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Insight into controllable synthesis of zinc oxide-based nanomaterials and their toxicity effects on biological wastewater treatment processes

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In recent years, the increasing utilisation of nanomaterials has resulted in their wide prevalence reported in the environment due to sources originating from atmospheric emissions, municipal, manufacturing and industrial waste streams. Sewage systems and municipal Wastewater Treatment Plants (WWTPs) have become important intermediate hotspots for the transfer of nanomaterials into the environment. This is because municipal wastewater is found to be a great source of nanomaterials, and increasing concerns are aroused toward their potential impairment on biological WWTPs. Zinc Oxide (ZnO) is a well-known antibacterial agent that has drawn broad interdisciplinary attention for understanding on its toxicity effects over biological activities. To a lesser extent, however, there is a knowledge gap on the influence of shape and morphology of ZnO nanomaterials accompanied by a systematic comparison of toxicity effects towards bacteria found in biological sludge. In this study, four different dimensionality of ZnO nanomaterials, which are Zero-Dimensional (0D)-ZnO nanoparticles, One-Dimensional (1D)-ZnO nanorods, Two-Dimensional (2D)-ZnO nanosheets, and three-dimensional (3D)-nanoflowers were synthesized via bottom-up hydrothermal approaches. Subsequently, the toxicity effects of these ZnO nanomaterials were experimented over the biological activities of aerobic wastewater microorganisms and activated sludge. Results showed that the presence of ZnO nanomaterials significantly impacted on the treatment efficiency of biological aerobic wastewater treatment process, where both the Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD5) removal rates have been adversely hindered. Additionally, the 0D-ZnO nanoparticles with an average diameter of 209.67 ± 0.05 nm exhibited the highest toxicity effects toward the inactivation of activated sludge microbes. This was evidenced from the highest inhibition rate of 17.9% of activated sludge microbes among the synthesized ZnO nanomaterials and control experiment. By gaining an insight into the controllable synthesis of ZnO nanomaterials on aerobic microorganisms and activated sludge functions, this study helps to predict the potential detrimental impacts of ZnO as a nanopollutant, minimises the inherent ecohazard, and enables the optimum operation of biological WWTPs.

Biography

Chang Jang Sen is currently pursuing his postgraduate studies under the supervision of Assoc. Prof. Dr. Meng Nan Chong and Dr. Phaik Eong Poh at Monash University Malaysia. His research interest is focussed on the evaluation of different zinc oxide-based nanomaterials and their nanotoxicology effects on biological wastewater treatment processes.

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