



Terpene Biomass as a Renewable Feedstock for Sustainable Monomer Production

Monika Dabrowska,* Robert Stockman,** Parimala Shivaprasad*

ezzmd9@nottingham.ac.uk

*Department of Engineering, The University of Nottingham, University Park, Nottingham, NG7 2RD

**School of Chemistry, The University of Nottingham, University Park, Nottingham, NG7 2RD

Background and Challenges

Research on new **monomers** and **polymers** will continue to advance, but starting with bio-based materials from the outset can greatly enhance sustainability.

Bioplastics represent just **0.5%** of the **400 million tonnes** of plastic produced annually.¹

¹World plastics production 2022, Plastics Europe, 2023.

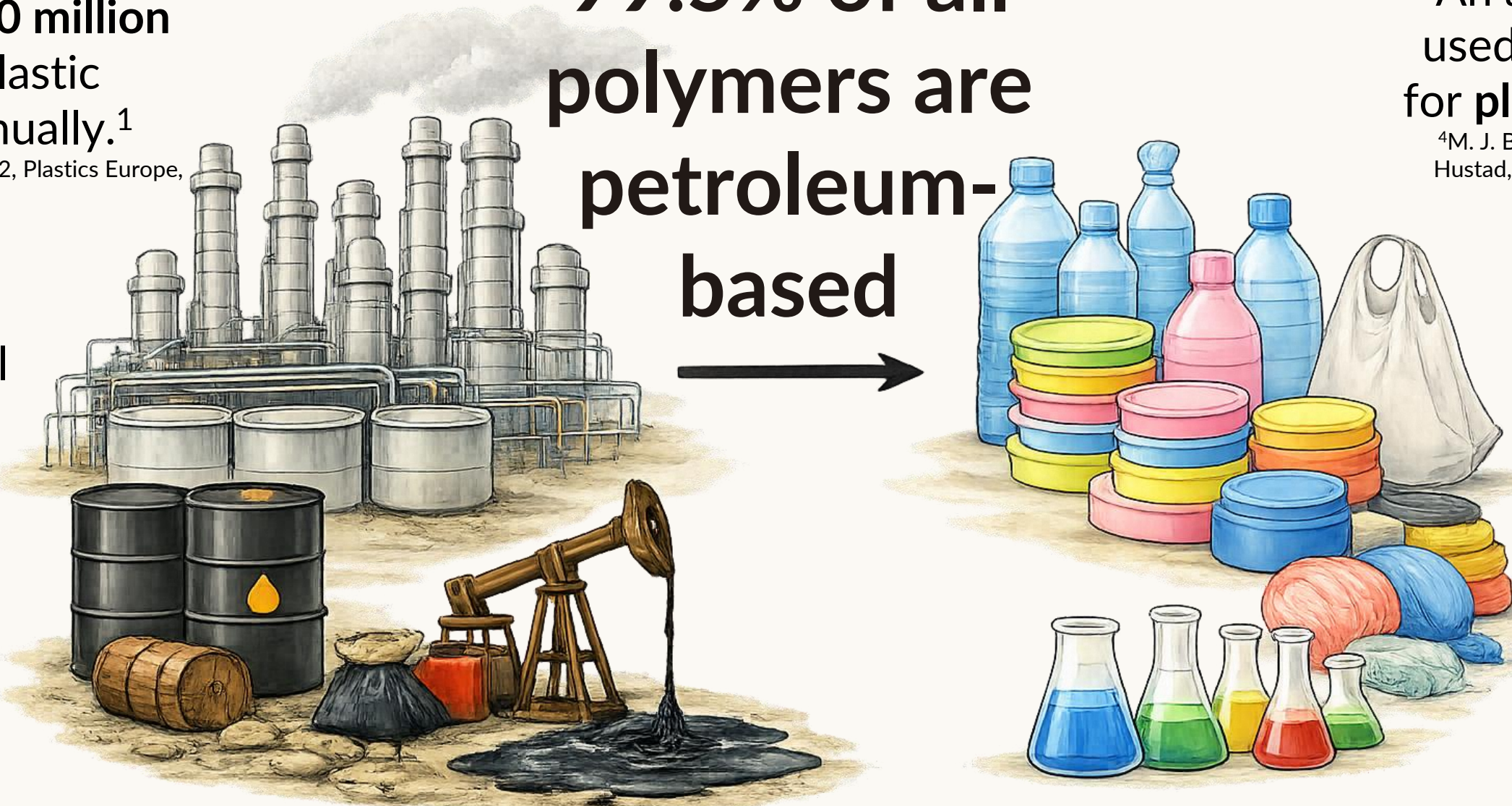
90% of plastics are derived from virgin fossil feedstocks.²

²Plastics in a circular economy - European Parliament

6% of global oil and gas production is used as feedstock for plastics.³

³The New Plastics Economy: Rethinking the future of plastics.

