CHEMICALLY RECYCLED POLYESTER

fashionpositive+
Cradle to Cradle Products Innovation Institute

+ What is recycled polyester?

Polyester is a synthetic fiber derived from crude oil. It is composed of long chains of polyethylene terephthalate (PET) polymers. It is inherently durable, elastic and quick to dry. Polyester is the most popular fiber in the world. It is used in apparel as well as home furnishing, automotive, construction, filtration, and personal care.

Recycled polyester is simply polyester that is produced from a waste stream; this may be plastic water bottles, industrial polyester waste and polyester or polyester blended garments.

In terms of chemistry, performance and durability, recycled polyester offers the same benefits as virgin polyester, including high strength and functional versatility. However it has a lower environmental impact than traditional virgin polyester because it is made without the energy needed to extract crude oil.

+ How is recycled polyester made?

There are two different methods that can be used to make recycled polyester. It can be made through a chemical recycling route or it can be mechanically produced, which is the more common route.

Mechanical Recycling uses clear plastic (polyethylene terephthalate) bottles that are also made from PET resin. The bottles are cleaned, chipped, melted and extruded into new PET fibers. The mechanical method uses post-consumer waste and less energy during processing. PET bottle recycling is more practical than many other plastic waste streams because of the high value of the plastic PET resin. It is often a clear material that is relatively pure and free from colorants and other functional additives. It must pass FDA requirements for food packaging, which eliminate the ability to add a lot of hazardous chemicals. Plastic bottles made to carry water and other soft drinks are made almost exclusively from PET, which simplifies the sorting process at the recycling facility.

Chemical Recycling involves using chemicals to break down, or depolymerize, the polyester fiber back into its original monomers, which can then be polymerized back into new materials. The polyethylene terephthalate (PET) polymer is returned to its original ethylene glycol and terephthalic acid monomers via chemical reactions. Once it is polymerized back into PET resin and polyester, the resulting textile is indistinguishable from virgin polyester. This method is quite expensive and primarily used for dyed and finished polyester products.

The benefits of chemical recycling include:

- The process results in new chemicals or monomers that can be used to make a variety of new materials, not just more polyester.
- The waste stream does not need to be sorted as thoroughly as a waste stream designed for mechanical recycling which only works if the waste is thoroughly sorted.
- Contaminants such as dyes, pigments, spandex, metals can be removed or eliminated during the chemical recycling process.
- It provides the opportunity to use a different catalyst during the polymerization process. Currently, antimony trioxide, a suspected carcinogen, is used to speed up the reaction to create the PET polymer resin from the monomers.

+ What currently limits recycled polyester as an input for the circular economy?

Recycled polyester made in a chemical process using plastic PET bottles or polyester clothing poses some issues for *Cradle to Cradle Certified* Gold-level certification. There are three main concerns.

1. PET, whether it is used in plastic water bottles or in apparel, is typically made from petrochemical sources which are non-renewable and thus not circular.

2. A hazardous chemical called antimony trioxide is used as a catalyst during the manufacture of PET resin. The PET resin is used to make both plastic bottles and virgin polyester. There have been many research studies that show that antimony trioxide has suspected carcinogenic potential for humans; any suspected or known carcinogens are unacceptable *Cradle to Cradle Certified* materials. Antimony may leach out of products via air and water emissions when heated. Antimony trioxide is used as a catalyst during the processing of polyethylene resin, which is then used to make polyester fiber and food grade packaging, such as water bottles. A study at the University of Heidelberg in Germany by Shotyk et al (2005)[1] showed that antimony concentrations increase in water stored on PET bottles with time. After 3 months of storage at room temperature, the antimony level increased significantly in PET bottles when compared to water stored in glass bottles. A report conducted by Westerhoff et al (2008)[2] in the U.S. tested the antimony concentration in nine commercially available bottled waters in Arizona. Initial antimony concentrations in the water were well below the USEPA maximum contaminant level (MCL) of 6 ppb. However at elevated temperatures of 60, 70 and 80 C, the exposure durations necessary to exceed the 6 ppb threshold was 176, 12 and 2.3 days respectively. Heat is used a great deal during textile manufacturing. For example, temperatures of 60°C are commonly used to pretreat, wash and rinse textile fabrics and polyester is dyed at 80 to 100°C. These elevated dyeing temperatures are the most common routes for antimony to potentially leach out of polyester fiber into wastewater.

3. Antimony may leach out of the polyester fiber and/or plastics bottle when it is landfilled or incinerated. During this process of incineration, the antimony is released as a gas and can cause problems due to its carcinogenic nature.

Unfortunately, mechanically or chemically recycled polyester made from plastic bottles or apparel contains residual amounts of antimony trioxide, thus negating the opportunity for *Cradle to Cradle Certified* Gold-level certification. Having toxic chemicals such as antimony trioxide in a material reduces its viability as a circular material, since recycling or reuse of that material would perpetuate the exposure to that toxic chemical.

In addition to the possible perpetuation of toxic antimony trioxide, mechanical processing of PET leads to material degradation, thus making it difficult to use the material in perpetual cycles.

The chemical recycling process offers the opportunity to get rid of the antimony trioxide from its original source (plastic bottles or post-consumer waste) and re-catalyze the PET resin with an alternative catalyst, which is not common today because antimony trioxide is cheap and a very effective catalyst.

[1] Shotyk et al (2005): Contamination of Canadian and European bottled waters with antimony from PET containers
[2] Westerhoff et al: (2008) Antimony leaching from polyethylene terephthalate plastic used for bottles drinking water

+ Why was chemically recycled polyester chosen for the Call to Innovation?

Chemically recycled polyester was chosen for the Call to Innovation because of the important role polyester already plays in the apparel industry, especially in athletic apparel and for the need to open-up chemical recycling as a pathway for achieving circular fashion.

Chemically recycled polyester has some environmental benefits when compared to virgin polyester and because it is, in essence, the same as virgin polyester, it makes sense that polyester should be diverted from the landfill and used again and again with no loss in value. In addition,

1. Chemically recycled polyester can be made from post-consumer waste, thus diverting waste streams from entering the landfill.
2. Chemically recycled polyester means uses less energy and water during PET resin production.

There are a few global companies with a diverse range of innovations that address the catalyst; some innovations are in research and development and others are costly. Industry support is needed to advance chemically recycled polyester into circularity and the big need is to replace the catalyst used during the polymerization process.

+ What is the action plan for chemically recycled polyester through the Call to Innovation?

Fashion Positive PLUS members have identified chemical recycling as a necessary innovation for circular growth of polyester in apparel.

The group is searching for a supplier with the capability to make recycled polyester through a chemical route.

Once the chemically recycled polyester has been certified at the Gold-level, it will be added to the Fashion Positive Materials Collection.

+ What's exciting about priming chemically recycled polyester as an input for the circular economy?

Recycled polyester, made through a chemical process, offers opportunities for the circular economy. Recycled polyester is growing in popularity thanks in part to brands committing to increasing recycled content in their fiber strategies. Providing an option primed for the circular economy for this popular fiber could pave the way for more fibers to follow.