




Sustainable Material Answers™
Recycled PET (rPET)



As climate change continues to be one of the defining issues of our time, a commitment to sustainable solutions is essential—now more than ever. At Avient, we are proud to be a part of the solution, supporting the shift from a linear economy to a circular economy and driving sustainability for all of our stakeholders. We know designing sustainable solutions often comes with challenges and questions. That's why we created a three-part eBook series that dives deeper into the questions you have about sustainability.

What is rPET?

Polyethylene terephthalate, or PET, is a type of plastic that's strong, lightweight and easily recyclable. It is designed to be repeatedly recycled because it can be heated and reshaped over and over again. When PET is recycled and transformed into a new product, it becomes rPET, or recycled PET. Anything that has a #1 recycling symbol is made from PET or rPET. Products like bottled water, 2-liter soft drinks, salad dressing, mouthwash, liquid hand soap, and window cleaner are often packaged using PET or rPET.

PET is the [most recycled plastic](#) worldwide, with more than 1.5 billion pounds of PET bottles and containers recycled every year in the U.S. alone. Nearly all municipalities in North America and Europe accept PET as part of their recycling programs. More and more, consumers are seeking out companies that demonstrate a commitment to sustainability in the products they make, the materials selected in production, and packaging of those products. PET is therefore a popular choice for businesses who want an eco-friendly plastic that can be recycled again and again.





How is rPET made?

The process for collecting, recycling and creating new rPET starts with consumers. Bottles and packaging made from plastic are recycled by consumers – either in their community curbside collections or by depositing recyclables in designated bins. From here, the items are taken to a recycling facility. At the recycling facility, PET and rPET materials are separated from non-plastics and other plastics, then compressed and gathered into bales for easy transportation to a processing center.

At the processing center, the compressed PET is separated by color, crushed into small flakes, cleaned, and dried. The flakes are then heated to over 400 degrees Fahrenheit (F) for several hours. Next, the heated rPET is stretched into long thin cables, cooled, and chopped into pellets. These pellets are sent to manufacturers who reheat the pellets, then form the material into the size and shape needed for their products.

How is rPET used?

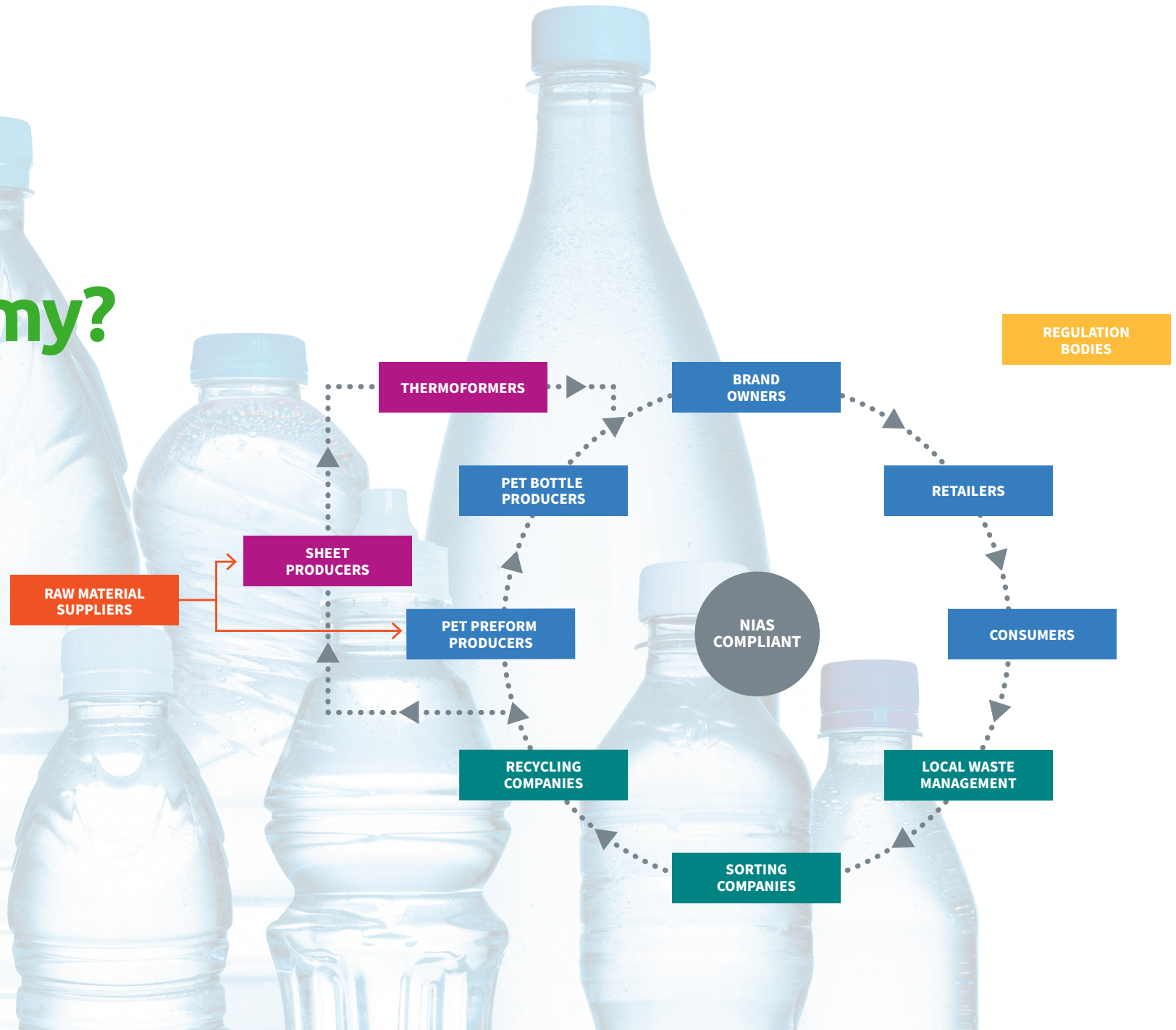
Bottles made of PET or rPET can be recycled into new bottles or packaging. However, when recycled bottles are not high enough quality to transform into new bottles or packaging, rPET can be washed, heated, and stretched into fiber to create polyester yarn and fabric. You can create a multitude of items from polyester, such as clothing, shoes, luggage, carpet, seat belts, and even bungee harnesses.

