Beyond the package: Tackling the plastic problem from within

Sustainable pathways for replacing ABS and PVC

PRESCOUTER

May 2022

Implementing a combination of interventions using known technologies and approaches can reduce virgin plastic production by 55% by 2040.

Plastic pollution is currently one of most discussed environmental issues worldwide. Large volumes of plastic waste are generated due to the short lifespan of many plastic products. It is estimated that approximately 40% of plastic products have a service life of less than 1 month (for example, single-use plastics such as packaging). Moreover, plastics often contain additives (e.g., phthalic esters, PAEs, and bisphenol A) to improve their functionality, and in many cases, these increase the environmental toxicity of the products they are used in.

Looking beyond packaging, plastic challenges also need to be addressed in different consumer goods where plastic is the product itself, for example toy products, construction materials, automotive materials, and electronics, among others. As part of a circular and sustainable economy vision, there has been recently a growing demand to transition toward more environmentally friendly products and manufacturing processes (e.g., the use of bio-additives and/or improve product recyclability). Also, there is an increasing idea among consumers that a product's price and environmental impact, as well as the raw materials' origins, should be seen as the essential attributes when buying a product. Thus, incorporating sustainability principles into product value and supply chains improves environmental and social performance, which consequently may represent significant competitive advantages.

In this Intelligence Brief, we explore innovative technologies and case studies based on 5 sustainable pathways for plastics, identifying different opportunities for the consumer goods industry.

1. https://www.unep.org/news-and-stories/press-release/historic-day-campaign-beat-plastic-pollution-nations-commit-develop
2. https://www.nationalgeographic.com/environment/article/plastic-pollution
3. https://microplastics.news/2021-06-17-common-plastic-additive-linked-to-fertility-problems.html
4. https://www.sciencedirect.com/science/article/pii/S030438941730763X
5. https://www.resourcepanel.org/reports/policy-options-eliminate-additional-marine-plastic-litter

Nearly half of the plastic problem is packaging-related.

In 2020, around 360 million tons of plastics were produced globally for a large number of industrial and household applications, from wrapped food and disposable bottles to microbeads in body washes, involving different varieties of plastics.

Plastics' largest market is packaging, which is predominantly composed of polypropylene (PP), polyethylene terephthalate (PET), and polyethylene (PE). Packaging accounts for the largest plastic demand by application (around 44.8% of all polymers).

The consumer packaged goods (CPG) industry, however, is also one of the major players that can deviate from plastic waste through innovation and foster actions aimed at respecting and preserving the environment.

Two of the main concerns about plastics today are that none of the commonly used plastics are biodegradable and that materials and product design principles sometimes lack a feasible plan for recovery and treatment based upon existing systems. Hence, plastics accumulate rather than being recycled or decomposing in landfills or the natural environment.

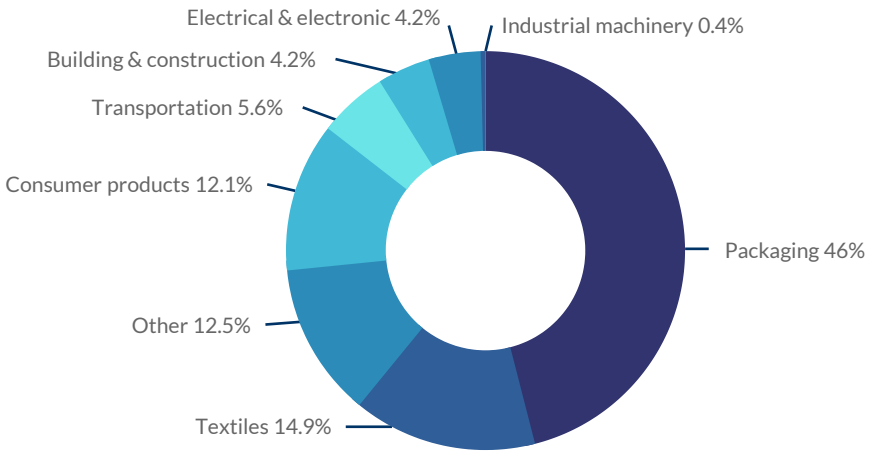


Figure. Plastic waste generation by industrial sector in 2018. Source: Statista.

Out of the 9.2 billion tonnes of plastic produced between 1950 and 2017, approximately 7 billion tonnes became plastic waste, ending up in landfills or being dumped (UNEP).

Looking beyond packaging, acrylonitrile-butadiene-styrene (ABS) and polyvinyl chloride (PVC) pose even greater challenges in recycling.

The overall thermoforming plastic market is dominated by the polypropylene (PP) segment due to the extensive use of this plastic in packaging applications including food packaging, medical device packaging, and automotive packaging.

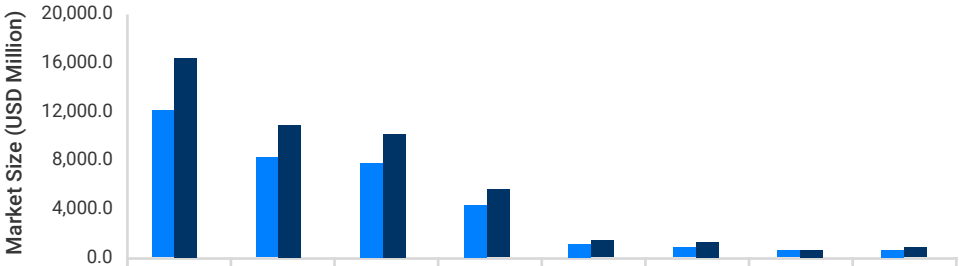
But what about other less frequently mentioned commonly used plastics?

Acrylonitrile-butadiene-styrene (ABS)

A widely used thermoplastic with lightweight and impact-resistant properties. ABS is used in products such as children's toys and consumer appliances, making it one of the three major types of plastics that are found in home appliances (the other two are polypropylene and polystyrene).

Polyvinyl chloride (PVC)

One of the most widely used plastics, with attributes including inherent flame retardance and chemical resistance. PVC is also widely used in the construction industry.



	PP	PS	PET	PE	PVC	Bio-plastics	ABS	Others
2019	11,906.0	8,052.8	7,577.2	4156.6	1037.4	940.1	345.4	766.5
2024	16,001.5	10,592.9	9,871.4	5367.4	1328.8	1324.8	439.8	964.6
CAGR (2019-2024)	6.1%	5.6%	5.4%	5.2%	5.1%	7.1%	4.9%	4.7%

Figure. Thermoforming plastic market from 2019 to 2024 by plastic type. Polymer types are as follows: PE (polyethylene); PP (polypropylene); PS (polystyrene); PVC (polyvinyl chloride); PET (polyethylene terephthalate); ABS (acrylonitrile butadiene styrene). Sources: MarketsandMarkets; Statista.

