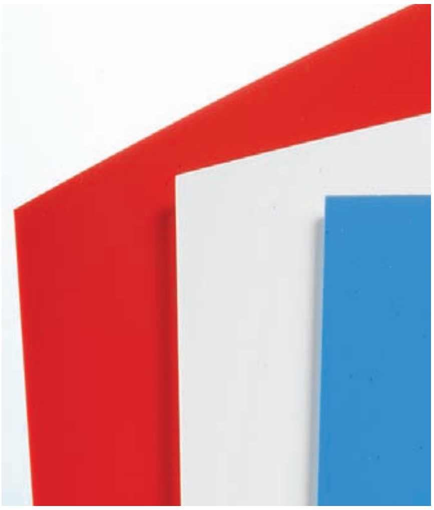
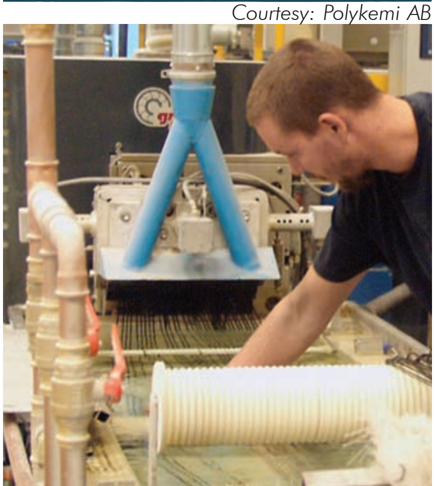


Courtesy: BASF

Compounding process for POLYfill HC

Courtesy: Polykemi AB



A polymer pre-blending station

Courtesy: Polykemi AB

Polymer compounding

Reinforcing application-driven materials

As market potential increases, there is a growing demand for polymers with certain high performance characteristics. To meet this market imperative, polymer compounding has been one of the most sought-after methods, chiefly due to its cost-effectiveness and versatility in applications. **Annabel Dsouza** and **Kymberlee Fernandes** zoom in on the material innovations and technological advancements in the compounding industry.

In recent times, compounding has been used to a great extent to make grades of plastics with diverse specifications, because a variety of plastic materials are required to satisfy a wide range of applications. It is an incredibly expensive proposition to determine and manufacture a new molecule to fit each one of these applications. It is well-known that long fibre reinforcement can increase impact strength in Polypropylene (PP), Polyamide (PA), Polycarbonate (PC), Polyetheretherketone (PEEK) and other polymers. This makes compounding a technology that allows existing processors and entrepreneurs to dream big without worrying about the cost.

Compounding offers a quick, easy and low-cost alternative to discover new grades of plastics. The plastics additives industry has emerged victorious after facing more than five strenuous years of structural market changes, including reduction in margins, swift increases in feedstock prices, product lifecycle maturity, transfer of growth to emerging markets, and regulatory demands.

According to a technical market research report from BCC Research, the global market for plastics additives was worth more than $ 36.2 billion in 2008 and is expected to increase to $ 45.8 billion in 2014, by a CAGR of 4.1 per cent. The market can be categorised into property modifiers, property stabilisers, property extenders and processing aids. Of these, the property modifiers segment holds the largest share of the market. Following suit are the property stabilisers; and property extenders make up for the third-largest marketshare.

Additives are integral components to plastics and contribute to the success of plastics not only in processability but also in property modification and performance. Although used only 5-7 per cent in terms of weight or about 10 per cent by cost, they provide immense benefits. They make plastics safer, cleaner, tougher and colourful. Additives are sometimes expensive. However, by reducing production costs and increasing the life of products, they result in bringing down overall costs and the use of raw materials.

A 'mine' of innovations

Minerals account for a major proportion of the additives used in compounding polymers with a key role as fillers. The minerals' particle size, shape, surface area, matrix compatibility and dispersion, among others factors, affect the plastics performance. K G Chandan, Technical Director, Technovinyl Polymers India Ltd, says, "Fillers have a role in cost reduction. Functional fillers and nano size minerals are making inroads into polymer compounding, leading to novel composites. Binary reinforcing is also an innovative concept in designing new-generation mineral filled compounds."

The main function of a mineral in a thermoplastic is to reduce cost. This is a common misconception, even if it was largely true about 30 years ago. Henrik Eriksson, Development Manager, Polykemi AB, says, "Today, the addition of minerals is mainly done for technical reasons. Many minerals certainly have the apparent benefit of reducing price per kilo even after the compounding cost is taken into the equation, especially calcium carbonates as well as coarser talc and untreated wollastonites."

However, the more technical mineral additives have a price per volume that is equal or much higher than the volume price for polypropylene. Therefore, if a pure polypropylene is good enough from a mechanical performance point of view for a certain application, it rarely makes sense to consider a filled grade to save money, unless the part can be redesigned to take advantage of the different property profile of the mineral containing the grade.

An apt example would be the finely ground talc that is employed in scratch resistant automotive interior grades, as well as grades for large exterior trim parts, and is often in the same or higher price per volume range as is the polypropylene into which they are mixed. "At the design stage, it is a matter of finding a material with the best price per property, which might very well be a mineral-reinforced material, but too often people focus on the price per kilo at the design stage and forget all about the impact of density. Many of the sophisticated surface-treated wollastonites are more expensive per volume. Still, the properties offered by these minerals make them attractive for cases where glass fibre reinforcement is over-engineered. Especially for wollastonite, there are some innovative and effective surface treatments available. Surface treatment of talc in only cost-effective in rare cases," Eriksson adds.