What is the Circular Economy?

PET Water Bottles can be recycled in a closed loop

The goal of a circular economy is to minimize waste and make the most of available resources to create a world that is restorative and regenerative by design. This means ensuring the materials we make can be recycled or upcycled to avoid waste and downcycling, which means products can only be reused in a degraded form.

This graphic shows how the circular economy works through PET water bottles.





Why is PET so Popular?

Most Recycled Plastic

One major reason? It's the most recycled plastic on the planet. In addition, the reasons why PET is used to package so many food, beverage, and consumer items—from water and juice bottles to hand soap and cooking oil—include several unique characteristics of the material.

Convenient & Cost Effective

Products packaged with PET are popular among consumers because they are convenient, easy to take on the go and, often, affordable options. PET and rPET are also popular options for manufacturers because they are cost-effective materials compared to alternatives like glass and aluminum.

Lightweight & Strong

PET has the dynamic qualities of being both lightweight and strong. PET is shatter proof and not prone to breakage, making it ideal for food, beverage and healthcare products. This means products packaged with PET material can be easily and safely transported without risk of breaking.

Why is PET so Popular?

Perfect for Food & Beverage

PET and rPET are non-toxic, do not react with foods, and provide thermal insulation. This makes the material ideal for food and beverage packaging because the ingredients held within the bottle or package are preserved and protected. In fact, PET is approved as safe packaging for food and beverages by the FDA, EMA, and other governments worldwide.

Energy Efficient

PET takes less energy to manufacture than alternative materials like glass. It also has a lower carbon footprint than alternative packaging materials. Because PET is lightweight, it also uses much less energy and fuel to transport. Although lightweight, PET is also extremely durable, which means less packaging is needed during transportation and a higher volume of product can be delivered.





What are the Challenges of Using rPet?

Color

Although rPET as a sustainable material has many advantages, recycling PET and rPET isn't without challenges.

When PET is processed for recycling, a yellowing of the material often occurs. Although the yellowing does not indicate impurities, the yellow hue is problematic as most manufacturers prefer clear PET flakes that produce a transparent or clear material for their containers and bottles. Fortunately, there are several kinds of additives that don't affect future recyclability of PET that can be used during processing to correct for this yellowing.

