THE DEFINITIVE GUIDE TO PLASTICS

FOR THE PACKAGING INDUSTRY

National Association of Container Distributors

NACD

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PLASTICS: A BRIEF HISTORY AND WHERE WE ARE TODAY

Since the early 19th century, plastics have a played a major role in the world's economy. From textiles and building materials, to medical applications and packaging.

Plastics are America's third largest manufacturing industry, employing over 885,000 workers. Add in those employees of companies that supply the plastics industry, and you're looking at over 1.4 million Americans working in plastics today. In the last thirty years, the industry has grown 2.4% annually, continually increasing in volume and value.

The development of plastics began in the 1860's when billiard companies began searching for an alternative to ivory for the production of pool balls. The race was on to develop a strong, lightweight synthetic that would allow the game to continue. Researchers and chemists all over the world began experimenting with plant resins to create a new kind of man-made material.

In 2015, plastic products and packaging are an $800 billion dollar industry with almost 150,000 companies involved and it's common knowledge in the world of container sales and manufacturing that plastics play a key role in the industry.

Because of their diversity and incredibly flexible nature, plastics are often the best solution to a tough packaging problem. They're cost effective, readily available, and reliable enough to be the first and best choice for thousands of companies. They're also generally highly recyclable, with over a billion pounds being recycled into new applications every year.

The purpose of this ebook is to provide professionals with a working knowledge of some of the most common plastics used in the container industry, and to compare and contrast their different uses, values, strengths, and weaknesses. And maybe most important in today's eco-conscious climate, we'll explore the relative **sustainability of 6 popular plastics in production today**. We'll also cover the best applications for each plastic.

KEY PLASTIC TERMINOLOGY

Here are a few key terms used in plastics and ones you may come across in this ebook:

MONOMER

A monomer is a molecule that can bind chemically to other molecules to form a polymer.

POLYMERS

Polymers are made up multiple monomers (AKA molecules) that are strung together.

THERMOSETTING POLYMER

Thermosetting polymers are also known as plastics. They are materials which become liquid or malleable at low temperatures and become hard and rigid in high temperatures.

SIX PLASTICS THAT DOMINATE THE INDUSTRY

There are many unique varieties of plastic material made from a diverse range of sources, including many made from reclaimed or recycled material. Depending on your business, you may be deeply informed about one type of material, but be seeking out information on others to broaden your knowledge base. In this book we'll cover six major materials:

HDPE - High-Density Polyethylene

LDPE - Low-Density Polyethylene

PET - Polyethylene Terephthalate

PS - Polystyrene

PP - Polypropene

PVC - Polyvinyl Chloride

We'll begin by covering their **backgrounds** and the basics of the **processes by which each material is produced**, and then offer insight into the **strengths and weaknesses** of each in terms of **durability, diversity** of applications, and finally take a look into their relative **sustainability**.

This last area will be explored in depth, bringing you up to speed on this hot button issue and giving you an easy reference for key facts about recycling and the relative sustainability of each material.

First let's take a look at two varieties of polyethylene, the most common plastic in the world. Over 88 million tons of polyethylene are produced a year in thousands of different forms for a variety of applications. The two most common types in production today are HDPE and LDPE.

Known for its strength and durability, 26% of all HDPE produced worldwide is used in the production of rigid packaging.

