Paths to sustainable plastic waste recycling

The outbreak of COVID-19 has driven increased use of medical personal protective equipment, packaged take-out meals, and home-delivered groceries, exacerbating the accumulation of waste plastics (*1*, *2*). The adoption of inappropriate management strategies such as local burning, incineration, and landfilling has also increased, leading to the leakage of waste plastics into the environment and hindering the mitigation of micro- and nanoplastics (*3*). Approximately 6% of the world's annual oil production is devoted to plastics, and 850 million metric tons of greenhouse gases was associated with new plastics production and incineration of waste plastics in 2019, which is equivalent to the annual emissions from 189 500-megawatt coal-fired power plants (*4*, *5*). In the face of these challenges, it is imperative to develop strategies to recycle waste plastics more sustainably.

Some national and regional governments are taking action toward this goal. The European Commission has marked plastic recycling as a key priority for the new Circular Economy Action Plan and is planning to introduce a range of quotas for minimum recycled content in new plastic products (*8*). Some states in the United States have proposed minimum recycled content mandates to end plastic pollution. For example, California has required thermoform plastic containers to contain no less than 20% or 30% (depending on the recycling rate) postconsumer recycled plastic by 2030 (*9*). These efforts will help mitigate plastic pollution.

Coordinated global actions are also needed. In June, a United Nations Environment Assembly working group began planning for the development of an international legally binding instrument, which 175 nations committed to completing by the end of 2024, to shift away from single-use plastics and ensure the achievement of the UN Sustainable Development Goals (*8*). The treaty should include recycling standards of practice and require commitments to implement them.

Joint development efforts should work toward technologies that can recycle waste plastics [e.g., (*9*, *10*)]. Designing catalytic processes to recover plastic monomers or valuable alkane products from waste plastic could potentially close the plastic use loop and bring a new and profitable branch to the plastic recycling industry (*11*, *12*). Collective efforts to recycle plastic waste could substantially contribute to achieving an economy with net-zero greenhouse gas emissions by 2050 and limiting global warming to less than 1.5°C by 2100.

Leilei Dai[1], Roger Ruan[1]*, Siming You[2], Hanwu Lei[3]

[1]University of Minnesota, Saint Paul, MN 55108, USA. [2]University of Glasgow, Glasgow, UK. [3]Washington State University, Richland, WA 99354, USA.
*Corresponding author. Email: ruanx001@umn.edu

REFERENCES AND NOTES

1. J. Prata *et al*., *Environ. Sci. Technol.* **54**, 7760 (2020).
2. S. Bengali, "The COVID-19 pandemic is unleashing a tidal wave of plastic waste," *Los Angeles Times* (2020).
3. M. Shams *et al*., *Environ. Adv.* **5**, 100119 (2021).
4. The Ellen MacArthur Foundation, "The new plastics economy: Rethinking the future of plastics" (2016); https://ellenmacarthurfoundation.org/the-new-plastics-economy-rethinking-the-future-of-plastics.
5. Center for International Environmental Law, "Plastic & climate: The hidden costs of a plastic planet" (2019); www.ciel.org/wp-content/uploads/2019/05/Plastic-and-Climate-FINAL-2019.pdf.
6. European Commission, "A new Circular Economy Action Plan for a cleaner and more competitive Europe" (2020); www.eumonitor.eu/9353000/1/j9vvik7m1c3gyxp/vl6vh7khf4n9.
7. The California Legislative Information, "AB-478 solid waste: Thermoform plastic containers: Postconsumer thermoform recycled plastic: Commingled rates" (2021); https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202120220AB478.
8. The United Nations Environment Assembly, "Ad hoc Open-ended Working Group to Prepare for the Intergovernmental Negotiating Committee to End Plastic Pollution" (2022); https://enb.iisd.org/working-group-intergovernmental-negotiating-committee-end-plastic-pollution-oewg-inc-summary.
9. L. Dai *et al*., *Prog. Energ. Combust. Sci*. **93**, 101021 (2022).
10. H. Li *et al*., "Expanding Plastics Recycling Technologies: Chemical Aspects, Technology Status and Challenges" *ChemRxiv* 10.26434/chemrxiv-2022-9wqz0-v2 (2022).
11. Y. Jing *et al*., *Angew. Chem. Int. Educ.* **60**, 5527 (2021).
12. X. Wu *et al*., *J. Am. Chem. Soc*. **144**, 5323 (2022).

10.1126/science.ade2221