

Supporting Information

Fabrication of NiCo₂O₄@CeO₂ Core@shell Nanotubes with Enhanced Catalytic Performances

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Experimental Section:

NiCo-LDH precursors: the synthetic process is according to the previous report by Lou's group.³¹ Typically, 0.5 mmol of $\text{Ni}(\text{Ac})_2 \cdot 4\text{H}_2\text{O}$ and 1 mmol of $\text{Co}(\text{Ac})_2 \cdot 4\text{H}_2\text{O}$ are dissolved into 3 mL of 1,3-propanediol completely. Then, 47 mL of isopropanol is added into the above solution to form a pink solution. Thereafter, the resulting mixture is transferred into a Teflon-lined stainless steel autoclave and kept at 160 °C for 12 h. Finally, the NiCo-LDH precursors are collected by centrifugation.

For pure Ni or Co hydroxides, the synthetic method is similarly with NiCo-LDH, the only difference is using 1.5 mmol $\text{Ni}(\text{Ac})_2 \cdot 4\text{H}_2\text{O}$ or 1.5 mmol of $\text{Co}(\text{Ac})_2 \cdot 4\text{H}_2\text{O}$ to replace 0.5 mmol of $\text{Ni}(\text{Ac})_2 \cdot 4\text{H}_2\text{O}$ and 1 mmol of $\text{Co}(\text{Ac})_2 \cdot 4\text{H}_2\text{O}$ in the reaction solution.

NiCo_2O_4 , Co_3O_4 and NiO products: The as-obtained precursors are heated in air directly at 300 °C for one hours (1 °C/min).

$\text{NiCo}_2\text{O}_4@ \text{CeO}_2$ core@shell nanotubes: 60 mg NiCo_2O_4 nanotubes is first dispersed in a mixture contained 20 mL water and 20 mL ethanol. Then, 2 mL $\text{Ce}(\text{NO}_3)_3$ aqueous solution (0.1 M) and 3 mL hexamethylenetetramine aqueous solution (HMT, 0.1 M) are added in turn, followed by a heating treatment at 70 °C for two hours. Then the as-obtained products are purified by centrifugation, and washed with water and ethanol for two times.

$\text{Co}_3\text{O}_4@ \text{CeO}_2$ and $\text{NiO}@ \text{CeO}_2$ core@shell samples are synthesized via the similar process expect by using Co_3O_4 and NiO sample to replace NiCo_2O_4 samples at the start of the synthetic reaction, respectively.

Characterization: The X-ray diffraction patterns of the products were collected on a Rigaku-D/max 2500 V X-ray diffractometer with $\text{Cu-K}\alpha$ radiation ($\lambda = 1.5418 \text{ \AA}$), with an operation voltage and current maintained at 40 kV and 40 mA. Transmission electron microscopic (TEM) images were obtained with a TECNAI G2 high-resolution transmission electron microscope operating at 200 kV. XPS measurement was performed on an ESCALAB-MKII 250 photoelectron spectrometer (VG Co.) with $\text{Al K}\alpha$ X-ray radiation as the X-ray source for excitation.

Catalytic test: 50 mg catalysts are put in a stainless steel reaction tube. The experiment is carried out under a flow of reactant gas mixture (1% CO, 99% air) at a rate of 50 mL/min.

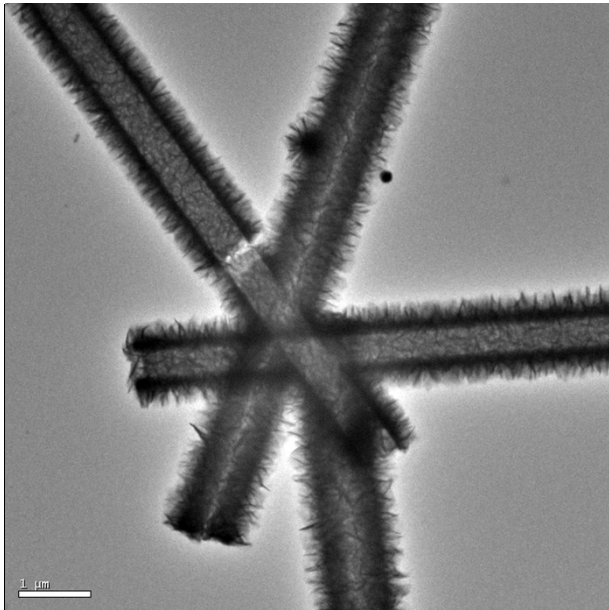


Figure S1. TEM image of the as-obtained NiCo-LDH nanotubes.