99.5% of all polymers are petroleum-based



An additional **3-4%** is used to provide energy for plastic manufacture.⁴

⁴M. J. B. Kabeyi, O. A. Olanrewaju and J. E. Hustad, *Journal of Energy*, 2023, 2023, 1-25.

Plastics are responsible for **4.5%** of global greenhouse gas emissions.⁵

⁵L. Cabernard, S. Pfister, C. Oberschelp and S. Hellweg, *Nature Sustainability*, 2022, 5, 139-148.

By 2050, plastics may reach **20%** of oil consumption and **15%** of the carbon budget.⁶

⁶The New Plastics Economy: Rethinking the future of plastics

The chemical industry is the **third-largest** emitter of CO₂, and **87%** of its processes depend on fossil fuels!

Solution: Polymers from Terpenes

Terpenes derived from **waste streams**, like **waste flower oil** and **gum turpentine**, provide a low-cost and readily available starting material for monomer synthesis.⁷

⁷F. Della Monica and A. W. Kleij, *Polymer Chemistry*, 2020, 11, 5109-5127.

Did you know the UK produces **5 million** waste flowering plants and cut flowers every year?

Globally, flower waste reaches **800 million tonnes!**

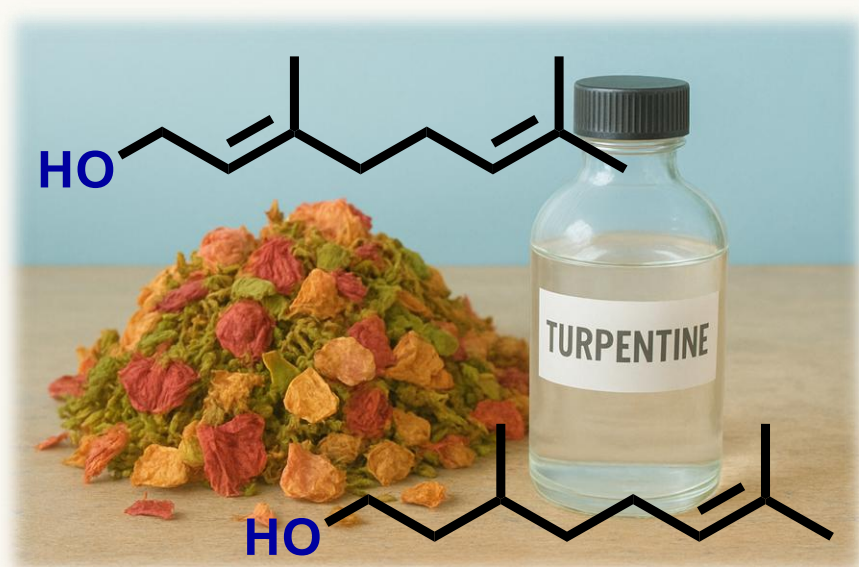
Turning this waste into sustainable polymers could cut fossil fuel use and boost the economy!

In 2020, the UK imported **£1.23 billion** worth of fragrance ingredients.⁸

⁸Statista

Processing **10%** of the UK's flower waste could yield **£100 million** in fragrance ingredients.

And reduce CO₂ emissions by **30%** compared to conventional commercial production!



Functionalisation
Modifying a molecule to give it new properties

POLYMER BUILDING BLOCKS (MONOMERS)

BIO-DERIVED POLYMERS



PERSONAL AND HOME CARE

My Current Research at University of Nottingham

Terpenes like **geraniol** and **citronellol** are key components of many floral essential oils. In the UK, nearly **35,000 tonnes** of flower waste are generated annually. Most is composted for growing fruits and vegetables, but extracting crude flower oil first could add value and enable conversion into bio-based polymers.

1. Sustainable Enzymatic Functionalisation of Terpenes

- ✓ Enzymatic
- ✓ Solvent-free
- ✓ All turned into product
- ✓ Inexpensive
- ✓ Quantitative yield
- ✓ Scalable
- ✓ Easy set-up
- ✓ No by-products

2. Synthesis of Low-Molecular-Weight Polymers

Fragrance from **geraniol** and **citronellol** polymers is released slowly from the polymer matrix, lasting longer than free oils.

NEXT STEP

3. Enzymatic Slow Fragrance Release

Reducing reliance on fossil fuels and valorising biomass waste, while helping consumers enjoy clothes that stay fresh longer.

