



Future Research and Challenges of Industrial Biotechnology

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Abstract

Industrial biotechnology is the application of biotechnology principles and techniques to develop new products or improve existing products and processes in a variety of industrial sectors. This field has enormous potential for developing innovative solutions to address some of the significant global challenges, such as the depletion of fossil resources, climate change, food security, and public health. In this paper, we discuss the future research and challenges of industrial biotechnology, focusing on key areas such as synthetic biology, bioprocessing, biomaterials, and bioremediation.

Keywords: Industrial biotechnology, Innovative, Fossil resources, Climate change, Food security

INTRODUCTION

Industrial biotechnology, also known as white biotechnology, is an emerging field that aims to develop and optimize biological processes to produce renewable fuels, chemicals, and materials from renewable, sustainable sources. Advancements in this field hold significant promise for creating a sustainable future since it enables the development of bio-based products that have lower carbon footprints, reduce dependence on fossil fuels, and encourage the circular economy. However, the development of industrial biotechnology requires considerable investment in terms of research, innovation, and policy support to overcome the challenges that still exist in the field (Wilson RC et al., 2013). This paper discusses future research and challenges of industrial biotechnology in detail, outlining the work that needs to be done to achieve the full potential of this field.

Future research in industrial biotechnology

The following are some of the areas of research that continue to drive innovation in industrial biotechnology:

Genomics and metabolomics

One of the significant challenges in industrial biotechnology is identifying and understanding the complex biochemical

pathways that microorganisms use to produce valuable products. The development of genomics and metabolomics tools that enable researchers to comprehend these biological processes can significantly impact the scalability and efficiency of industrial bio production. Genome sequencing allows researchers to detect and characterize metabolic pathways, identify targets for metabolic engineering, and optimize microbial strains for industrial applications. Metabolomics, on the other hand, allows researchers to analyze the metabolic processes that occur within cells and determine how these processes can be optimized for the production of desired biochemical products (Sinha SK 2010).

Synthetic biology

Synthetic biology is an interdisciplinary field that combines biology, chemistry, and engineering to design and develop new biological systems or to modify existing ones. Synthetic biology can help enhance the scalability and performance of bio-based production by designing and engineering biological systems to optimize product yields and reduce production costs. This field may also identify new metabolic pathways and enzymes for use in bio production that would be otherwise challenging to discover. Additionally, synthetic biology can simplify the design and deployment

of microorganisms for commercial-scale production in ways that reduce costs (**Williams M et al., 2004**).

Synthetic biology is a rapidly evolving field of biotechnology that aims to design and construct new biological systems or modify existing natural systems to perform specific functions. It combines the principles of engineering, genetics, and molecular biology to create novel biological systems with specific functionalities. The potential applications of synthetic biology are vast, ranging from healthcare to energy, agriculture, and the environment. One of the key challenges in synthetic biology is the optimization of the design and construction of biological systems. The field is rapidly expanding, and there are vast amounts of data generated from different studies (**Liu S et al., 2020**). However, the integration of this data to create more efficient biological systems remains a challenge. Additionally, synthetic biology is often limited by the availability of standardized biological parts that can be used in the design and construction of biological systems.

Another significant challenge in synthetic biology is the ethical and regulatory considerations associated with the development and commercialization of new biological systems. At present, there is a lack of consistent regulatory frameworks to guide the development and use of synthetic biological systems. Governments and other regulatory bodies need to develop guidelines to ensure the safe and responsible use of synthetic biology (**Dalakouras A et al., 2018**).

Process engineering

The development of economically feasible bio-based production technologies requires innovative process engineering. Process engineering comprises the engineering aspects of designing, optimizing, and controlling the process variables in bio-based production. This includes designing and optimizing the reactor system, equipment design, the choice of bioreactor, fermentation process, and more. Process engineering is crucial to maximizing product yields and reducing production costs, and it requires close collaboration between biologists, chemists, and engineers (**Sakurai K et al., 2010**).

