Plastic Recycling Methods

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Introduction:

We talk about "plastic" as though it's a single material, but there are in fact many different plastics. What they have in common is that they're *plastic*, which means they are soft and easy to turn into many different forms during manufacture. Plastics are (mostly) synthetic (human-made) materials, made from polymers, which are long molecules built around chains of carbon atoms, typically with hydrogen, oxygen, sulfur, and nitrogen filling in the spaces. You can think of a polymer as a big molecule made by repeating a small bit called a monomer over and over again; "poly" means many, so "polymer" is simply short for "many monomers." If you think of how a long coal train is made from many trucks coupled together, that's what polymers are like. The trucks are the monomers and the entire train, made from lots of identical trucks, is the polymer. Where a coal train might have a couple of dozen trucks, a polymer could be built from hundreds or even thousands of monomers. In other words, polymers typically have very large and heavy molecules.

Brief History of Plastic: Bakelite, an important early thermosetting plastic, was widely used to make telephones, lamp fittings, and other electrical equipment during the first half of the 20th century because it's tough, hard, heatproof, and an excellent insulator. If you see a phone in this characteristic brownish-black color, with a dull finish, it's probably made of Bakelite (although it's worth noting that Bakelite also came in other colors). This power adapter from England dates from the early 1960s. 1982: The Jarvik 7, a complete artificial heart, made from plastic polyurethane, is first implanted in a human. 1988: Australia becomes the first country to issue high-security plastic banknotes. 1998: Smart cars made from composites enter production.

TYPES OF PLASTICS:

Thermoset or thermosetting plastics. Once cooled and hardened, these plastics retain their shapes and cannot return to their original form. They are hard and durable.

Thermosets can be used for auto parts, aircraft parts and tires. Examples include polyurethanes, polyesters, epoxy resins and phenolic resins.

Thermoplastics. Less rigid than thermosets, thermoplastics can soften upon heating and return to their original form. They are easily molded and extruded into films, fibers and packaging. Examples include polyethylene (PE), polypropylene (PP) and polyvinyl chloride (PVC).

Polyethylene terephthalate (PET or PETE): John Rex Whinfield invented a new polymer in 1941 when he condensed ethylene glycol with terephthalic acid. The condensate was polyethylene terephthalate (PET or PETE). PET is a thermoplastic that can be drawn into fibers (like Dacron) and films (like Mylar). It's the main plastic in ziplock food storage bags.

Polystyrene (Styrofoam): Polystyrene is formed by styrene molecules. The double bond between the CH2 and CH parts of the molecule rearranges to form a bond with adjacent styrene molecules, thereby producing polystyrene. It can form a hard impact-resistant plastic for furniture, cabinets (for computer monitors and TVs), glasses and utensils. When polystyrene is heated and air blown through the mixture, it forms **Styrofoam**. Styrofoam is lightweight, moldable and an excellent insulator.

Polyvinyl Chloride (PVC): PVC is a thermoplastic that is formed when vinyl chloride (CH2=CH-Cl) polymerizes. When made, it's brittle, so manufacturers add a plasticizer liquid to make it soft and moldable. PVC is commonly used for pipes and plumbing because it's durable, can't be corroded and is cheaper than metal pipes. Over long periods of time, however, the plasticizer may leach out of it, rendering it brittle and breakable.

Polytetrafluoroethylene(Teflon): Teflon was made in 1938 by DuPont. It's created by polymerization of tetrafluoroethylene molecules (CF2=CF2). The polymer is stable, heat-resistant, strong, and resistant to many chemicals and has a nearly frictionless surface. Teflon is used in plumbing tape, cookware, tubing, waterproof coatings, films and bearings.

Polyvinylidine Chloride (Saran): Dow makes Saran resins, which are synthesized by polymerization of vinylidine chloride molecules (CH2=CCl2). The polymer can be drawn into films and wraps that are

impermeable to food odors. Saran wrap is a popular plastic for packaging foods.

Polypropylene (PP): In 1953, Karl Ziegler and Giulio Natta, working independently, prepared polypropylene from propylene monomers ($CH_2=CHCH_3$) and received the Nobel Prize in Chemistry in 1963. The various forms of polypropylene have different melting points and hardnesses. Polypropylene is used in car trim, battery cases, bottles, tubes, filaments and bags.

Now that we have discussed the various types of plastics, let's look at how plastics are made.

DIFFERENT METHODS OF PLASTIC FABRICATION

Methods of Plastic Fabrication

Plastic fabricationis the design, manufacture, or assembly of plastic products through one of a number of methods. Some manufacturers prefer plastic fabrication over working with other materials (such as metal or glass) due to the process's advantages in certain applications. Plastic's malleability and cost-effectiveness can make it a versatile and durable material for a range of different products.

Plastic Welding: Like metal welding, plastic welding involves the use of heat to melt two or more work pieces together. This process is effective when handling thermoplastics that are unsuitable for adhesive binding. Individual pieces are often fused with a filler material between them, especially if the plastics have dramatically different melting points. Welding can be accomplished through several different methods, including hot gas emissions, high-frequency vibration, spinning, or contact welding. The equipment used in welding depends on the selected process and type of plasticinvolved.

