Lord of the Renewable Rings - The Journey towards Rapid Production of Polyethylene Furanoate (PEF) from Cyclic Oligomers

Peter Fleckenstein and Jan-Georg Rosenboom

ETH Zürich, Deptartment of Chemistry & Applied Biosciences, Vladimir-Prelog-Weg 1, 8093 Zurich, Switzerland
jan-georg.rosenboom@chem.ethz.ch

Polymers and plastics are very useful materials that make a wide range of everyday applications possible in the first place. Lighter cars, modern clothes, many medical devices and of course convenient packaging would not exist, had we not invented polymers. Since climate change and environmental pollution have now become viral topics of our time, the question is how we can reduce the negative impact of plastics while maintaining their benefits for our society?

Polyethylene furanoate (PEF) represents a promising renewable resource-based bioplastic as replacement for fossil-based polyethylene terephthalate (PET), which is one of the most prominent plastics worldwide with a production of more than 60 million tons/year mostly for textile fibres and packaging materials[1]. PEF is a polyester that can be fully sourced from bio-based furandicarboxylic acid (FDCA) and ethylene glycol (EG), which is estimated to reduce its carbon footprint by 50%[2]. While the molecular structure of PEF is very similar to that of PET, the non-linearity of FDCA and the permanent dipole hinder ring rotation, allowing for improved material properties of PEF compared with the terephthalic acid-based PET[3].

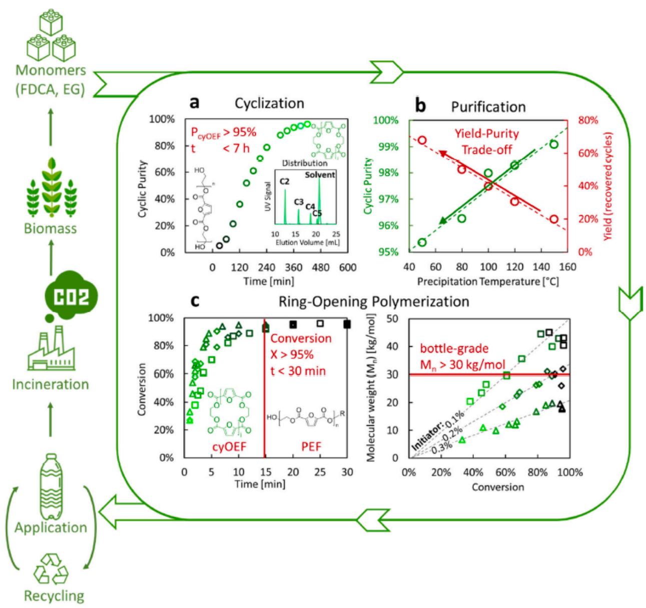

Figure 1. Overview of the ROP process in the frame of a potential circular economy. a) Conversion of 10 g/L short prepolymer (1-3 repeat units) from FDCA and EG in o-DCB to cyOEF at 180°C during DA-DCP, small: distribution of cyOEF as analyzed by HPLC-MS. b) Cyclic purities (left axis) and yields (right axis) as a function of temperature in selective cooling precipitation. c) Conversion of purified cyOEF to PEF (left) and molecular weight evolution during ROP using 0.1% (squares), 0.2% (diamonds) and 0.3% (triangles) of cyclic stannoxane initiator with 33% tetraglyme (per weight cyOEF) at 260°C.

1. Zhu, Y., Romain, C. & Williams, C. K. Nature 2016, 540, 354-364.
2. Eerhart, A. J. J. E., Faaij, A. P. C. & Patel, M. K. Energy Environ. Sci. 2012, 5, 6407–6422.
3. Burgess, S. K. et al., Macromolecules 2014, 47, 1383–1391.