

Hydrothermal production of multifunctional zinc ferrite nanoparticles as fertilizer, supercapacitor electrode, and NPK sensor

Abstract

Fertilizers based on nanoparticles can provide crops with nutrients more efficiently and increasing agricultural output. Conventional iron fertilizers can be substituted with ferrite nanoparticles. For plants to flourish, iron is more important, and a lack of it mostly impacts cellular functions. Plant enzymes such as urease include zinc ferrite that transforms nitrogen into usable ammonia. Additionally, it keeps harmful urea levels from building up in plant tissues. The superior properties of zinc ferrite (ZnFe_2O_4) make it a popular choice for spinel ferrites. ZnFe_2O_4 nanoparticles have the highest capacity and excellent electrochemical performance. They have been successfully synthesized using a hydrothermal process, and their properties are examined using XRD, FTIR, SEM and EDAX, CV, and UV techniques. The cubic spinel structure with a crystallite size of 40.11 nm is confirmed by XRD. The functional groups in the sample are identified by the FTIR spectrum. The size and shape of the produced nanoparticles are displayed in the SEM pictures. It has been investigated how zinc ferrite nanoparticles (NPs) affect the growth of tomatoes, as well as certain types of spinach and millets. Continuous aeration primes the application with concentrations of ZnFe_2O_4 NPs 5 μM for 24 h. With synthesized NPs, plant height, spike length, and the dry weights of roots, shoots, grains, and spikes all increase. The findings demonstrate that ZnFe_2O_4 NPs significantly impacted tomato growth as well as that of some varieties of millets and spinach. ZnFe_2O_4 NPs are created as supercapacitor electrodes, and their capacity to store charge is evaluated using electrochemical methods. Even after 2400 galvanostatic charge discharge (GCD) cycles, it still shows a cyclic retention of 93.1% and a specific capacitance of 347 Fg^{-1} . ZnFe_2O_4 NPs have also been demonstrated as NPK sensor by optical means using UV-visible spectroscopy to measure the quantities of nitrogen, phosphorous, and potassium. ZnFe_2O_4 NPs have shown multifunctional performance as nano fertilizer, supercapacitor, and NPK sensor, which are required for agriculture and energy storage devices.

Keywords

Energy storage; Nano fertilizer; NPK sensor; Supercapacitor; Zinc ferrite