In tackling the plastic problem, there is no single solution; There are instead 5 sustainable pathways for plastics.

FIVE potential pathways:

Recycling (downcycling/upcycling)

Enables plastic waste to re-enter the system after use and replace virgin raw materials in new products. It is linked to ideas of a more circular economy in which material loops are narrowed or closed through improved end-of-life processes and better product design. However, there is a challenge regarding how to improve the rates of collecting, sorting, washing, and recycling plastics.

Material replacement and reduction of complexity

Implies substituting plastic with paper and compostable materials, decreasing the complexity of plastics to enable cleaner flows, and improving recyclability and reuse of plastics. This could be achieved by phasing out or replacing certain types of additives, by using mono materials, and by steering future plastics innovations.

Bio-based plastics and/or additives

Mainly based on biological feedstock, typically oils, starches, and sugars from agricultural crops. Feedstock can also be cellulose, bio-waste, and carbon dioxide. Some bio-based plastics are also biodegradable, yet bio-based and biodegradable plastics are not synonymous.

Examples: PLA, PBS, TPS, bio-PE, bio-PET, etc.

Biodegradable plastics

Imply a system in which plastics are decomposed into carbon dioxide or methane, water and compost, or digestate when exposed to environmental conditions such as temperature and microorganisms. In most cases, this is achieved through industrial processes rather than in the natural environment.

Reduced use

Implies design options, material substitution, changing habits, or outright refusal to use. This pathway can overlap and synergize with the previous pathways.

Based on: Madsen, Stine & Nilsson, Lars & Lindblad, Ellen & Palm, Ellen & Nielsen, Tobias. (2018). Pathways to sustainable plastics - A discussion brief, and Law, K.L., Narayan, R. Reducing environmental plastic pollution by designing polymer materials for managed end-of-life. Nat Rev Mater 7, 104–116 (2022).

ADDITIONAL INSIGHT:

"Other CPG plastic challenges aside from ABS or PVC that are worth mentioning include PP, PE, HIPS, PET, in terms of collecting, sorting, and recycling of mixed plastics to be able recycle at least 95% of all consumer plastics."

- Mahmood Mehrabzadeh, PhD in Polymer Engineering, Specialist in Plastic Recycling

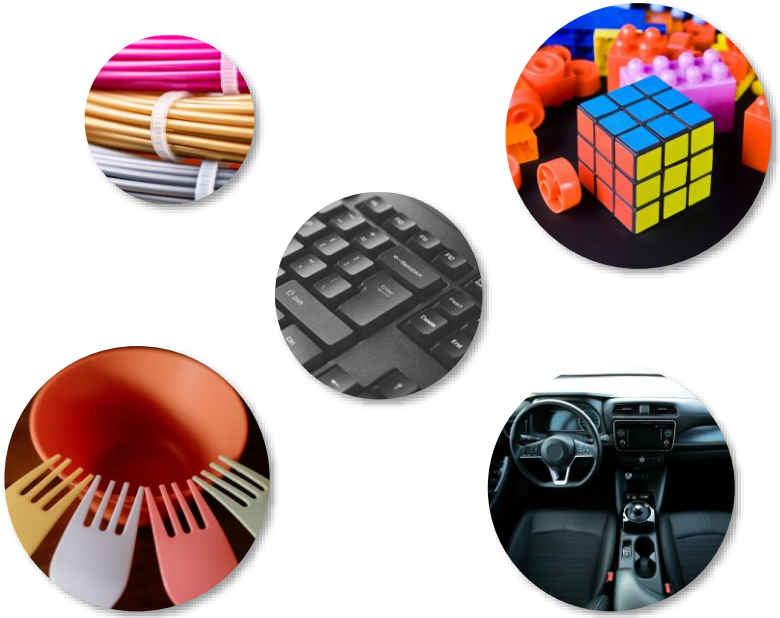
Acrylonitrile-butadiene-styrene (ABS)

ABS is a petroleum-based polymer plastic made up of three monomers: acrylonitrile for strength, butadiene for toughness, and styrene for toughness and a smooth finish. Currently, there are over 6,000 grades of ABS plastic that are designed for several applications, and only in the U.S., it is forecasted that ABS & polycarbonate will have a market revenue of around USD 467.2 million in 2023.

What is acrylonitrile-butadiene-styrene (ABS) used in?

ABS is extensively used in:

- The electrical & electronic industry and semi-structural applications (e.g., 3D printing, caps for keyboards, and computer cases).
- Appliances for control panels, wall sockets, vacuums, food processors, fridges, and even furniture and luggage.
- Plumbing, as a substitute for metal in pipes and fittings.
- Plastic instruments (e.g., recorders, clarinets, and pianos) and toys.
- The medical industry (e.g., non-absorbable sutures, artificial tendons, attachments for drug delivery through tracheal tubes, inhalers, and nebulizers).
- The automotive industry (e.g., panels, door handles, seat belts, dashboards, among others).



What are the challenges associated with ABS?

ABS plastic is a non-biodegradable thermoplastic* that, although 100% recyclable, in North America, has been assigned resin code No. 7 (“other plastics”), which is usually not accepted at recycling plants. Thus, a large percentage of these “other plastics” ends up in landfills, if there are not curbside pickup programs.

ABS plastic is not known to be harmful or related to any health issues; however, it is composed of acrylonitrile, a toxic product that’s use must be carried out under strict emission control conditions. Also, processes such as 3D printing or extrusion could cause ABS dust and fine particles to be dispersed in the air. These are known to cause adverse health effects such as eye, skin, and lung irritants, or asthma. Moreover, ABS undergoes degradation with UV exposure, which could cause some of the chemicals to leach out over time. Currently, numerous companies are still searching ways to develop a successful alternative to petroleum-based ABS.

**Thermoplastics are a type of plastic that soften and melt when heated and flow by applying pressure. Since they harden when cooled, this process can be repeated multiple times.*

Mahmood Mehrabzadeh
PhD in Polymer Engineering,
Specialist in Plastic Recycling

"The main challenge for ABS is sorting and separation from other plastics. For example, in e-plastics, ABS is normally mixed with HIPS, PC-ABS, PC, PP, PE, and separation is a challenge.“

1. https://3dsolved.com/is-abs-recyclable-and-also-biodegradable/
2. https://all3dp.com/5-reasons-why-abs-needs-to-go-away/
3. https://3drific.com/abs-plastic-recycling-everything-you-need-know/
4. http://industryarcblog.com/bio-abs-new-green-polymer-replace-petroleum-derived-abs/
5. https://www.statista.com/statistics/987765/us-plastic-compounding-market-size-by-product/

CASE STUDIES | Key initiatives from top players

LEGO	MATTEL	SIEMENS	MITSUBISHI ELECTRIC Changes for the Better
Replacement of ABS bricks	Recycled, recyclable, or bio-based plastic materials in products and packaging	Green polymer made of CO_2 from exhaust gases	Plastic material recycling

LEGO – Replacement of ABS bricks

Key initiatives

Lego uses 20 different kinds of plastic to make its products, and as many as 80% of Lego pieces consist of ABS. In 2015, the company invested $155 million into a Sustainable Materials Center on the commitment of using fully sustainable materials in its products by 2030. In 2018, the company began producing elements from sugarcane-based **bio-polyethylene (bio-PE)**, rather than oil-based plastic. Lego unveiled a prototype brick made from **recycled PET plastic** in 2021.

