



# The Eco-Friendly PET Bottle

## The Big Picture

Bottled water is the second largest beverage type (as measured in volume of sales) in the US. Among all beverages, including alcohol, juices and soft drinks, its market grows at an annual rate about twice as fast as other beverages. Bottled water is increasingly preferred over tap water and carbonated soft drinks, due to purity and hygiene concerns with the former; and obesity and general health related issues with the latter. Moreover, its suitability for ready consumption and the convenience that the light, but efficient PET bottle offers has contributed to consumers' enthusiasm for bottled water worldwide.

According to the International Bottled Water Association, despite the decrease in the total produced volume and per capita consumption by 2.5 and 3.2% respectively, the US market is still the largest player at a global level. Based on estimates given by the Beverage Marketing Company, the average American drank roughly 28.3 gallons of bottled water in 2010, and the global overall consumption exceeded 53.5 billion gallons.<sup>a</sup>

In the US alone, 2.7 million tons of plastic are used to bottle water every year. About 1.5 billion gallons of oil are said to be consumed for the production of this plastic.<sup>b</sup> This production process has highly evident environmental impacts, which include:

- a) Resource depletion – the endangered supply of crude oil is exacerbated with this growing demand for plastic
- b) Greenhouse gas emissions resulting from the burning of fossil fuels used for the production of this plastic
- c) Footprint of transport and distribution – according to a study by the Earth Policy Institute, Washington, the bottled water industry in the UK generates about 30,000 tons of CO<sub>2</sub> per year through transportation alone.<sup>c</sup>

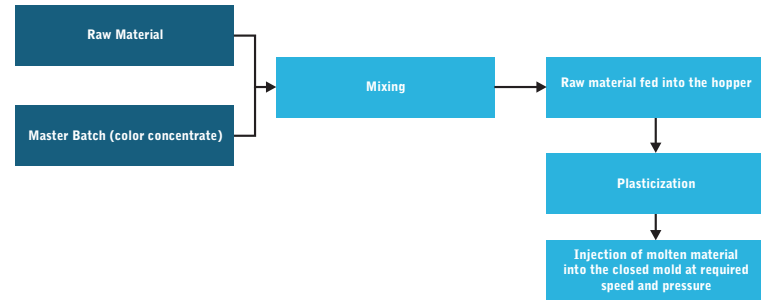
According to the US EPA, a pound of PET recycled is equivalent to 12,000 BTUs saved, and recycling a ton of PET bottles saves up to 7.4 cubic yards of landfill space. However, due to these advantages, there has been a 700% increase in the production of PET bottle in the past decade, with a 5% increase in its recycling.<sup>d</sup> The current recycling rate in the US is less than 25%<sup>e</sup>, translating to about 40 million such bottles thrown away as trash or litter every day. It has been estimated that it takes around 500 years for plastic bottles in landfills to start bio-degrading effectively, requiring more than 1000 years for complete decomposition. However, plant-based bottles take only 80 days to degrade under commercial composting conditions (with high heat and humidity maintained to ensure microbial growth).<sup>f</sup> Thus, plant-based plastic is the need of the hour.

A comparison on the production processes for the conventional plastic bottle and bottles made from natural raw materials is made below.

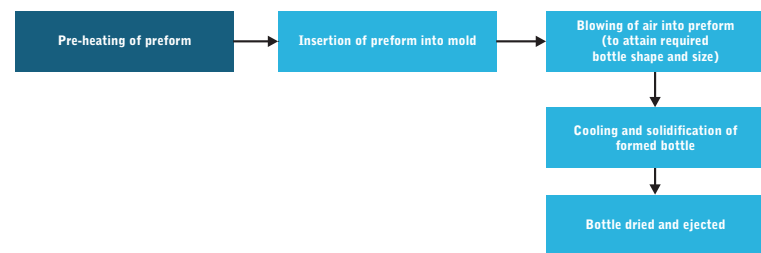
## The Process

The average bottled-water container is made from a polymer of the polyester family, polyethylene terephthalate, and is hence named the PET bottle. The basic monomer is derived from ethylene glycol and terephthalic acid. In the typical two-step production process, a preform is first formed by injection molding, which is then inflated into the actual size and shape by stretch blow molding.

## Injection Molding Process



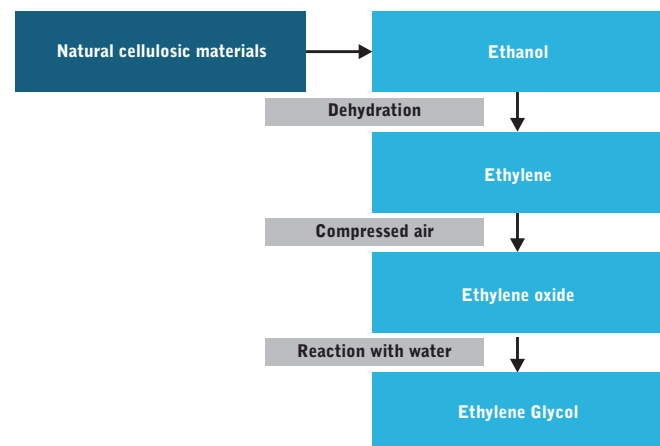
## Blowing Process



These processes that use petroleum as a raw-material, emit 3.4 tons of CO<sub>2</sub> for the production of a ton of PET.

