Dispersion of NiO and $Ni(OH)_2$ in aqueous media

colloidal processing

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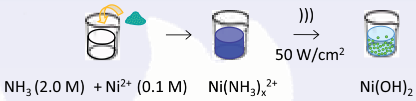
OBJECTIVES

- Synthesis of sub-micrometer $Ni(OH)_2$ and NiO powders.
- Study the effect of an anionic surfactant (polyacrylic acid) in the colloidal stability of the synthesized powders in terms of zeta potential and mean particle size.
- Fabricate a Ni-Al_2O_3 composite by slip casting with highly dispersed metallic nickel particles within the alumina matrix.

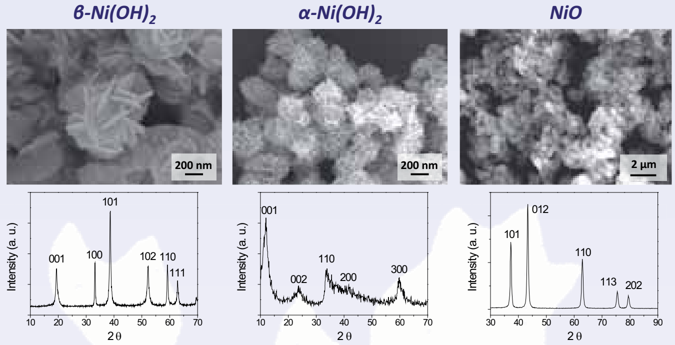
SYNTHESIS

$Ni(OH)_2$ is synthesized with the aid of ultrasound and using Ni(NO3)2·6H2O as nickel source and a 2M NH_3 solution.

Depending on the Ni^{2+} concentration and the way the reactants are mixed, two different polymorphs (α and β-Ni(OH)2) can be obtained.



The calcination of α-$Ni(OH)_2$ at 400 °C/15 min results in NiO.



	β-$Ni(OH)_2$	α-$Ni(OH)_2$	NiO
SSA (m^2/g)	30.3	73.0	42.3
ρ (g/cm^3)	3.9	2.7	5.6
D_{BET} (nm)	51.0	30.0	25.3

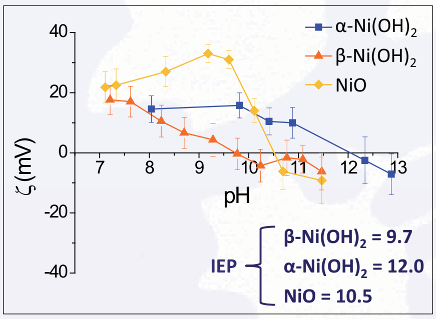
Specific surface area, density and BET diameter

COLLOIDAL STABILITY

Colloidal stability was evaluated in terms of zeta potential and particle size.

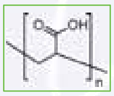
The isoelectric point (IEP) and the optimal surfactant concentration were measured using solid contents of 0.1 % in a KCl 10^{-2} M solution. Samples were ultrasonically homogenized for 1 min before measuring.

Zeta potential vs pH



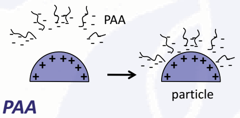
Dispersion guideline

According to the measured IEP's, at pH ~ 9.5 the three powders present positive zeta potential. For this reason, an anionic surfactant (derived from polyacrylic acid, PAA) was used for particles stabilization. PAA was expected to generate the electrosteric mechanism allowing the particles to remain dispersed within the slurry.

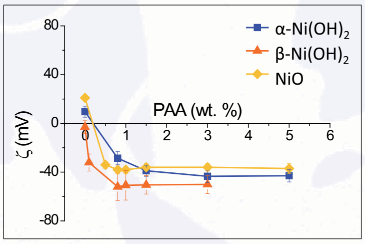


PAA, M_w = 2000

Electrosteric mechanism scheme

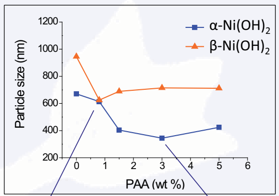


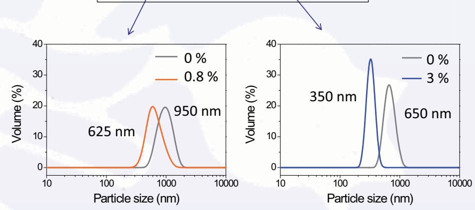
Zeta potential vs PAA



The measure of particle size vs PAA content for $Ni(OH)_2$ slurries shows that the smallest particle sizes are obtained when using the optimal PAA concentration previously calculated.