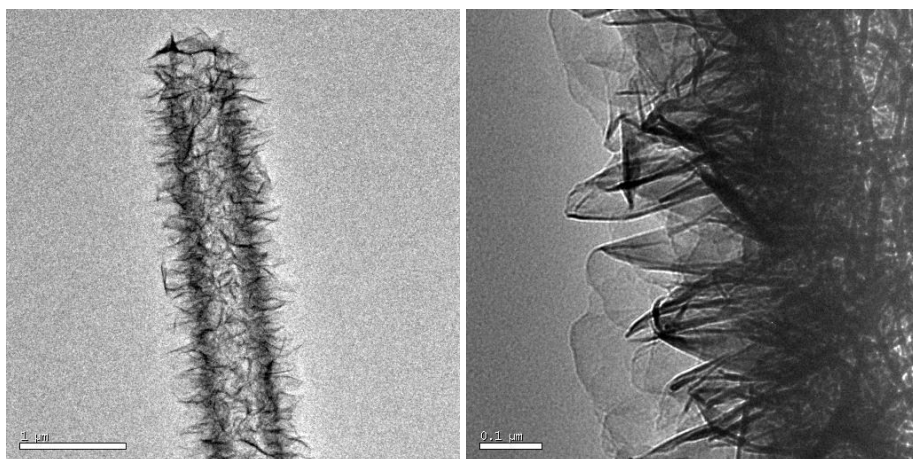


Figure S2. TEM images of NiCo₂O₄ nanotubes obtained by annealing NiCo-LDH at 300 °C for 1 hours.

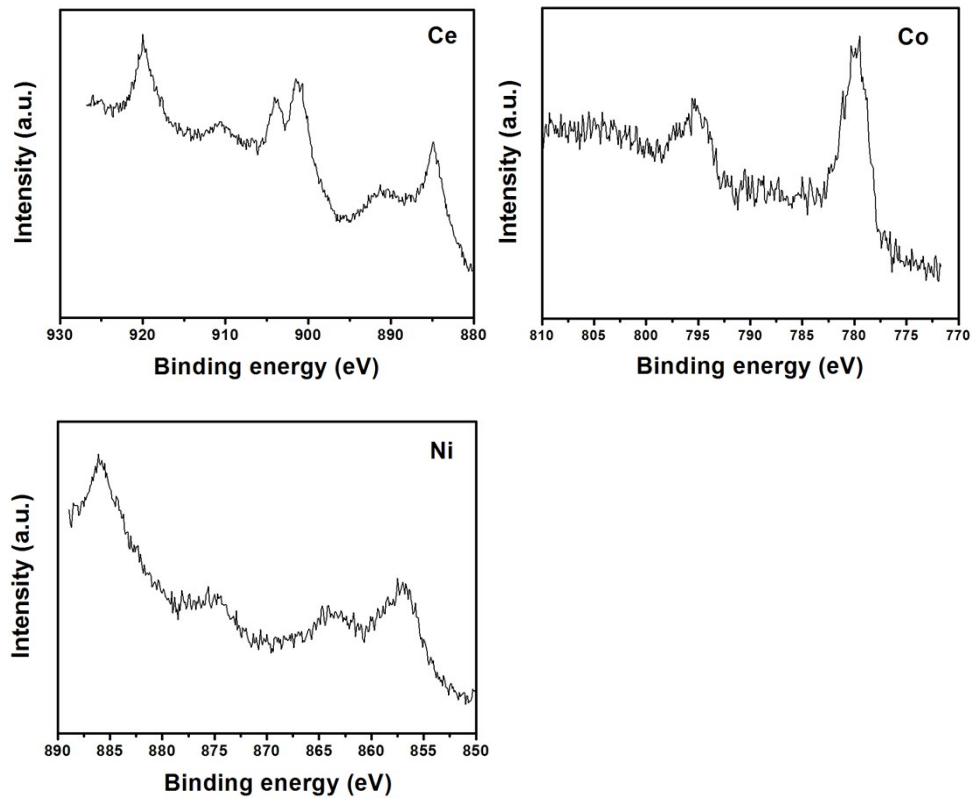


Figure S3. XPS data of NiCo₂O₄@CeO₂-2 core@shell nanotubes.