HDPE

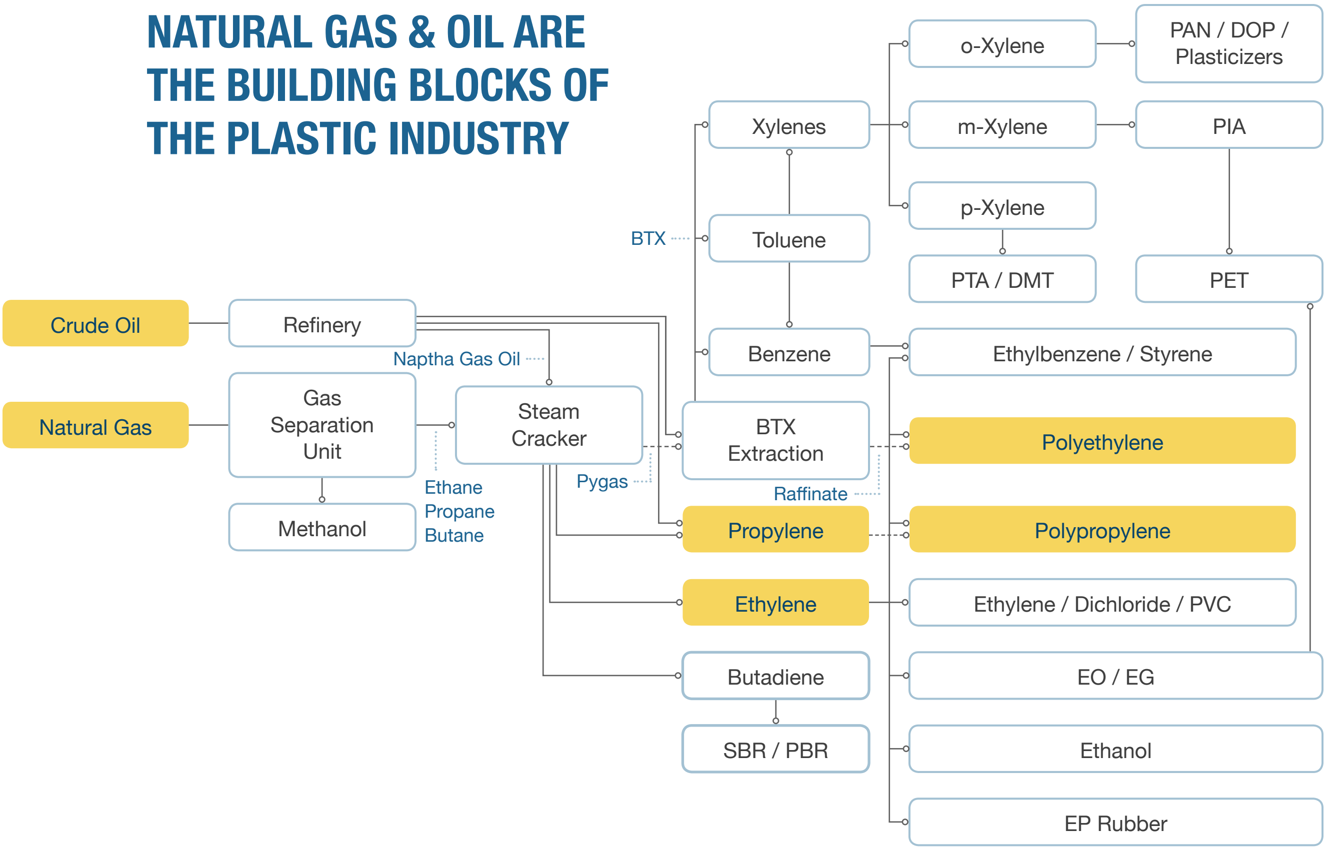
Developed by two researchers in 1953 high-density polyethylene is one of the most common packaging and construction materials in use today. Known for its strength and durability, 26% of all HDPE produced worldwide is used in the production of rigid packaging. In 2014 the global capacity for production, including facilities which can also be used to create other Polyethylene-based materials, was around six hundred million tons.

Growth in production is consistent to meet rising demand, although pricing can fluctuate along with the naphtha and crude oil markets as both are precursors for HDPE production. It's the second most recycled plastic in the United States, with approximately 28% of bottles and jars reclaimed.

HDPE is a great choice for food and beverage applications as many grades of the material are USDA, NSF, and FDA approved for direct contact with food. In addition, it has good impact resistance, is lightweight, and has very low moisture absorption.

HDPE is made from crude oil, but it only takes 4% of the world's annual oil production to produce all the plastic made in the world each year. To produce HDPE, petroleum is heated in a process known as cracking, which produces ethylene gas. These gas molecules link together to form long chains known as polymers — specifically polyethylene. The polyethylene is then pushed through fine holes to form long thin strings that are cut to form small granules.

NATURAL GAS & OIL ARE THE BUILDING BLOCKS OF THE PLASTIC INDUSTRY



Reliability and safety are two of HDPE's strongest value propositions. Unlike some other container materials, HDPE will not degrade due to extreme high or low pH, intense concentrations of salts, or other common chemical corrosives. It is generally extremely inert and as a result makes an ideal material for food and beverage applications.

However, there are some shortcomings to working with HDPE. It has a high instance of thermal expansion, and while it is a strong material it can be subject to some stress cracking. It's also difficult to bond to other materials, and has a relatively low strength/stiffness, making it unsuitable for some of the more rugged applications. Additionally, like many petroleum-based plastics, it can be very flammable and is not suitable for high-temperature applications.

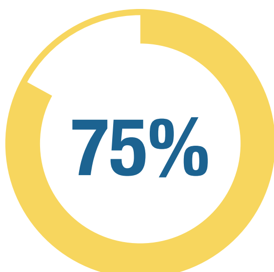
HDPE's SPI Resin Identification Code is 2, and it can be recycled easily throughout the United States. The market for, and production of, post-consumer recycled HDPE products is stable and growing, and the main use for reclaimed HDPE is in creating a new life for the material as a bottle or food and beverage packaging.