The production of plant-based PET bottles involves a synthesis of individual principal monomers, ethylene glycol and terephthalic acid, from biological sources.

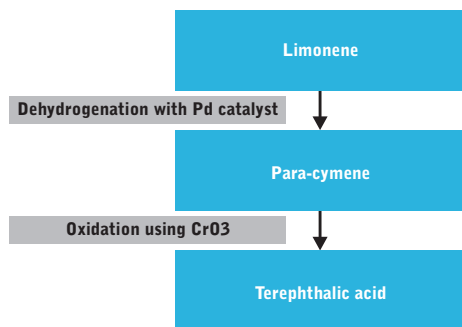
- a) **Ethylene Glycol:** It is derived from ethylene oxide, which is produced from ethylene and compressed air/oxygen. Ethylene is synthesized from ethanol by dehydration. In addition, the production of ethanol from natural cellulosic raw materials, like sugar cane bagasse, switch grass, wheat straw, harvested corn, or waste wood and paper is well-established.



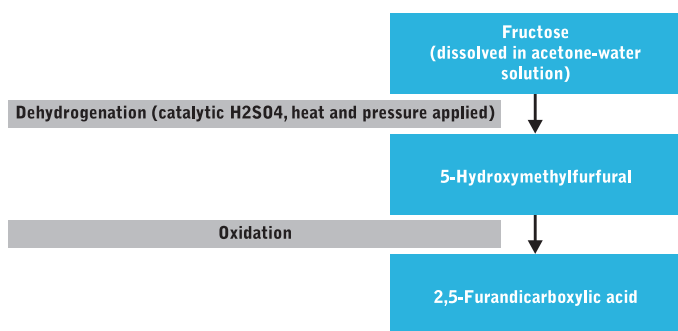
This process does not have a negative impact in terms of resource depletion, as renewable natural materials and wastes are fruitfully used. In addition, roughly 2 kg of CO<sub>2</sub> is sequestered per kg of polyethylene produced, accounting for the absorption of CO<sub>2</sub> by sugarcane during the growth stages.<sup>g</sup>

b) **Terephthalic Acid:** Three sources from which terephthalic acid can be produced are identified:<sup>h</sup>

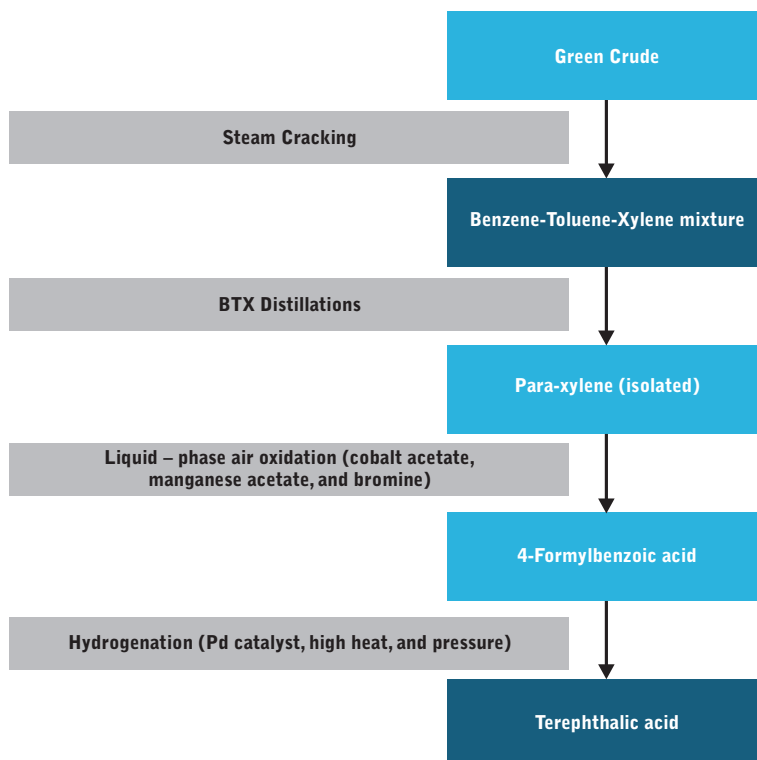
1 **From Limonenes:** This group of compounds is extracted from peels of citrus fruits.



2 **From D-Fructose:** In essence, this product can be used to produce a monomer, 2, 5 furandicarboxylic acid, that is structurally very close to terephthalic acid.



3 **From Green Crude:** Green crude is a petroleum substitute, derived from cellulosic biomass and algae oils.<sup>l</sup> Para-xylene is derived from green crude, which is then oxidized to terephthalic acid through the American Amoco process.



