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Biochemical pathways in *Penaeus vannamei* protease stabilization via ZnS nanoparticle mediation

Mozhgan Razzaghi [1], Ahmad Homaei [2,*], Elaheh Mosaddegh [3]

1. Department of Marine Biology, Faculty of Science, University of Hormozgan, Bandar Abbas, Iran
2. Department of Biochemistry, Faculty of Science, University of Hormozgan, Bandar Abbas, Iran
3. Department of New Materials, Institute of Science and High Technology and Environmental Sciences, Graduate University of Advanced Technology, Kerman, Iran

Abstract

Zinc sulfide (ZnS) nanoparticles have gained extensive attention in biomedical and biotechnological research due to their biocompatibility and non-toxic properties, positioning them as ideal platforms for various therapeutic and industrial applications. This study investigates the potential of ZnS nanoparticles synthesized via chemical precipitation as a support for immobilizing protease enzyme derived from *Penaeus vannamei* shrimp. Immobilizing enzymes on nanoparticle surfaces often leads to improved stability and performance, addressing common challenges in enzyme applications, such as decreased catalytic efficiency over time. Advanced characterization techniques, including Fourier-transform infrared (FT-IR) spectroscopy, ultraviolet-visible (UV-Vis) spectroscopy, dynamic light scattering (DLS), and transmission electron microscopy (TEM), were employed to comprehensively assess the ZnS nanoparticles before and after enzyme immobilization. These methods provided insights into particle size, surface structure, and morphological changes post-immobilization, which are essential for optimizing immobilized enzyme functionality. Results demonstrated a significant enhancement in the thermal and long-term stability of the immobilized protease enzyme compared to its free form. Additionally, immobilization improved the enzyme's resistance to extreme pH levels, advantageous for industrial applications. Notably, the immobilized enzyme exhibited an increase in optimal operating temperature, while kinetic parameters remained largely unaffected, indicating minimal loss in catalytic efficiency. These findings suggest that ZnS nanoparticle-supported enzymes have promising potential for diverse industrial applications, offering enhanced enzyme stability and resilience under challenging operational conditions.

Key words: ZnS nanoparticles, Protease enzyme, Iimmobilization, Stability, Catalytic efficiency