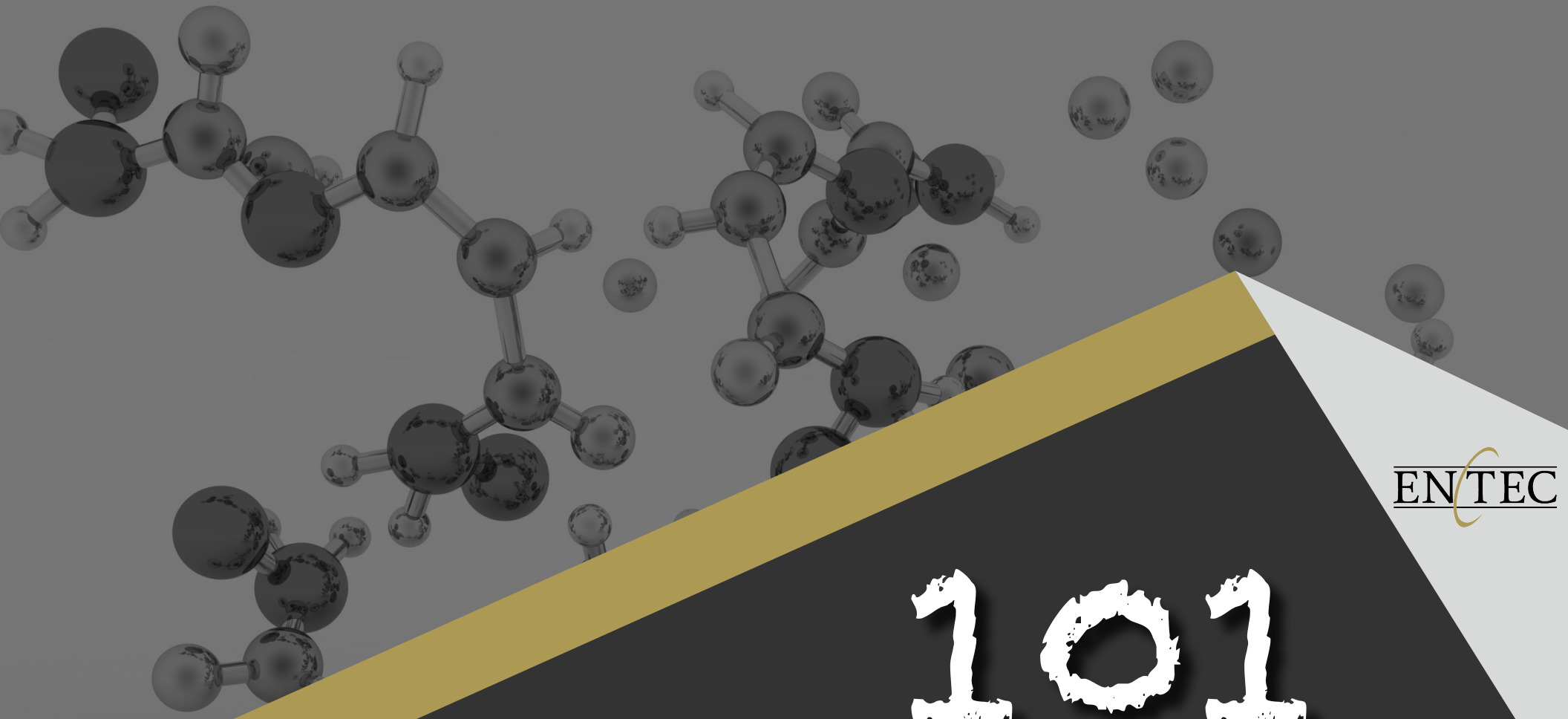
POLYPROPYLENE



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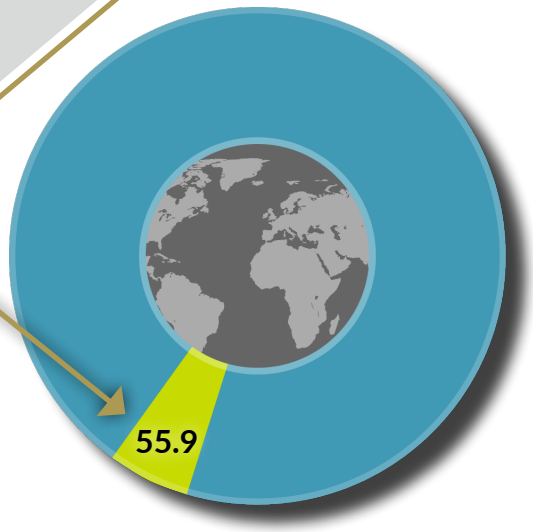
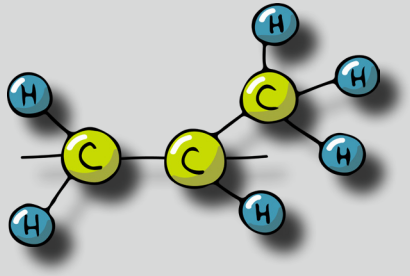
Polypropylene was first produced in 1954 and is one of the major types of commodity plastics. It is the 3rd largest volume polymer after Polyethylene and PVC, with about

55.9 Million

Metric Tons Produced.



