Omnexus
Powered by SpecialChem

Provided by Omnexus.com

Print

Polyurethane Recycling Gains as Regulatory and Cost Pressures Mount

Sep 20, 2006

Gordon Graff

Introduction
Impact of regulations
Materials and methods
Energy recovery
Mechanical recycling
Chemical recycling
Conclusion

Introduction

Polyurethane recycling is an issue that is becoming increasingly important, especially in Europe, where landfill space is dwindling and waste disposal costs are soaring. Growing regulatory pressures to "close the loop" in polyurethane (PUR) product life cycles are additional factors promoting recycling. Many innovative recycling technologies have emerged over the past decade, and quite a few of them are already being used routinely.

Which particular recycling process is suitable for a particular product depends on the nature of the material, plus a variety of economic and environmental considerations. For example, incinerating PUR wastes for their energy value may be a viable option if many different products are co-mingled and regulations limit their disposal in landfills. But if the wastes are relatively pure, it is often more profitable to break them down into valuable monomeric PUR starting materials.

Impact of regulations

TOP

The European Union is gradually implementing stringent new quotas on recycling and energy recovery for materials used in the packaging, automotive, and the electrical and electronics sectors. These quotas affect plastics in general, and polyurethanes in particular. In addition, landfills in most central European countries will be phased out over the next few years.

Recycling regulations are less strict in North America, although, more and more manufacturers who produce and consume plastics in this region are developing voluntary recycling programs. Their aim is to reduce the likelihood of mandatory government quotas and imposed technological solutions, which could be more costly than voluntary programs. Several trade groups, such as the U.S.-based Alliance for the Polyurethanes Industry (API), and the European Isocyanate Producers Association (ISOPA), have actively promoted PUR recycling initiatives within the industry.

Materials and methods

TOP

Common sources of PUR for recycling are post-consumer products such as appliances, automobiles, bedding, carpet cushions and backings, and upholstered furniture. Industrial manufacturing scrap is another important source of recycled PUR.

Recycling and Recovery of Polyurethane

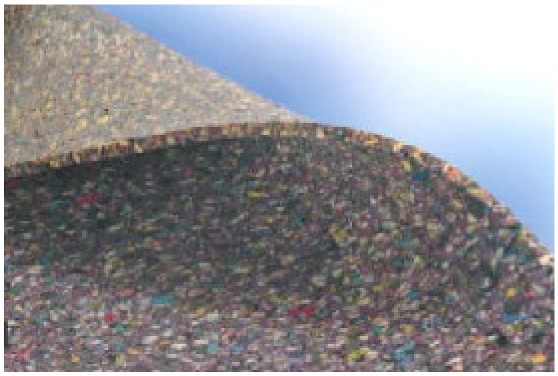
Mechanical Recycling	Feedstock Recycling	Energy Recovery
Rebonded flexible foam	Pyrolysis	MSW Combustion
Adhesive pressing	Hydrogenation	Fluidised bed boiler
Particle bonding	Gasification	Rotary kiln
Regrind/ powdering	Iron ore reduction	Two-stage combustion
Compression molding	**Chemical recycling**	

Injection molding Glycolysis
Hydrolysis

Recycling Methods
(Source: Bayer MaterialScience)

MSW: Municipal Solid Waste

PUR accounts for about 5% of all plastic waste, according to the Polyurethane Recycle and Recovery Council (PURRC), a unit of API. The extent of recycling varies with the type of product. PUR carpet cushions have a particularly high rate of recycling. In 2002, some 98% of the PUR used to make carpet cushions in the U.S. came from scrap PUR foam, reports PURRC. Of the total scrap used, about 6% came from post-consumer waste.



PUR-carpet backing & cushioning
(Source: Bayer Material Science)

Although transportation is a major consumer of PUR, recycling of PUR in this sector has been modest. The high costs of separating the PUR wastes from other components of discarded automobiles have been barriers to recovery and re-use of PUR in motor vehicles. However, automakers around the world are beginning to design vehicles for easy and economical removal of PUR seat cushions for recycling. Reaction injection molded (RIM) parts in autos, found in bumper skins and side protection panels, have been commercially recycled for various applications, both automotive and non-automotive.