Plastic Lamination: Plastic lamination creates a barrier along the surface of another material. This process is most often used to improve the durability, styling, or aesthetic quality of a product. It can also be a cost-effective measure by shielding a sensitive or deterioration-prone material and reducing its potential need for maintenance. Film and resin are the two most common types of lamination. In both processes, heat and pressure are applied to a fabricated film to enable its adhesion to a moving substrate. Film lamination is more effective for forming a plastic barrier on the

exterior of a product, while resin lamination is more frequently used to create an adhesive layer between two substrates. Paper, fabrics, metal sheeting, and flexible foam are common lamination base materials.

Molding Processes: In molding, plastic is formed into a specified shape by allowing the heated, pliable work piece to cool and harden around or within a mold. There are numerous plastic molding methods, including injection molding, blow molding and rotational molding. Blow molding is often used to create containers, such as bottles or fuel tanks, while injection molding is helpful in applications requiring a higher melt index, like dishware production. Rotational molding results in hollow plastic products, such as canoes, toys, buoys, and automotive parts.

Plastic Extrusion : Plastic extrusion can be used to create tubing, piping, or sheeting components. It is also applied to enhance the effectiveness of further forming or processing stages. For example, plastic extrusion is often a precursor to adhesion or lamination procedures. Profile extrusion and sheet extrusion are the most common forms of the process. Profile extrusion uses a single screw extruder to melt plastic pellets, move the molten plastic through a pressurized screw mechanism, and force it into an annular die. The plastic then solidifies around a calibration sleeve to create a pipe or tube component of a specific diameter. Sheet extrusion, unsurprisingly, uses a similar technique to create thin plastic sheeting.

Plastic Foaming: Foam products can be formed into a variety of different shapes. Common foaming configurations include round, sheet, film, solid plank, rod and bun stock. To achieve the desired characteristics, polymer composites are typically shaped through a process of physical or chemical blowing. As in compounding, additives such as pigments, antioxidants and fire-retardants can be included in the base material to optimize product performance for the user.

Choosing a Plastic Fabrication Process: Product functionality and ease of manufacturing are important things to consider when choosing a plastic fabrication process. Some methods are inefficient for fabricating certain types of plastic, and therefore may not be helpful for your particular project. Some other

issues to keep in mind include:

• The need for single plastics versus plastic compounds
• The intended proportion of plastic to non-plastic material in the product
• The role of plastic in your fabrication process (as adhesion, lamination or base product)

• The dimensions and use of the final product

Processes of Plastic Recycling: Among the many processes of recycling plastic waste, the following two are the most popular in the industry. Heat Compression type of plastic recycling is gaining special demand in the United States, Australia, and Japan because of its ability to recycle all types of plastic at once. It takes unsorted and cleaned plastic waste and mixes it in huge tumblers that churn the entire mixture. The major advantage of this process is that it does not require matching forms of plastic to be recycled together. Through the elaborate and accurate monomer recycling process, major challenges of plastic recycling can be overcome. This process actually reverses the polymerization reaction in order to recycle the same type of condensed polymer. This process not only purifies but also cleans the plastic waste to create a new polymer

Re-cyclic methods- recycling plastics;
Plastic recycling is the process of recovering different types of plastic material in order to reprocess them into varied other products, unlike their original form. An item made out of plastic is recycled into a different product, which usually cannot be recycled again. Before any plastic waste is recycled, it needs to go through five different stages so that it can be further used for making various types of products.

1. **Sorting: I**t is necessary that every plastic item is separated according to its make and type so that it can be processed accordingly in the shredding machine.
2. **Washing:** Once the sorting has been done, the plastic waste needs to be washed properly to remove impurities such as labels and adhesives. This enhances the quality of the finished product.
3. **Shredding:** After washing, the plastic waste is loaded into different conveyer belts that run the waste through the different shredders. These shredders tear up the plastic into small pellets, preparing them for recycling into other products.
4. **Identification and Classification of Plastic:** After

shredding, a proper testing of the plastic pellets is conducted in order to ascertain their quality and class.

5. **Extruding:** This involves melting the shredded plastic so that it can be extruded into pellets, which are then used for making different types of plastic products.

6. Plastics are petroleum-based synthetic materials whose main constituents are carbon and hydrogen." (Wolf, Nancy & Ellen Feldman, page 104). Most plastics that are recycled come from the thermoplastic family, which represents about 90% of all plastics sold. Thermoplastics can be readily recycled as they melt when heated to high temperatures. The entire spectrum of packaging plastics come from the thermoplastic family. "Common thermoplastics include polyolefins (polyethylene, polypropylene), styrenes (polystyrene, acrylonitrile butadiene styrene), vinyls (polyvinyl chloride, polyvinylidene chloride), and thermoplastic polyester (polyethylene terephthalate)." (Wolf, Nancy & Ellen Feldman, page 106). The other group of plastics which comprise the remaining 10% are known as thermosets. Thermosets are insoluble and infusible, and cannot be resoftened or melted by heat. Thermosets include phenolics, epoxies, urea-formaldehyde resins and crosslinked polyesters.

