Plastics – one of the most resource-efficient materials available

by Michael M. Fisher, Chair, ISO/TC 61, Plastics

This issue of *ISO Focus*, with its emphasis on environmental sustainability, offers an opportunity to examine the relationship between plastics and the environment. Plastics [1] play an important role in protecting the environment by reducing material consumption, fossil-fuel usage and hydrocarbon emissions, conserving natural resources and helping manage solid waste. Products derived from plastics also support economic development and social progress, making these materials key to sustainable development.

Driving product innovation

Design versatility is a hallmark of plastics and key to understanding how they help the environment. No other category of material is as versatile in terms of diversity of families/grades available and breadth of properties obtainable, or offers so many ways to modify composition or molecular structure to customize performance. Polymers are routinely manipulated to reduce material consumption and provide the right balance of cost, performance and mass. As a result, in many applications today, plastics have become thinner and lighter, while offering higher performance.

"Plastics play an important role in protecting the environment."

Material and design changes in the packaging industry have led to minimal shrink-wrapping that adequately protects food, and replacement of rigid-plastic containers with flexible pouches using 70 % less material.

Today's average plastic package weighs 28 % less than a decade ago, yet accomplishes the same task while saving 1.8 million tonnes of material. A German study [2] calculated that packaging waste (and material consumption) would increase 158 % if plastics did not exist.

Reducing fossil-fuels and greenhouse gas emissions

Two important and interconnected ways in which plastics help the environment are reductions in the use of fossil fuels and in the emission of greenhouse gases, particularly carbon dioxide (CO_2).

Of all the oil consumed globally each year, 42 % is used for heat and to generate electricity and 45 % powers commercial and personal transportation. Only 4 % goes to produce plastic feedstocks and monomers, yet plastic products help many industries reduce their energy needs.

Polymeric foams help refrigerators/freezers keep food cold with less energy, a savings that translates directly into reduced hydrocarbon emissions. Increasing foam thickness just 15 mm saves 17 times more energy over the appliance's use-life than is consumed producing the insulation.

Similarly, insulation reduces the energy required to heat/cool buildings. Fuel consumption for an old house can be lowered from about 20 litres/m^2 to 3 litres/m^2. In just the first year, the energy required to produce the insulation is saved, and CO_2 emissions are reduced two to five times.

Plastics help reduce fuel usage and emissions in transportation, too, because their low specific gravity yields lighter parts, which are less energy-intensive to ship. As plastics replace traditional materials on components for commercial and personal transport, greater mass reduction is attained, lowering fuel consumption and tailpipe emissions.

A European study estimated that 100 kg of plastics already replace 200-300 kg of traditional materials on a typical passenger vehicle, yielding fuel savings of 750 litres over the vehicle's 150 000 km lifetime. Using Europe's annual vehicle build, this represents 12 million tonnes of fuel saved each year.

Life cycle assessment (LCA; ISO 14040) studies show that when plastics replace traditional materials, reductions in energy usage and emissions achieved for a vehicle over its entire use-life are far greater than values for the production of the polymer in the first place.

About the author

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Even removing a few kilograms has impact because a vehicle's "use phase" dominates the life cycle in terms of emissions and energy consumption. In one LCA study, the conservative estimate for a "lightweighted" generic vehicle over its lifetime provided calculated energy savings of 830 litres of gasoline and 1.6 tonnes of CO_2, while less conservative calculations projected reductions of about 3 200 litres of fuel and 5.8 tonnes of CO_2. When such savings are multiplied across a global fleet of "lightweighted" vehicles, the numbers become extremely significant.

"Plastics offer many recycling options."

Newer bio-plastics (derived from annually renewable plant-based chemicals rather than petroleum) consume CO_2 during growth of the plant "feedstock," creating a net reduction in hydrocarbon emissions. Plastics-enabled alternative power devices (e.g. fuel cells, windmill blades, photovoltaics) are also helping transition from a fossil-fuel economy while reducing emissions.

Conserving natural resources

Plastics also have a role to play in conserving other natural resources. Plastic packaging helps preserve food from spoilage, reducing waste. Plastic piping and cisterns bring water to humans and animals. Lightweight

1) The terms plastics and polymers here include a broad range of thermoplastic and thermoset rigid and elastomeric materials, coatings, adhesives, gels, as well as composites, including bio-composites, nanocomposites, polymer-matrix composites and plastic-metal hybrid systems.

2) Gesellschaft fuer Verpackungsmarktforschung, 1991.