Circular economy

Industrial biotechnology is well-placed to contribute to the circular economy, which emphasizes the use of renewable resources to produce long-lasting products and reduce waste. This can be accomplished by identifying feedstock and waste streams that can be used as inputs for bio production processes. For example, lignocellulosic biomass, such as agricultural and forestry waste, can be converted into fermentable sugars and other useful products through bioprocessing. The circular economy approach may also reduce carbon emissions, provide low-carbon alternatives to various sectors of the economy, and promote the use of bio-based products over fossil fuel-derived products.

Bioprocessing

Bioprocessing is a critical area of industrial biotechnology that involves the use of biological systems or their derivatives to produce value-added products. This includes the use of microorganisms, enzymes, and other biological agents to transform raw materials into useful products, such as biofuels, food, pharmaceuticals, and chemicals. Bioprocessing has the potential to provide sustainable and environmentally friendly solutions to a wide range of global challenges. The main challenge in bioprocessing is the development of efficient, cost-effective, and sustainable production processes (**Das PR et al., 2020**). The optimization of bioprocesses involves multiple factors, including selection and cultivation of microbial strains, optimization of fermentation conditions, downstream processing, and product purification. Bioprocess optimization requires the integration of different disciplines, including microbiology, biochemistry, chemical engineering, and process development.

Another challenge in bioprocessing is the development of scalable production processes. Scaling up bioprocesses from the laboratory to industrial scale involves multiple challenges, including maintaining product quality, managing production costs, and meeting regulatory compliance. The design and optimization of scalable bioprocessing facilities require the integration of different engineering disciplines, including process engineering, equipment design, and automation.

Biomaterials

Biomaterials are materials derived from biological sources or designed to interact with biological systems. They have numerous applications in various fields, including biomedical engineering, environmental remediation, and energy production. Biotechnology offers new opportunities for the development of sustainable and environmentally friendly biomaterials. One of the significant challenges in biomaterials is the development of new materials with improved biological properties. This includes the development of biocompatible materials that can interact with biological systems without inducing adverse effects (**Koch A et al., 2014**). Additionally, the development of biomaterials with controlled biological function and degradation properties is essential for their effective use.

Another challenge in biomaterials is the integration of different disciplines in the design and development of new materials. The development of biomaterials involves the integration of biological, chemical, and material sciences. This requires interdisciplinary collaborations that bring together different disciplines to create new biomaterials with specific properties.

Bioremediation

Bioremediation is the use of biological organisms or their derivatives to remove pollutants from contaminated

environments. It offers a sustainable and cost-effective solution for environmental remediation, with potential applications in the cleanliness of air, water, and soil. Bioremediation can be applied in various settings, including industrial, agricultural, and urban environments (**Meister G et al., 2004**). The main challenge in bioremediation is the optimization of biological systems for the efficient removal of pollutants. Bioremediation involves the selection and cultivation of microorganisms capable of degrading pollutants under different environmental conditions. The optimization of bioremediation requires an understanding of microbial ecology, biogeochemistry, and environmental science.

Another significant challenge in bioremediation is the development of bioreactor systems for the treatment of contaminated environments. Bioreactor systems are used to provide optimal conditions for the growth and activity of microorganisms involved in the degradation of pollutants. The design and optimization of bioreactor systems require the integration of different disciplines, including process engineering, reactor design, and microbiology (**Haiyong H 2019**). The interdisciplinary nature of biotechnology research poses both challenges and opportunities for the development of industrial biotechnology. There is a need for the integration of different disciplines, such as biology, chemistry, engineering, and material science. The development of interdisciplinary research collaborations and training initiatives is necessary to support the growth of industrial biotechnology.

Challenges of industrial biotechnology

Despite the demonstrated potential of industrial biotechnology, several challenges still need to be overcome for its full realization. The following are some of the most pressing challenges of industrial biotechnology.

Scaling up

One of the biggest challenges facing industrial biotechnology is scaling up from lab-scale to commercial-scale production. This often requires significant investment in process design, engineering, and validation, which can be costly and time-consuming. Additionally, the scalability of a given process depends on the biological system being used, and some systems may be challenging to scale up due to technical, environmental, or regulatory constraints.