Polypropylene is a simple molecule composed of hydrogen and carbon atoms but it can be found in a diverse array of applications from film (BOPP), food packaging, bags, containers, toys, automotive parts, fibers and fabrics, pipes and fittings and furniture.



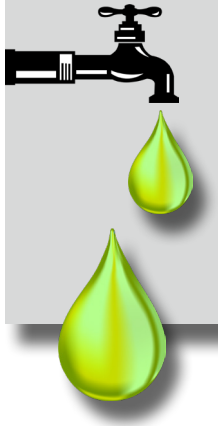
POLYPROPYLENE CAN BE BROKEN DOWN INTO THREE MAIN TYPES

- PP Homopolymer (Isotactic)
- PP Random Copolymer
- PP Impact Copolymer (Heterophasic)

PP Homopolymer (Isotactic)

Polypropylene homopolymer is made in a single reactor with propylene and a catalyst. PP homopolymer has the highest tensile strength, stiffness and temperature resistance of the PP products but has poor toughness and impact resistance, especially at cold temperatures.

MELT FLOW INDEX (g/10 min)



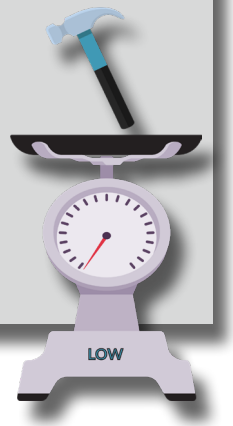
0.7 - 55

ADDITIVE PACKAGES

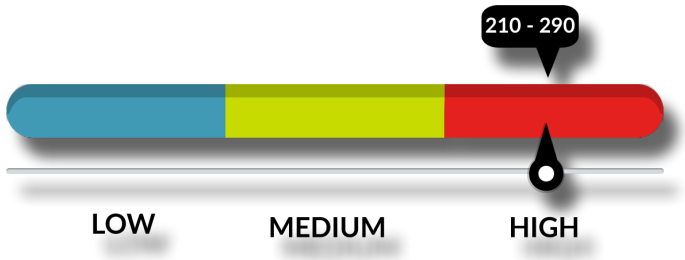
- ☑ Anti-Static
- ☑ Anti-Gas
- ☑ Clarifier
- ☑ Long Term Heat Aging
- ☑ Nucleator

NOTCHED IZOD IMPACT (ft-lb/in)

0.4 - 0.9



FLEX MODULUS (kpsi)



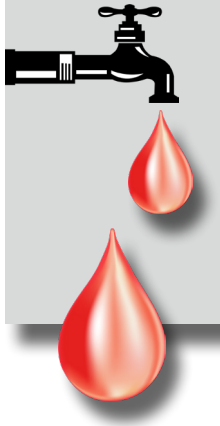
TENSILE STRENGTH (psi)

5,000 - 5,800

PP Random Copolymer

Polypropylene random copolymers are made in a single reactor with a small amount of ethylene, typically 1.5 to 6%, which disrupts the crystallinity, resulting in a lower melting point, lower stiffness and improved clarity. PP random copolymers have better impact resistance than PP homopolymers at room temperature, but they still suffer from poor cold temperature impact.

MELT FLOW INDEX (g/10 min)



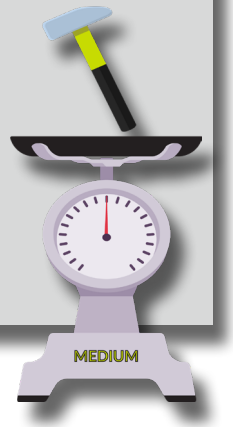
1.5 - 100

ADDITIVE PACKAGES

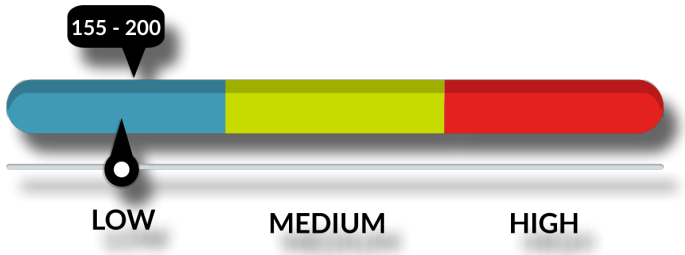
- [x] Anti-Static
- [ ] Anti-Gas
- [x] Clarifier
- [ ] Long Term Heat Aging
- [ ] Nucleator

