Supporting Information

Evolution and magnetic characteristics of NiO/Ni(OH)$_2$ core-shell nanostructures

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Experimental details:

Nickel oxide nanostructures were synthesized by a co-precipitation route followed by calcination.[1,2] The precursor β-Ni(OH)$_2$ was prepared by reacting aqueous solutions of nickel nitrate and sodium hydroxide (both AR grade reagents). The green coloured nickel hydroxide precipitate obtained was washed several times with deionized water and dried in an oven. This dried precursor was calcined at 300 °C in air for 3 hrs to get nickel oxide nanostructures. The freshly calcined sample was dispersed in water for various durations and then the samples were filtered and dried in air to get NiO/Ni(OH)$_2$ core-shell type nanostructures. The different samples are labelled as 'NiO-X' where 'X' is time of dispersion in hours (0 for freshly calcined sample). The sample exposed to air for 6 months is labelled as NiO-6M. α-Ni(OH)$_2$ was also synthesized by the method reported in the literature,[3] for comparison of the results.

Powder X-ray diffraction:

X-ray diffraction patterns of α-Ni(OH)$_2$ and β-Ni(OH)$_2$ are compared with water treated NiO-96 and air oxidised NiO-6M samples (Fig. S1). The XRD data of water treated and air oxidised nickel oxide samples do not show any additional peaks of Ni(OH)$_2$. This can be clearly seen in the inset of Fig. S1, where powder XRD pattern of NiO-6M recorded at very slow scanning rate is shown. Fig. S2 shows XRD patterns of other NiO-X samples which are dispersed in water for 'X' hours (X= 1, 12, 48, 72).

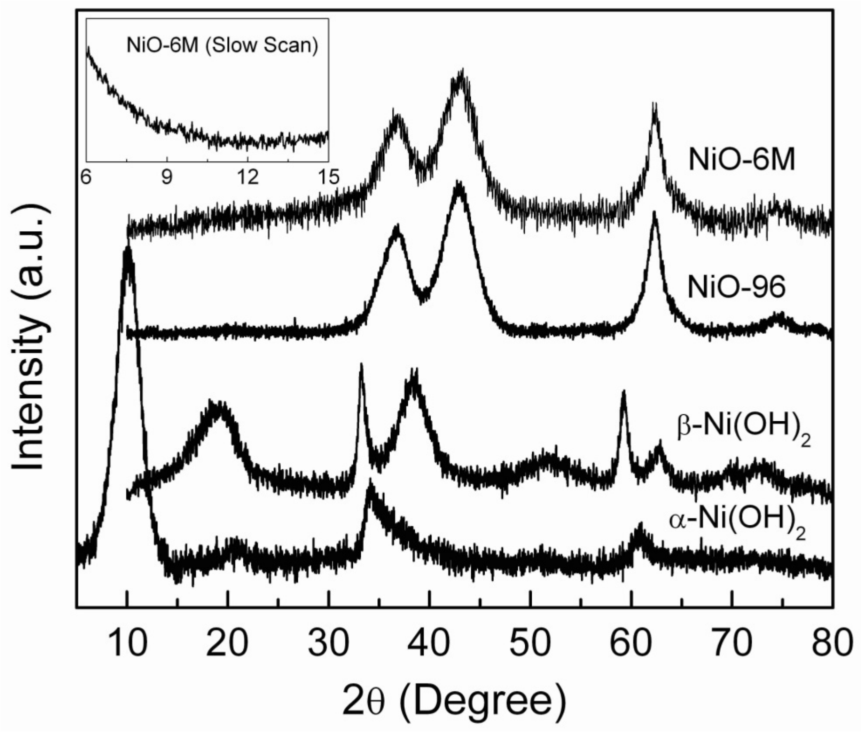

Fig. S1 Powder XRD patterns of the precursor β-$Ni(OH)_2$, α-$Ni(OH)_2$, NiO-96 and NiO-6M. Inset shows XRD pattern of NiO-6M recorded at a very slow scan rate to show the absence of the intense peak from α-$Ni(OH)_2$.

