Source Reduction, Recycling, Incineration and Landfilling with

XT® polymer AND Cyrolite®

ACRYLIC-BASED MULTIPOLYMER COMPOUNDS

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XT polymer and CYROLITE molding and extrusion compounds are a small part of the solid waste problem. They can also be part of the solution.

XT polymer and CYROLITE compounds can help with source reduction efforts because they are strong, rigid and do not contain heavy metals or chlorine.

XT polymer and CYROLITE compounds can be recycled, reprocessed and are compatible with many other polymers such as polystyrene.

XT polymer and CYROLITE compounds can be safely incinerated. The base polymers are free of heavy metals and chlorine. Both products are safe to landfill.

More than 160 million tons of waste entered the municipal solid waste stream in 1988. The waste stream is expected to reach 190 million tons by the year 2000. Plastics make up about 8 percent by weight and 14 to 20 percent by volume of the waste stream. Acrylics likely account for less than 0.1 percent by weight of the waste stream.

Plastics are receiving a disproportionate amount of blame for the solid waste problem. Education may help in this area. However, the plastics industry must take some of the responsibility for solving the solid waste problem in order to ensure the continued growth of the industry.

Today, 80 percent of this country's solid waste ends up in landfills. The cost of landfilling waste has increased dramatically in recent years. The cost to bury waste is likely to continue to increase as available space shrinks and regulation increases.

The Council for Solid Waste Solutions (CSWS), the EPA and most experts in the field agree that the solid waste problem can only be solved with an integrated approach. CSWS and the EPA endorse the following hierarchy for waste management:

1. Source reduction is the first priority. Source reduction is the use of less, lighter, and more environmentally safe material.
2. What cannot be reduced should be recycled.
3. Waste to energy incineration of that which cannot be recycled or reduced.
4. Finally, landfill that which cannot safely be reduced, recycled or converted to energy.

XT polymer and CYROLITE compounds are impact modified acrylic multipolymers. This Tech Brief focuses on how XT polymer and CYROLITE compounds fit into the EPA's hierarchy for solid waste management as detailed above.

Source Reduction

Reducing the amount of material that enters the waste stream is the preferred method of making waste more manageable and less threatening. There are many techniques used in source reduction programs. These techniques include:

- elimination of parts/packaging
- thin walling/material efficiency
- use of concentrates, refills
- reduction in toxicity
- increase in life expectancy, eliminate planned obsolescence.

Most of these techniques must be used by the product designer in order to obtain a reduction in waste. Two areas where XT polymer and CYROLITE compounds can help the designer are thin walling and reduction in toxicity.

The use of plastic by itself contributes to source reduction. Plastics in general replace heavier and thicker materials. Acrylic multipolymers in particular are stronger and more rigid than many other plastic materials. A reduction in wall thickness can often be made while maintaining strength requirements when switching from a weaker material.

XT polymer and CYROLITE compounds are free of chlorine or heavy metals. Incineration of materials that contain chlorine or heavy metals can lead to environmental and regulatory problems. XT polymer and CYROLITE compounds can be used to replace such materials.

Recycling

Currently, about two percent of plastics are recycled. Collection and sorting difficulties have led to availability and economic problems for many recycling programs. Those programs that have had some success involve plastics that are readily identifiable and used in volumes high enough to justify collection such as PET and polyethylene.

The Society of Plastics Industries (SPI) developed a voluntary recycling coding system in 1988. The code is imprinted onto the part as it is molded. This code can then be used to identify the type of plastic from which the part was manufactured. The coding system identifies six plastic families and a seventh code is used for all other plastic materials. The codes and their respective plastic type are shown in Table 1. Consumers and collectors use the SPI codes to help sort plastics in recycling programs. Future improvements in sorting techniques may lead to increased recycling rates. Those gains are likely to be limited to the high volume plastics and have little effect on the recycling rates of specialty materials such as XT polymer and CYROLITE compounds.

XT polymer and CYROLITE compounds fit into SPI coding category seven, "all other materials." The fact that acrylics do not have their own category is not a reflection of their recyclability. The volume of XT polymer and CYROLITE compound usage, as with many other polymers such as polyurethane, nylon, polycarbonate, acetal, polysulfone, etc., make them less significant in the waste stream and make it more difficult to collect sufficient amounts to justify recycling as a separate material.

XT polymer compounds, CYROLITE compounds and most acrylic based materials can be recycled. There are generally two ways to recycle a material. The material can be reprocessed by itself or it can be reprocessed while mixed with other materials.

