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Making plastics sustainable isn't the whole solution

Chemists are inching closer to more-sustainable plastics. But a step change is needed in industry and governments, too.

Since Bakelite was revealed in 1907 as the first synthetic plastic — it was used as an electrical insulator — this lightweight, strong and mouldable class of materials has helped to make the modern world. Plastics are a staple ingredient in product design and manufacture, and their use, especially as single-use items such as water bottles and food wrappings, is expanding. The total weight of plastics produced per year currently stands at more than 380 million tonnes and is set to top 900 million tonnes by 2050.

But, like the fossil fuels from which they are made, plastics can have negative environmental consequences. By 2050, an estimated 12 billion tonnes of plastic waste will be sitting in landfills or polluting the natural environment. For comparison, this number stood at around 4.9 billion tonnes in 2015. Used plastics also form a large proportion of the fuel fed into energy-generating waste incinerators, which are a source of carbon emissions. Documentary films such as those narrated by David Attenborough have drawn attention to the environmental hazards posed by waste plastics. Footage of discarded water bottles suffocating marine life has also helped to trigger a public outcry and propelled plastics pollution up global agendas.

Although many plastics now carry the recycling symbol, in practice plastics recycling is crude and energy-intensive. Recycled plastics tend to be of lower-quality — they have less strength — than newly manufactured plastics. Increasingly, consumers are being sold products made from biodegradable plastics, derived from plant sources or spiked with oxygen and other chemicals to allow them to be broken down in the environment. However, this is complicating recycling efforts, because biodegradable plastics have a detrimental effect on the quality of recycled plastics, and there is no reliable way for recycling plants to separate these plastics from other forms.

How more-sustainable plastics might be created has become one of the biggest and most urgent questions in chemistry today. Researchers from many branches of the field are now working on ways to reduce plastics waste and to improve the chances that it can be recycled.

One such effort is reported on page 423 of this issue. Stefan Mecking and his colleagues at the University of Konstanz in Germany describe a new type of polyethylene — one of the most common types of single-use plastic — that can be recycled by recovering most of the starting materials[1] — something that is hard to do with existing materials and recycling technologies.

> "Companies need to take more responsibility for the full life cycle of their plastic products."

This new plastic needs to be further tested, and its impacts on existing recycling infrastructure need to be evaluated. It will require a different kind of recycling technology from that available at existing recycling centres. If there's a consensus that it should be used, and if it can be scaled up, it has the potential to accelerate the shift to recycled plastics. It could be a part of the solution to making plastics use less harmful.

But chemistry alone can take us only so far. If the burning of plastics and the accumulation of the materials in oceans and landfill is to be reduced, industry cannot continue to manufacture plastics at the current rate. Companies need to take more responsibility for the full life cycle of their plastic products. And, for this to happen, governments will need to introduce more regulations, and a proposed United Nations plastics treaty needs also to succeed.

One-way system

Plastics are made by combining chains of simple molecular building blocks. It isn't easy to run that process backwards to create materials for reuse — although researchers have made some progress[2]. The main obstacle to improved plastics recycling is how to break the chemical bonds in a systematic and low-energy way to recover valuable materials that can then be used to make equally high-quality plastics.

There are several ways to give plastics an afterlife. These include mechanical recycling — whereby they are chopped up, melted and reused as a lower-quality plastic. Another option is for them to be chemically recycled — by breaking the bonds that hold the long plastics molecules together, creating smaller, useful molecules that can be made into new plastics. The latter approach, possibly the harder of the two, is what Mecking and his colleagues have been working on.

This team is one of several around the world that have been trying to find such a way to recycle polyethylene. Using a renewable source, Mecking and his colleagues made a robust polyethylene-like material that contains chemical groups that can be more easily split than those in conventional plastics, allowing the material to be deconstructed at the recycling stage. The scientists were able to recover almost all of the starting material through the recycling process, and, from it, remake the polyethylene-like material.

This work comes on the heels of that of another team, which reported similar findings in October. Susannah Scott at the University of California, Santa Barbara, and her colleagues used a catalyst to help break polyethylene into smaller molecules that could be used as starting blocks to make different types of polymer[3].

This is clever chemistry and vital research. The approach must now be investigated for different types of plastic and at larger scales. But, as long as plastics use continues to rise, recycling alone will not reduce plastics pollution.