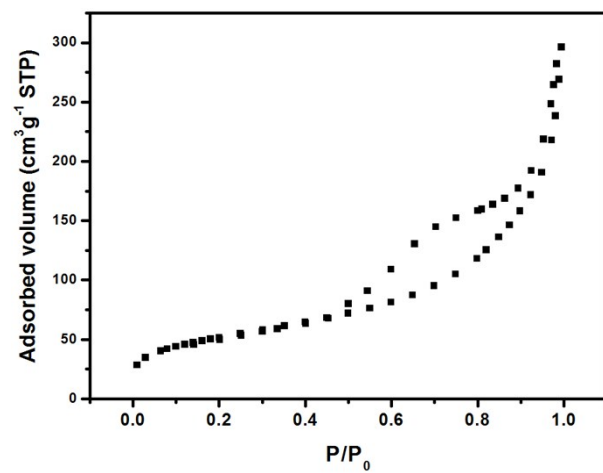


Figure S4. BET data of NiCo₂O₄@CeO₂-2 core@shell nanotubes.

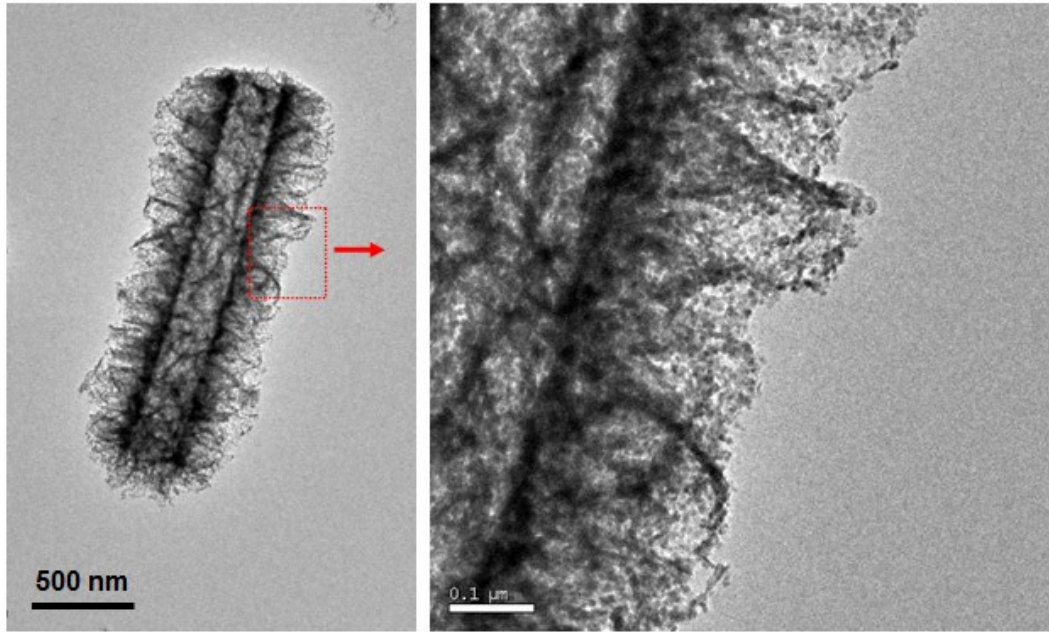


Figure S5. TEM images of NiCo₂O₄@CeO₂-1 core@shell nanotubes.

