Nexant’s ChemSystems Process Evaluation/Research Planning program has published a new report, *Polyolefin Elastomers (05/06S7)*. To view the table of contents or order this report, please click on the link below: [http://www.chemsystems.com/reports/index.cfm?catID=2](http://www.chemsystems.com/reports/index.cfm?catID=2)

**OVERVIEW**

A thermoplastic polyolefin elastomer is a polymer or polymer compound which, above its melt temperature, exhibits a thermoplastic character that enables it to be shaped into a fabricated article and which, within its design temperature range, possesses elastomeric behavior without cross-linking during fabrication. Even though these materials are thermoplastic, they exhibit elasticity similar to that of a cross-linked rubber. Thermoplastic polyolefin elastomers provide an excellent balance of performance and price. They are available in a broad range of hardnesses, have excellent chemical resistance to acids, bases and other aqueous media and have good property retention despite the swelling caused by exposure to hydrocarbon fluids. Their service temperature range is from -60 to 275 degrees F (-50 to 135 degrees C); hardness ranges from 35 Shore A to 50 Shore D.

Industry molders increasingly use thermoplastic polyolefin elastomers due to the significant cost savings because of their ability to be processed on plastics machinery. The thermoplastic molding and extrusion processes used for these materials avoid the cross-linking step that conventional rubber molders use. Therefore, a cycle time that normally took hours can be completed in as little as 20 seconds.

Various properties that can be applied to thermoplastic polyolefin elastomers include: custom colors, specific gravity adjustment, anti-static and conductivity modification, flame retardancy, UV resistance, anti-microbial enhancements, wear resistant lubrication, and modified substrate adhesion for overmolding.

**In-Situ TPOs**

An in-situ TPO is defined as a polyolefin material containing between 22 and 55 percent ethylene as produced in the reactor; essentially all of the remaining composition is propylene. In some cases the ethylene content can be as low as 10 percent, but majority of in-situ TPOs are between 22 to 55 weight percent ethylene. Small amounts of additional co-monomers, such as octene or butene, may also be present so as to provide unique functionality. Propylene polymers with less than 22 percent ethylene are fairly hard and usually have poor elastomeric properties - these are classified as impact polypropylenes for the purposes of this report. Polymers containing greater than 55 percent ethylene are quite soft and also have relatively poor elastomeric properties – these are classified as plastomers.
In-situ TPO applications include the following, although, the automotive applications are the largest segment, accounting for about 75 percent of global in-situ TPO demand.

- Automotive (exterior and bumpers, impact modifiers, interior head impact trim, under-the-hood impact, cladding, wire harness, weather strip, etc.)
- Building & Construction (roofing applications, decorative sheet, protect sheet, etc.)
- Medical (fluid bag, bottle, etc.)
- Food packaging (wrapping film, shrink film, sealant, etc.)
- PP flexibility modifier (used in compounds, instrument panel, interior wall, etc.)
- Other miscellaneous end-uses

In-situ TPOs, materials made in special polypropylene reactors, compete to some extent against Compounded TPOs. However, high elastomer content in-situ TPOs are difficult to produce, and high levels of other additives, especially colorants such as carbon black, must still be added. This has largely relegated in-situ TPOs to applications with either low ethylene content, or where dispersing other ingredients can be done easily during fabrication. In-situ materials are used to reduce cost and increase the end use value in cases where the TPO does not need to be compounded prior to fabrication. Displacement of compounded TPOs by in-situ materials appears to have largely run its course.

**Compounded Thermoplastic Olefinics (TPOs)**

Compounded TPOs generally contain 20-40 percent elastomer, such as EPDM or POE (typical is 35 percent EPDM or POE) in impact polypropylene. They are produced by a post-polymerization compounding step.

Compounded TPOs are generated when polypropylene resins are either colored or otherwise modified prior to fabrication. The activity of compounding generally began as an obligation of the resin supplier, and indeed remains with the resin producer in many parts of the world (e.g., Japan, Korea, and Western Europe). However, in other parts of the world, new entrepreneurial entities entered the compounding business which became increasingly competitive, particularly for commodity compounds, giving rise to a separate group of companies, occupying this part of the value chain. The current state of the captive versus independent nature of the polypropylene compounding business in the countries covered in this study is illustrated in Figure 1.

Although polypropylene resin producers developed compounding technologies and markets, they are slowly yielding ground to the independent compounders, particularly in producing compounded TPOs that they cannot do in a cost effective manner. This is often in the compounding of small lots, which is a part of the compounding business that is dependent on low labor cost – an area where a resin producer with unionized or otherwise highly skilled and highly paid labor may be at a distinct disadvantage.
Independent compounders are a very dynamic group of companies, characterized by entrepreneurial firms that compete on a local basis in a very cost competitive business. Note that in addition to compounding, many independent compounders perform other services such as distribution (breaking bulk) and tolling (compounding resin provided by others for a set fee). In addition to compounding, most compounders are important purchasers of out-of-specification resin, and will sometimes resell some of this material to others.