Multifarious technology

Globally, more than 30,000 processing units comprising single-screw extruders, internal mixers or dispersive kneaders, reciprocating single-screw extruder (co-kneaders) and twin-screw extruders are currently used for compounding. "Over the years, co-rotating twin-screw extruders have played a dominant role in compounding – used by resin suppliers, proprietary and custom compounders or end-users, making it the most preferred processing equipment," says Dr Babu Padmanabhan, Founder and MD, STEER Engineering Pvt Ltd.

In India, there is an increasing amount of compounding activity in terms of investment in new equipment and capacity increase. Simon TING, Shanghai Technical Polymers Development Branch, Arkema, observes, "This can be attributed to the 'mismatch' between the materials

Fillers have a role in cost reduction. Functional fillers and nano size minerals are making inroads into polymer compounding, leading to novel composites.

K G Chandan
Technical Director,
Technovinyl Polymers India Ltd

formulated for the overseas market and the local requirement. Locally designed and developed products are demanding material solutions tailored to their operation specifications. This is one of the key drivers for more local compounding facilities to support the requirement."

The perpetual trend of trying to get more performance at a lower cost is as influential for the compounders as it is for any other industry. An example of how such challenges are met is a super high-performing, short glass fibre-reinforced polypropylene, with stiffness high enough to compete with significantly more expensive

Wood ploymer

Jute composite

Courtesy: STEER Engineering Pvt Ltd

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PA6 glass fibre-reinforced compounds or even PBT with the same amount of glass fibre.

"In some cases, this material makes it possible to slash costs in half. With this material, Polykemi has enjoyed its major part of commercial successes and is now finding its way into the automotive industry," asserts Eriksson.

One of the latest innovations is from a Germany-based manufacturer that is producing fibres with completely new performance and longevity characteristics that has propelled the industry into the new age of artificial turf. The company has developed a technology that offers revolutionary fibre with superior performance. It combines the best in polymer technology with the strongest Ultra Violet (UV) inhibitors and a state-of-the-art extrusion process. After years of experimentation, it seems that the perfect formula has been developed. The creation of this new compound will enable to produce a fibre that will resist splitting and reduce degradation caused by the Sun's UV rays – better than any other fibre the industry has ever known.

Material outlook

With constant developments in the polymer compounding industry, the characteristics and grades of resins also keep advancing. There are over 300 grades of Acrylonitrile Butadiene Styrene (ABS) alone and more than 10,000 different grades of plastic materials are manufactured using the compounding process. Macro, micro & nano fillers, plasticisers, reinforcements, flame retardants, colourants, carbon black, impact modifiers, lubricants, heat stabilisers, UV stabilisers, antioxidants, organic peroxides blowing agents, anti-microbial agents, and antistatic agents are the most common additives that are compounded. "Other additives include clarifying & cross-linking agents, coupling agents, deodorants, fragrance, nucleating agents, slip & vulcanising agents. These are added separately or in combinations to one or several different resin types, forming products with unique characteristics suited for myriad applications. Further, these are added in different stages of the process in the form of liquids or solids, either separately or in mixtures to get the required properties in the final compound," observes Dr Padmanabhan.

As polymer compounding takes centre stage, the demand for polyolefins globally is expected to grow to 132 Million Tonne (MT) by 2013 according to research reports from Applied Market Information. PP constitutes 53 MT and PE is 79 MT of this. Demand has risen the fastest in Asia (excluding Japan) with an annual rate of 10 per cent, with Central and South America at around 6.5 per cent and Europe & NAFTA at 4 per cent. The increase has been double that of the Gross Domestic Product (GDP). The rapid rise in some economies has been due to increased investments, exports and domestic consumption.

While these polymers hold considerable significance, the recent focus has shifted to biodegradable options. Biodegradable plastics are established in the marketplace as alternative materials. Compounding and processing technology is rapidly developing so that these relatively new polymers can be used in a wider range of applications. There are plenty of issues to consider – the compatibility and environmental aspects of the additives going into compounds, ways to process materials that are made to degrade, their availability, etc.

Since the polymer compounding process is rather cost-effective, many small and medium enterprises opt for it, while making their contribution to the environment. Due to availability constraints, Polylactic Acid (PLA) or perhaps bio-based polyolefins, are the only bio-based polymers of real interest for small to medium-sized independent compounders at the moment. Eriksson avers, "It is still a niche market but everyone tries to keep track of the

Bio-based polymers can further reduce weight, increase design freedom, and materials can also be more eco-responsible, fulfilling the renewable, reuse and recycle concept.

Simon TING
Shanghai Technical Polymers Development Branch, Arkema

most recent developments to be able to join the race once these polymers start making a more considerable impact on the market. Currently, very small amounts of bio-based polymers enter the compounding stage."

"Bio-based polymers can further reduce weight, increase design freedom, and materials can also be more eco-responsible, fulfilling the renewable, reuse and recycle concept. All these features are providing resin producers additional advantages to convince end-users/OEMs to replace metal and rubber for a more sustainable development," says TING.

A compound of challenges

And while the course to triumph is never smooth, so is the case with the polymer compounding industry. In the compounding industry, Chandan observes, "Rising cost of polymer products; non-organised industry segment, mainly in processing; unstable marketing dynamics; unhealthy price competition; shortage of raw materials, and the like are some of the major roadblocks." Independent compounders rely on a stable availability of a wide range of raw materials. Material shortages have posed difficulties for many compounders ever since the industry started to recuperate from the financial crisis.

While addressing the challenges encountered by new applications, it is important to review the steps involved during any compounding, and also the fundamentals to avoid common problems. Efforts are constantly being directed towards upgrading this integral process in plastics processing. The industry is striving to overcome the capital and manpower deficit since the compounding process is one that ensures homogeneity in ingredients through chemical blending. ■