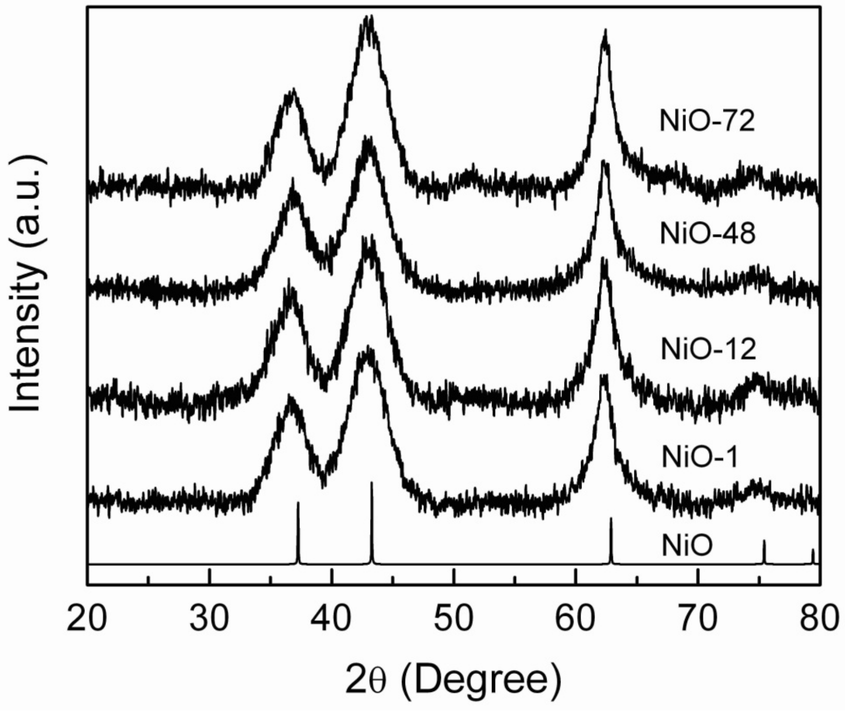

Fig. S2 Powder XRD patterns of NiO-X samples dispersed in water for 'X' hours and the simulated pattern of NiO.

TEM images of NiO-6M:

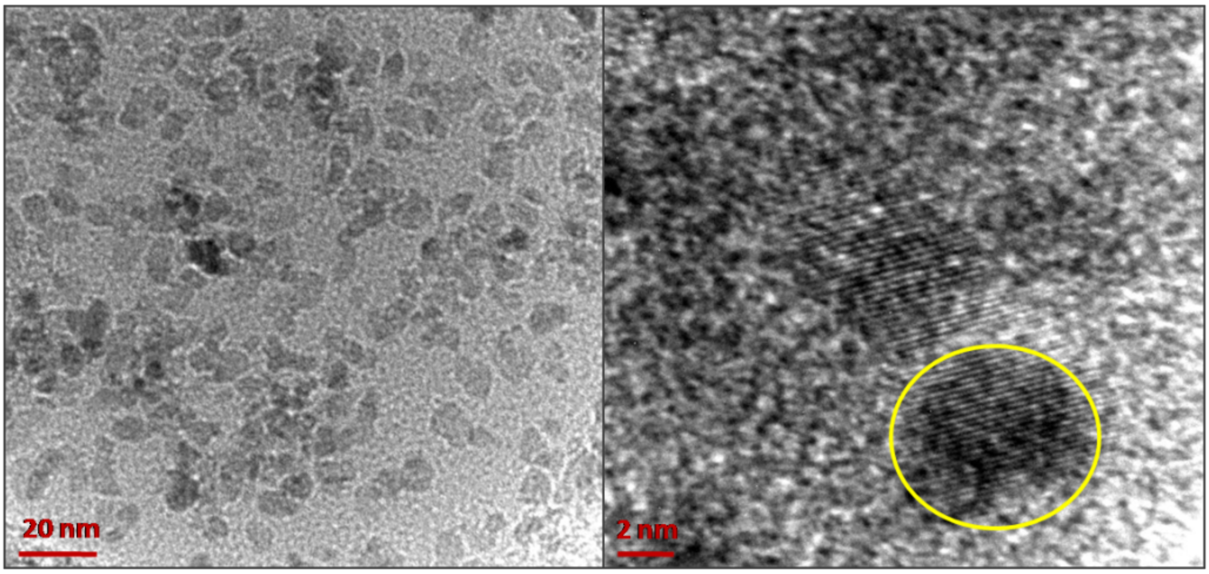

Fig. S3 TEM images of NiO-6M.

