Low temperature "green" synthesis of ZnO wurtzite nanoparticles: tailoring the process for effective production yield

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INTRODUCTION

At a time of climate emergency, pyroelectric energy harvesting is a promising technology for collecting some of the enormous amount of wasted heat and transforming it into electrical energy. One of the simplest, inherently pyroelectric materials is the hexagonal phase of zinc oxide, also known as wurtzite ZnO. Wurtzite based materials have the advantages of being cheap, non toxic and offering excellent opto-electrical properties. The nanocrystalline wurtzite ZnO, being a RT stable material unlike its bulk counterpart, is interesting for its potential in pyroelectric energy harvesting.

Various synthesis methods have been reported in the literature for obtaining this phase. The aim of our study was to find an appropriate "green" synthesis that can be optimized to increase the nanopowder production in an environmentally friendly and cost-effective way. We chose a *low-temperature aqueous chemical growth method* known to be a high-performance growth technique for ZnO nanostructures.

The influence of several parameters, in particular the type of Zn precursor and the selected precipitating agents, as well as the reaction temperature, were explored to increase the nanopowder production yield. The possibility of reusing the solvent that still contains Zn from the previous reaction was explored as well.

METHODS

1. Wet chemical synthesis
2. Zn source: Zinc acetate dihydrate or Zinc chloride
3. Precipitating agents: NaOH or KOH
4. Solvents: Ethyl alcohol and deionized water
5. Chemicals recycling
6. Process's temperature (room temperature- 60°C)
7. Post-synthesis thermal treatment (100°C for 2 hours)
8. Characterization: XRD (SmartLab Rigaku powder diffractometer), SEM (Zeiss-LEO 1530) .

RESULTS

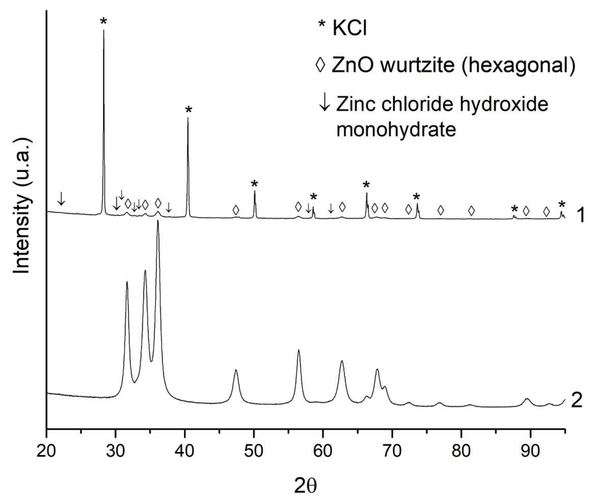

Figure 1. XRD patterns of ZnO nanopowders produced using: 1) Zinc Chloride and KOH, 2) Zinc Acet. Dihydrate and NaOH.

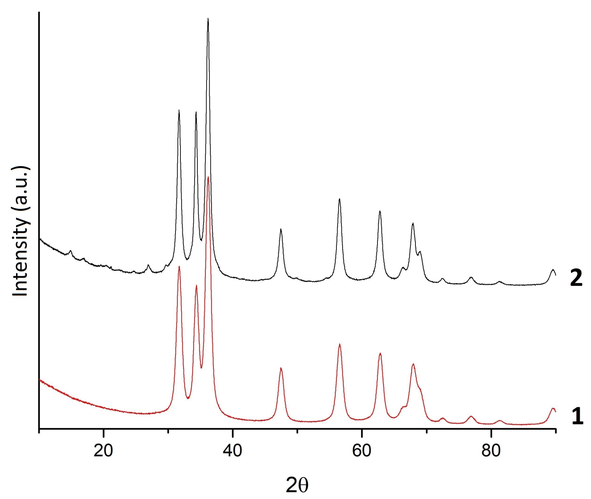

Figure 2. XRD patterns of 1) sample #2 (red line) and 2) sample with chemical recycling (black line).

DISCUSSION

- The synthesis route used for sample #1 production needs to be improved.
- The synthesis used for sample #2 production was optimized by altering some parameters to increase the ZnO nanopowder production yield.
- Using Zinc acetate dihydrate and NaOH (Zinc acet. dehydr./NaOH =2) in ethanol a high efficiency of ZnO nanopowder was obtained (sample #2).

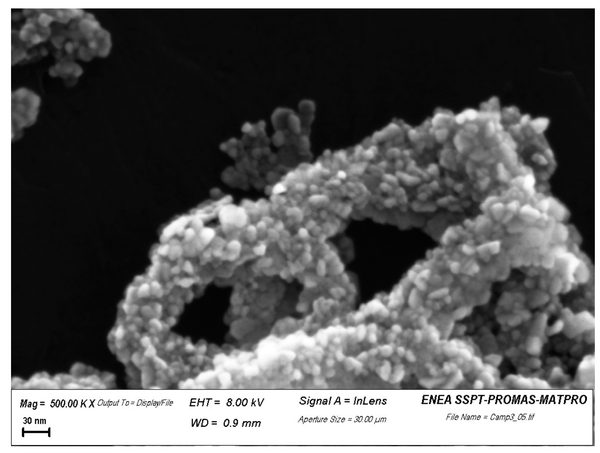

Figure 3. Nanocrystalline wurtzite ZnO with nanoparticles of approx. 10 nm in size, sample #2

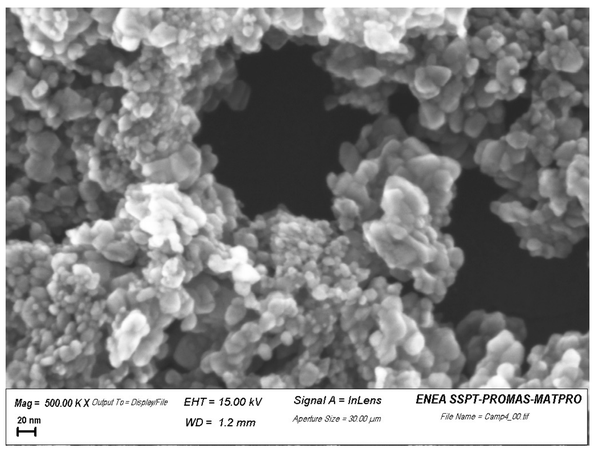

Figure 4. Nanocrystalline wurtzite ZnO with nanoparticles of approx. 10 nm in size, sample #1

ZnO nanopowder of wurtzite hexagonal structure, made up of spherical NPs with a size of about 10 nm, was obtained under mild synthesis conditions (working temperature of 60°C for 2 hours).
Following these successful preliminary results, we plan to improve the production yield of ZnO wurtzite nanopowders. We aim to tailor this simple synthesis method for nanocrystalline wurtzite ZnO production, which would be easy to scale up. Our next step is to use an in-house pilot plant to produce substantial amounts of wurtzite ZnO nanopowder in an environmentally friendly and cost effective way.

Ref: Yang Y., Guo W., Pradel K.C., Zhu G., Zhou Y., Zhang Y., Hu Y., Lin L., Wang Z.L. Pyroelectric Nanogenerators for Harvesting Thermoelectric Energy. Nano Lett. 2012;12:2833–2838. doi: 10.1021/nl3003039

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