperatures.

## Significantly faster cycle times

These formulations deliver on impact and modulus (with thermal performance of course) in injection molded products – and with significantly faster cycle times than legacy products in the market.

These products are not currently food contact approved.

# Excellent Chemical Resistance vs. ABS

## ESCR Performance

SOLVENT / CHEMICAL	INGEO MEDIUM IMPACT FORMULATION (884-41-1)			INGEO HIGH IMPACT FORMULATION (884-41-2)			ABS		
	1 hour	24 hours	96 hours	1 hour	24 hours	96 hours	1 hour	24 hours	96 hours
none	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Distilled Vinegar (5% acidity)	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Isopropanol	Good	Good	Good	Good	Good	Good	Good	Good	Fair
AJAX Spray & Wipe Cleaner	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Poor
Dawn Liquid Dish Soap	Excellent	Excellent	Good	Excellent	Excellent	Good	Excellent	Excellent	Excellent
Bertolli Extra Virgin Olive Oil	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Poor	Poor
Unsalted Butter	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Poor	Poor

Based on ASTM D543-06 Standard Practices for Evaluating the Resistance of Plastics to Chemical Reagents. Tested under 1% strain.

■ Excellent    ■ Fair  
■ Good    ■ Poor



## Simulating the Chemical Resistance of Plastics used in Consumer Electronics\*

CHEMICAL	INGEO	ABS
Hand Cream	Pass	Pass
Sunblock	Pass	Pass
Insect Repellent	Pass	Fail
Acetone (nail polish)	Pass	Fail
Isopropyl Alcohol (hand sanitizer)	Pass	Pass

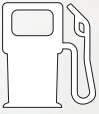
\*Testing performed by Nypro, A Jabil Company

ingeo

# did you know?

Did you know that if you convert a total of 500,000 mobile phones made from ABS to Ingeo it would save the following<sup>2</sup>:

**non-renewable energy use equal to:**



OR



757 gallons of  
gasoline

10 years powering  
a single 100 watt  
light bulb

AND

**greenhouse gas emissions equal to:**

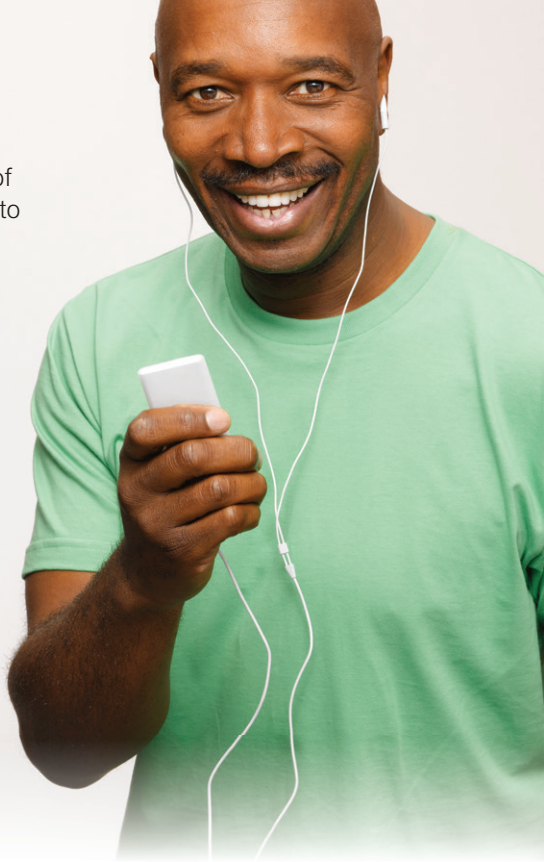


OR



electrical use in an  
average household  
for one year

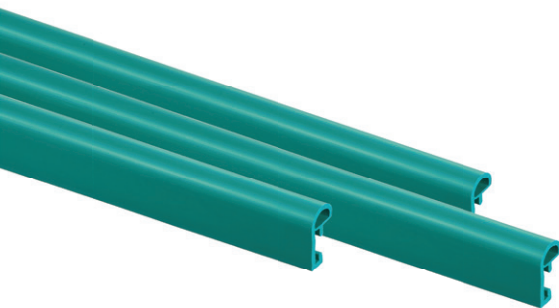
driving a new car  
22,640 miles



<sup>2</sup> These benefits are provided as an example and are based on the Ingeo eco-profile and available data on ABS. Assumes complete replacement of 3.7822g of ABS in a standard mobile phone housing with 4.3138g of Ingeo, with no changes in the eco-footprint associated with the downstream processing from polymer to finished item.

## Interested in looking at a sustainable solution to your durables needs?

Please contact your business development manager or email us at [durables@natureworkslc.com](mailto:durables@natureworkslc.com).



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