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# CRYSTALLOGRAPHIC EVOLUTION AND PHASE INTERACTIONS IN ZSM-5-MODIFIED ZnO NANORODS: A POWDER X-RAY DIFFRACTION STUDY

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Zinc oxide (ZnO) nanorods possess promising semiconducting, piezoelectric, and gas-responsive properties, making them attractive for sensing, catalysis, and environmental remediation. However, their structural stability and performance are often hindered by surface reactivity, structural imperfections, and aggregation under operational conditions. This study investigated the effect of incorporating Zeolite Socony Mobile-5 (ZSM-5) in different weight ratios on the crystal structure of ZnO nanorods, using powder X-ray diffraction (PXRD) to analyse phase interactions, crystallite size, and peak positions. PXRD analysis revealed that increasing ZSM-5 content in ZnO nanorods (ZnO:ZSM-5 = 10:1, 7:1, 4:1, 1:1, 1:4 and 1:7) leads to weakened, broadened, and shifted ZnO peaks, indicating reduced crystallinity, increased lattice strain, and structural confinement. In contrast, ZSM-5 peaks became sharper and more dominant. To determine whether ZnO peak broadening is due to crystallite size reduction, lattice strain, or both, the crystallite size was estimated using the Scherrer equation. Pristine ZnO nanorods exhibited a large crystallite size of 481±10 nm, indicating unrestricted growth. With ZSM-5 addition, the crystallite size gradually decreased due to zeolite-induced confinement and surface interactions. The smallest crystallite size, about 222±10 nm, was observed at a ZnO:ZSM-5 ratio of 1:4. Beyond this ratio, crystallite size slightly increased again, likely due to particle agglomeration or structural rearrangement. These findings show the effect of ZSM-5 incorporation on the ZnO nanorods' crystal structure. As ZSM-5 content increases, ZnO peaks weaken and broaden, suggesting increased strain and reduced structural order, while crystallite sizes decrease at moderate ratios due to constrained growth. Slight size increases at higher ZSM-5 content may result from aggregation. This study highlights how zeolite loading modulates ZnO nanostructures and provides a basis for optimizing hybrid materials. Future studies should employ Rietveld refinement and high-resolution transmission electron microscopy to better understand strain effects and guide the development of more stable, high-performance materials.

**Keywords:** Crystallite size, Nanorods, Zeolite, Zinc oxide