LyondellBasell Technical Tip

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Material Selection —Polypropylene

■ INTRODUCTION

Choosing the right grade of polypropylene for an application can appear to be an overwhelming task, especially if no material specification or history with similar applications exists.

Although product literature is readily available, the amount of information provided on data sheets may raise questions, especially to a molder or extruder with relatively little experience with polypropylene.

There are no formulas to apply to material selection but the following discussion provides guidelines to assist in the material selection process.

■ PRODUCT SELECTION CRITERIA

There are four primary criteria to consider when selecting a grade of polypropylene:

1. The process to be used
2. The aesthetic requirements of the application
3. The mechanical function of the part
4. Special additive requirements

These are not listed in order of importance as each application has its own "hierarchy" of requirements that vary from application to application. For example, with a one-time use or throw-away item, processability may
be the most important factor, but for an automotive bumper fascia, all of these criteria are nearly equal in importance.

The three types of polypropylene — homopolymers, random copolymers and impact copolymers — exhibit distinctly unique 'strong-points" (see table below) and it is rare that one type can be interchanged with another without compromising some performance property. Choosing the type of polypropylene is generally the first and easiest choice made based on the unique characteristics of each type.

For most applications, selecting among these characteristics can determine the type of polypropylene used. Once defined, other criteria need to be addressed by listing all requirements and then prioritizing the list.

■ PROCESS

The choice of an appropriate melt flow rate (MFR) depends on the process used. Processes requiring high melt strength, such as blow molding, blown film extrusion, profile extrusion, etc., require high molecular weight (low MFR) grades. Injection molding permits more latitude of choice because the inherent, low melt viscosity of polypropylene means a wide range of MFRs can be easily injection molded. Generally, high-speed, thin-wall, molding applications need a higher MFR grade, while thicker-walled, functional parts favor a lower MFR grade. Impact properties of impact copolymers are controlled to some degree by the MFR and, all other things being equal, lower MFR grade have better impact properties. However, other factors such as the composition and amount of the impact phase present influence these same properties.

Products with a narrow molecular weight distribution, achieved either by controlled rheology or high activity catalysts, exhibit less warpage, more uniform mold shrinkage and improved drawdown, but have less melt strength.

■ AESTHETICS

For many applications, especially packaging and housewares, contact or see-through clarity are necessary characteristics. In these cases, the selection of product is limited to homopolymers or random copolymers except for extremely thin-walled parts or films where essentially all products display some degree of clarity. Both homopolymers and random copolymers provide contact clarity when there is intimate contact between the object and the container wall. Only random copolymers provide see-through clarity. The degree of clarity can be enhanced by nucleating agents called "clarifiers".

At most practical wall thicknesses for functional applications, impact copolymers exhibit a milky, opaque appearance. However, in very thin-wall applications such as deli tubs, some degree of contact clarity can be achieved.

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CHARACTERISTIC	HOMOPOLYMER	RANDOM COPOLYMER	IMPACT COPOLYMER
Contact Clarity	YES	YES	NO
"See Through" Clarity	NO	YES	NO
Cold Temperature Impact	NO	LIMITED	YES
Extreme Elevated Temperature	YES	NO	LIMITED

HOMOPOLYMERS			
Property	**Increasing MFR**	**Narrowing MWD**	
Tensile Strength	+++	—	
Stiffness	+++	—	
Impact	—	+++	
Resistance	+++	—	
Heat Distortion	+++	—	
Hardness			
RANDOM COPOLYMERS			
Property	**Increasing MFR**	**Narrowing MWD**	**Increasing Ethylene Content**
Clarity	NME	—	+++
Tensile Strength	+++	—	—
Stiffness	+++	+++	—
Impact	—	—	+++
Resistance	+++	—	—
Heat Distortion	+++	—	—
Hardness			
IMPACT COPOLYMERS			
Property	**Increasing MFR**	**Narrowing MWD**	**Increasing Modifier Content**
Tensile Strength	+++	—	—
Stiffness	+++	—	—
Impact	—	+++	+++
Resistance	+++	—	—
Heat Distortion	+++	—	—
Hardness	NME	NME	—
Bruise Resistance			

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■ MECHANICAL FUNCTION

Within each type of polypropylene, the mechanical properties of individual grades are controlled by the molecular weight, molecular weight distribution, ethylene content (random copolymers) and the content and composition of the modifier phase (impact copolymers). The general trends are shown in the table above.

For ease of understanding, this table is greatly simplified, and it is not unusual to observe synergism when two or more controlling variables are changed at the same time. It is important in product selection to be aware a change in one property often creates change in another property, often in the wrong direction. This phenomenon underscores the importance of prioritizing the application's requirements prior to reviewing the product data.

Because subtle differences may exist in sample preparation, testing technique or data interpretation, extreme care must be used when comparing published property data obtained from different suppliers.

■ ADDITIVE REQUIREMENTS

Specific additives enhance the characteristics of polypropylene or impart properties not normally present. The prioritized list of application requirements must be used to specify special additives. One must recognize additives may have a negative effect on material processing or application properties such as mold plateout, high water carryover, interference with colors or pigments, etc. Some of the more commonly used additives include:

•Antioxidants •Acid scavengers •Anti-static agents
•Nucleators •Clarifiers •Mold release agents
•Slip agents • Anti-block agents •UV stabilizers

The specific use and function of many of these are discussed in related Polypropylene Tech Tips from Equistar.

■ SUMMARY

The selection of a specific grade of polypropylene can be simplified by systematically identifying, analyzing and prioritizing process and application requirements. Consultation with your Equistar technical service representative is encouraged to address any specific questions or concerns.

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