Image source: Lego

Pathways:

- Recycling (downcycling/upcycling)
- Material replacement and reduction of complexity
- Bio-based plastics and/or additives

1. https://www.wired.com/story/lego-sustainable-bricks/
2. https://www.lego.com/en-us/aboutus/news/2021/june/prototype-lego-brick-recycled-plastic
3. https://www.prescouter.com/2018/04/shift-toward-bioplastics-insights-from-lego-and-current-opportunities/

ADDITIONAL INSIGHT:

“PVC is frequently utilized in combination with ABS to form toy action figures. For non-collectible items in which quality and aesthetic preservation are less important, recycled plastics or biodegradable/compostable alternatives that are amenable to the same manufacturing processes should be leveraged.”

- Daniel Morales, Technical Director at PreScouter

Mattel – Recycled, recyclable, or bio-based plastic materials in products and packaging

Key initiatives

In 2019, Mattel announced that it was going to replace the petroleum-based plastic in its products and packaging by using **recycled or bio-based plastic materials** by 2030. In some cases, the company uses virgin plastic but ensures that this material will be recyclable. Mattel launched a sugarcane-based plastic building block set in 2020.

Moreover, the company also adopted the **How2Recycle label**, a standardized labeling system that communicates recycling instructions to customers.

Pathways:

- **Recycling (downcycling/upcycling)**
- **Material replacement and reduction of complexity**
- **Bio-based plastics and/or additives**

Image Source: FastCompany [Photo: courtesy of Mattel]

1. https://www.fastcompany.com/90445332/mattel-vows-to-shift-to-sustainable-plastic-by-2030
2. https://corporate.mattel.com/news/mattel-announces-goal-to-achieve-100-recycled-recyclable-or-bio-based-plastic-materials-in-all-products-and-packaging-by-2030
3. https://corporate.mattel.com/news/mattel-advances-product-sustainability-commitment-launches-latest-sugarcane-based-products-in-the-u-s-in-time-for-earth-day

Siemens – Green polymer made of CO_2 from exhaust gases

Key initiatives

In 2012, researchers at Siemens developed an alternative material to polystyrene-based ABS plastic that is a mixture of **polyhydroxybutyrate (PHB) bioplastic (from palm oil and starch), and carbon dioxide-based polypropylene carbonate (PPC)**. Researchers used the new material to create a vacuum cleaner cover. The project's partners included BASF, Munich Technical University, and the University of Hamburg.

Pathways:

Bio-based plastics and/or additives

Image. This vacuum cleaner cover is made from two bioplastics - one of which is derived from CO_2. **Source:** Engineerlive

1. http://w1.siemens.com.cn/news_en/frontier_technology_en/2292.aspx

Mitsubishi Electric Corporation – Plastic material recycling

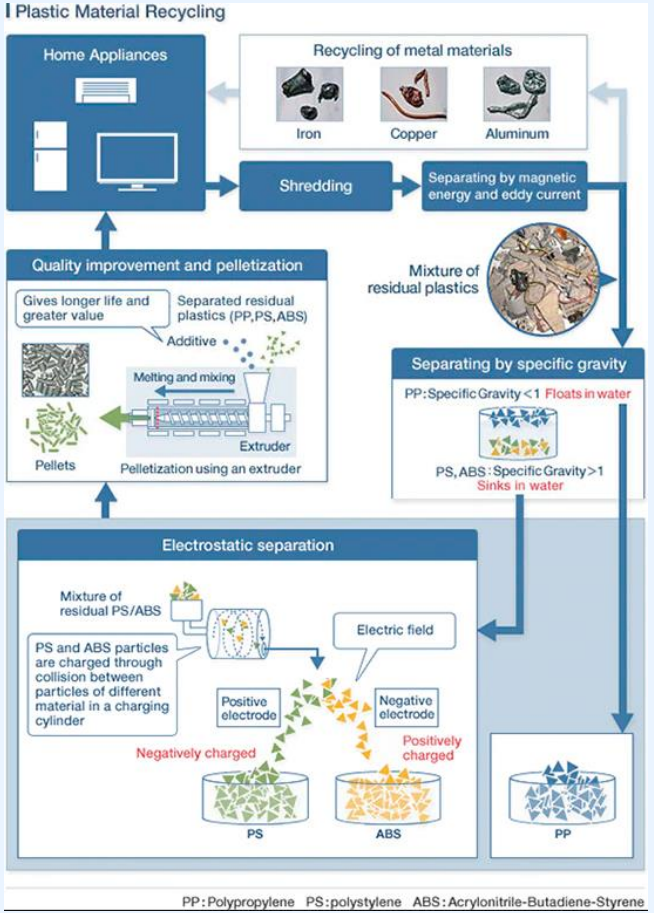
Key initiatives

Mitsubishi Electric has developed **closed-loop recycling technologies** for home appliances plastics. The company is reusing recycled plastics as raw material in consumer durable goods such as refrigerators and dishwashing machines. Through this recycling system, PP, PS, and ABS can be separated into high purity (approx. 99% purity) and recovered in large quantities. The technologies reach recycling rates as much as 70% of all plastics that are recovered from used home appliances.

Mitsubishi Electric has developed technologies for separating and recycling plastic materials from used home appliances to make new products. Plastic materials salvaged from dismantled home appliances are a mixture of various types of plastics. Because they are a mixture, they have little material value and used to be burned or disposed as landfill. Therefore, the company has developed a unique method for automatically separating mixed plastics using specific gravity and static electricity. Using this method, the three major types of plastics that are found in home appliances — polypropylene, polystyrene, and acrylonitrile-butadiene-styrene — can be separated to high purity and recovered in large quantities. Mitsubishi Electric has also developed technology for quality improvement (modification), which gives recycled materials longer life and greater value. These technologies make it possible to recycle as much as 70% of all plastics that are recovered from used home appliances.

Pathways:

Recycling (downcycling/upcycling)



1. https://www.mitsubishielectric.com/en/about/rd/research/highlights/appliances/plastic_recycle.html#:~:text=Using%20this%20method%2C%20the%20three,and%20recovered%20in%20large%20quantities.

