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$ZnFe_2O_4$ nanoparticles synthesis by laser pyrolysis: interest as new anode material for lithium-ion batteries

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The development of portable devices, electric vehicles and renewable energies has motivated research works about energy storage for years. Existing lithium-ion batteries cannot reach sufficient energy density to address the needs for such applications. One of the issues limiting the energy density is the low specific capacity of the graphite anode (372 $mAh.g^{-1}$).
Mixed-transition metal oxides with a spinel structure (AB_2O_4 – A, B transition metals) appear as a promising solution to replace graphite with a higher theoretical capacity (between 750 and 1000 $mAh.g^{-1}$). Nanostructuration of these compounds was studied to maintain mechanical stability and to enhance lithiation kinetics. $ZnFe_2O_4$ is an interesting substitute to graphite as the storage mechanism gives rise to a theoretical capacity of 1001 $mAh.g^{-1}$ and among various oxides, $ZnFe_2O_4$ is cheap, abundant and non-toxic.
Compared with oxides like Fe_2O_3, the combination of two transition metals contributes to lower the working voltage vs. Li/Li^+ (1.5V for $ZnFe_2O_4$ vs. 2.1V for Fe_2O_3).
$ZnFe_2O_4$ nanoparticles were synthesized by laser pyrolysis. In this process, an aerosol containing precursors droplets produced by a nebulizer, is flown into the reactor with a carrier gas. In the reactor, a 10.6 µm-CO_2 laser beam decomposes the precursors to obtain nanopowders which are then collected on a filter. The key advantage of laser pyrolysis is the ability to obtain nanomaterials in large scale with a high purity while controlling the grain size with the appropriate parameters.
Solutions containing $Zn(NO_3)_2.6H_2O$ and $Fe(NO_3)_3.9H_2O$ dissolved in deionized water were used for the synthesis of $ZnFe_2O_4$ nanoparticles. Ethylene was used as sensitizer gas to absorb the CO_2 laser and allow the decomposition of the precursors whereas air and argon were tested as carrier gases. Powders of different morphologies and crystallinities were obtained and characterized by XRD, SEM, EDX, HRTEM and XPS. ZnO and Fe_2O_3 were also synthesized to compare their electrochemical performances with those of $ZnFe_2O_4$. All the results were compared with literature.