Sustainable β-Lactam Production Using Zr-MOFs-Bioenzyme Catalysis

GA, UNITED STATES, April 15, 2025 /EINPresswire.com/ -- In a groundbreaking study, a series of zirconium-based metal-organic frameworks (Zr-MOFs) were successfully synthesized in aqueous environments by researchers, followed by precise enzyme immobilization achieved through ligand-exchange strategies. A fully green technological system spanning material preparation to biocatalyst construction was established, with the developed immobilized enzyme formulations demonstrating remarkable enhancements in both catalytic activity and operational stability.

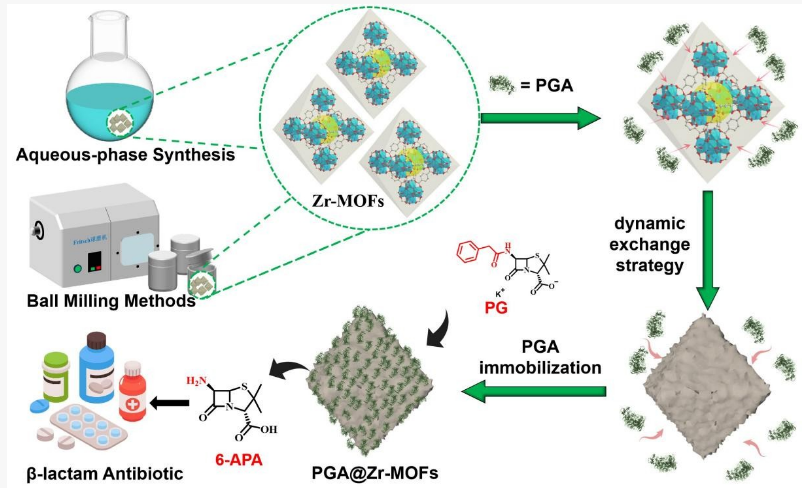

ILLUSTRATION OF PGA IMMOBILIZATION BY Zr-MOFs VIA DYNAMIC EXCHANGE STRATEGY.

With the intensification of population aging and advancements in healthcare, the global antibiotic market is projected to exceed $50 billion by 2030. However, the conventional chemical synthesis of antibiotic involves the use of a wide range of toxic chemicals and generates a large amount of waste during the production process. To address the inherent limitations of free enzymes, including poor stability and high operational costs, immobilized enzyme technology has been rapidly developed. Metal-Organic Frameworks (MOFs), recognized as ideal enzyme immobilization carriers owing to their high surface area and tunable porous structures, have been extensively investigated. Nevertheless, the practical implementation of MOFs has been hindered by energy-intensive synthesis procedures and prohibitive costs. In a recent study published in Green Chemical Engineering, a fully green technological system spanning material synthesis to enzyme immobilization was developed by Chinese researchers, enabling sustainable continuous production of β-lactam antibiotics.

In this study, the synthesis of a series of Zr-MOFs has been successfully greened through the aqueous phase method. Leveraging the ligand-exchange capability inherent in MOFs, enzymes were innovatively employed as "macroscopic ligands" to replace organic ligands within Zr-MOFs under ambient aqueous conditions, achieving effective enzyme immobilization. This mild strategy was proven to preserve the native enzymatic activity, while the structural advantages of MOFs substantially enhanced operational stability and recyclability. Furthermore, the unique porous architecture and high surface area of the material were observed to improve mass transfer efficiency during catalytic processes.

"This study establishes a paradigm shift in MOF-mediated enzyme immobilization," emphasized Dr. Yao Chen, corresponding author of the research. "By creating a green manufacturing platform that integrates MOF with biocatalyst engineering, we've addressed two critical bottlenecks simultaneously: eliminating organic solvent dependence during synthesis while achieving industrial-grade enzyme operational stability. This dual innovation provides both fundamental methodological guidance and scalable technological pathways for sustainable biomanufacturing."

References

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