Scrap from the production of raw materials and formed articles is best reprocessed by itself. As demonstrated in Table 2, XT polymer and CYROLITE compounds can be ground, reheated and reformed many times without a significant loss of properties. Typical reprocessing does not result in the generation of corrosive or toxic products. Reprocessing these polymers in this way helps retain their value, much of which is lost once they are mixed with other polymers. However, the reuse of scrap generated during production is not generally considered recycling. Most people consider recycling to be the reuse of post consumer waste.

Post consumer XT polymer and CYROLITE compound waste can be reprocessed by itself, just as scrap from production sources is reclaimed. The difficulty with this approach is separating the materials from the rest of the waste stream. Small amounts of contamination can reduce transparency and physical properties and can make the material unsuitable for food contact applications. There is no *economical* way of separating XT polymer and CYROLITE compounds from the waste stream at this time. For this reason, commingled recycling is the accepted approach.

XT polymer and CYROLITE compounds contain methacrylates, acrylates, styrene and butadiene. In addition, XT polymer compounds contain acrylonitrile. This varied makeup leads to compatibility with many polymers. Table 3 outlines the compatibility of acrylic multipolymers with other plastics.

Applications for articles made from commingled-recycled plastic are new and still developing. The markets for these articles are expected to increase significantly in the coming years. Increases in the demand for commingled plastic materials will allow production facilities to take advantage of economies of scale and improve their currently low profitability. Current applications for recycled plastics are listed in Table 4.

Chemical recycling is an old technique which has recently been applied to plastics. The principal is to take a polymer, break it apart to the constituent chemicals, then recombine the parts to yield a new material. The new material could be the same polymer type. PETG regrind is converted to virgin PETG pellets, or the recycled material could yield fuel oil, wax or a host of intermediates depending on the process and polymer.

Some of this technology has already been applied to plastics on a commercial basis. Work has not been done to determine the feasibility of using these techniques with XT polymer and CYROLITE compounds.

Incineration

Incinerating solid waste in a waste to energy plant has two major benefits over the exclusive use of landfills.

Currently, 10-15 percent of solid waste is incinerated. The incineration process eliminates 80 percent of the weight and 90 percent of the volume of waste. The remaining ash is most often landfilled, but much less space is needed.

In addition to a reduction in volume, incineration can be used to save energy. Plastics have the highest energy value of materials commonly found in the waste stream. Polyethylene generates about as much heat as oil does when burned. Burying these materials is a waste of energy. Each ton of mixed solid waste that is burned can provide electricity for 12 households for a day.

There are four major concerns with incineration:

— dioxin formation

— acid rain

— concentration of heavy metals

— precludes recycling

The mechanism of dioxin formation is not completely understood. Some believe that incomplete combustion in the presence of chlorine (halogens) promotes their formation. XT polymer and CYROLITE compounds do not contain chlorine and have not been linked to the formation of dioxins.

Acid gas emissions from incinerators contribute to acid rain formation. These acids also cause corrosion problems in the incinerator. Ninety percent of plastics are considered to be "clean burning" (don't contribute to acid formation). See Table 5 for a description of how XT polymer and CYROLITE compounds behave when incinerated.

Heavy metals are most often present in plastics due to the addition of pigments, satabilizers and antimicrobials. XT polymer and CYROLITE compound formulations are heavy metal free.

Incineration is a common way to dispose of hospital waste. A significant portion of this waste is plastic, much of which is PVC. Unfortunately, much of the incineration is done using outdated equipment. The result can be the generation of unacceptably high levels of ash and air pollutants. XT polymer and CYROLITE compounds, because they do not contain chlorine or heavy metals, are less of a problem in these old incinerators than are some other polymers.

Landfills

XT polymer and CYROLITE compounds are well suited for landfill material. They do not degrade very quickly and will not leach toxins into groundwater. They do not emit foul gases or react with other trash. They are, in effect, inert fill.

The problem is that landfills have become an expensive option and they are wasteful. It is wiser to use landfills as a disposal method of last resort.

Plastics are resistant to biological attack, but most plastics will be adversely affected by exposure to ultraviolet radiation. Research into degradable plastics has focused on reducing the resistance of plastics to biological attack (biodegradation) and increasing their susceptibility to attack by ultraviolet rays (photodegradation). Included in this class of materials are the products modified with starch or sugars. The addition of biodegradable components aids in the breakup of polymer film and articles. This results in less bulk as the additive or constituents are consumed by microbes. The remaining polymer then breaks up into finely dispersed particles. Some commercially important products have come out of this research (six-pack rings, agricultural film and grocery sacks).

While the future of degradable plastics looks promising in some markets, the industry has, in general, decided that degradable plastic is not a solution to the waste management problem. At most, they will be a small part of the solution with source reduction, recycling and incineration programs receiving most of the attention and research dollars.

