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A comprehensive comparison study on magnetic behaviour, defects-related emission and Ni substitution to clarify the origin of enhanced acetone detection capabilities

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Abstract:
In this work, nickel (Ni) substituted zinc ferrite nanoparticles (NPs) with formula NixZn1-xFe2O4 (x = 0, 0.1, 0.3, 0.4) were synthesized using a microwave-assisted hydrothermal method. We further evaluated the effects of Ni substitution on structural, defects, magnetic and gas sensing properties of the pure ZnFe2O4 arising from the nickel substitution. The gas sensing findings revealed that the sensor based on 0.1 Ni substituted ZnFe2O4 displayed a high response of 34.5–40 ppm of acetone at an optimal working temperature of 120 C. All sensors demonstrated an excellent response towards acetone and remarkable selectivity against NO2, NH3, CH4, and CO with the sensor based on Ni0.1Zn0.9Fe2O4 displaying the best response as compared to the rest. The enhanced sensing capability of the Ni0.1Zn0.9Fe2O4 based sensor stems from combined effects of high concentration of surface defects and Fe2+ cations in the octahedral sites which promoted greater adsorption of oxygen species and adsorption capacity. The gas sensing mechanism of the Ni0.1Zn0.9Fe2O4 sensor was therefore explained in consideration of a higher surface reaction which occurs at its surface due to higher adsorbed oxygen molecules serving as direct adsorption sites for oxygen and acetone.