ABSTRACT

The intent of this paper is to provide the electronics recovery industry with accurate, well-researched information on plastics from recovered consumer electronics. It includes ten facts that everyone in the industry should know based on the most current research.

KEYWORDS
Recycling, plastics, consumer, electronics.

INTRODUCTION

In April 2000, the American Plastics Council (APC) published a groundbreaking report called “Plastics from Residential Electronics Recycling: Report 2000.” In that report, it was noted that much of the information—particularly that related to plastics—was based on limited collection programs and a limited analysis of material. It also explained that as more consumer electronics were collected, and as more research was conducted, our understanding of what could and could not be done with end-of-life (EOL) electronics, and the materials with which they are made, should evolve.

Evolve it has. In the past few years, interest in and knowledge about EOL electronics recovery has grown significantly. That includes knowledge about how plastics from EOL electronics can be managed responsibly. The intent of this paper is to share with those in the electronics recovery industry the ten key facts the APC has learned about EOL electronic plastics since 2000.

FACT 1: PLASTICS MAKE UP A RELATIVELY SMALL PORTION OF CONSUMER ELECTRONICS

When you look at EOL electronic products, plastics might appear to be the dominant material. In fact, early studies conducted by the U.S. Environmental Protection Agency (EPA) put it at more than one-third of the total materials. Several recent studies, however, have documented that plastics make up a much smaller portion of EOL consumer electronics.

For example, a recent study conducted by the Swiss Association for Information, Communication, and Organization Technology (SWICO) found that plastics comprise only 17 percent—or less than one-fifth—of the materials from end-of-life electronics (see Figure 1). This is nearly identical to what the Association of Plastics Manufacturers in Europe (APME) found in its own study. (Steel and glass from cathode ray tubes typically comprise about 30 and 20 percent respectively.) These two studies are believed to be representative of what we would expect to find in the U.S. Therefore, while plastics may appear to be the dominant material in EOL electronics, they are not.

1 APC is a national trade association representing twenty-four of the nation’s largest resin producers, including monomer and polymer production and distribution. Founded in 1988, APC demonstrates that plastics are a responsible choice and promotes the countless ways they make people’s lives better, healthier, and safer.


FACT 2: THE NUMBER OF DIFFERENT PLASTICS USED IN ELECTRONICS IS NOT A BARRIER TO RECYCLING.

It was once thought that there were too many different types of plastics found in EOL electronics to be recycled. However, recent research counters that belief. For example, a report published by the APME found there were only twelve types of plastic in all the electrical and electronic products analyzed.\(^5\) Findings were similar in the U.S. where a study conducted by the Minnesota Office of Environmental Assistance (MOEA) found only eight types of plastic in consumer end-of-life electronics.\(^6\) Interestingly, the same study found that one resin—high impact polystyrene (HIPS)—accounts for more than half of those plastics (see Figure 2).

FACT 3: DIFFERENT PLASTICS CAN BE IDENTIFIED AND SEPARATED FOR REPROCESSING

Research to develop and test equipment for identifying and separating plastics from durable goods has been underway for more than a decade—well before managing EOL electronics became a prominent issue. Such research—much of which was conducted by the APC in partnership with MBA Polymers\(^7\)—has resulted in commercially available recycling equipment that (1) accurately detects more than 20 kinds of plastics found in EOL durable goods, (2) identifies various additives that may be present, and (3) separates EOL electronic plastics into single generic streams.

Furthermore, technology is in use that enables plastics recyclers to separate plastics with flame retardants (FRs) from those without. This differentiation is already taking place: It is estimated that 30 percent of some new photocopiers contain recycled plastic with FRs—material that was intentionally specified by the manufacturer so that new FRs would not be needed.\(^8\)

FACT 4: REPROCESSED PLASTICS HAVE VALUE

Clearly, one of the ongoing challenges of recycling any material involves the value-to-recovery-cost ratio—or determining whether the material itself has enough intrinsic value to make the cost of processing and marketing it economically worthwhile.

