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Size control mechanism of ZnO nanoparticles obtained in microwave solvothermal synthesis

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Statement of the Problem: The properties of ZnO nanostructures result to a large extent from the specificity of the method of production: Conditions of synthesis, nature of the solvent and substrates used. The way to control and understand the impact of synthesis parameters on the properties of the obtained ZnO NPs is to learn the mechanism of their synthesis. The solvothermal method is a popular method of synthesizing ZnO NPs. The relevant literature reveals several attempts to roughly understand the mechanism of solvothermal synthesis of ZnO. The process examined was consisted in the microwave heating of a $Zn(CH_3COO)_2 \bullet 2H_2O$ solution in $C_2H_4(OH)_2$ in a pressure chamber. Author observed that during the synthesis of ZnO NPs, the size of ZnO was a function of water concentration in the solvent used. By controlling the water concentration in the precursor, it is possible to control the size of the obtained ZnO NPs in a repeatable manner.

Methodology & Theoretical Orientation: The aim of this study was to determine the impact of H_2O on the course of ZnO synthesis reaction. Author examined the following properties of products for different synthesis durations: phase composition, morphology, chemical composition, functional groups, pycnometric density, specific surface area, specific conductance of suspension, pH of suspension, change of H_2O content.

Findings: The intermediates of the microwave solvothermal synthesis reaction of ZnO are $Zn_5(OH)_8(CH_3COO)_2 \bullet xH_2O$ as well as water and esters.

Conclusion & Significance: The mechanism of the solvothermal synthesis of ZnO can be divided into three stages: Formation of the intermediate, $Zn_5(OH)_8(CH_3COO)_2 \bullet xH_2O$, and its growth; decomposition of $Zn_5(OH)_8(CH_3COO)_2 \bullet xH_2O$ to ZnO and; growth of ZnO. The greater the water content in the precursor, the lower the temperature and the greater the speed of $Zn_5(OH)_8(CH_3COO)_2 \bullet xH_2O$ decomposition. $Zn_5(OH)_8(CH_3COO)_2 \bullet xH_2O$ decomposes into ZnO sized ≈13-15 nm, which grow until the building material, $Zn(CH_3COO)_2 \bullet 2H_2O$, is exhausted.

Biography

Jacek Wojnarowicz researches and develops the microwave hydro-/solvothermal synthesis of nanoparticles (NPs). He has developed an innovative technology of microwave solvothermal synthesis of ZnO NPs with controlled size. The performance of syntheses of NPs enabled him to learn the advantages and disadvantages of commercial microwave reactors. He makes use of the acquired knowledge to develop new types of microwave reactors constructed in the Laboratory of Nanostructures, Institute of High Pressure Physics-Polish Academy of Sciences, dedicated to hydro-/solvothermal syntheses of NPs. He participated in the creation of the new design of the specialized MSS2 reactor. The unique design of the MSS2 microwave reactor enables him to examine the mechanisms of the NPs synthesis reaction.

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