SUSTAINABLE ABS TECHNOLOGIES | Examples from industry players

INEOS Styrolution

Prisma

Keene Village Plastics (KVP)

Well Lim Industrial Co. Ltd.

Change Plastic for Good Ltd.

Summary of sustainable ABS technologies profiled

COMPANY	HQ	TECHNOLOGY NAME	MARKET FOCUS	TYPE OF MATERIAL	PATHWAYS
INEOS STYROLUTION	Germany	LIFE ABSolutely Circular project	Automotive, healthcare, electronics, household, and toys/sports/ leisure	ABS with recycled styrene	Recycling (downcycling/ upcycling)
PRISMA RENEWABLE COMPOSITES	USA	BioLAN™	Plastics, elastomers, and carbon fibers for different applications	An ABS plastic replacement material based on lignin	Bio-based plastics and/or additives
KVP KeeneVillagePlastics	USA	N-Vire™ ABS	3D printing materials	Bio additive with ABS	Biodegradable plastics
OSEP101	Taiwan	OSEP101	Disposable plastic products, engineering plastic material products, etc.	Biodegradable additive	Biodegradable plastics
Change plastic for good	Canada	BDP®	A variety of plastics	Biodegradable additive	Biodegradable plastics

INEOS Styrolution – LIFE ABSolutely circular project

Overview

The project "ABSolutely Circular" is addressing ABS production from chemically recycled plastic waste (ABrS). In 2021, INEOS Styrolution announced plans to build a demonstration plant in Belgium and also announced that the first 10 kg of ABrS were produced at the company's laboratory. The material was subsequently processed at INEOS Styrolution's R&D partner Neue Materialien Bayreuth.

INEOS Styrolution claims that the production of ABrS offers up to 30% lower greenhouse gas footprint compared to production of common ABS.

Pathways:

Recycling (downcycling/upcycling)

Main market focus

Automotive, healthcare, electronics, household, and toys/sports/ leisure

Type of Material

ABS with recycled styrene

Partners

Indaver and Neue Materialien Bayreuth GmbH

Founded

2011

Website: https://www.ineos-styrolution.com
Contact: ralf.leinemann@ineos.com

HQ: Germany
Company size: 1,001-5,000 employees

LIFE ABSolutely circular project

ADDITIONAL INFORMATION

The project, which is planned for a duration of four years, is funded by the EU LIFE programme (a European Union funding instrument). It intended to demonstrate scaling of the solution from lab scale to demo plant and ultimately to commercialization.

1. *https://absolutely-circular.com/*
2. *https://absolutely-circular.com/wp-content/uploads/2021/06/20210616-ABSolutely-Circular-first-10kg-ABrS-PR.pdf*
3. *https://absolutely-circular.com/wp-content/uploads/2021/10/20211005-ABSolutely-Circular-Project-Recognition.pdf*
4. *https://www.ineos-styrolution.com/news/EU-LIFE-project-ABSolutely-Circular-Indaver-and-INEOS-Styrolution-announce-production-of-first-ABS-with-recycled-styrene*
5. *https://www.ineos-styrolution.com/news/INEOS-Styrolution-plans-to-build-a-demonstration-polymerisation-plant-for-production-of-ABS-plastic-from-recycled-feedstock*
6. *https://www.youtube.com/watch?v=maHeEzW8BtE*
7. *https://www.linkedin.com/company/styrolution/about/*
8. *https://www.crunchbase.com/organization/ineos-styrolution*

Prisma – BioLAN™

Overview

The company has developed and licensed a bio-based replacement for ABS under the trademark BioLAN. Prisma's BioLAN is produced using lignin, a byproduct of the pulp and paper making process. The company claims that BioLAN improves key properties of traditional ABS plastic, such as cost, higher UV resistance, and higher tensile strength, while reducing total greenhouse gas emissions.

The company claims that it can produce BioLAN based on a wide range of commercial ABS grades to match the performance requirements of the end-use customer.

Pathways:

Bio-based plastics and/or additives

Main market focus

Plastics, elastomers, and carbon fibers for different applications

Type of Material

An ABS plastic replacement material based on lignin

Partners

Yanfeng Automotive Interiors (YFAI)

Founded

2015

Website: https://prismacomposites.com/
Contact: info@prismacomposites.com

HQ: United States
Company size: 2-10 employees

BioLAN™

ADDITIONAL INFORMATION

In 2019, Yanfeng Automotive Interiors (YFAI) obtained the exclusive use of the lignin-based material developed by Prisma Renewable Composites for automotive interiors.

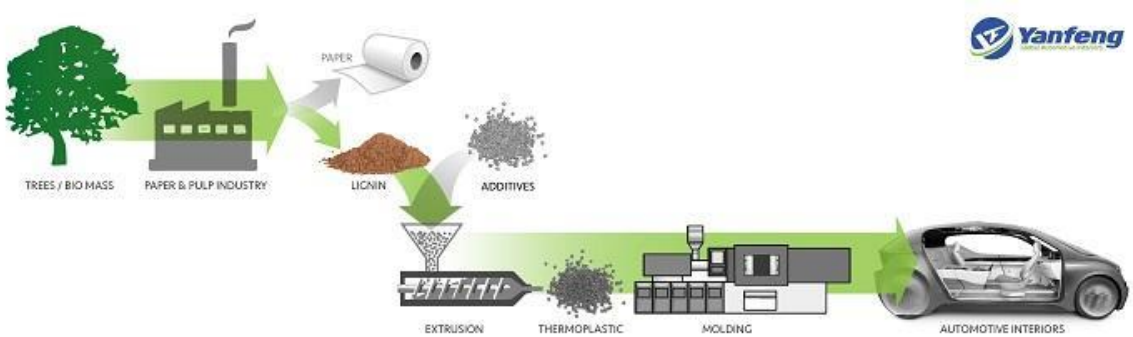


Figure. Prisma's lignin technology in automotive applications. Source: Bioplastics News.

1. *https://prismacomposites.com/why-it-matters/*
2. *https://www.yfai.com/en/yanfeng-automotive-interiors-and-prisma-renewable-composites-collaborate-bring-plant-based-lignin-0*
3. *https://prismacomposites.com/our-technology/#material*
4. *https://pitchbook.com/profiles/company/230586-31*
5. *https://www.linkedin.com/company/prisma-renewable-composites/about/*

Keene Village Plastics (KVP) – N-Vire™ ABS

Overview

KVP offers a proprietary bio additive with ABS filament for the 3D printing industry. It is specially formulated to promote bacterial consumption in commercial composting or active landfill facilities meeting the ASTM D5338 Standard for Biodegradability.

Pathways:

Biodegradable plastics

Figure. N-Vire™ ABS.