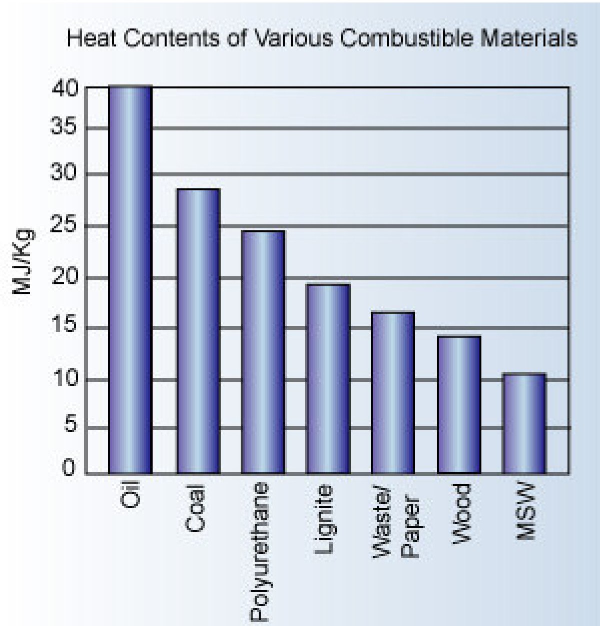
Sound Deadening Cladding
(Source: Bayer Material Science)

Among the methods used to recycle PUR products are energy recovery processes such as incineration and use of the resulting heat for electric power generation. Another strategy involves mechanical recycling, such as grinding and re-use of PUR wastes as fillers in molded PUR goods. A third method is to chemically break down PUR into its monomeric constituents and then re-use the monomers to make new PUR products.

Energy recovery

TOP

When PUR is part of a larger, undifferentiated waste stream - such as municipal solid waste, or ground up post-consumer products made of a variety of combustible materials - incineration and recovery of the thermal energy is often the most satisfactory recycling option. As a fuel, a given amount of PUR has an energy content nearly equal to coal on an equivalent weight basis. Incineration reduces PUR to about 1% of its original volume, thus lessening the burden on landfills.



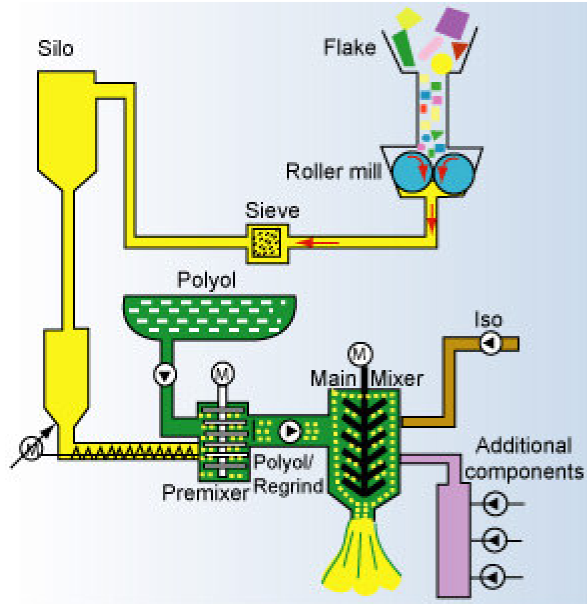
Polyurethanes Heat Content
(Source: European Isocyanate Producers' Association (ISOPA))

PURRC studies have found that PUR can be added to municipal solid waste in amounts up to 20% by weight without increasing levels of undesirable gas emissions or ash. ISOPA reports that PUR can be fed into advanced incinerators linked to thermal energy recovery units and flue-gas cleaning equipment. Such combination units are said to be capable of providing up to 10% of electricity requirements of local communities. PUR wastes have also been used as fuel for domestic heating and cement kilns

