ROYAL SOCIETY OF CHEMISTRY

Towards more sustainable plastics

Plastics are light, versatile, durable, cheap, and have low toxicity levels, and as such they deliver many benefits for society.

Since their introduction they have radically improved medical technology and food handling, as well as reducing carbon emissions for goods transportation. But their usefulness has led to an explosion in the amount of plastics that we use, and often carelessly discard.

Plastics impact the environment through the mountains of waste which persist for many decades, the microplastics and nanoplastics formed as part of their degradation, and because of the non-renewable resources used as ingredients for their production.

Developments in chemistry, and collaborations across disciplines and sectors are and will be key to understanding and mitigating the impact of plastics in the environment, and making positive changes.

We don't have the best track record on living with plastics, and especially disposing of plastics, but they have improved lives, and are a valuable resource.

Of the **8.3 billion** tons of plastic made since its invention in the 1950s, it is estimated that…

An increasing amount of plastic collected in the UK is being disposed of by energy recovery through incineration. For generic post-consumer plastic waste, this is now the most common treatment at **45.7% (nearly 2 million tonnes)** in 2018.[2]

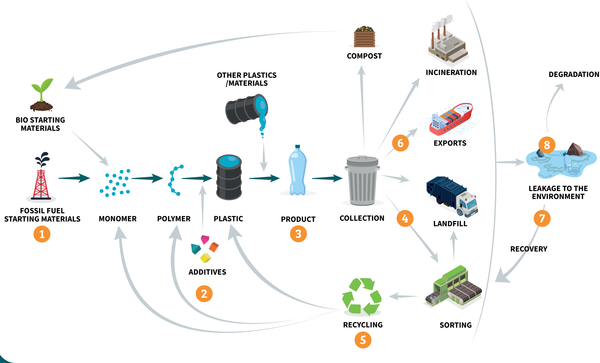
Analysis from the BBC suggests that in the 12 months to October 2018, the UK exported **611,000 tonnes** of recovered plastic packaging, primarily to Malaysia to be recycled.[3]

Plastics are important for a wide variety of applications: keeping food fresh and safe, building materials, and healthcare products.

They are used in electric vehicles, solar cells and wind turbine blades, and plastic based insulation can make your home more energy efficient. Many essential healthcare products, including those used in the fight against COVID-19, are made of plastic, from Personal Protective Equipment (PPE) to medicine packets.

Recent developments in plastic composites mean that plastic can form **50%** of the primary structure of aeroplanes **making them lighter**, resulting in significant greenhouse gas emissions savings.[4]

The existing plastics lifecycle, from starting materials to waste, is complex. There are many areas for improvement, and chemical scientists are looking for solutions across the lifecycle.



What are the key problems that chemical scientists are addressing?

(see # in diagram)

We will be covering many of these challenges and solutions in this series of explainers.

	CHALLENGE	HOW CHEMICAL SCIENTISTS ARE TACKLING THIS
1	Pollutants and energy usage from fossil resources used as starting materials	• Exploring alternative materials to plastic on the basis of overall environmental impact over their lifetime • Designing plastics derived from sustainable starting materials
2	Additives presenting challenges for recycling / when released in the environment	• Identifying the environmental impacts of additives, for instance when plastic degrades in the environment • Designing more sustainable and less harmful additives • Designing systems to remove additives prior to recycling
3	Moving away from single-use as default	• Changing plastic design for different consumer behaviours eg reusable plastic cups/bottles • Designing compostable plastics for specific applications (eg agriculture)
4	Mixed plastics, or contaminated streams	• More effective waste sorting methods using chemistry techniques • Informing better labelling for citizens and waste management workers
5	Recycling opportunities	• Innovative recycling methods eg chemical recycling, or using enzymes • Designing plastics for easier recycling eg using fewer different plastics in a single product
6	Current exports of waste	• Focus on moving towards a circular economy in the UK • Better options for reuse and repair of products eg plastic in mobile phones
7	Plastic leakage to the environment	• New, innovative environmentally biodegradable materials, which are proven to be safe and sustainable
8	Plastics already leaked to the environment	• Detection and measurement of existing pollution, including microplastics and nanoplastics, and monitoring health impacts • Potential innovative options for collecting and processing plastic pollution

Bio derived plastics

Bio derived plastics – those which are made from plant based starting materials rather than fossil fuels - currently make up 1% of the market.[3] In order to grow, and break-even with petroleum derived plastics, much more efficient production methods are needed. As always, the full lifetime impact of a material should be considered, including the land and water use of production, and its end of life treatment.

Plastic leakage

is that which has escaped from the existing collection and disposal network eg through littering, deliberate release into the sea, through sewage or other outlets. Some of this plastic pollution is in the form of microplastics, fragments of plastic which have been shown to be widespread, and can be consumed by and accumulate in living organisms.

As you can see, the system is complicated, and this is reflected in citizens' struggle with understanding how to dispose of plastics appropriately.

When thinking about potential solutions to plastic waste, there is a balance to strike between what is technically possible and what is practically applicable in a well-functioning circular economy with minimal leakage.

Decisions for that future should rely on sound science and research that is in constant dialogue with experts on collection and treatment infrastructure, citizen behaviour, policy and legislation, and manufacturing requirements. Industry will also be an important change maker here. Any measures should be designed to truly tackle the problem at the scale required, while avoiding unintended consequences.

[1] https://advances.sciencemag.org/content/3/7/e1700782 [2] Plastics – the Facts 2020, Plastics Europe
[3] https://www.bbc.co.uk/news/science-environment-46566795, https://www.bbc.co.uk/news/science-environment-49827945
[4] https://royalsocietypublishing.org/doi/10.1098/rstb.2008.0304
[5] https://www.european-bioplastics.org/market/