**Design Principles and Synthetic Methodologies in the New Era of Polymer Science**

*Eugene Y.-X. Chen, Colorado State University, Fort Collins, Colorado 80523-1872, United States*

Facing mounting environmental pollution, societal outcry, and regulatory pressure, polymer science is now at a crossroads. The large majority of today's commodity polymers were invented almost a century ago (e.g., polyamides or nylons and polyesters in the 1930’s and polyolefins in the 1950’s) and were further developed for capability, durability, scalability, profitability, and disposability, rather than for renewability, recyclability, and biodegradability. The failure to address the latter three fronts by the traditionally practiced linear economic model has not only accelerated the depletion of finite natural resources but also caused severe global plastic pollution and enormous loss of energy and material value to the economy. It is also important to recognize that this global plastics problem is a *trifecta*, concerning not just environment, widely known as plastics pollution, but also energy and climate, as the global production of plastics is predicted to consume about 20% of oil and contribute to about 15% of carbon budget by 2050.

To address this global grand challenge, new polymer design principles and de/polymerization methods must be developed in order to create next-generation sustainable polymers that exhibit *designer functions to perform, renewable resources to produce, and circular paths to regenerate*. In this context, this lecture will focus on our recent efforts1-15 in redesigning polymers to leverage a circular economy in this new era of polymer science. Examples will include redesigned sustainable polymers that not only are chemically circular (for a circular economy) and biodegradable (for environmental protection), but also exhibit closed-loop lifecycles with comparable consumptive and regenerative timescales (for sustainable development).

* 1. Zhang, Z.; Quinn, E. C.; Olmedo-Martínez, J. L.; Caputo, M. R.; Franklin, K. A.; Müller, A. J.; Chen, E. Y.-X. *Angew. Chem. Int. Ed.* **2023**, e202311264.
  2. Chen, E. Y.-X. *Nat. Sustain.* **2023**, *6*, 1140−1141.
  3. Quinn, E. C.; Knauer, K. M.; Beckham, G. T.; Chen, E. Y.-X. *One Earth* **2023**, *6*, 582−586.
  4. Li, X.-L.; Clarke, R. W.; An, H.-Y.; Gowda, R. R.; Jiang, J. -Y.; Xu, T.-Q.; Chen, E. Y.-X.*Angew. Chem. Int. Ed.* **2023**, *62*, e202303791.
  5. Shi, C.; Reilly, L. T.; Chen, E. Y.-X. *Angew. Chem. Int. Ed.* **2023**, *62*, e202301850.
  6. Clarke, R. W.; Sandmeier, T.; Franklin, K. A.;Reich, D.; Zhang, X.; Vengallur, N.; Patra, T. K.; Tannenbaum, R. J.; Adhikari, S.; Kumar, S. K.; Rovis, T.; Chen, E. Y.-X. *Nature* **2023**, *616*, 731−739.
  7. Zhou, L.; Zhang, Z.; Shi, C.; Scoti, M.; Barange, D. K.;Gowda, R. R.; Chen, E. Y.-X. *Science* **2023**, *380*, 64−69.
  8. Quinn, E. C.; Westlie, A. H.; Sangroniz, A.; Caputo, M. R.; Xu, S.; Zhang, Z.; Urgun-Demirtas, M.; Müller, A. J.; Chen, E. Y.-X. *J. Am. Chem. Soc.* **2023**, *145*, 5795−5802.
  9. Song, Y.; He, J.; Zhang, Y.; Gilsdorf, R. A.; Chen, E. Y.-X. *Nat. Chem.* **2023**, *15*, 366−376.
  10. Li, X.-L.; Clarke, R. W.; Jiang, J. -Y.; Xu, T.-Q.; Chen, E. Y.-X.*Nat. Chem.* **2023**, *15*, 278−285.
  11. Jehanno, C.; Alty, J. W.; Roosen, M.; De Meester, S.; Dove, A. P.; Chen, E. Y.-X.; Leibfarth, F. A.; Sardon, A. *Nature* **2022**, *603*, 803−814.
  12. Cywar, R. M.; Rorrer, N. A.; Hoyt, C. B.; Beckham, G. T.; Chen, E. Y.-X. *Nat. Rev. Mater.* **2022**, *7*, 83−103.
  13. Tang, X.; Westlie, A. H.; Watson, E. M.; Chen, E. Y.-X. *Science* **2019**, *366*, 754−758.
  14. Zhu, J.-B.; Watson, E. M.; Tang, J.; Chen, E. Y.-X. *Science* **2018**, *360*, 398−403.
  15. Hong, M.; Chen, E. Y.-X. *Nat. Chem*. **2016**, *8*, 42−49.