Mechanical recycling

TOP

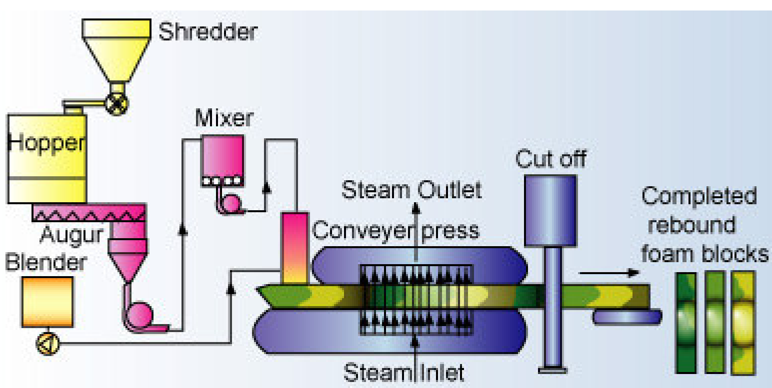
Grinding PUR wastes into powders and then re-using these powders in various ways constitute the mechanical recycling approach. Wastes for this process can come from factory trim and scrap, as well as post-consumer products. The powdered PUR is available as filler in production of PUR foams or elastomers. When used as fillers, the powders are usually first added to the polyol component in a PUR production process. Molded PUR products, such as auto seat cushions, can contain up to 20% regrind without any deterioration in properties or performance.



Regrind Process
(Source: European Isocyanate Producers' Association (ISOPA))

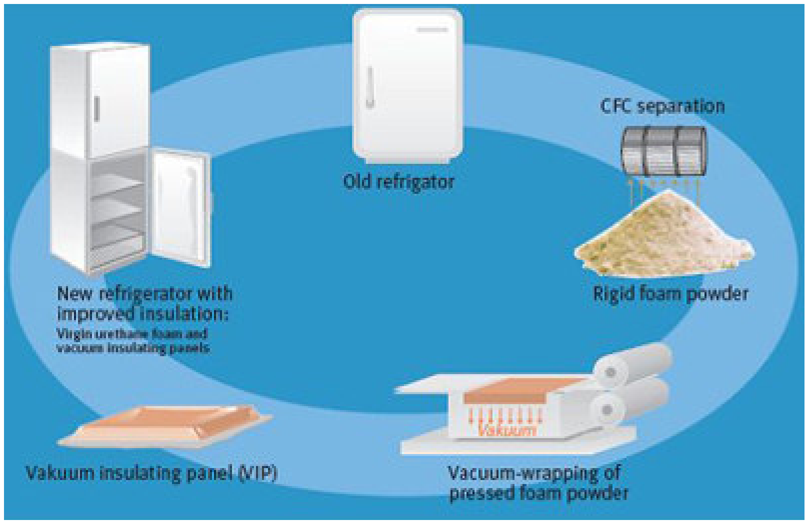
Mechanical recyclers grind PUR into powders with various milling and knife-cutting processes. To be used as fillers, PUR particles should be less than 200 microns in size, and preferably under 100 microns.

Shredded PUR foam wastes can be rebonded using heat, pressure and an adhesive binder. Rebonding is commonly used to make vibration sound dampening mats, flooring, sports mats, cushioning and carpet underlay. In a similar process, known as adhesive pressing, PUR granules are coated with a binder and cured under heat and pressure. Contoured products are made from adhesive pressing; they include automotive floor mats and tire covers.



Foam Bonding
(Source: European Isocyanate Producers' Association (ISOPA))

RIM and reinforced-RIM parts can also be ground into small particles, which can be molded under high pressure and heat to form solid parts for the auto industry. These compression-molded solid parts - such as pump and motor housings, and catalytic converter shields - can contain up to 100% RIM regrind.



