

# Single-Use Bioreactors: Advancing Modern Bioprocessing

## Introduction

Single-use bioreactors (SUBs) are disposable, pre-sterilized systems increasingly used in biopharmaceutical and biotechnology manufacturing. Unlike traditional stainless-steel bioreactors, which require extensive cleaning and sterilization between production runs, single-use bioreactors are designed for one-time use and are discarded after each batch. Their adoption has expanded rapidly due to the growing demand for biologics, personalized medicines, and flexible manufacturing solutions. By reducing turnaround time and operational complexity, single-use bioreactors have become a key component of modern bioprocessing strategies [1,2].

## Discussion

Single-use bioreactors consist of a disposable plastic bag housed within a reusable support structure, equipped with integrated sensors, mixing systems, and ports for sampling and media addition. They are commonly used in upstream processes such as cell culture and microbial fermentation, particularly for the production of monoclonal antibodies, vaccines, and cell and gene therapies [3,4]. SUBs are available in various configurations, including stirred-tank, wave-induced, and orbital shaking systems, with working volumes ranging from laboratory scale to several thousand liters.

One of the primary advantages of single-use bioreactors is operational flexibility. Since they eliminate the need for cleaning-in-place (CIP) and sterilization-in-place (SIP), production changeovers are faster, and the risk of cross-contamination is significantly reduced. This makes SUBs especially suitable for multiproduct facilities and clinical manufacturing, where rapid scaling and frequent product changes are required. Additionally, lower water and energy consumption contribute to reduced operational costs and environmental impact during operation.

Despite these benefits, single-use bioreactors also present certain challenges. Material compatibility and leachables or extractables from plastic components must be carefully evaluated to ensure product safety and regulatory compliance [5]. Waste management and environmental sustainability are ongoing concerns, as disposable systems generate significant plastic waste. Furthermore, while SUBs have advanced in scale, extremely large-volume commercial production may still favor stainless-steel systems due to long-term cost considerations.

## Conclusion

Single-use bioreactors have transformed biomanufacturing by offering increased flexibility, reduced contamination risk, and faster deployment compared to conventional systems. Although challenges related to material safety, waste disposal, and scale remain, continued innovation and regulatory guidance are addressing these limitations. As biopharmaceutical pipelines diversify and demand for agile manufacturing grows, single-use bioreactors are expected to play an increasingly important role in efficient and scalable bioprocessing.

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