Segmentation by compounding responsibility is an interesting approach warranting further explanation. At the simplest level, the compounding is responsible only for the production of the compounded TPO using base polymer, additives, and a formulation supplied by the customer. Next is “custom” compounding, whereby the compounding is responsible for manufacturing and purchasing some or even all of the additives. General purpose grades are compounded TPOs made by the compounder, typically sold under their own brand name as part of a general product line, even though the formulation may be very well known in the industry. Finally, “proprietary” compounding is a joint effort of the compounding and the end user working together to develop a formulated TPO that meets the particular needs or specifications dictated by the end-user’s application.

The compounding business will continue to face a dynamic future. The demand for compounded TPO continues to grow at an annual rate of 4-6 percent per year.

**Thermoplastic Vulcanizes (TPVs)**

Thermoplastic vulcanizes (TPVs) typically contain 60-70 percent EPDM and 30-40 percent impact polypropylene. These products contain a low level of crosslinks, but they are true thermoplastic materials. TPVs have superior strength, high-temperature mechanical properties, hot oil and solvent resistance, and better compression set than partially cured material. These materials are almost always “dynamically cured”, which refers to the process whereby the rubber phase is vulcanized during melt-mixing with the molten non-crosslinked plastic. Static curing occurs when the rubber is cured prior to mixing with polypropylene.
Further demand growth is anticipated, especially in automotive sealing where TPVs are displacing EPDM in less demanding (e.g. static) molded window seals. However, compression set remains an issue in more demanding (e.g. dynamic) applications such as door seals. The current market trend is toward softer materials.

TPVs have many of the elastomeric properties of vulcanized rubbers, and yet can be molded or extruded using conventional thermoplastic fabrication equipment. They derive their properties from a unique physical network of seemingly incompatible structures, which coexist through chemical bonding. These structures can generically be referred to as soft-block and hard-block components. These materials can exhibit a range of properties because of the different types of hard and soft blocks, ratio of blocks, degree of polymer linearity, crystallinity, and degree of polymerization and cross-linking. Properties can be further changed by co-blending and compounding with vulcanized rubbers, silicone, or other components.

The soft blocks are amorphous, rubber like elastomer components. The hard blocks, with their melting point or glass-transition temperature above room temperature, form domains that prevent plastic deformation and provide tensile strength at normal-use temperature. At melt-processing temperatures, the hard blocks become fluid and the polymer flows under pressure. Upon cooling, the hard blocks again form solidified domains.

**Polyolefin Elastomers (POE)**

POEs contain about 65 percent ethylene and 35 percent octene-1, hexene-1 or butene-1. These products are produced via metallocene catalysts and are finding use as the elastomeric portion in TPOs, or as polymer modifiers.

All compounded TPOs were formerly PP/EPDM blends. However, POEs have rapidly displaced EPDM, and now account for about a third of the elastomer content in compounded TPOs. Additional displacement of EPDM is projected on the basis of the ability to better tailor end-use properties (the POEs are made with metallocene catalysts and thus their properties can readily be tailored), ease of handling (POEs are in pellet form, whereas EPDM is typically baled), and lower overall cost (bales are more labor intensive to use than pellets).

The new polyolefin elastomers (POEs) are essentially very low molecular weight, linear low density polyethylenes (VLMW-LLDPE). A product of advancements in polymerization catalyst technology, this material was originally slated for use in improved flexible packaging films. Recently, POEs have seen uses as low-cost rubber replacements for some non-demanding molded goods applications: those that will not be exposed to extremes in temperatures, pressures, loads or stress environments. In molded goods, POEs are being used where "some" degree of flexibility or tactile feel is desired.
ECONOMICS

The in-situ TPO polymerization plants are assumed to operate 8,000 hours per year. In contrast, compounding equipment is assumed to be operated 24 hours per day, five days per week. This is representative of the industry, which uses the weekends for maintenance and to meet periods of high demand. The on-stream factor is 96 percent; thus the compounding lines are running at 6,000 hours per year. Scrap was assumed to be 1.5 percent for TPOs and 2.0 percent for TPVs. Utilities consist mainly of power, although a constant three dollars per ton was allowed for miscellaneous utility costs such as process water.

Cost of production analyses were prepared for the following TPO’s:

- Compounded TPO
- In-situ TPO (Catalloy)
- In-situ TPO (Spheripol)
- TPV
- POE

It is evident from the summary of the economics that those materials produced by the in-situ processes (CATALLOY and SPHERIPOL) are considerably less costly to produce than the compounded TPOs, TPVs, and POEs. This explains why the in-situ materials rapidly displaced the compounded products in those applications where they are suitable. The economics presented in the report do not include application development or technical support costs, which can be considerable depending on the application.

MARKET ANALYSIS

Regional demand analyses for In-situ TPOs, Compounded TPOs, TPVs and POEs out to 2011 are provided in the report.