If you're looking for a durable, lightweight, food safe, and easy-to-manipulate material for your packaging needs—and one that comes with reasonably good marks for sustainability—HDPE might be right for your project.

LDPE

LDPE stands for low density polyethylene, but you might have guessed that already. It was the first type of polyethylene that was commercially produced. It was developed in 1933 by Imperial Chemical Industries (ICI), which was for many years, the largest manufacturer of LDPE in Great Britain. Of note, ICI is responsible for many other material innovations including the acrylic plastic perspex, an early competitor to plexiglass.

LDPE has slightly less tensile strength than HDPE but is correspondingly more flexible. Its most common application in the modern word is as the material used to make many plastic bags, but there are many other applications for LDPE.



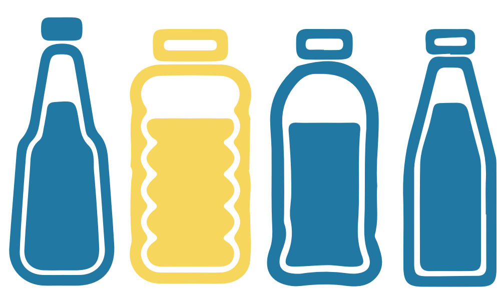
About 75% of all Polyethylene produced globally is LDPE.

It can be used to make shrink film, overwrap film, food safe packaging film, and strong liquid containers. About 75% of all Polyethylene produced globally is LDPE.

LDPE's low density makes it highly malleable and allows for stretching—one of its chief strengths—and makes it a great choice for lightweight, form fitting film-type packaging. Unlike rigid HDPE, LDPE can be used to create lightweight and flexible packaging. Keep in mind however, that its relatively lower density does make it susceptible to puncture.

Because of its similarity to HDPE, low density polyethylene shares many of HDPE's shortcomings, including low strength/stiffness, high thermal expansion, and poor temperature capability. Like HDPE, it is also subject to stress cracking and is flammable. It is also more difficult to bond than other plastics, limiting its applications slightly.

Another bonus with LDPE is that its high durability allows for packaging (like plastic bags) to be reused by the consumer many times before it has to be recycled or disposed of. Embracing a push towards increased sustainability, some packaging producers are designing LDPE products whose useful life extends past their initial purpose.



Unfortunately, in the United States, LDPE is recycled at a rate of only about 5.7% — lower than its denser sibling.

Unfortunately, in the United States LDPE is recycled at a rate of only about 5.7%—lower than its denser sibling. If sustainability is one of your chief concerns, LDPE may not be the best material choice for your application. Although, recycled LDPE is available and can be combined with a percentage of virgin material to rejuvenate it for a variety of uses. Its resin identification code is 4, and while few curbside programs accept LDPE for recycling many stores and some communities will accept plastic bags.

PET

HDPE and LDPE are both great materials for food and beverage containers, but when it comes to plastic bottles there's one plastic that leads the field—PET.

PET stands for polyethylene terephthalate, and is the most popular polyester produced globally. It is used primarily as a fiber for textile production and as a packaging material for food and beverage products.

PET has an especially good moisture barrier and makes a great material for soft drink bottles. Some kinds of PET can be treated with a thin layer of metal to make it reflective and opaque, while others can be thermoformed into blister packs.

Developed in England in 1941, PET is one of the most common polyesters in the world, and ranks fourth globally in terms of overall polymer production. It also goes by the names PETE and the brand names Dacron, Terylene, and Lavsan.

It's the material responsible for everything from emergency "space blankets" to polar fleece. It's versatility and excellent recyclability make it a great choice for many packaging applications.

The production of PET is a fairly complex process, but there are a few basic points to keep in mind. The precursors for PET production are terephthalic acid and ethylene glycol, both readily available and relatively low-cost materials. After these components are combined they undergo a series of controlled reactions in the presence of specific catalysts and environmental conditions which determine the characteristics of the final product.

PET can be copolymerized with other substances to adjust its internal structure to make it more suitable to certain kinds of extrusion or molding.

On the flip side, one of PET's main shortcomings is its high susceptibility to heat degradation. During the production process temperatures must be carefully maintained to ensure the resulting material is clear, and in many applications high heat will fundamentally compromise packaging and other products made from PET. However, compared to other plastics like HDPE and LDPE, PET is considerably less flammable.