Main market focus
3D printing materials

Type of Material
Bio additive with ABS

Partners
n/a

Founded
2004

Website: www.villageplastics.com
Contact: Support@villageplastics.com

HQ: United States
Company size: 2-10 employees

1. https://www.linkedin.com/company/keene-village-plastics/about/
2. https://www.villageplastics.com/product/n-vire-abs/

Well Lim Industrial Co. Ltd – OSEP101

Overview

OSEP101 is a biodegradable additive made of oyster shell (chitin) and calcium carbonate ($CaCO_3$) powder. It is designed to be mixed with plastics to make them biodegradable. It can be used in plastics for containers, shopping handbags, bags, and mulch film, among others. The additive can be utilized in various plastic production lines such as injection, extruding, blowing, and even coating.

The company claims that the additive complies with FDA and 21 CFR 177.1520 standards for food contact applications.

Pathways:

Biodegradable plastics

Main market focus

Disposable plastic products, engineering plastic material products, etc.

Type of Material

Biodegradable additive

Partners

n/a

Founded

2009

Website: https://osep101.com/
Contact: Contact Form

HQ: Taiwan
Company size: 2-10 employees

1. https://osep101.com/
2. https://www.globalsources.com/si/AS/Well-Lim/6008835517759/pdtl/Eco-friendly-Biodegradable-Granules/1098102373.htm

Change plastic for good Ltd – BDP®

Overview

BDP is a patented additive that accelerates the biodegradation of plastics in environments such as landfills, oceans, soil, and anaerobic compost. The additive uses organic (carbon-based) ingredients to enable polymers to biodegrade like organic matter. BDP can be used with any petroleum-based plastic types including but not limited to polyolefins, nylons, polycarbonates, and PVC. It has been tested via the ASTM D5511 Standard (anaerobic biodegradation proven).

Moreover, the company claims BDP neither causes microplastics nor affects the recyclability of treated products.

Pathways:

Biodegradable plastics

Main market focus
A variety of plastics

Type of Material
Biodegradable additive

Partners
n/a

Founded
2016

Website: www.changeplasticforgood.com
Contact: Contact form

HQ: Canada
Company size: 11-50 employees

1. https://www.changeplasticforgood.com/faq/
2. https://www.linkedin.com/company/breakdown-plastic/

Polyvinyl chloride (PVC)

PVC is one of the oldest and most ubiquitous plastics in the world. In the United States alone, it is forecasted that PVC will have a market revenue of almost $1,185.9 million in 2023.

PVC uses ethylene as well as industrial-grade salt to produce the vinyl chloride monomer (VCM) that is the main component. In addition, a variety of additives, including plasticizers, are added for specific performance properties.

What is polyvinyl chloride (PVC) used in?

PVC is extensively used in:

- Infrastructure materials like water pipes, fittings, cables, sheets, fastening elements, flooring, wallpaper, coatings, and window frames used in buildings and automobiles.
- Durable consumer products such as toys, credit cards, and vinyl curtains, among others.
- Medical supplies and settings, including blood bags, catheters, mattresses, examining tables, wall coverings, and gloves, among others.

What are the challenges associated with PVC?

The biggest concern about PVC is that the chemicals used to make it, from chlorine to mercury and from phthalates to vinyl chloride monomers, are known to cause cancers, neurological disorders, reproductive and developmental problems, and other deleterious health effects (some health effects are well established while others are debatable).

Of all industrial uses, currently, PVC manufacturing is the most significant chlorine consumer, with about 30% of elemental chlorine used in PVC. Also, a fundamental green chemistry principle is to design safer chemicals. So, it is pointed out that “a truly revolutionary PVC alternative would contain no dioxin-producing compounds, and research on how to replace those is still in the early stages.”

PVC recycling is challenging due to various additives, pigments, and low economic value for the outcomes. Thus, incineration is the common way to treat used PVC (a significant source of dioxin emissions).

Mahmood Mehrabzadeh
PhD in Polymer Engineering,
Specialist in Plastic Recycling

"The current equipment in recycling plants is not suitable for recycling this material. Also, during the recycling process, PVC could corrode and may produce HCl that is harmful to health and could damage the equipment if it is not correctly chrome coated.“

1. https://www.buildinggreen.com/blog/biobased-pvc-take-vinyl-industry-claims-grain-salt
2. https://www.statista.com/statistics/987765/us-plastic-compounding-market-size-by-product/
3. http://www.hyle.org/journal/issues/23-1/iles2.htm
4. https://www.mdpi.com/2075-5309/8/2/28/htm
5. https://vinyl.org.au/pvc-dioxins
6. https://advancedplastiform.com/using-pvc-in-medical-supplies-and-applications/

CASE STUDIES | Key initiatives from top players

crocs™

Lowering the carbon footprint of footwear

THALES

Recycled, recyclable, or bio-based plastic materials in products and packaging

vinyl plus

COMMITTED TO SUSTAINABLE DEVELOPMENT

Voluntary commitment to sustainable development

Crocs – Lowering the carbon footprint of footwear

Key initiatives

Crocs announced a partnership with Dow to manufacture footwear using bio-based materials. The goal is to reduce Crocs' carbon footprint by 50% by 2030. Crocs will incorporate the new bio-based croslite using Dow's ECOLIBRIUM technology to new and existing product lines. Dow's ECOLIBRIUM is a bio-based (plant-based) plasticizer alternative to petroleum-based materials. It is also marketed as PVC compounds for wire applications.

Pathways:

Bio-based plastics and/or additives

Image source: Crocs

1. https://newsdirect.com/news/dow-and-crocs-announce-a-new-collaboration-to-help-lower-the-carbon-footprint-of-crocs-iconic-footwear-694931069
2. https://parroquiadepiera.com/dow-ecolibrium-28/
3. https://www.aiche.org/product/dow-ecolibrium-bio-based-plasticizers

Thales – Recycled, recyclable, or bio-based plastic materials in products and packaging

Key initiatives

Thales aims to reduce the PVC used for bank card manufacturing by substituting it with polylactic acid. PLA is a plastic substitute produced from non-food corn. Using the plant-based material could reduce 80% of the PVC used in the card.

The company also offers other alternatives for PVC bank cards, such as cards containing a portion of post-consumer recycled plastics.

Image source: Thales Group

Pathways:

- Recycling (downcycling/upcycling)
- Bio-based plastics and/or additives

1. https://www.thalesgroup.com/en/markets/digital-identity-and-security/banking-payment/cards/alternative-to-pvc
2. https://www.thalesgroup.com/en/markets/digital-identity-and-security/banking-payment/cards/eco-friendly-credit-card

VinylPlus® – Voluntary commitment to sustainable development

Key initiatives

VinylPlus is a voluntary sustainable development program of the European PVC industry. Companies look for continuous development of collection and recycling schemes for PVC waste in Europe. Also, VinylPlus promotes products made from recycled materials. The company claims that PVC waste recycling within the VinylPlus framework reached a volume of 731,461 tonnes in 2020. Another area of interest is the progressive replacement of problematic additives.