Given that some electronic products are already being collected—primarily to divert potentially hazardous materials from the waste stream but more and more to recycle the scrap derived from them—it appears that many electronic plastics have potentially favorable value-to-recovery cost ratios. This is because the plastics used in electronic products are mostly “engineering thermoplastics,” which have high intrinsic value. When pelletized, these plastics typically sell for a dollar-per-pound as opposed to cents-per-pound for bottle- and container-grade plastics, thereby making recovery more economically viable. In fact, the

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\(^{7}\) MBA Polymers, Inc, is a research center and durables processor located in Richmond, California.

\(^{8}\) The Bromine Science and Environmental Forum Newsletter, Number 3, 2001.
2001 MOEA demonstration project concluded that “engineering plastics may present the single greatest opportunity for adding revenue to the electronics recycling process.”9

The same may also be true of scrap plastics. During the MOEA project just mentioned, Waste Management Asset Recovery Group found that, after collection, scrap plastics from end-of-life electronics generated positive revenue regardless of how they were marketed. Plastics even generated positive revenue when the cost of landfilling mixed wood and plastic waste was taken into account.10

FACT 5: MARKETS FOR REPROCESSED PLASTICS ARE GROWING
For the most part, markets for plastics from EOL electronics have been evolving slowly. That does not mean, however, that no progress has been made. When the APC published its last report on recycling plastics from EOL electronics in 2000, plastics were being used primarily in lumber, outdoor furniture, and roadbed materials. Now, in addition to those relatively established applications, it is being used in camera casings, battery boxes, compact disc trays, hot mix asphalt concrete, and high quality pellets for use in molded plastics parts.

While it would be inaccurate to imply that markets for plastics from electronics are plentiful and/or widespread, it is fair to say that the groundwork is being laid to make sure that once EOL electronic plastics are collected on a more consistent basis—and with quality control in mind—markets should develop accordingly.

FACT 6: RECOVERED PLASTICS CAN BE USED IN HIGH-END APPLICATIONS
While it is true that many of the plastics recovered from EOL electronics today are going into applications that have relatively lenient performance requirements, it is not a function of the plastic. Instead, it is a function of not having (1) adequate performance information, (2) sufficient supplies for testing, and (3) manufacturers who are willing to use the material without more performance data. That, however, is starting to change.

Over the past few years, the Gordon Institute at Tufts University has worked with the electronics supply chain to identify products that could potentially use engineering thermoplastics from recovered EOL electronics. That work resulted in a list of 30 products that are now considered viable end-markets.

Another Gordon Institute project led to the preparation of “Electronic Engineering Thermoplastics Recycled Material Guidelines.” The guidelines, arranged in the form of a matrix, were designed to help develop a common language and grading system for recovered plastics from EOL electronics, which in turn should facilitate the marketing of plastics.

In another research effort, the MOEA and its project partners, working with MBA Polymers, found that HIPS from recovered consumer electronics was comparable to virgin plastic in some important ways, meaning it could potentially be used in similar applications as virgin HIPS given a consistent quantity and quality of supply.

Related studies are also being undertaken at West Virginia University to determine the characteristics of thermoplastics from recycled electronic shredder residue. The goal of these studies is to identify additional, higher-end applications for recycled plastics from durable goods.

Furthermore, Region 5 of the U.S. Environmental Protection Agency is working to determine how much plastic Sony Electronics, Inc, would need to meet its production demand for recycled engineering plastics. It also will determine how much EOL electronic plastics must be collected from the region to meet that demand.

These and other ongoing research and development initiatives are (1) further substantiating the economic and functional viability of recycling electronic plastics and (2) broadening the markets into which recovered plastics can go as supplies increase.

FACT 7: EXPORTING PLASTICS FROM EOL ELECTRONICS IS A RESPONSIBLE CHOICE
In today’s world, the global economy depends upon trade, including the import and export of scrap materials for recycling. In recent years, the import and export of EOL electronics and the scrap derived from them has grown as a component of world trade. In the vast majority of cases, these products and the resulting scrap are managed responsibly with an eye toward using them in the manufacture of new goods.

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There is, however, mounting evidence that in some instances, some products containing hazardous materials—such as lead, cadmium, and mercury—are being mismanaged, particularly in developing countries. The open burning of electronic parts to retrieve metals, as an example, has been documented in parts of Asia. This practice should be ended voluntarily or by regulation if necessary. It is inappropriate for EOL electronics containing plastics, or any organic materials for that matter, to be managed in this fashion.

