SCIEPublish

Editorial

Reflections on Synthetic Biology in the Manufacturing of Chemicals and Fuels

Xiujuan Qian [1,2], Jie Zhou [1,2], Weiliang Dong [1,2,*] and Min Jiang [1,2]

[1] State Key Laboratory of Materials-Oriented Chemical Engineering, College of Biotechnology and Pharmaceutical Engineering, Nanjing Tech University, Nanjing 211816, China; xiujuanqian@njtech.edu.cn (X.Q.); jayzhou@njtech.edu.cn (J.Z.); bioengine@njtech.edu.cn (M.J.)

[2] Key Laboratory for Waste Plastics Biocatalytic Degradation and Recycling, Nanjing 211816, China

* Corresponding author. E-mail: dwl@njtech.edu.cn (W.D.)

Received: 22 August 2025; Accepted: 25 August 2025; Available online: 28 August 2025

Synthetic biology is the design and construction of new biological parts, devices, and systems, and the re-design of existing, natural biological systems for useful purposes. As an emerging, interdisciplinary field, synthetic biology has greatly advanced in many directions. This special issue, “Synthetic Biology in the Manufacturing of Chemicals and Fuels”, highlights groundbreaking advances in synthetic biology methodologies and their applications. It features two research articles and four high-quality reviews that showcase the field’s progression from fundamental research to industrial applications.

In terms of methodology innovation, Prof. Chong Zhang’s team introduced the pioneering concept of genotypic navigation in genome engineering, establishing a new paradigm for AI-assisted optimization through stepwise generation of high-quality genotype-phenotype association data [1].

In terms of metabolic regulation strategies, Prof. Yajun Yan’s team systematically summarized typical dynamic regulation strategies based on control logic, providing novel approaches for heterologous pathway optimization [2]; while Prof. Shang-Tian Yang’s team comprehensively reviewed metabolic engineering and cofactor regeneration engineering for n-butanol biosynthesis, proposing an innovative strategy using noncanonical redox cofactors to drive production [3]. Notably, significant technological breakthroughs are demonstrated through two exemplary studies: Prof. Xiaosong Gu’s group achieved a remarkable 21.5% reduction in glycerol byproduct formation during industrial-scale ethanol fermentation by synergistically combining targeted metabolic engineering with whole-genome adaptation strategies [4]. Simultaneously, Prof. Jufang Wang’s team has redefined production benchmarks by engineering sophisticated quorum-sensing circuits that yield unprecedented *iso*-butylamine titers reaching 44.23 g/L [5].

In terms of application fields, Prof. Weiliang Dong’s team summarized the critical significance and incremental progress of biotechnology in plastic waste recycling, with an in-depth exploration of synthetic biology’s potential in boosting biological depolymerization and upcycling of waste plastics [6].

Despite significant advances in methodological innovation, technological development, and application expansion in synthetic biology, several critical challenges remain: First, current biomanufacturing relies predominantly on model microorganisms as chassis cells, which represent merely the tip of the iceberg of microbial diversity. Numerous novel microbial resources with specialized capabilities await discovery and application. Second, biological metabolic pathways are highly complex, and one- or two-dimensional pathway modifications may induce unforeseen metabolic perturbations, increasing experimental unpredictability. Future efforts must leverage AI technologies to enhance the simulation and evaluation of metabolic engineering interventions. Third, advanced technologies, tools, and chassis strains developed in synthetic biology are highly fragmented. Reconstructing systems based on published studies is often difficult and time-consuming. Establishing shared or commercial platforms for computational modeling, standardized biological parts, and high-quality chassis cells would significantly accelerate the application of synthetic biotechnology across various fields.

https://doi.org/10.70322/sbe.2025.10012

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

1. Yu X, Guo J, Sun J, Zhang C. Navigable Genome Engineering: Stepwise Correlation for Precision-Guided Optimization of Microbial Cell Factory Phenotypes. *Synth. Biol. Eng.* **2025**, *3*, 10003. doi:10.70322/sbe.2025.10003.
2. Jiang T, Li C, Teng Y, Zhang J, Logan DA, Yan Y. Dynamic Metabolic Control: From the Perspective of Regulation Logic. *Synth. Biol. Eng.* **2023**, *1*, 10012. doi:10.35534/sbe.2023.10012.
3. Moore CD, Wang Q, Wang G, Yang S-T. Recent Advances and Challenges in Engineering Metabolic Pathways and Cofactor Regeneration for Enhanced n-Butanol Biosynthesis. *Synth. Biol. Eng.* **2025**, *3*, 10005. doi:10.70322/sbe.2025.10005.
4. Xu N, Chen H, Zhang Y, Yang Y, Wang Y, Liao B, et al. Metabolic Engineering and Genome-Wide Adaptive Evolution for Efficient Reduction of Glycerol in Industrial *Saccharomyces cerevisiae*. *Synth. Biol. Eng.* **2025**, *3*, 10004. doi:10.70322/sbe.2025.10004.
5. Liu M, Li Y, Yu P, Fu H, Wang J. Quorum Sensing Systems Engineering for Enhanced *iso*-Butylamine Production in *Escherichia coli*. *Synth. Biol. Eng.* **2025**, *3*, 10008. doi:10.70322/sbe.2025.10008.
6. Wu M, Zhuang J, He X, Zhu F, Lai Q, Qian X, et al. Synthetic Biology Boosts the Biological Depolymerization and Upcycling of Waste Plastic Resources. *Synth. Biol. Eng.* **2025**, *3*, 10002. doi:10.70322/sbe.2025.10002.