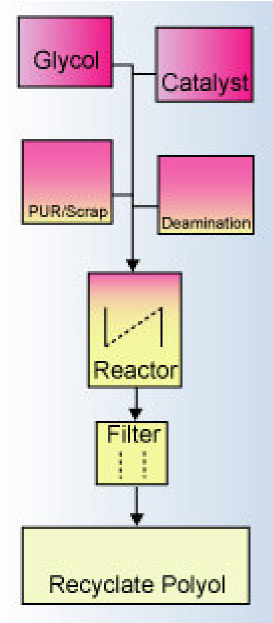
Recycled Refrigerators Panel
(Source: Bayer MaterialScience)

Chemical recycling

Depolymerization of PUR into its chemical constituents, known as chemolysis, is best practiced when the starting PUR wastes are of known and uniform chemical composition. PUR products made from the recovered monomers are usually of the same chemical type as the original products and offer the same performance. According to PURRC, chemolysis yields polyols that can replace up to 90% of the polyols in semi-rigid foams, creating a foam with a recycled content of 30%. Similar results have been reported with rigid foams, the organization adds.

Chemolysis exists in the following variants:

- Hydrolysis, where PUR wastes react with water under heat and pressure, producing polyether polyols and diamines (the hydrolysis products of the original diisocyanates). These components can be separated, purified and re-used.
- Glycolysis, in which PUR foam reacts with diols at elevated temperatures (above 200° C) in the presence of a catalyst. The high molecular weight polyurethane chain, and its many cross-linkages, are cleaved by this process to form lower molecular weight polyols and other liquid products. After purification, the polyol recyclate can be used to make various goods such as rigid foams, flexible foams and shoe soles. Much of the work in glycolysis has been done in Europe. Glycolysis is most useful for recycling production waste rather than post-consumer waste.
- Aminolysis, in which the PUR foam is reacted under heat and pressure with amines such as dibutylamine, ethanolamine, lactams or lactam adducts. Aminolysis is still in the research stage.



Glycolysis Process
(Source: Polyurethane Recycle and Recovery Council (PURRC)

Location	Polyurethane Feedstock	Application
Austria	Elastomeric foams/ Instrument panels(IP)	Elastomeric foams/ IP COMPONENTS
France	Rigid Foam	Rigid Foam
Germany	RIM	RIM/ Intergral skin foam
Germany	Shoe soles	Shoe soles
Italy	Shoe soles	Rigid Foam
Italy	Shoe soles	Shoe soles
England	Flexible slabstock	Flexible and rigid foam

Glycolysis Applications
(Source: European Isocyanate Producers' Association (ISOPA))

Also included in the chemical recycling category is pyrolysis, in which mixtures of PUR and other plastic wastes are heated in the absence of oxygen. The resulting products are various gases and oils that can be used as fuels and chemical feedstocks. Hydrogenation is a further treatment, in which the pyrolysis products are reacted with hydrogen to produce even purer gases and oils. Economic issues, such as the high cost of hydrogen, occasionally rule out hydrogenation. Briquetted waste PUR can be used as an iron ore reducing agent, another process that that harnesses the chemical properties of PUR.

Conclusion

TOP

Technologies for recycling polyurethane wastes have been under development for more than a decade, but the recycling issue has recently become more urgent. Reasons for this include the closing of landfill sites, rising waste disposal fees, and government regulations that mandate quotas for recycled plastics. The main technologies for PUR recycling are energy recovery, mechanical recycling and chemical recycling. Which of these methods is suitable depends on the product being recycled, the location, local energy costs, and intended end-use markets. Much of the PUR recycled today is industrial scrap. The lack of a collection, sorting and processing infrastructure has hindered recycling of post-consumer PUR wastes to some extent, although industry is addressing this issue through the efforts of various trade groups.

References:

Website:
Bayer, Cannon, Dow, Elastogran, Hennecke, Huntsman, Mobius Technologies, Recticel SA, Repsol YPF, Shell Chemicals.

Organizations:
Alliance for the Polyurethanes Industry (API), European Isocyanate Producers Association (ISOPA), Polyurethane Recycle and Recovery Council

(PURRC).

Publication:
Stephanie Bernard, "Increasing Use of Polyurethane Adds to Fuel Options," Plastics News, Mar. 20, 2006.
"PUR Foam is Gleaned from Mattresses," Modern Plastics, Feb., 2003.

TOP