Magnetic measurements:

The zero field cooled (ZFC) and field cooled (FC) curves of α-Ni(OH)$_2$ and β-Ni(OH)$_2$, measured in a field of 100 Oe are shown in Fig. S4. The higher magnetization of α-Ni(OH)$_2$ is due to the ferromagnetic nature of the material, whereas β -Ni(OH)$_2$ is antiferromagnetic in nature.[4] The peak temperatures in the ZFC curves of α-Ni(OH)$_2$ and β-Ni(OH)$_2$ are obtained as 17 K and 22 K, respectively, and are comparable to the reported values.[4,5,6] The zero field cooled (ZFC) magnetization curves of α-Ni(OH)$_2$ and β-Ni(OH)$_2$ compared with that of air oxidised sample NiO-6M and NiO-PM which is a physical mixture of 95% NiO-0 and 5% α-Ni(OH)$_2$) samples by weight are shown in Fig. S5. An increase in the magnetization is observed below 25 K in the ZFC curve of NiO-6M with a peak maximum at 8 K, which is observed to be closer to the magnetic characteristics of α-Ni(OH)$_2$.

Magnetization Vs field curves of NiO-96 and physical mixtures of α-Ni(OH)$_2$ and β-Ni(OH)$_2$ (95% NiO-0 and 5% Ni(OH)$_2$ by weight) are shown in Fig. S6. The magnetic characteristics of NiO-96 observed is closer to that of the physical mixture of NiO-0 and α-Ni(OH)$_2$. The decrease in the coercivity of NiO-96 can be due to the reduced interactions between the bare NiO-0 particles and/or the lowering of the size of core NiO.

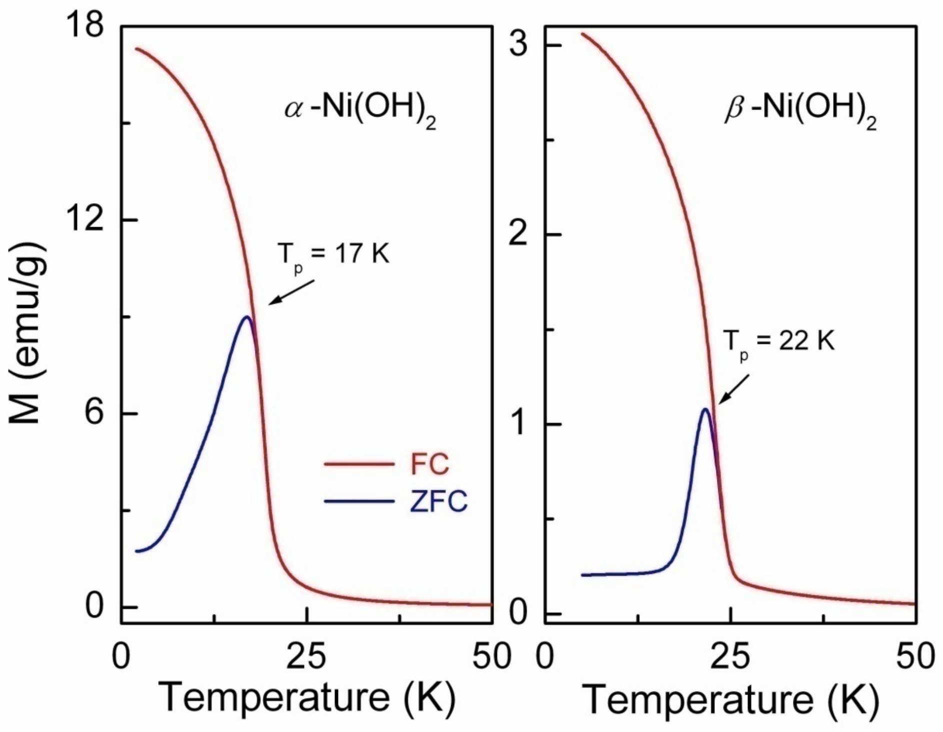

Fig. S4 Zero field cooled (ZFC) and field cooled (FC) magnetization curves of α-Ni(OH)$_2$ and β-Ni(OH)$_2$.