An issue of concern with this highly eco-friendly bottle is that it cannot be distinguished from the conventional bottle in terms of appearance and basic material properties. As a result, it makes recycling of PET bottles risky, as maintaining homogeneity in each recycle batch is of utmost importance – even if one bottle is different from the rest (in terms of material composition) in a batch as large as 2000 bottles, the entire recycling operation will be ruined, causing losses.

### Commercial Eco-Efforts

Pepsi's Aquafina and Coca-Cola's Dasani constitute 24% of the total bottled water sales in the US. Pepsi and Coca-Cola constitute 13% and 11% respectively of the bottled water market in the US, thus proving that Aquafina and Dasani are the top two brands in the country, as measured by retail sales.<sup>j</sup> These brands are sold worldwide, and utilize state-of-the-art technologies, like the HydRO-7 purification system to treat water before it is bottled. In addition, these brands incorporate sophisticated purification processes, like UV filtration, ozonation, and reverse osmosis.

As part of Corporate Social Responsibility (CSR) efforts, both companies are aggressively trying to reduce the environmental footprint of their products. These companies have incorporated numerous green strategies in their respective manufacturing, packaging and distribution phases. The green strategies pertaining to plastic consumption are:

- The use of at least 10% recycled polyethylene terephthalate (rPET) in their primary soft drink containers.
- The introduction of Eco-Fina (in 2009), the lightest water bottle in the market – which uses 50% less plastic than the (half-liter) Aquafina bottle. As a result, it saves roughly 75 million pounds of plastic from being used per year and reduces GHG emissions by 18,000 metric tons per year (by PepsiCo).
- Reduction of about 85,000 metric tons of primary packaging material due to the system-wide packaging efficiency efforts adopted by Coca-Cola.<sup>k / l</sup>

The latest, and biggest, of such efforts is the introduction of a plant-based bottle which is more biodegradable and highly environment friendly. First, Coca Cola introduced a plant bottle that composed of 30% plant-based plastic material, along with another 35% recycled plastic material. The company has announced that the percentage of this plant-based plastic will vary from country to country. In return, PepsiCo launched a 100% plant-based bottle made from switch grass, corn husks, and pine bark. Pepsi also plans to incorporate by-products and waste products from its other food businesses, such as potato peels (Frito-Lay), orange peels (Tropicana) and oat hulls (Quaker Oats) in this green bottle.<sup>m</sup> On using chemical and biological processes, PepsiCo has devised a method to produce a molecule very closely resembling PET from these natural and renewable raw materials.

The bottled beverage industry has a major impact on the economy, society, and the magnitude of its current foot-print. These important sustainable innovations, if implemented on a commercial scale, along with other practices, like the introduction of fully-compostable chips bags, plastic cups and reusing shipping cartons, is likely to create a large positive effect on our stressed environment.

**Source:**

- <sup>a</sup> <http://www.bottledwater.org/files/2009BWstats.pdf>
- <sup>b</sup> <http://www.beveragemarketing.com/?service=publications&section=bottledwaterustxt>
- <sup>c</sup> <http://www.smh.com.au/news/environment/disaster-in-a-bottle/2007/04/23/1177180569554.html>
- <sup>d</sup> <http://www.ensobottles.com/FAQ/FAQ-Environmental-Impact.html>
- <sup>e</sup> <http://www.ensobottles.com/FAQ/FAQ-Environmental-Impact.html>
- <sup>f</sup> [http://www.msnbc.msn.com/id/5279230/ns/us\\_news-environment/t/plastic-bottles-pile-mountains-waste/](http://www.msnbc.msn.com/id/5279230/ns/us_news-environment/t/plastic-bottles-pile-mountains-waste/)
- <sup>g</sup> [http://en.wikipedia.org/wiki/Renewable\\_Polyethylene](http://en.wikipedia.org/wiki/Renewable_Polyethylene)
- <sup>h</sup> <http://biopolymersgroup1.webs.com/terephthalicacid.htm>
- <sup>i</sup> <http://biopolymersgroup1.webs.com/greencrude.htm>
- <sup>j</sup> <http://www.droptheprop.info/bottled-water-statistics>
- <sup>k</sup> <http://www.greenbiz.com/news/2009/03/25/pepsico-launches-industrys-lightest-water-bottle>
- <sup>l</sup> [http://www.thecoca-colacompany.com/citizenship/pdf/SR09/2009-2010\\_The\\_Coca-Cola\\_Company\\_Sustainability\\_Review.pdf](http://www.thecoca-colacompany.com/citizenship/pdf/SR09/2009-2010_The_Coca-Cola_Company_Sustainability_Review.pdf)
- <sup>m</sup> <http://pepsico.com/PressRelease/PepsiCo-Develops-Worlds-First-100-Percent-Plant-Based-Renewably-Sourced-PET-Bott03152011.html>

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