That said, it is important to remember that plastics themselves are not inherently hazardous nor are scrap plastics regulated as hazardous waste under the Basel Convention. When scrap plastics are purchased for recycling by responsible parties, their destiny after processing is new products, not open burning.

**FACT 8: INTEGRATED EFFORTS ARE A GOOD APPROACH TO HANDLING PLASTICS FROM EOL ELECTRONICS**

Recent events in Europe may have caused some people to believe that waste-to-energy is the preferred option for managing the combustible fraction of EOL electronics. There, legislation is pending that would require plastics containing halogenated flame retardants to be handled separately from all other waste electronic parts and materials. Under that scenario, energy recovery may make the most sense. Why? Because complying with the legislation would necessitate the total dismantling of everything in the waste electronics stream, including the minutest parts. Given increasing integration and miniaturization, this simply is not economically or practically feasible.

In the U.S., however, industry continues to favor an integrated approach to handling plastics from EOL electronics. Such an approach includes varying combinations of mechanical recycling, feedstock recycling, energy recovery, and when necessary, the safe landfilling of plastics. Numerous studies have shown that all of these options are viable for managing plastics from EOL electronics, even those containing Brominated Flame Retardants (BFRs).

**FACT 9: FLAME RETARDANTS IN PLASTICS DO NOT POSE SIGNIFICANT ENVIRONMENTAL RISKS OR BARRIERS TO RECYCLING**

In recent years, concerns have grown about flame retardants (FRs) and their potential impact on the environment. These concerns—which have really centered on a few FRs—have caused many people to assume that (1) all plastics in electronics contain FRs, and (2) all FRs pose a significant environmental risk. Neither of these assumptions is correct.

First, a recent study published by the APME found that less than half of the plastics in electronics are treated with FRs (see Figure 3). They are found in some housings and in connection cables and printed wire boards. They also are found mostly in products that are exposed to high internal heat, as required by the U.S. government. They are not, however, used in the majority of plastics and certainly not all of them.

Second, concerns about the environmental impact of FRs have really centered on just one family of FRs—those containing bromine or BFRs.

Within that family—which itself includes many different substances—only two are commonly used in electronic products today: deca-brominated diphenyl ether (deca-BDE) and tetrabromobisphenol-A (TBBPA). Both of these...
BFRs—which provide an exceptional level of fire safety—have been investigated in the U.S. and found to present minimal risks to humans and the environment. Similarly, science-based risk assessments in Europe have concluded there is little concern associated with their use. Several other studies have additionally demonstrated that plastics containing deca-BDE will not degrade and can withstand repeated melting for recycling without any loss of properties.

FACT 10: THE PLASTICS INDUSTRY SUPPORTS RECYCLING PLASTICS FROM EOL ELECTRONICS

The plastics industry supported research into the recovery of plastics from durable goods long before managing EOL electronics became a recognized waste management issue. In the early 1990s the APC, along with equipment manufacturers, published a guide on how to design durable goods for the environment and undertook numerous research projects to determine if and how plastics recovered from end-of-life durable goods could be identified and separated for recycling.

In addition, through the APC, the plastics industry has (1) participated in several public/private initiatives to determine how best to collect, dismantle, and recycle EOL electronics; (2) funded several plastics characterization studies to determine what plastics are potentially available from recovered EOL electronics in what amount; (3) published numerous reports on the most effective and efficient ways to recover plastics from durable goods; and (4) joined in various national efforts to help develop the EOL electronics recovery infrastructure. The plastics industry recognizes that its products—plastics—are an integral part of modern electronics. Because of that, it fully intends to continue to help find effective ways to recover and recycle plastics from EOL electronic goods.

CONCLUSION

So where are we now in terms of recovering plastics from EOL electronics? Can they really be recycled? While some questions remain, the overriding evidence suggests that plastics from discarded electronics can, if fact, be recycled. The technology to process plastics is available, sound research is being conducted to provide more and better information, and the plastics supply chain is working together to ask and answer all the right questions. Like any growing industry, it will take time to put the entire infrastructure in place; but, it appears that a system for efficiently managing plastics from EOL electronics will be ready once larger volumes of quality material becomes available. APC, for its part, will continue to disseminate current and accurate information that will aid in the development of the recycling infrastructure, technology, and markets.