PET is accepted in almost all U.S. recycling programs, and for every pound of recycled material used in place of a new plastic, greenhouse gas emissions are reduced by a whopping 71%!

PET is one of the most easily recycled plastics currently in use today, and consumer packaging made from 100% recycled material is becoming increasingly common in today's sustainability-focused market. In fact, research shows that PET packaging may be more environmentally preferable than many new bioplastic materials due to its healthy closed-loop lifecycle.

It has the resin identification code 1, and most curbside programs accept PET/PETE materials. Thanks to its resilience, PET can be recycled many times very efficiently. It's accepted in almost all U.S. recycling programs, and for every pound of recycled material used in place of new plastic, greenhouse gas emissions are reduced by a whopping 71%!

Let's take a look at another extremely popular and widely used plastic available today—polystyrene.

PS

As one of the oldest plastics still in use, polystyrene was discovered in 1839 by German apothecary Johann Edouard Simon. The original batches of polystyrene were made from the natural resins of the Turkish sweetgum tree. Almost 100 years later, researchers at DOW Chemical developed a process to make a closed-cell, moisture resistant product, and introduced Styrofoam to the world in 1941.

You may know it by the brand name Styrofoam and be surprised to learn about some of its other useful applications.

Polystyrene is one of the most commonly used and versatile plastics available today. It can be made both transparent and opaque, with a variety of densities and strengths depending on the application. It can be formed into a solid or a foam, and is a relatively inert and non-reactive material.

Through copolymerization, PS can be combined with other materials to expand its range of properties. For example, so called “high-impact plastic” is a result of one such process. PS can also be stretched into a clear rigid film called Oriented Polystyrene (OPS) that can be used to create comparatively inexpensive transparent packaging, though its durability may suffer greatly.

Polystyrenes disadvantages make it unsuitable for some applications. It is highly flammable (though flame retardant varieties do exist), and low impact varieties can break very easily. It has notoriously poor resistance to most solvents, and is not suitable for containing many types of liquids. It’s also worth noting that while the recyclability of polystyrene is on the rise in the U.S., it has a track record as being one of the least sustainable plastic materials, and without special treatment is virtually non-biodegradable.

Applications include rigid plastic packaging for things like computers, as well as food containers, disposable utensils, and even as a building material when used in conjunction with reinforced concrete. Additionally, much of today’s conventional protective packaging materials are made from PS. A variety of production techniques and technologies allow polystyrene to be a strong choice for many diverse applications.

It’s worth noting that there is a rising trend in American municipalities to ban PS food containers, as they are perceived as a major source of non-biodegradable waste in landfills. Earlier this year, New York City banned single-use expanded polystyrene food containers, citing their belief that these materials could not be recycled effectively. If sustainability is amongst your primary concerns, you may want to consider alternatives to PS for your applications.

Contrary to what many believe, it is completely possible to recycle polystyrene, including styrofoam food service containers. And while traditionally products made from polystyrene have been considered non-biodegradable, new research with biological agents has led to a process by which PS materials can be converted into more easily broken down substances.

Ongoing research in this area is improving the relative sustainability of PS over time. Polystyrene has the resin identification code 6 and can be picked up by some curbside recycling programs in the U.S.

PP

One of the strongest and most resistant plastics available today, Polypropylene has a wide variety of applications ranging from packaging to textiles. Developed by Phillips Petroleum chemists J. Paul Hogan and Robert L. Banks in 1951, Polypropylene was brought into commercial production within the decade. More than half of all PP produced today is used in flexible packaging, and demand continues to rise for this versatile material.

Polypropylene is produced through a variety of methods, and the resulting materials have various properties such as an anti-static nature to resist dust, or a treated surface designed to improve paintability.

Due to its great physical durability when properly oriented, PP can be used to form strong, long lasting, living hinges in packaging as well. Its strength also allows for very low density production, which reduces its environmental impact.

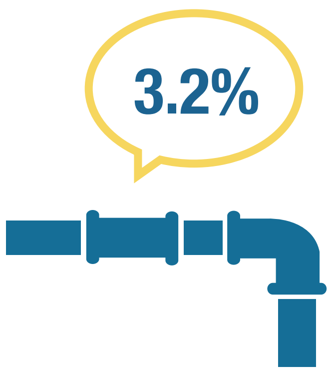
Like Polystyrene, PP can be produced in an "oriented" structure that allows for increased clarity and thinness, without the brittleness of PS. Biaxially Oriented PP is commonly used as packaging for food products due to it being easy to coat, print on, and laminate.