Another color-related challenge is the multitude of different color streams of recycled PET, which can limit the uses for recycled colored PET. For example, if you want a translucent green plastic for a final product, you won't be able to use the translucent orange PET stream. Fortunately, there is new technology that can analyze the color of the PET or rPET to be used for a new product and predict the range of colors possible for the end product. This predictive technology maximizes the use of different color streams and reduces waste.

What are the Challenges of Using rPET?

Performance

Reheating rPET, so that it can be molded into a bottle preform shape, also decreases the plastic's intrinsic viscosity (IV) due to a decrease in polymer chain length. This diminishes the material's strength and capabilities. Also, the more rPET used in manufacturing, the higher the acetaldehyde levels, which can lead to odor and taste issues. Similar to the ones that correct yellowing, there are special additives that "scavenge" or otherwise reduce the levels of acetaldehyde. In addition, chain extender additives can improve IV for better strength and performance.

Infrastructure

Recycling PET depends on participation from consumers, but it also requires that their local governments have the infrastructure for collection programs and the proper sorting equipment. In order to keep up with the demands of manufacturers who want to use the recycled material for new products, communities must be committed to maintaining the necessary structure and processes for recycling PET. [San Francisco](#) is a prime example of a community with infrastructure and legislation that aggressively support recycling. Because residents are required by law to separate their recyclables, compostables and landfill trash, there are clear processes and support services to help residents and renters set up and maintain their recycling services.





What is the State of the rPET Industry Today?

Market Size and Drivers

In 2020, the global rPET market was valued at \$8.56 billion with Asia Pacific as the largest regional market, accounting for over 45% revenue share. Landfill bans in North American and European countries, government recycling initiatives, and increased consumer focus on sustainability continue to drive the rPET market.

PET Types

Clear PET—Clear PET accounted for over 76% of the revenue share in 2020 and is expected to continue as the market leader. This type of PET is in high demand because changes in the contents of the container that may indicate impurities can be easily detected.

Colored PET—As manufacturers look to transfer packaging away from less recycled polymers to PET, there is an expectation that color will remain an important brand differentiator on the shelves. Careful consideration will need to be made as to how these packages are sorted and reprocessed into usable rPET. In many instances, these colored bottles may offer an outlet to utilize some of the less transparent rPET feedstock as the colorant can mask the original recyclate color.

What is the State of the rPET Industry Today?

PET End Uses

Fiber—Fiber accounted for over 44% of the global revenue share and is used for clothing, athletic jerseys and accessories, mattresses, cushions, car seating and insulation products.

Food & Beverage—Bottles and containers for food and beverages represent a significant share of the market. The expanding beverage market in Asia Pacific and the ease of bottle-to-bottle recycling is expected to drive further growth for this use case.

Sheet & Film—Sheets and films made of PET are another major use case. PET sheets can be used to make a variety of plastic products and film is often used for tape backing, plastic wrap, medical packaging, and protective coating on windows.

Strapping—Strapping material made from PET is used to bundle products together and secure pallet loads for transportation and storage. Thanks to its strength and elasticity, PET strapping can be used for large, heavier loads such as metals, lumber, bricks or bottles and cans.

[Some of the biggest](#) players in the industry include Alpha, Plastipak, Novelplast, Placon, Clear Path Recycling LLC, Verdeco Recycling, Inc, Indorama Ventures Public Ltd., M&G Chemicals, Zhejiang Anshun Pettechs Fibre Co., Ltd., Polyquest, Evergreen Plastics, Inc., Phoenix Technologies and Libolon.





What's Up Next for rPET?

Projected Growth

The [global rPET market is expected to grow](#) at a compound annual growth rate of 6.7% from 2021–2028.

Consumers and investors alike are [paying close attention to plastic packaging](#) and its potential negative impact on the environment. As a result, many businesses are making commitments to use a minimum percentage (usually between 25–100%) of post-consumer recycled plastic in their plastic products or packaging.

In 2019, the EU enacted its Single Use Plastics directive aimed at reducing the impact that such products have on the environment. For example, this directive has set a target for plastic bottles. They should contain at least [25% recycled plastic](#) in their manufacture by 2025 (for PET bottles), and 30% by 2030 (for all bottles).