NOTCHED IZOD IMPACT (ft-lb/in)

0.9 - 2



FLEX MODULUS (kpsi)



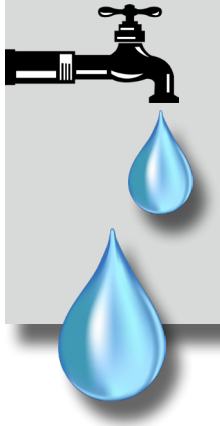
TENSILE STRENGTH (psi)

3,600 - 4,600

PP Impact Copolymer

Polypropylene impact copolymers, also called heterophasic copolymer, is made in a two reactor system where the first reactor polymerizes the homopolymer backbone and the second reactor polymerizes an ethylene-propylene rubber which is dispersed in the homopolymer matrix. PP impact copolymers have improved impact resistance even at cold temperatures. PP impact copolymers are typically produced with different levels of notched Izod impact resistance with common grades having 2, 6 or 10 ft-lb/in impact resistance. Grades with 10 ft-lb/in notched Izod are called “no break”.

MELT FLOW INDEX (g/10 min)



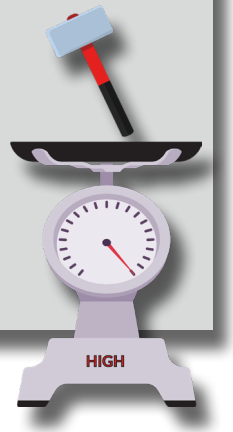
0.4 - 100

ADDITIVE PACKAGES

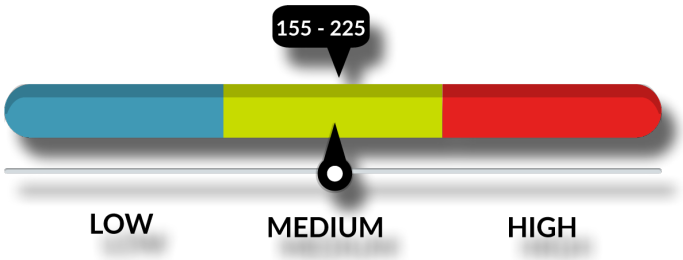
- [x] Anti-Static
- [ ] Anti-Gas
- [ ] Clarifier
- [x] Long Term Heat Aging
- [x] Nucleator

NOTCHED IZOD IMPACT (ft-lb/in)

1.2 - No Break



FLEX MODULUS (kpsi)



TENSILE STRENGTH (psi)

3,000 - 4,900

PP Characteristics

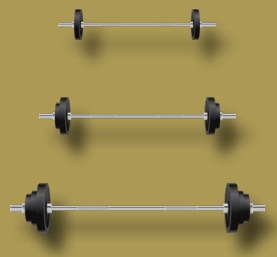
Important characteristics for Polypropylene include the type of PP, molecular weight (melt flow index), notched Izod impact and additive package. PP can be used unfilled, mineral filled (talc, mica, calcium carbonate) or glass fiber reinforced. PP can be a “reactor” grade or a “controlled rheology” (also called vis-broken) grade.

Melt Flow Index

Melt flow index is a measure of melt viscosity (molecular weight) and is measured at 230°C and a 2.16 kg load and the units are grams/10 minutes. Because melt flow index is inverse to molecular weight, a high melt flow grade has low molecular weight while a low melt flow grade has high molecular weight. Melt flow index is an important characteristic as many mechanical properties are related to the molecular weight. Melt flow index also affects the processability and processing cycle time of the PP compound. Standard grades of PP range from fractional melt flow (less than 1 gm/10 minutes) to well over 100 gm/10 minutes. Melt flow index is one of the primary characteristics for describing different grades of PP.

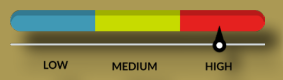
Notched Izod Impact

Notched Izod impact is another primary characteristic for describing PP especially for impact copolymers. PP homopolymers typically have notched Izod values 0.4 to 0.8 ft-lb/in so there is not much difference between the various homopolymer grades. For random copolymers the notched Izod values are slightly higher than homopolymers and are between 1 and 2 ft-lb/in. However, for impact copolymers the notched Izod impact varies between 1.5 and 10 ft-lb/in, so this is a very important property when specifying PP impact copolymers.



Tensile Strength

Tensile strength is the actual strength of the polypropylene polymer. PP homopolymers will have the highest tensile strength, followed by random copolymers. Impact copolymers will typically have the lowest tensile strength due to the higher level of ethylene comonomer.

