

Book of Abstract

AMYC-BIOMED 2025

6th Edition - Summer Edition



Palermo, Addaura Village Hotel, 23-25 June 2025

Shaping ZnO Synthesis through Design of Experiments to Enhance Photocatalysis and Antibacterial Activity

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Keywords: Zinc oxide (ZnO); Design of Experiments (DoE); Photocatalytic activity; Micro/nano-robots (MNRs); Antibacterial applications.

The widespread misuse of antibiotics over the past decade has led to the emergence of antibiotic-resistant bacterial strains, complicating infection treatments. Along with the synthesis of new antibiotics, materials-based strategies could be designed to tackle antibiotic resistance. For instance, Zinc oxide (ZnO) when in the form of nanostructured material shows promise for photocatalytic and antibacterial applications, due to the release of reactive oxygen species and zinc ions. However, ZnO nanoparticles are hindered by poor colloidal stability and toxicity to various cell lines. To address such issue, this study employs a Design of Experiments (DoE) approach based on a two-level factorial design to assess the effects of Zn precursor concentration, KCl concentration, and reaction time on the ZnO's functional properties. The synthesised ZnO materials were analyzed via SEM, XRD and UV-visible reflectance. Photocatalytic performance was tested by methylene blue dye degradation under simulated solar light. Building upon an optimized synthesis for wearable electronics, [1] the DoE approach identifies the optimal synthesis conditions whilst minimising time and costs. Unlike prior studies that overlooked parameter interactions [2] or lacked response surface analysis, [3] this study integrates the influence of Zn precursor concentration, KCl concentration and reaction time on reaction yield and photocatalytic activity. Moreover, based on these parameters, clusters of optimal conditions were identified through Principal Component Analysis (PCA), pinpointing the best-performing samples (Fig.1). Additionally, cellulose-based composites, such as ethylcellulose, APTES-cellulose, and microcrystalline cellulose, were studied as structural supports, complementing prior studies on ZnO/cellulose acetate composites. [4] These composites provide stable platforms for ZnO's biomedical applications, with preliminary results confirming antibacterial efficacy against Gram-positive and Gram-negative bacteria. The DoE-driven approach and KCl-induced (002) plane stabilization establish a framework for improving ZnO's photocatalytic and antibacterial properties. Modified synthesis protocols are under development to achieve asymmetric functionalization with the aim of enabling micron-scale motion in micro-nano robots (MNRs). These findings open avenues for further studies on silver- or copper-based doping, enzyme functionalisation, and cellulose-based composites, aiming to refine ZnO's asymmetric properties. Such progress has potential implications for antibacterial technologies and innovative MNR designs.

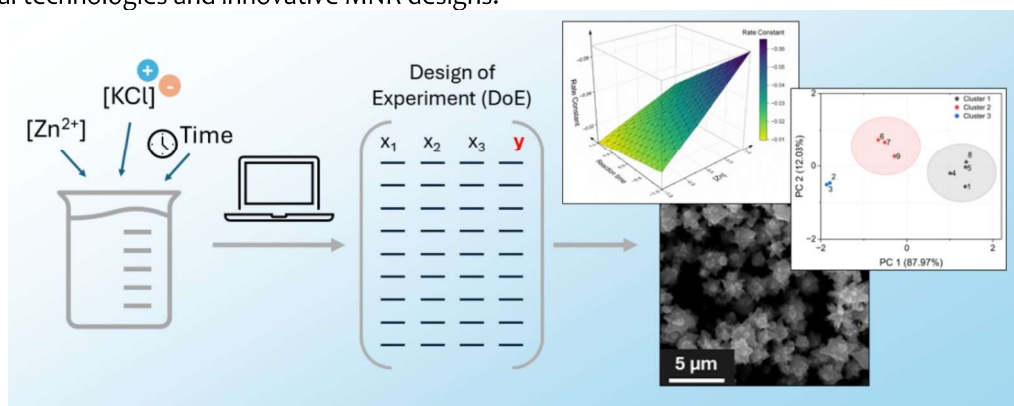


Figure 1: Graphical abstract.

Acknowledgments

Financial support from MUR is acknowledged under grants PRIN 2022 "2022WZK874 - Smart biopolymeric ZnO Nanowires composites for enhanced antibacterial activity (Soteria)", PRJ-1310, CUP: B53D23015730006 and PNRR "Network 4 Energy Sustainable Transition – NEST", code PE0000021, CUP B73C22001280006, Spoke 1, Mission 4, by EU – NextGenerationEU.

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