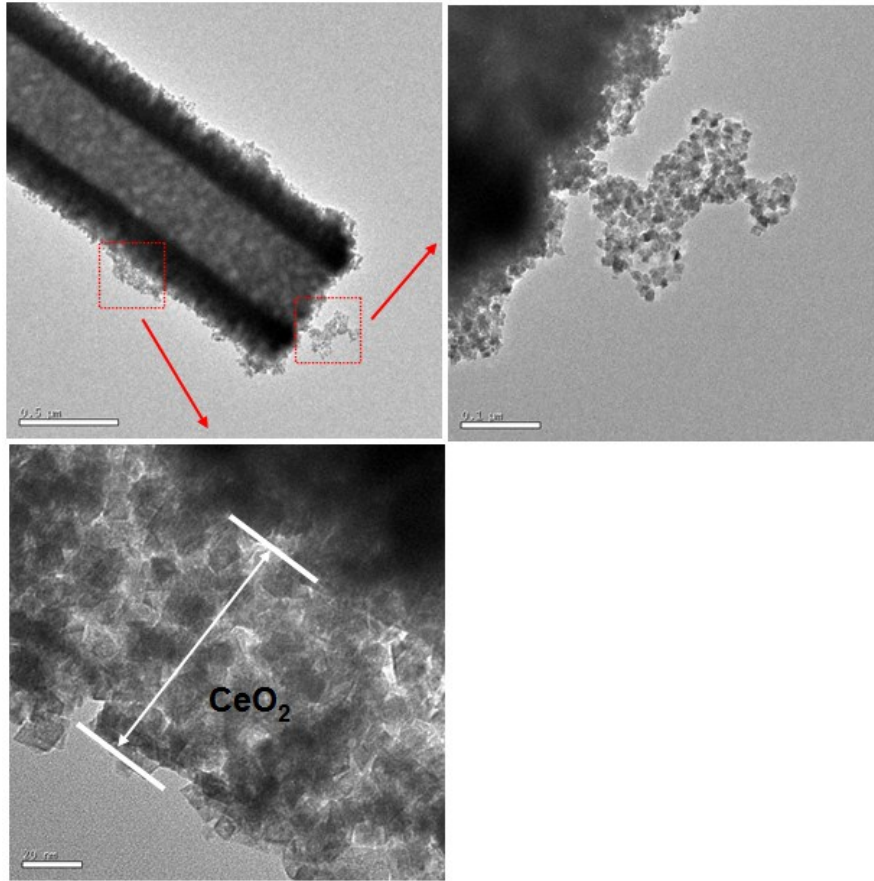


Figure S6. TEM images of $\text{NiCo}_2\text{O}_4@ \text{CeO}_2$ -3 core@shell nanotubes.

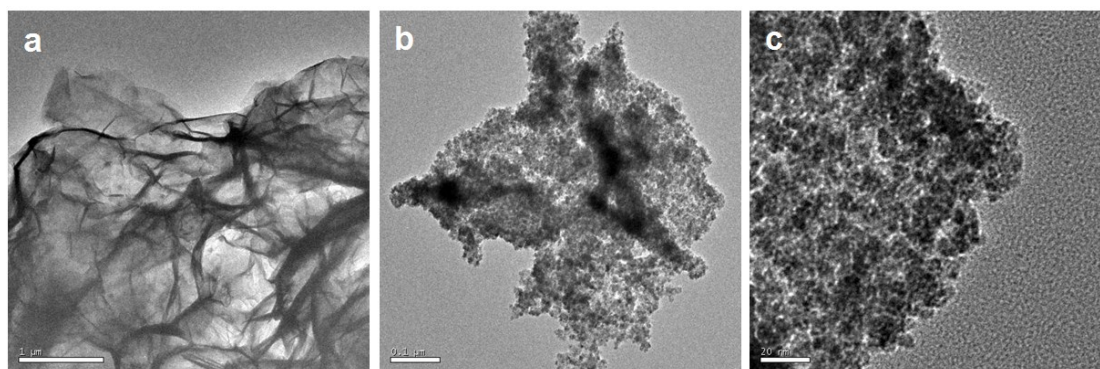


Figure S7. TEM images of Co_3O_4 nanosheets (a) and $\text{Co}_3\text{O}_4@ \text{CeO}_2$ core@shell samples (b and c).