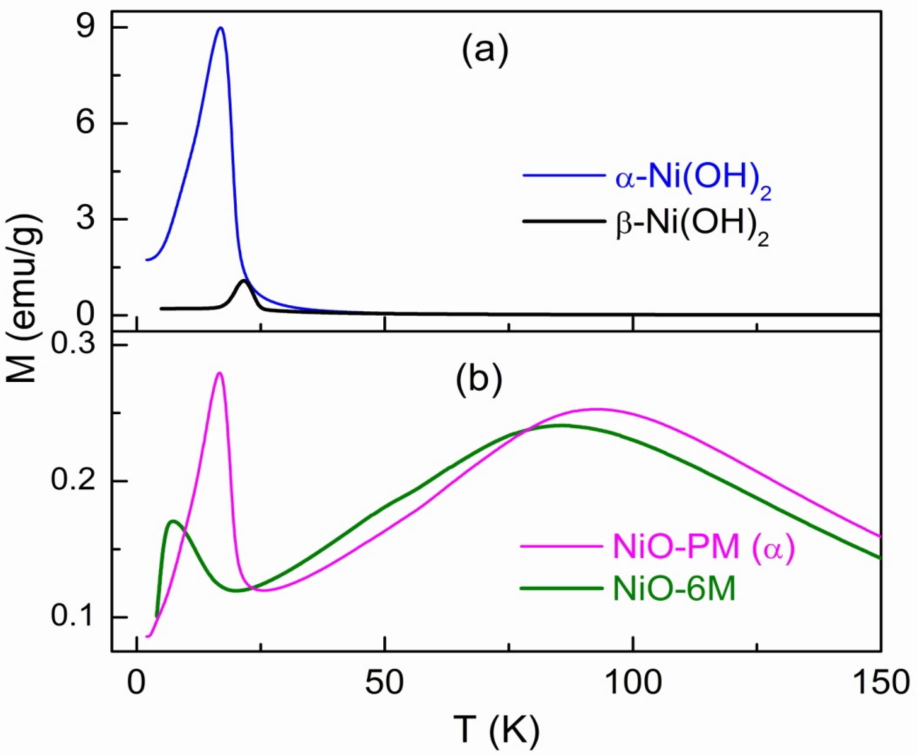

Fig. S5 Comparison of the zero field cooled (ZFC) magnetization curves of (a) β-Ni(OH)$_2$ and α-Ni(OH)$_2$, and (b) a physical mixture of 95% NiO and 5% α-Ni(OH)$_2$ (NiO-PM), and NiO-6M.

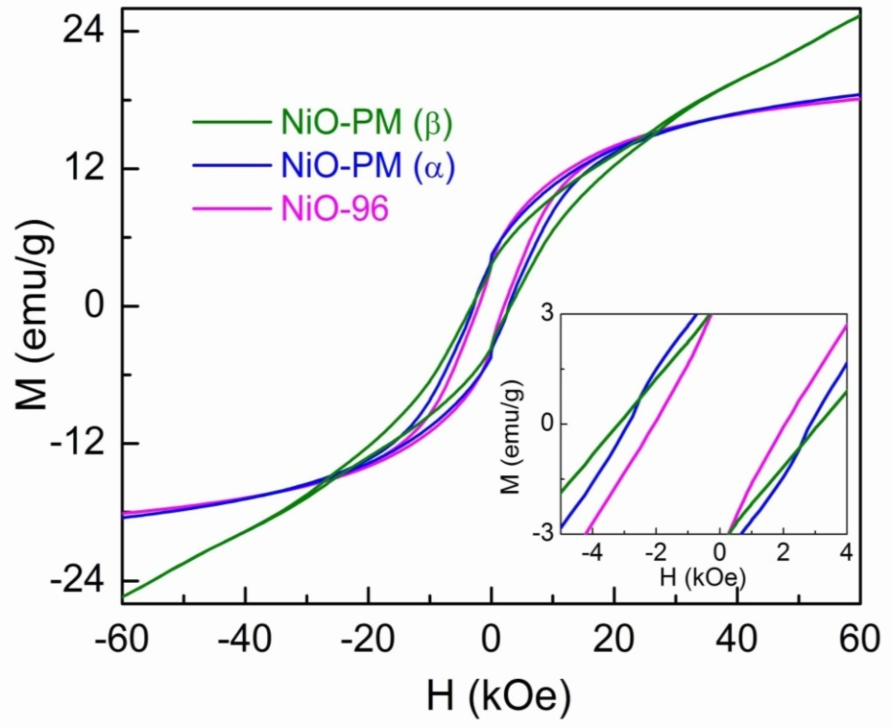

Fig. S6 Magnetization Vs field curves of NiO-96, physical mixture of 95% NiO and 5% $Ni(OH)_2$ (both α and β phases) NiO-PM (α) and NiO-PM (β) measured at 5 K. Inset shows enlarged curves at low field region.

References for Supporting Information:

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