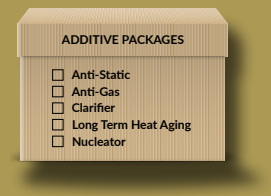


Flex Modulus

Flex modulus is the stiffness of the polypropylene polymer. PP homopolymers will have the highest flex modulus followed by impact copolymers. Random copolymers will typically have the lowest flex modulus due to the ethylene comonomer being in the polymer backbone.

Controlled Rheology

The melt flow index of polypropylene can be increased by exposing the material to peroxide in a post-reactor step. Exposure to peroxide breaks the polymer chains into shorter lengths, hence the term “viscosity breaking”, which increases the melt flow index (reduces molecular weight). Because the peroxide preferentially attacks the longer polymer chains, as opposed to the shorter polymer chains, it also causes a narrowing of the molecular weight distribution. Because of the higher melt flow index and narrower molecular weight distribution, controlled rheology grades will typically have faster cycle times in injection molding as well as lower warpage.



Additive Packages

Common additives used in polypropylene include nucleators, clarifiers, anti-stats, long term heat aging additives, and low-water-carryover additives. A = Anti-Static, AG = Anti-Gas, C = Clarifier, L = Long Term Heat Aging, N = Nucleator.

A = Anti-Static

Added to PP to help minimize electrostatic charges that can cause dust to adhere to parts. Anti-stats migrate, or bloom, to the part surface and adsorb small amounts of moisture from the air.

AG = Anti-Gas

Certain types of anti-oxidants can discolor to a pink or yellow color when exposed to certain conditions such as fumes of nitrous oxides. This effect is called ‘pinking’ or gas-fading. When the anti-oxidant additive package is modified so that this pinking effect will not occur, these products are known as an anti-gas-fading.

C = Clarifier

Similar to nucleators except that they are soluble in the PP and are more commonly used in random PP, but also in some homopolymers, to improve the clarity. Clarifiers cause the PP to form more and smaller crystals which makes the parts clearer and more transparent.

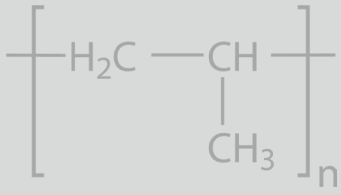
L = Long Term Heat Aging

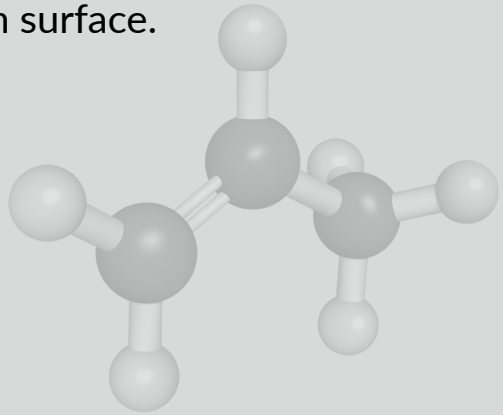
Added to PP to prevent oxidation and degradation when parts are exposed to elevated temperatures for prolonged periods of time.

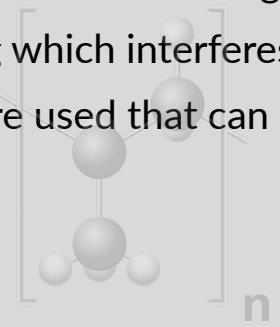
N = Nucleator

Speeds up the crystallization of PP and therefore reduces the molding cycle time allowing for faster processing. Nucleators can improve the stiffness and impact of PP as well as improve the clarity. Nucleators are typically insoluble in PP.

In certain film applications, special grades of polypropylene are required that have low-water-carry-over (LWCO) characteristics. LWCO refers to the additive package used in some film applications where the molten film goes through a water bath for quenching. Some additives tend to make the film carry water along which interferes further down the conversion process. The LWCO additive package ensures that no additives are used that can absorb water and allow it to stick to the film surface.







SUMMARY:

COMMON PROPERTIES OF POLYPROPYLENE

PROPERTY	HOMOPOLYMER	RANDOM COPOLYMER	IMPACT COPOLYMER
Melt Flow Index, g/10 min (drops)	0.7 - 55	1.5 – 100	0.4 – 100
Tensile Strength, psi (weights)	5,000 - 5,800	3,600 - 4,600	3,000 - 4,900
Notched Izod Impact, ft-lb/in (scale)	0.4 – 0.9	0.9 - 2	1.2 – No Break
Flex Modulus, kpsi (sliders)	210 - 290	155 - 200	155 - 225
Additive Packages	A, AG, C, L, N	A, C	A, L, N