ZnO synthesis from Zn-C and alkaline spent batteries by alkaline leaching: properties and applications

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Abstract

This report describes the leaching experiments to recover Zn from spent household Zn-C and alkaline batteries. Basic zinc carbonate $Zn_5(CO_3)_2(OH)_6$ nanoparticles have been successfully synthesized by the leaching of an ammoniacal ammonium carbonate solution of black mass. Zinc oxide (ZnO) were prepared by the thermal decomposition of basic zinc carbonate precursor. The synthesis of ZnO micro and nanostructures is carried out through the vapor solid growth process.

Synthesis of ZnO

Leaching, evaporation and calcination

Leaching

Black mass + $NH_3/(NH_4)_2(CO_3)$ → $Zn_5(OH)_6(CO_3)_{2\ (ac)}$

Zincite (ZnO), Hetaerolite ($ZnMn_2O_4$) Silvite (KCl), Graphite, Ca_6Mn_8

0.1mol/L NH_3
1.72 mol/L $(NH_4)_2(CO_3)$
2800 rpm / 2 h.
100 g/L black mass

Evaporation

Rotavapor/34 bars/56ºC

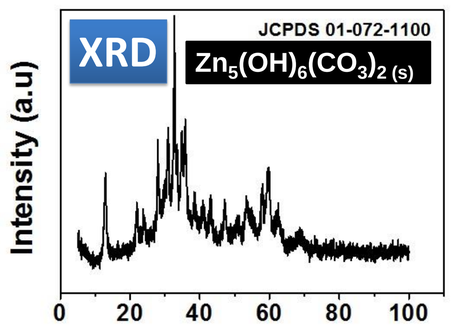
$Zn_5(OH)_6(CO_3)_{2\ (ac)} \rightarrow \mathbf{Zn_5(OH)_6(CO_3)_{2\ (s)}} + NH_{3\ (ac)} + H_2O_{(ac)}$

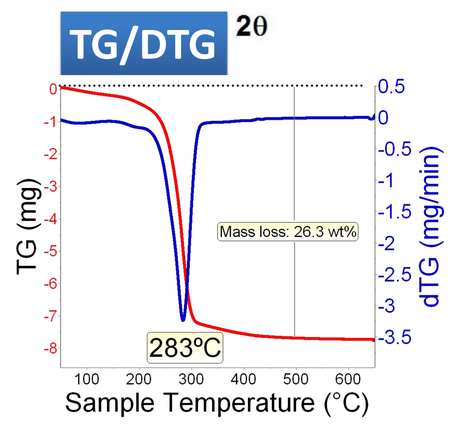
Calcination

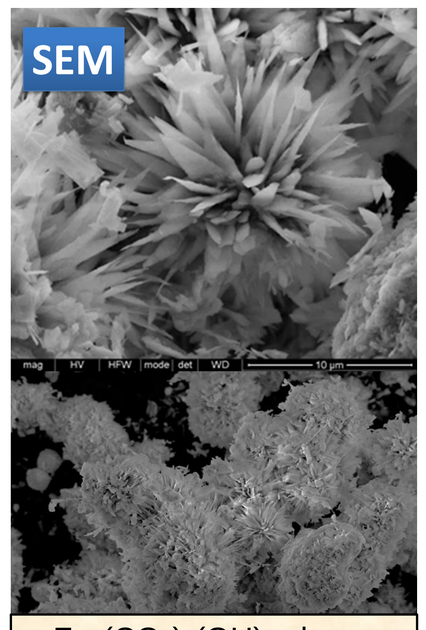
800ºC/5 h

$Zn_5(OH)_6(CO_3)_{2\ (s)} \rightarrow 5\mathbf{ZnO} + 3H_20 + 2CO_2$

Precursor Characterization

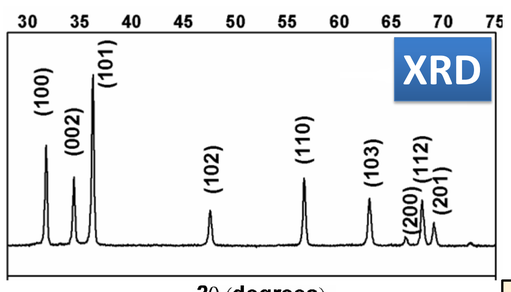




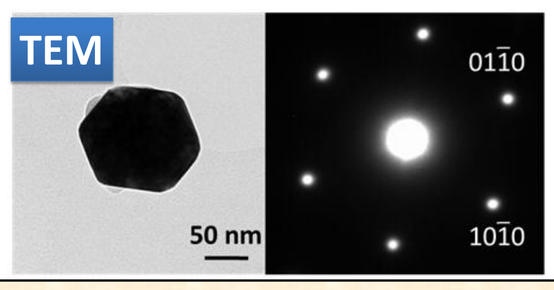


$Zn_5(CO_3)_2(OH)_6$ shows structures such as **microflowers**

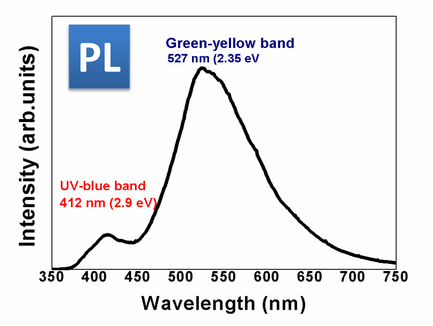
ZnO characterization



Wurtzite ZnO phase (JCPDS card No. 01-079-0206)



Nanometric hexagonal plates. The SAED patterns revealed the values *d*=2.86 and *c*=5.19 Å which correspond to a lattice spacing of {1010} planes.



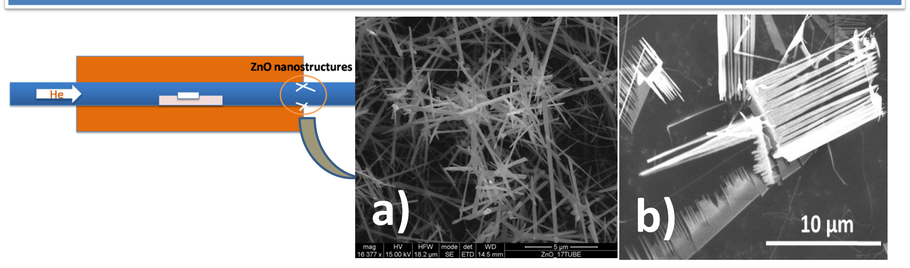
RAMAN

Raman Spectroscopy (λ= 633 nm)
Peaks centered in 102, 204, 131, 330, 382, 438, 580 cm^{-1} reveal **wurtzite structure of ZnO**

- ✓ **Presence of oxygen vacancies**
- ✓ **Intrinsic defects** such as Zn interstitials, oxygen vacancies and Zn vacancies, along with complex extrinsic defects.

High degree of crystalinity

ZnO nanostructures



Nanocombs (a) and nanobelts (b) were obtained at lower temperature due to the thermal gradient of the furnace and were extracted from scratching the tube walls.

Conclusions

Properties of synthesized ZnO are comparable to those reported for commercial ZnO powders.
ZnO powders obtained by recycling of spent batteries are suitable for growing micro and nanostructures.

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