7. Recycling processes are firmly established for materials such as glass, paper and metals but the recycling of plastics is in its infancy. Recycling of plastics, like all other materials, is highly desirable based on energy use alone. Recycling of scrap plastics from the production line has been in place for many years, but recycling of post-consumer plastics has been lagging. "The recycling of plastics is different from the recycling of glass and metals. Whereas glass bottles and metal cans come back into use in the same mode, many recycled plastics must be made into other products, due to the inability of plastics to be remanufactured and sterilized to meet food-contact standards." (Wolf, Nancy & Ellen Feldman, page 9). While some pilot programs are beginning to produce recyclable containers, most recycled plastics become fiber for carpets or jacket filler and some combined plastics are being made into furniture.

8. The primary recycling of plastics, which conserves the greatest amount of energy, involves the reconversion of uncontaminated plastic waste into its original pellet or resin form. The recycled version contains chemical and physical characteristics similar to those of the

original product. "Primary recycling is suitable mainly for industrial wastes, since they generally consist of one type of resin and have not been contaminated by use in consumer precuts." (Wolf, Nancy & Ellen Feldman,

9. As mentioned earlier, the one point about recycling post-consumer waste plastics is that, unlike materials such as metals and glass, plastics cannot be sterilized at present and reused for food packaging. So, for example, recycled plastic soda bottles do not come back as other bottles but as pillows, fiber, plastic lumber, etc. "While it is desirable to recycle as much plastic as possible, most plastics cannot be used in the "closed-loop" recycling so advantageous to other post-consumer materials." (Wolf, Nancy & Ellen Feldman, page 65). Although much progress has been made, the recycling of post-consumer plastics is limited by the absence of a strong recycling infrastructure. "The main obstacle to increased recycling include: the lack of economically feasible collection, separation, and transportation mechanisms; the dearth of large-scale commercial recycling operations capable of handling a heterogeneous mix of contaminated post-consumer materials; and the lack of steady and demanding markets for recycled plastic products." (Wolf, Nancy & Ellen Feldman, page 66

USES of Plastic Recycling: After knowing the processes and stages of plastic recycling, it is also important to know its various benefits. A few of them are:

There's A Ton of Plastic: One of the biggest reasons for recycling plastic is its huge quantity. It has been observed that 90% of the waste accumulated by the municipal corporation is a plastic waste. Apart from this, plastic is used for manufacturing various types of goods and items that are being used on a daily basis. This will not only help increase the production of plastic but will also take care of the environment.

Conservation of Energy and Natural Resources: The recycling of plastic helps save a lot of energy and natural resources as these are the main ingredients required for making virgin plastic. Saving petroleum, water, and other natural resources help conserve the balance in nature.

Clears Landfill Space: Plastic waste is accumulated on land that should be used for other purposes. The only way this plastic waste can be removed from these areas is by

recycling it. Also, various experiments have proven that when another waste material is thrown on the same ground as plastic waste, it decomposes faster and emits hazardous toxic fumes after a certain period. These fumes are extremely harmful to the surrounding area as they can cause different types of lung and skin disease

As stated earlier, plastics constitute one of the fastest growing categories of materials used and disposed of in our economy today. Plastics are used for so many different materials and used in so many different industries. The two major industries where plastics are used are the packaging industry and the construction and building industry. Plastics are also used in transportation, consumer goods, furniture, electrical components and adhesives. For this paper I will primarily focus on the packaging industry and how that relates to recycling.

Environmental Effects of Plastic Pollution: Plastic pollution is a global problem. The majority of plastic winds up in landfills where it remains indefinitely. No one exactly knows how long plastic takes to break down, but it is believed to take hundreds or even thousands of years. It is not just the accumulation of plastics that harms the environment—it is also the fragments and toxins released during photo-decomposition that pollute our soil and water. Some plastics are designed to degrade quickly, such as Oxo-Degradables and while they may become less noticeable, they are still present in the environment. For example, in ocean environments, plastic fragments are taken in by filter-feeding organisms. When tiny plankton ingest plastic, animals up the food chain can bioaccumulate larger quantities. So while some plastic may be designed to degrade quickly, it is still present in the environment. Floating plastic waste that can survive thousands of years in water can serve as a transportation device for invasive species that disrupt habitats

Conclusion

To me, it's apparent that recycling is very important and a subject that all families, communities, business's, etc. should embrace. Particularly with the plastics industry and the amount of plastics this country uses and produces each year. It's amazing just how much our society has changed with the introduction of plastics for industries such as manufacturing, building and construction, transportation and most importantly, consumer goods. We've changed as a nation to being a disposal society, a society that looks for something simple and easy. With products hitting the shelves in record

numbers packaged or containing plastics, it's essential for us to recycle and continue to develop technologies to combat the excessive wastes we generate. I think pollution prevention is the key to at least help alleviate the strains of wastes when it comes to materials that need to be or must be recycled and handled carefully

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