VinylPlus' partners include Dow, Lubrizol, Forbo, and Profine, among others.

Pathways:

- **Recycling (downcycling/upcycling)**
- **Material replacement and reduction of complexity**

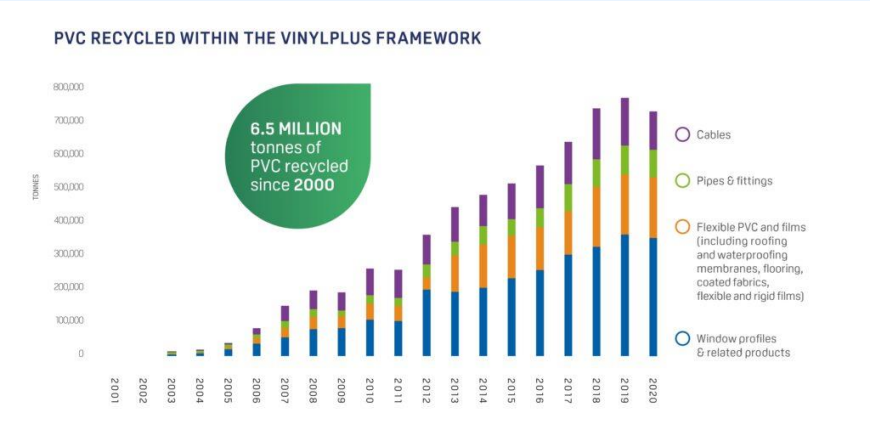


Figure. PVC recycled within the VinylPlus Framework. Source: VinylPlus.

1. https://www.vinylplus.eu/our-achievements/our-progress/
2. https://www.linkedin.com/company/vinylplus/?originalSubdomain=be
3. https://www.vinylplus.eu/news/vinylplus-marking-20-years-of-progress-towards-circularvinyl/
4. https://vinylplus.eu/wp-content/uploads/2021/06/VinylPlus-Progress-Report-2021_WEB_sp-1.pdf

SUSTAINABLE PVC TECHNOLOGIES | Examples from industry players

Rivertex Technical Fabrics Group

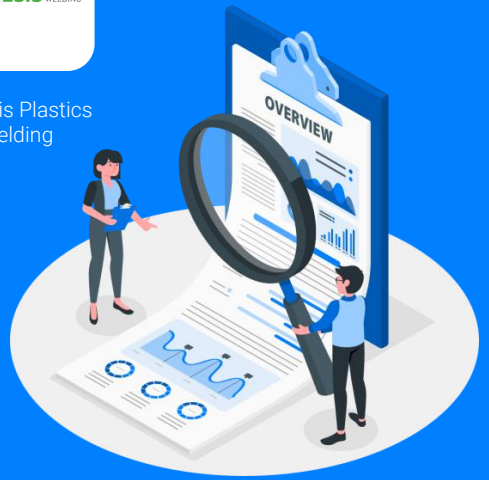
HALLSTAR

BASF

BIO-TEC

Dow

Genesis Plastics Welding



Summary of PVC technologies profiled

COMPANY	HQ	TECHNOLOGY NAME	MARKET FOCUS	TYPE OF MATERIAL	PATHWAYS
RIVERTEX	Netherlands	Rivercyclon	Textiles, fabrics, and films	Recyclable alternative to PVC coated fabrics	Recycling (downcycling/ upcycling); Material replacement and reduction of complexity
HALLSTAR	USA	HallGreen®	Plastics	Renewable esters for PVC, PLA, PHA, PSM, and other bio-polymers	Recycling (downcycling/ upcycling); Bio-based plastics and/or additives
BASF We create chemistry	Germany	Hexamoll® DINCH	Medical Devices, Toys & Children's Articles, Food Contact Materials, Leisure and Sports Products, Flooring, etc.	Non-phthalate plasticizer	Material replacement and reduction of complexity
BIO-TEC	USA	EcoPure®	Different plastic applications (single-use plastics, durable goods, disposable goods, etc.)	Drop-in additive for biodegradable PVC	Biodegradable plastics
DOW	USA	ECOLIBRIUM	Footwear and Construction	Bio-based phthalate-free plasticizers	Material replacement and reduction of complexity; Bio-based plastics and/or additives
GENESIS PLASTICS WELDING	USA	ecoGenesis™	Medical, Automotive, Consumer Products, Military, and Packaging	Plastics welding technology to replace PVC	Material replacement and reduction of complexity; Bio-based plastics and/or additives

Rivertex Technical Fabrics Group – Rivercyclon

Overview

Rivercyclon is described as a non-toxic, heat-sealable, and cost-effective alternative to PVC-coated fabrics. The product is fully recyclable. It is made from a single polymer derived from recycled plastic and contains no plasticizers or other toxins.

The company points out that Rivercyclon is up to 40% lighter than PVC-coated alternatives. It is claimed to have high impact strength, good abrasion resistance, and high UV resistance. Rivercyclon is available in different widths and colors.

Pathways:

- Recycling (downcycling/upcycling)
- Material replacement and reduction of complexity

Main market focus

Textiles, fabrics, and films

Type of Material

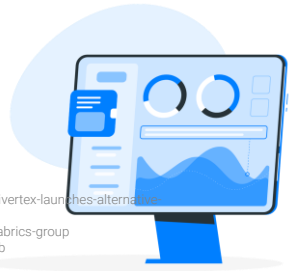
Recyclable alternative to PVC coated fabrics

Partners

n/a

Founded

1986



Website: www.rivertex.com
Contact: Contact Form

HQ: Netherlands
Company size: 11–50 employees

1. https://www.technicaltextile.net/news/netherlands-rivertex-launches-alternative-to-pvc-coated-fabrics-279272.html
2. https://nl.linkedin.com/company/rivertex-technical-fabrics-group
3. https://www.rivertex.com/en/our-brands/rivercyclonb

HALLSTAR – HallGreen®

Overview

Hallstar is a polymer additive manufacturer with over 50 years of experience. The company focuses on the design and synthesis of polymer modifiers and collaborates with other companies to innovate in a variety of applications. Hallstar's latest product lines are "environmentally responsible renewable esters" under the Hallgreen label. The Hallgreen collection are esters derived from renewable raw materials that can function as process aids, polymers, and impact modifiers and are deemed "completely biodegradable" under the ASTM D6400 standard and ISO 17088.