Particle size vs PAA





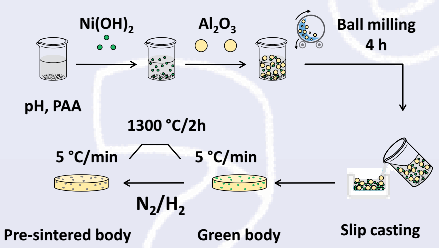
The higher the SSA, the higher the PAA content to stabilize the particles.

Ni/Al_2O_3 COMPOSITE

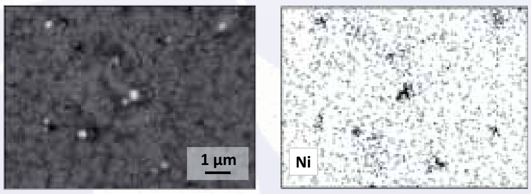
As α-$Ni(OH)_2$ presents smaller particle sizes than the β phase, it was chosen to be incorporated into an alumina matrix in order to fabricate a Ni/Al_2O_3 composite where the nickel hydroxide would be reduce during the sintering process.

Suspension 30 vol. %, pH ~ 9.5

- 2 vol. % Ni (6.7 wt. % α-$Ni(OH)_2$); 3 wt. % PAA
- 98 vol. % Al_2O_3; 1 wt. % PAA

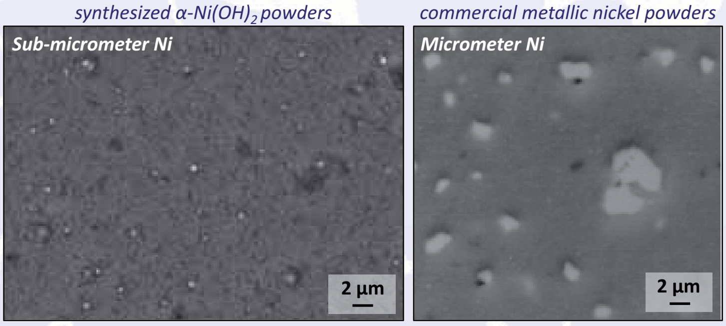


The nickel mapping image of pre-sintered Ni/Al_2O_3 composite obtained by colloidal processing shows a well dispersed nickel phase within the alumina matrix.



Ni/Al_2O_3 composite fabricated using synthesized α-$Ni(OH)_2$ powders

Ni/Al_2O_3 composite fabricated using commercial metallic nickel powders



The incorporation of synthesized $Ni(OH)_2$, instead of the addition of commercial metallic nickel, leads to smaller nickel grain sizes within the composite structure and favored the colloidal processing due to the better compatibility between alumina and nickel hydroxide powders.

CONCLUSIONS

- The optimal dispersion conditions for α-$Ni(OH)_2$, β-$Ni(OH)_2$ and NiO powders have been established by measuring the isoelectric points (α-$Ni(OH)_2$→12; β-$Ni(OH)_2$→9.7; NiO →10.5), the optimal PAA concentration (α-$Ni(OH)_2$→ 3 wt. %; β-$Ni(OH)_2$→0.8 wt. %; NiO →0.8 wt. %) and the particle size (α-Ni(OH)20.6 µm → 350 nm; β-Ni(OH)2 1 µm→ 0.6 µm).
- Stabilization conditions for the α-$Ni(OH)_2$ powders were used to fabricate a Ni/Al_2O_3 composite with highly dispersed nickel phase within the alumina matrix and particles sizes < 1 µm.

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