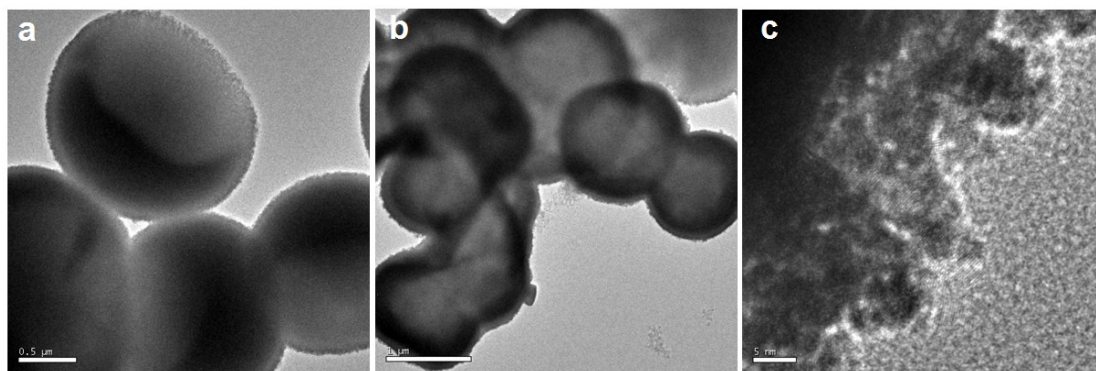


Figure S8. TEM images of NiO nanospheres (a) and NiO@CeO₂ core@shell samples (b and c).

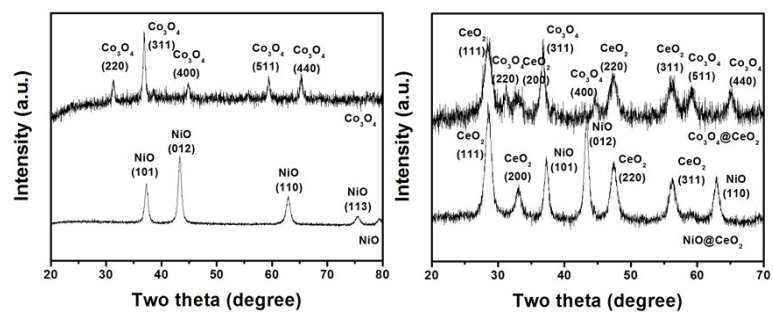


Figure S9. XRD data of the as-obtained NiO, Co₃O₄, NiO@CeO₂ and NiCo₂O₄@CeO₂ samples.

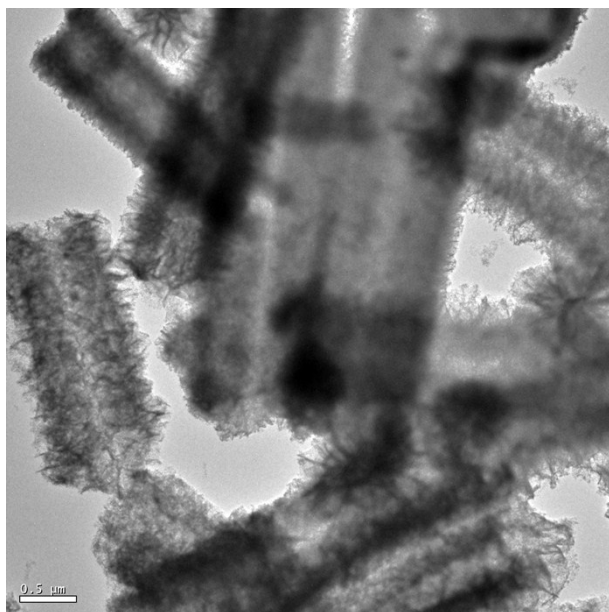


Figure S10. TEM image of NiCo₂O₄@CeO₂-2 sample after the catalytic test.

	NiCo ₂ O ₄ content (wt %)	CeO ₂ content (wt %)
NiCo ₂ O ₄ @CeO ₂ -1	83.3	16.7
NiCo ₂ O ₄ @CeO ₂ -2	64.7	35.3
NiCo ₂ O ₄ @CeO ₂ -3	57.2	42.8

Table S1. NiCo₂O₄ and CeO₂ contents in the as-obtained three kinds of core@shell nanostructures calculated from the ICP results.