Pathways:

- Recycling (downcycling/upcycling)
- Bio-based plastics and/or additives

Main market focus

Plastics

Type of Material

Renewable esters for PVC, PLA, PHA, PSM, and other bio-polymers

Partners

n/a

Founded

1986

Website: www.hallstarindustrial.com
Contact: IndustrialCS@hallstar.com

HQ: United States
Company size: 51-200 employees

1. https://www.hallstarindustrial.com/brand/hallgreen/
2. https://www.linkedin.com/company/the-hallstar-company/about/

BASF – Hexamoll® DINCH

Overview

Hexamoll DINCH is a non-phthalate plasticizer for PVC developed for applications with close human contact. The plasticizer can be used for special applications such as food contact materials, medical devices, and toys. For example, A. Kolckmann GmbH has used Hexamoll DINCH in their PVC yoga mats of the AKO Yoga line.

BASF claims that the plasticizer does not show any adverse effects such as environmental hazards, accumulation within the body, or carcinogenicity.

Pathways:

Material replacement and reduction of complexity

Main market focus

Medical Devices, Toys & Children's Articles, Food Contact Materials, Leisure and Sports Products, Flooring, etc.

Type of Material

Non-phthalate plasticizer

Partners

A. Kolckmann GmbH

Founded

1865

Website: hexamoll.basf.com
Contact: hexamolldinch@basf.com

HQ: Germany
Company size: 10,001+ employees

1. https://hexamoll.basf.com/portal/basf/en/dt.jsp?setCursor=1_1223483
2. https://www.hexamoll.com/portal/basf/de/dt.jsp?seite=hexamoll-dinch
3. https://www.hexamoll.com/portal/basf/en/dt.jsp?setCursor=1_1225099
4. https://www.linkedin.com/company/basf/

BIO-TEC – EcoPure®

Overview

EcoPure is an organic plastic additive. With the addition of EcoPure, PVC products can be manufactured to biodegrade in landfills. EcoPure additives are tested using the ASTM D5511 test method.

The additive can be used in a variety of plastic applications, from disposable single-use products to custom-engineered durable goods, including EVA, HDPE, PET, LDPE, PP, PVC, nylon, and polycarbonate. The company claims that the additive does not affect the chemical durability or flexibility inherent in PVC plastic during its useful life.

Pathways:

Biodegradable plastics

Main market focus

Different plastic applications (single-use plastics, durable goods, disposable goods, etc.)

Type of Material

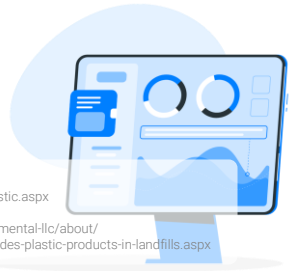
Drop-in additive for biodegradable PVC

Partners

n/a

Founded

2005



Website: www.goecopure.com
Contact: sales@goecopure.com

HQ: United States
Company size: 11-50 employees

1. https://www.goecopure.com/biodegradable-pvc-plastic.aspx
2. https://www.goecopure.com/what-is-ecopure.aspx
3. https://www.linkedin.com/company/bio-tec-environmental-llc/about/
4. https://www.goecopure.com/how-ecopure-biodegrades-plastic-products-in-landfills.aspx

DOW – ECOLIBRIUM

Overview

DOW ECOLIBRIUM bio-based plasticizers, made of 100% renewable feedstocks, are designed to be incorporated into PVC compounds used to make wire insulation and jacketing.

It is claimed that ECOLIBRIUM can reduce greenhouse gas emissions by 40% when used as a replacement for traditional PVC plasticizers. Moreover, they are safe for wiring in buildings and for data communication.

Pathways:

- Material replacement and reduction of complexity
- Bio-based plastics and/or additives

Main market focus
Footwear and Construction

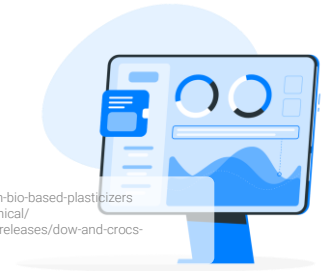
Type of Material
Bio-based phthalate-free plasticizers

Partners
Crocs

Founded
1897

Website: www.dow.com
Contact: Contact Form

HQ: United States
Company size: 10,001+ employees



1. https://www.aiche.org/product/dow-ecolibrium-bio-based-plasticizers
2. https://www.linkedin.com/company/dow-chemical/
3. https://corporate.dow.com/en-us/news/press-releases/dow-and-crocs-announce-new-collaboration.html

Genesis Plastics Welding – ecoGenesis™

Overview

ecoGenesis is a proprietary radio frequency (RF) welding technology that enables the joining of polymeric materials without the addition of plasticizers or toxic additives. ecoGenesis provides numerous options for PVC and PU replacement with phthalate-free materials such as polyethylene and polypropylene.

ecoGenesis is a "bolt-on" modification adaptable to existing stabilized RF machines. The technology is available through contracted manufacturing with Genesis or through private licensing.

Pathways:

- Material replacement and reduction of complexity
- Bio-based plastics and/or additives

Main market focus

Medical, Automotive, Consumer Products, Military, and Packaging

Type of Material

Plastics welding technology to replace PVC

Partners

n/a

Founded

1987

Website: genesisplasticswelding.com
Contact: sales@genesisplasticswelding.com

HQ: United States
Company size: 51-200 employees

1. https://www.linkedin.com/company/genesis-plastics-welding
2. https://genesisplasticswelding.com/wp-content/uploads/2019/05/GPW_WhitePaper_EcoGenesis_v4.pdf
3. https://genesisplasticswelding.com/capabilities/pvc-replacement/
4. https://plasticsdecorating.com/articles/2011/technology-offers-options-for-rf-welding-of-green-materials/

Subject Matter Expert Focus

What do you see as the greatest challenge that the consumer goods sector faces for lessening the environmental impact of the petrochemical plastics currently used in both goods and packaging?

Answer

The greatest challenges for the petrochemical plastics currently used in consumer goods and packaging are as follows:

- Educating people to collect and separate plastics from other waste sources at home for municipal collection
- Simplifying plastic products to facilitate recycling at the end of their lifetime, and companies reusing some percentage of their recycled plastics
- Improving collection procedures
- Improving and developing technologies for plastic sorting and recycling (mechanical and chemical)

Additional Insights from Dr. Mahmood Mehrabzadeh

- Companies that start to produce any plastic product must think about recycling their products after the end of their product life. The company must take back a minimum percentage of its recycled plastics and reuse them.
- Currently, biodegradable and bio-based plastics cannot compete with petrochemical-based polymers in terms of pricing. Moreover, the source for such plastics is also limited.

Key Takeaways

1. Plastic waste is dominated by single-use plastics and packaging applications, which are primarily comprised of PE, PET, and PP. Many recycling technologies and less environmentally detrimental alternatives exist to address this material set.

2. The consumer goods industry is a major contributor to plastic waste from both packaging and the product itself, and hence, it is positioned to greatly influence our shift to a more sustainable future.