Uncertainty about market conditions

Another challenge for industrial biotechnology is the uncertainty surrounding market demand and product acceptance. While bio-based products are gradually being adopted in many sectors, other traditional chemical or fuel products remain dominant, and their demand may continue to increase. Therefore, developing bio-based products that can compete with conventional products in terms of price, performance, and reliability is a crucial challenge

for industrial biotechnology. It will require collaboration between public and private stakeholders and significant investment in research and development to overcome this challenge.

Intellectual property rights (IPR)

The development of new microbial strain or metabolic pathway for bio-based production requires substantial research investment. Therefore, protecting intellectual property rights in industrial biotechnology must be considered. The biotech industry is characterized by complex and sometimes opaque intellectual property systems, which can hinder the development and commercialization of new products. In addition, the patent system imposed barriers to entry for small businesses and research institutions, limiting competition and increasing the concentration of the industry (**Gupta K et al., 2014**).

Energy intensity

Another significant challenge for industrial biotechnology is the high energy intensity of some bio-based production processes. Fermentation processes are energy-intensive, requiring a steady flow of temperature and oxygen during industrial processing. The energy intensity of bio-based production can limit the potential environmental benefits of using renewable resources because of the increased energy consumption associated with bioprocessing (**McLoughlin AG et al., 2018**).

CONCLUSION

In conclusion, industrial biotechnology has great potential to revolutionize the way we produce and consume goods, reduce our impact on the environment, and improve our overall quality of life. However, there are also many challenges that must be addressed in order to fully realize the potential of this field. Future research in industrial biotechnology should focus on developing new and innovative techniques for producing renewable and sustainable bio-based products, improving our understanding of the complex biological systems involved, and developing strategies for scaling up production to meet global demand. In addition, there are many ethical, regulatory, and social issues that must be considered as we move forward with industrial biotechnology. It is important that we continue to engage in a dialogue about the potential benefits and risks of this field, and work together to create a sustainable and ethical future for biotechnology.

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REFERENCES

1. Wilson RC, Doudna JA (2013). Molecular mechanisms of RNA interference. *Annu Rev Biophys.* 42: 217–239.
2. Sinha SK (2010). RNAi induced gene silencing in crop

- improvement. *Physiol Mol Biol Plants*. 16: 321–332.
3. Williams M, Clark G, Sathasivan K, Islam AS (2004). RNA Interference and Its Application in Crop Improvement. *Plant Tissue Culture and Biotechnology*. 1-18.
 4. Liu S, Jaouannet M, Dempsey DMA, Imani J, Coustau C, et al. (2020). RNA-based technologies for insect control in plant production. *Biotechnol Adv*. 39: 107463.
 5. Dalakouras A, Jaraus W, Buchholz G, Bassler A, Braun M, et al (2018). Delivery of Hairpin RNAs and Small RNAs into Woody and Herbaceous Plants by Trunk Injection and Petiole Absorption. *Plant Sci*. 1–11.
 6. Sakurai K, Chomchan P, Rossi JJ (2010). Silencing of gene expression in cultured cells using small interfering RNAs. *Curr Protoc Cell Biol*. 47: 1–28.
 7. Das PR, Sherif SM (2020). Application of Exogenous dsRNAs-induced RNAi in Agriculture: Challenges and Triumphs. *Front Plant Sci* 11: 946.
 8. Koch A, Kogel K (2014). New wind in the sails: improving the agronomic value of crop plants through RNAi-mediated gene silencing. *Plant Biotechnol J*. 12: 821-831.
 9. Meister G, Tuschl T (2004) Mechanisms of gene silencing by double-stranded RNA. *Nature*. 431: 343–349.
 10. Haiyong H (2019). RNA Interference to Knock Down Gene Expression. HHS Public Access. 1–9.
 11. Gupta K, Sengupta A, Saha J, Gupta B (2014). Gene Technology the Attributes of RNA Interference in Relation to Plant Abiotic Stress Tolerance 3: 1–4.
 12. McLoughlin AG, Wytinck N, Walker PL, Girard IJ, Rashid KY, et al (2018). Identification and application of exogenous dsRNA confers plant protection against *Sclerotinia sclerotiorum* and *Botrytis cinerea*. *Sci Rep*. 8: 7320.