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Published in:
Chem

DOI:
10.1016/j.chempr.2024.06.027

2024

Document Version:
Peer reviewed version (aka post-print)

Link to publication

Citation for published version (APA):
Bauer, F., & Cullen, J. M. (2024). Reaction: Circular Chemical Imaginaries. *Chem*, *10*(7), 1963-1964.
https://doi.org/10.1016/j.chempr.2024.06.027

Total number of authors:
2

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Reaction: Circular Chemical Imaginaries

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Fredric Bauer is an Associate Senior Lecturer in Technology and Society. His research focuses on climate change mitigation and transformation of the energy and emissions intensive industries. He has conducted extensive research on the plastics and chemicals industries. He was a contributing author to the IPCC Working Group III AR6 chapter on industry and is an active member of the Scientists Coalition for an Effective Plastics Treaty.

Jonathan M Cullen is a Professor of Sustainable Engineering at the University of Cambridge. He leads the Resource Efficiency Collective and has a reputation for top-down studies of resource systems, bringing skills in developing new metrics to reflect both energy and material consequences of materials production. He is a Lead Author for the IPCC AR6 Industry Chapter, an Expert Adviser to the IEA Technology Roadmaps, and co-authored the book Sustainable Materials: With Both Eyes Open, which pioneered the concept of material efficiency for energy-intensive industries.

It is irrefutable that the material value chains of the modern economy need to become more circular to mitigate not only climate change but also biodiversity loss and pollution associated with increasing use of natural resources. Contributions to these impacts, known as the triple planetary crisis, occur at all stages of product value chains, from primary production to use stages and ineffective end-of-life treatment strategies. This is true for chemical products and compels academia and industry to rethink current knowledge and business development priorities, to focus instead on solutions and enablers for a circular chemical economy.

The Catalyst article by Xuan and Cummings[1] describes a tantalising vision of a future circular chemical economy, where the impacts from chemicals disappear. Their vision describes a chemicals system where material loops are closed, waste is no longer generated, CO_2 is perfectly captured, and products are eternally recycled. However, just as a the idea of a perpetual motion machine challenges the laws of thermodynamics, this is in practice impossible to achieve for real materials and processes[2].

A more thorough examination of a circular chemical economy must also consider the practical limits and scalability of proposed circular solutions, the underlying assumption around unabated demand for chemical products, and the lack of trust between the industry and wider stakeholders. These three factors, are largely neglected in discussions about circular chemistry, including in the recent Catalyst article[1].

Firstly, visions of the future need to provide more concrete details of practical application and scalability of solutions. The article describes to recent chemical, such as, electrochemical transformation of CO_2 to olefins and hydrothermal liquefaction (HTL) of wet biomass to bio-oil, but provide no detail of their technology readiness, their scalability, or how these support a circular chemicals economy. The one circular business opportunity described, which transforms industrial waste gases into household detergents, is as best an open-loop, linear, down-cycling solution, as there is no way to recover the detergents post use. Recent modelling attempts show that even the most aggressive application of circularity strategies can only achieve a maximum 41% recycled content for plastic production[3]. The aim of a circular chemical economy must extend beyond finding non-fossil-based ways of producing olefins and aromatics to also think carefully about the qualities and properties of chemicals and materials and consider extending the lifetime of final products, enabling their reuse, and ensuring that new materials can be recycled, while ensuring production and recycling processes recycling must be developed to use renewable energy. For example, there is significant risk that the hyped chemical recycling technologies for plastics will fail to reduce GHG emissions from plastic value chains, when waste plastic is combusted to provide process heat.

Secondly, it is imperative to critically examine the assumption of unabated future demand for chemicals products, leading to a doubling of production within the next decade[4]. A circular economy which is growing is unable to close its material loops, as the available waste materials cannot keep pace with the growing demand. A central pillar of a circular chemical economy must be to reduce demand by delivering the benefits of chemicals with less materials, energy, and products. We must find ways to use fertilizers more effectively and deploy synthetic fibres and plastics more selectively, where reduced demand delivers smaller material loops, reduced production requirements and less the negative impacts on ecosystems and human health.

Finally, we underline the importance of building trust between the chemical industry and stakeholder groups by including them in the process of developing a circular chemical economy. There is a long tradition of collaboration between research institutions and the chemical industry which has enabled growth of the industry[5], but at a great cost to many frontline communities. Key to rebuilding trust with society is the provision of more transparent reporting of chemical production and the real impacts of chemical value chains[6]. The Global Chemicals Framework adopted under UNEP requires research institutions and firms to openly share the data to provide clarity and allow scrutiny of progress towards a more sustainable and circular chemical economy. An inclusive approach to shaping the future must also acknowledge other societal perspectives, including critical voices, to rebuild trust in chemistry as an enabler of more sustainable futures.

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