3. Companies are already working on the challenge of rendering the common plastics used in their products (such as ABS and PVC) more sustainable through innovative recycling strategies, additives to encourage benign degradation, and identifying biobased/biodegradable material alternatives.

Mahmood Mehrabzadeh
PhD in Polymer Engineering,
Specialist in Plastic Recycling

"The immediate business opportunity toward shifting to sustainable alternatives is not here. However, companies should develop best practices now as new legislation is enacted and novel recycling technologies and new renewable resources are developed."

About the Authors

Daniel Morales

Technical Director

Daniel is an alumnus of the PreScouter's advanced degree researchers network and has worked with PreScouter for more than three years and on over 70 projects, spanning across areas such as innovation strategy and roadmapping, product and process improvement and development, sustainability, and technology trends throughout the CPG industry.

Daniel earned his PhD in Chemical Engineering from the NC State University, where his research focused on developing stimuli-responsive polymer networks for microrobotics applications. After his graduate studies, he completed postdoctoral work at INSA Toulouse, France where his work focused on the intersection of nanoparticle assembly, nanofabrication and microfluidics to develop novel sensors. Before joining PreScouter, Daniel gained industrial experience in pharma manufacturing, polymer processing and science manuscript editing, and he is based in Raleigh, North Carolina.

Yutzil Castan

Project Architect

Yutzil is an environmental consultant and a PreScouter researcher. She has a background in Biology with a Master's degree in Sustainability Science from the National Autonomous University of Mexico (UNAM).

Yutzil has participated in natural resources, ecology, management, and sustainability projects for different academic, research, and governmental institutions. At Prescouter, she has been supporting clients in the natural resources, sustainable packaging, and chemicals areas.

Subject Matter Expert

Mahmood Mehrabzadeh

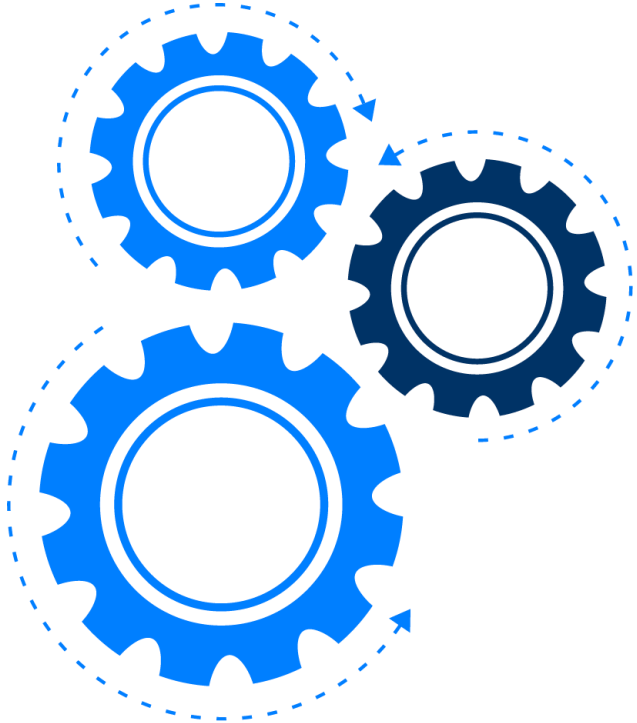
PhD in Polymer Engineering, Specialist in Plastic Recycling

A Polymer Engineer (PhD) and a Chemist with extensive experience in polymer science & technology, research, development, quality control, process optimization and manufacturing of polymer products.

In depth experience in Plastics Recycling (PP, PE and Electrical & Electronic Wastes), Development New Formulation, Polymer Compounding, Polymer Processing, Composites & Nanocomposites, Polymer Foaming and Polymer Characterization.

Hands on experience in the use of various methods and instruments such as: Extrusion, Injection molding, Mechanical Testing, DSC, DMTA, TGA, GC, GPC, FTIR, SEM, TEM and X-rays.

Experience in Project Management, Supervision, Teaching and Technical Training.



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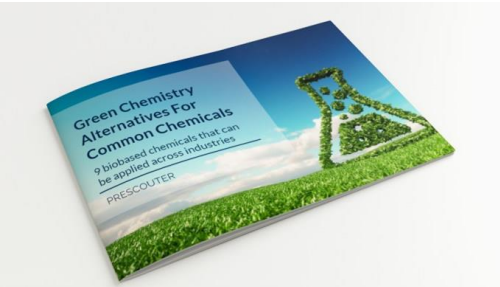

Green Chemistry Alternatives for Common Chemicals

Recycling of Thermoset Materials

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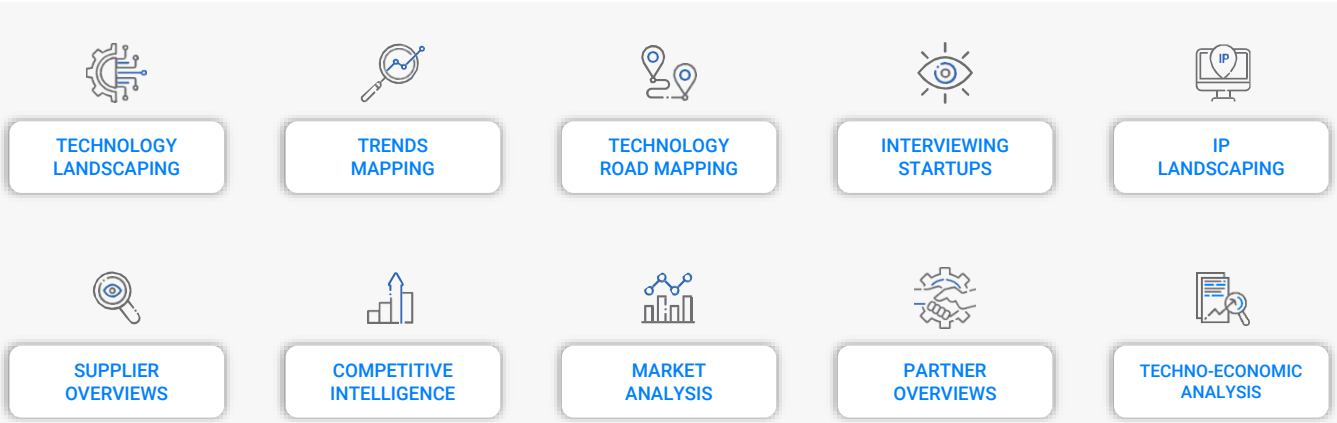
Potential Next Steps

- PreScouter can identify replaceable synthetic polymers in your manufacturing practices or product line and vet sustainable alternatives
- PreScouter can conduct anonymous interviews with vendors, experts and research groups that align with your business strategy
- PreScouter can organize direct consultations with Subject Matter Experts (SMEs) to validate the scalability, efficacy and legality of your upcoming sustainable product lines



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