Table 1
PLASTIC RECYCLING CODES

Category		Material
1	PETE —	Polyethylene Terephthalate
2	HDPE —	High Density Polyethylene
3	PVC —	Polyvinyl Chloride
4	LDPE —	Low Density Polyethylene
5	PP —	Polypropylene
6	PS —	Polystyrene
7*	Other —	All Other Materials

*All acrylic polymers fit into category seven. This is not an indication of their recyclability, but more an indication of their relatively low sales volumes.

Table 2
REGRIND STABILITY

	XT polymer 375 (301) compound		CYROLITE G-20 (300) compound	
	Virgin	3rd Regrind	Virgin	3rd Regrind
Tensile Strength, (psi)	8,300	8,100	6,000	6,600
Tensile Elong. Y (%)	3.2	3.0	2.8	3.2
Tensile Modulus x 10^6 (psi)	.38	.38	.30	.31
Izod Impact (fppi)	1.8	1.8	2.0	1.5
DTL @ 264°psi (°C)	87	87	89	89
Transmission %	82	70	88	84

Table 3
COMPATIBILITY OF XT POLYMER AND CYROLITE COMPOUNDS WITH OTHER PLASTICS

Category	Compatibility
1 PETE	Compatible with good blending. Properties between those of pure polymers. Clarity is lost.
2 HDPE	Limited Work
3 PVC	Miscible in all amounts. Synergism in improving impact. Clarity is often maintained.
4 LDPE	Limited Work
5 PP	Limited Work
6 PS	Compatible with good blending. Properties between those of pure polymers. Clarity is lost.
7 Other	Compatible with many resins including polycarbonate. Clarity lost with most blends.

Table 4
APPLICATIONS FOR RECYCLED PLASTICS

Battery Cases
Beverage Bottles (chemical recycling)
Boat Hulls
Bottles (soap, oil)
Carpets
Cassette Cases
Crates
Curb Stops
Erosion Control Timber
Fence Posts
Fiber Fill (pillows, jackets)
Flooring
Flower Pots
Garden Furniture
Geotextiles
Golf Bag Liners
Industrial Insulation
Livestock Pens
Loading Dock Bumpers
Lumber (benches, tables, planks)
Pails/Drums
Paint Brush Handles
Pallets
Pipe
Rope
Scouring Pads
Signs
Sinks/Tubs
Skis
Soft Drink Base Cups
Stadium Seating
Stair Treads
Strapping
Surfboards
Toilet Tank Floats
Toys
Traffic Cones
Trash Cans
Tree Supports/Guards
Vine Stakes

Table 5
INCINERATION OF XT POLYMER AND CYROLITE COMPOUNDS

The following is information regarding the types of volatile products that one might expect when XT polymer and CYROLITE compounds are subjected to combustion conditions. You need to be aware, however, that (1) combustion, even in a typical incinerator, is not a static phenomenon and thus the products of combustion and certainly their concentrations will change significantly as the heat, fuel and air sources vary and (2) no laboratory test procedure has been, nor is likely to be, developed that will accurately predict a material's performance in a real situation.

CYRO has, on several occasions, run experiments to determine the products of decomposition from XT polymer and CYROLITE compounds under combustion conditions. Typically, tests were run on small samples under carefully controlled laboratory conditions and therefore subject to the qualifications noted above. In tests in the presence of excess air and with the sample burning with a candle-like flame, the flow-through volatile products were found to be oxygen (O_2), nitrogen (N_2), carbon dioxide (CO_2), water (H_2O), and trace levels of carbon monoxide (CO). As the excess air was reduced, the concentration of CO_2 decreased and that of CO increased.

In other experiments, where gaseous products were trapped from start to finish of a burn, methyl methacrylate, benzene, toluene, acrylonitrile (for XT polymer compound only), as well as O_2, N_2, CO and H_2O were found. Pyrolysis experiments in the absence of air have shown the presence of methane, ethane, ethylene, acetylene and methyl isobutyrate in addition to CO, CO_2 and H_2O.

As you may deduce from this information, it is possible for a wide range of decomposition products to be formed and/or to result during the combustion process, all having some toxic properties. It should be pointed out, however, that the data does not indicate the presence of a "supertoxin" in the decomposition products. Overall, one would expect that the combustion products of XT polymer and CYROLITE compounds would present approximately the same toxicity concerns as those from burning wood.

Technical Support

Visit the TechKnowlogy Center at www.cyro.com where visitors have immediate access to FAQs, technical information, tips, and hundreds of other facts about acrylic-based polymers.

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1706A-398-10RA - CYROWEB