In 2020, California became the first U.S. state to legally mandate the use of recycled content in packaging, specifying a specific percentage of post-consumer recycled plastic be used starting with 15% by 2022.

These commitments and mandates will continue to drive the high and increasing demand for recycled plastic bottles.

Supply & Demand

Currently, [demand for rPET is outpacing the supply](#). In 2019, only 1.77 billion pounds of PET was collected for recycling out of the 6.4 billion pounds of PET that was available to be recycled in the United States. Looking ahead to 2025, there will be an annual gap of one billion pounds between the current U.S. supply and the estimated demand for rPET. Because rPET supply depends on local collection programs and consumers' participation in these programs, supply remains limited and the increased demand will drive prices up.

Collection and supply issues can be improved by more standardized packaging as well as better sorting equipment and technology. These improvements require significant investments in infrastructure that support the entire recycling process. However, there is still question who should pay for these investments—federal and state governments, businesses or consumers.





What's Up Next for rPET?

Making the Most of rPET

With demand rising and a limited supply, how do we make the most of rPET that does get recycled?

Manufacturers using rPET require different properties based on their specific application, such as certain colors, stiffness and strength. [Special additives](#) like peroxides, antioxidants, chain extenders, elastomers, colorants and performance modifiers can be added to rPET during processing to achieve these properties and remedy cross-contamination, discoloring or any other impurities.

One common challenge with using rPET bottles is the breakdown of the polymer chains that occurs as the material is heated and remelted during processing. This causes the rPET's intrinsic viscosity (IV) to drop, which weakens its strength and functionality. Chain extenders can be used in order to raise the IV and ensure the rPET strength and performance is suitable for the new application.

Material Solutions for rPET

Material suppliers are working on the issues we've raised in this eBook. For our part, Avient offers several solutions that enhance rPET recycling and address the challenges at every stage of the process.

| STAGE | SOLUTION | CAPABILITIES |
|----------------------------------|---|--|
| Polymer Recycling | ColorMatrix™ rePrize™ | <ul style="list-style-type: none"> - Increases intrinsic viscosity to enhance use of recycled PET - Reduces yellowing and decontamination |
| Materials Selection | ColorMatrix™ Joule™ RHB | <ul style="list-style-type: none"> - Reduces the energy required and costs - Ensures minimal yellowing and light-weighting |
| Preform Molding | ColorMatrix™ AAzure™ | <ul style="list-style-type: none"> - Reduces yellowing and acetaldehyde levels for improved bottled strength |
| Preform Molding | ColorWorks™ | <ul style="list-style-type: none"> - Provides a range of possible colors for end products based on the color of the rPET available for use |
| Preform Molding | Rejoin™ PCR Masterbatch | <ul style="list-style-type: none"> - Combines pigments and functional additives with a 100% PCR carrier for polyolefins - Enables packaging that is 100% PCR |
| Bottle Blowing & Filling | ColorMatrix™ Optica™ | <ul style="list-style-type: none"> - Excellent acid & thermal stability to reduce yellowing and create a haze-free container |
| Bottle Blowing & Filling | ColorMatrix™ Smartheat RHC™ Process Aid | <ul style="list-style-type: none"> - Optimizes weight distribution to increase bottle strength and quality - Reduces energy required and costs |
| Sales, Distribution, Consumption | ColorMatrix™ Amosorb™ | <ul style="list-style-type: none"> - Scavenges oxygen to extend the shelf life and preserve the freshness of food or beverages within container |
| Sales, Distribution, Consumption | ColorMatrix™ Ultimate™ UV | <ul style="list-style-type: none"> - Blocks ultraviolet light transmission to protect the container and its contents - Enables light-weighting |
| Sales, Distribution, Consumption | ColorMatrix™ Lactra™ | <ul style="list-style-type: none"> - High-performance light blocking that extends the shelf life of light-sensitive dairy products |



Taking the Next Steps

Move Your Sustainability to the Next Level

Because sustainable material solutions and technology are evolving at the speed of life, it takes fresh thinking, agile R & D, and imaginative use of next-generation materials to bring

life-changing products to market safely and quickly. Connect with us to learn more about how Avient can deliver specialized material solutions that keep pace with the ever-increasing demands for sustainability.

[Contact us today](#)