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plastic containers make it easier to transport goods into remote locations. Additionally, plastic films and irrigation systems help crops grow on sites that otherwise would not support agriculture. Plastic fabrics stabilize soils, preventing erosion and loss of valuable topsoil. Polymer-based geotextiles line landfills, preventing escape of leachate into the water table and surrounding soils. Corrosion-resistant plastic replaces steel tanks at gas stations to prevent leakage and ground contamination. Washable "synthetic straw," extruded from biodegradable plastics, helps reduce mountains of natural straw and manure at horse racetracks. Hot pepper in the synstraw makes the bedding unappetizing to horses.

Managing the solid-waste problem

Carelessly discarded plastic litter can be an aesthetic blight and endanger wildlife. However, both the littering problem and its solution lie in changing human behaviour and values. That said, another way plastics protect the environment is by helping manage solid waste. The motto "reduce–reuse–recycle" is very applicable to the plastics industry.

As previously discussed, plastics can improve performance, lower mass and costs, and also reduce material consumption and hence solid waste. Furthermore, plastics are less dense and can be compacted further than many traditional materials – a benefit for countries that landfill. Plastic bags are energy and space efficient and facilitate transport. Since durable-plastic components do not rot/rust, they can be reused longer and with less maintenance, extending intervals between replacements.

Plastics offer many recycling options. Programmes for recovering post-industrial and post-consumer plastic waste mean materials see multiple use-lives and the recovery of plastics is expanding worldwide. Plastic bottles are mechanically recycled to make plastic lumber for decking/fencing and seating, or spun into fibers to make "fleece" clothing or carpets.

"Plastics are key to sustainable development."

In the auto industry, specifications for non-critical parts often allow incorporation of post-industrial and occasionally post-consumer recyclate in virgin resin. Nylon carpeting is depolymerized (chemically recycled), then repolymerized back into nylon and blended with virgin polymer and additives. Auto suppliers have explored use of this material in under-the-hood applications. Confidence in the use of post-consumer plastics is growing with the introduction of advanced recycling technologies.

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Plastic scrap and components can be mechanically recycled into new products or chemically recycled into new polymer/chemical feedstock. Alternatively, their heat content can be recovered via high-temperature combustion as a substitute fuel. For example, replacing coal with plastics waste to fuel power generation has the potential to reduce CO_2 emissions by 20-25%.

Biodegradable plastics have a role to play in protecting the environment, and eight standards have been published in this field under the supervision of ISO technical committee ISO/TC 61, *Plastics*, subcommittee SC 5, *Physical-chemical properties,* working group WG 22, *Biodegradability.*

Degradability can be useful for single-use applications that are likely to end up (due to breakage or discarding) out in the environment (exposed

References

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2. PlasticsEurope: **www.plasticseurope.org**
3. PWMI Japan: **www.pwi.jp**
4. *Life Cycle Evaluation of Vehicle Lightweighting through the Use of Plastic Materials, Ecobalance, Inc.* / PricewaterhouseCoopers.
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6. Wulf-Peter Schmidt, Claudia Duranceau, and J. Sullivan, *Sustainable Materials in Automotive Applications*, 2001-01-3762, SAE (2001).
7. M. Fisher, *Plastics and energy: A cradle-to-cradle relationship*, *ISO Focus*, pp. 7-11, (June 2005).

to sunlight, water, and bacteria) and which would be difficult to collect after use. Examples include weed trimmer line, fishing nets, and agricultural films. Depending on the recycling process being employed, care needs to be taken to avoid commingling with non-biodegradable plastics in the recycling stream to avoid cross-contamination of recyclates.

ISO/TC 61/WG 2, *Guidance on environmental provisions in plastics standards,* continues to provide a forum and develop horizontal standards that will facilitate technical understanding of plastics' role in environmental issues. ISO 15270, *Plastics – Guidelines for the recovery and recycling of plastics waste,* is the most recent initiative and is presently undergoing a Final Draft International Standard (FDIS) ballot.

Recently, two new technical committees have formed that, along with ISO/TC 207, *Environmental management*, have a significant focus on environmental issues, ISO/TC 229, *Nanotechnologies*, and IEC/TC 111, *Environmental standardization for electrical and electronic products and systems*. The work programme of ISO/TC 61 can serve as an important plastics environmental resource for these committees.

Plastics are one of the most resource-efficient materials available. They improve the environment by lowering material consumption, increasing energy efficiency, reducing mass and emissions, replacing other fuels and preventing losses and spoilage. Production of polymers and products made from them also provides jobs, creates wealth, improves the quality of life and expands the creative potential of the human mind. Indeed, they are a key to sustainable development.