Industry is well aware of this, and is engaging — although not nearly as much as it needs to — with the question of how to reduce its output. One-fifth of companies that make or use plastic packaging have committed to a pledge called

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the New Plastics Economy Global Commitment, created by the Ellen MacArthur Foundation and the UN Environment Programme. Signatories promise to increase plastics recycling as part of a broader commitment to circular-economy principles, which aim to achieve continuous use of resources and eliminate waste. But, according to the latest report, progress is uneven — particularly when it comes to reducing single-use packaging and adopting fully reusable packaging.

Clearly, companies need to be nudged, or pressed harder to act. If they were required to take responsibility for the whole life cycle of their plastic products, they would be less inclined to use materials that are difficult to reuse or recycle. To that end, a proposed global treaty, which is being described as the equivalent of the Paris climate agreement for plastics pollution, needs to succeed. In the past, treaties aiming to tackle climate change and biodiversity loss have been opposed, and even weakened, by some in industry and by governments with interests in fossil fuels. History cannot repeat itself; the planet does not have time.

Chemists gave plastics to the world more than a century ago. But these extraordinarily useful materials are now a serious source of environmental distress. Thankfully, chemists in both academia and industry are determined to find an environmentally benign way of unpicking plastics. Companies and governments must now step up and take responsibility for their part in the accumulation of waste plastics. Action cannot come too soon.

1. Häußler, M., Eck, M., Rothauer, D. & Mecking, S. *Nature* **590**, 423–427 (2021).
2. Tournier, V. *et al. Nature* **580**, 216–219 (2020).
3. Zhang, F. *et al. Science* **370**, 437–441 (2020).

Why universities are key to tackling inequality

Two influential books suggest that universities contribute to societal divisions. In fact, they are essential to bridging divides.

How can universities increase social mobility? What can they do to reduce inequality? Many countries are aiming to boost the proportions of their populations that receive a university education. But with a revolution in online learning under way as a result of the COVID-19 pandemic, some governments, prompted by influential thinkers, will be questioning whether the present model of university education should survive once near-normality returns.

In *The Tyranny of Merit* (2020), philosopher Michael Sandel says that the United States, and the world, has not been served well by the US system, in which graduates from a small number of highly selective universities dominate the top of business and public life. Sandel should know. For four decades, he has taught at Harvard University in Cambridge, Massachusetts, including at the John F. Kennedy School of Government, whose faculty members have served as advisers or run agencies in Democratic governments in recent decades — including the present one.

> “Governments and universities alike must strive to ensure that teaching and research serve all of society.”

Sandel says that, for 40 years, “meritocratic elites” have presided over stagnant wages for most workers, inequalities of income and wealth not seen since the 1920s, wars in the Middle East and the 2008 financial crisis. By contrast, he writes, the people who led the United States from 1940 to 1980 helped to win the Second World War, strengthened the US welfare state and dismantled segregation.

A parallel argument is advanced by David Goodhart at Policy Exchange, a think tank in London that is close to the present Conservative UK government. In *Head Hand Heart* (2020), he says that the “cognitive class” — his name for people who hold many academic qualifications — has reduced the pay and status of other skilled jobs, such as the caring professions, where learning often also takes place outside universities. Both books imply that universities are also worsening societal divisions, in part because students are more likely to vote for left-wing parties, and those schooled outside universities are more likely to lean to the right.

The books are lighter on practical recommendations, although they rightly call for all forms of work to be valued by policymakers. But both authors are influential, too, and there is a risk that some governments might draw on their thinking to reverse the long-term trend towards mass higher education.

It is true that there is a particular problem with the most highly selective institutions, especially privately funded ones. Worldwide, institutions that demand the highest entry qualifications tend to admit few young people from low-income families and under-represented communities. People both inside and outside these institutions are pushing for change, but it isn’t happening nearly as fast as it needs to.

However, it would be turning back the clock if policymakers used Sandel and Goodhart’s arguments to justify cutting university budgets, or preventing an increase in university numbers. Instead, governments and universities alike must strive to ensure that teaching and research serve all of society: people from all backgrounds, from undergraduates to lifelong learners, as well as industry and public and non-profit organizations. Many institutions are already working to meet the needs of more diverse populations.

Inequality must be tackled, and divisions in society must be defused. But both are complex, and cannot be attributed to a single factor. The expansion of higher education is key to bridging a divide that both authors have rightly identified: the gap between the wider population and often privately educated leaders — including policymakers and researchers. It is right that more young people and their parents are seeking an experience that was once the preserve of a small group. Rather than questioning that goal, governments must support universities in achieving it.