There are many diverse advantages to using polypropylene. Because it's unusually strong, PP is a great choice for producing containers meant to package acid, base, or other highly corrosive substances. Due to its great physical durability when properly oriented, PP can be used to form strong, long lasting, living hinges in packaging as well. Its strength also allows for very low density production, which reduces its environmental impact.

Polypropylene is highly susceptible to some chlorinated solvents and aromatics. Without special treatment it is highly flammable, and difficult to bond or paint. It also oxidizes readily and suffers from UV degradation. While there are special processes available to treat PP to deal with these issues, there are other materials better suited to applications where weathering and UV exposure are likely.

PP recycling is quickly on the rise in the US, more than tripling between 2004 and 2010. Its production results in less solid waste than many alternatives, and it results in much lower CO2 emissions than other similar materials. Many states now have programs to accept polypropylene, with more joining in every year.

Recycled PP has uses across many markets, including packaging, consumer goods, and construction materials. It has the resin identification code 5, and is accepted in many curbside recycling programs.



Demand for PVC is expected to increase by 3.2% per year until 2021.

PVC

When most people hear PVC (Polyvinyl Chloride) their first thought might be the ubiquitous white plastic piping used in so many applications, but PVC is more than just pipes. It is the third most widely produced plastic after polypropylene and polyethylene and demand for PVC is expected to increase by 3.2% per year until 2021.

Discovered accidentally in 1872 by German chemist Eugen Baumann, PVC was originally a very rigid and somewhat brittle material that struggled to find widespread use. In 1926 Waldo Semon and B.F. Goodrich developed a way to plasticize PVC, increasing its flexibility and opening it up to a wide range of applications.

Semon, known as the father of the vinyl, is also known for inventing a non-digestible synthetic rubber bubble gum substitute that was so strong it could be used to blow enormous bubbles.

PVC is formed by combining its chemical components (primarily chlorine from industrial salt and carbon) together in a liquid within a pressure-tight container. Stirring and agitation causes the components to polymerize, forming PVC and generating heat which must be drawn off the reaction. Water is continuously added to facilitate the process until it is compete, and individual spheres of PVC have been formed.

PVC is highly durable and non-reactive, making it ideal for applications where contamination or degradation are serious concerns.

Amongst the most visible uses of PVC beyond white pipes are vinyl records, which were once a commonplace item in the days before iPods and streaming music. Other common applications are as a home siding material, a synthetic alternative to leather, and to make plastic bags that are far more durable than those produced from LDPE.

Low cost and lightweight, PVC has many advantages. As a thermoplastic, it can be recycled and reformed as needed. It's highly durable and non-reactive, making it ideal for applications where contamination or degradation are serious concerns. PVC also has low thermal conductivity and a high resistance to chemical stress cracking.

Conversely, there are some drawbacks to using PVC. Because of how it is made, there is the possibility that PVC may release toxins into the environment during production, when it is burned, or as it decomposes. This danger of environmental contamination has given PVC a somewhat bad reputation.

This is a major reason why it is banned in Europe and California presently. In fact, there are only a couple bottle makers left in the United States that still process this resin. Furthermore, due to the many different additives and processes used to produce PVC, recycling it efficiently and economically can often be a major challenge.

That said, PVC can be and is recycled in the U.S. today. With proper care and the right technology, PVC can be reclaimed effectively in two main ways: it can be ground down into small particles to be reformed into new PVC materials, or it can be chemically broken down into its component molecules so those materials can be reused in other applications.

PVC has the resin identification code 3, and is often accepted by manufacturers of plastic lumber for construction.

LOOKING TO THE FUTURE

Scientists and manufacturers working in plastics are always looking to the future to develop new technologies that meet the needs of the consumer market. New “green” materials are being developed every day, replacing older, less sustainable materials. By relying on raw materials rather than petroleum, these new plastics are helping to reduce our reliance on petrochemical energy.

Another big development in the world of plastics is “lightweighting”—finding ways to strengthen materials so less can be used, while reducing the weight of products and packaging. This has major implications in the automotive industry, where lighter weight vehicles can equal higher fuel efficiency.

Lightweighting in packaging also reduces the amount of plastic needed to produce common items like water bottles and reducing the overall amount of waste material.

The versatility and eco-friendly benefits that come with some plastics make them the packaging material of choice for most manufacturers. This is why staying ahead of the latest discoveries and trends in plastics is a top priority for suppliers and distributors who seek to remain on the cutting edge of the ever-shifting packaging industry.

For more information on upcoming trends in the container industry, be sure to check out our other ebook—Keeping a Pulse on the Container Industry.

LEARN MORE

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