Electronic Supplementary Material (ESI) for RSC Advances.

Supporting Information

Comparison of the electrochemical properties of yolk-shell and dense structured $CoFe_2O_4$ powders prepared by spray pyrolysis process

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EXPERIMENTAL DETAILS

Fabrication of yolk-shell and dense $CoFe_2O_4$ powders

In this study, yolk-shell and dense $CoFe_2O_4$ powders were fabricated by a one-pot spray pyrolysis process. In the spray pyrolysis system, droplets were generated using a 1.7-MHz ultrasonic spray generator consisting of six vibrators. The droplets were carried to a quartz reactor of length 1200 mm and diameter 50 mm, using air as carrier gas at a flow rate of 10 L min^{-1}. Reactor temperature was maintained at 900°C. The aqueous spray solution was prepared by dissolving cobalt acetate tetrahydrate and iron nitrate nonahydrate. Total concentration of Co and Fe components dissolved in distilled water was 0.2 M. Sucrose concentration was fixed at 0.7 M for fabrication of yolk-shell-structured $CoFe_2O_4$ powders.

Characterizations

Morphology of the $CoFe_2O_4$ powders fabricated by spray pyrolysis was observed by scanning electron microscope (SEM), (JEOL JSM-6060), and transmission electron microscope (FE-TEM), (JEOL JEM-2100F). Crystal structures of the prepared powders were investigated by X-ray diffraction (XRD), (X'Pert PRO MPD) using Cu Kα radiation (λ = 1.5418 Å) at the Korea Basic Science Institute (Daegu). The amount of carbon in the powders was determined using thermal gravimetric analysis (TGA), (SDT Q600). Specific surface area of the powders was measured by the Brunauer-Emmett-Teller (BET) method using N_2 as the adsorbate gas.

Electrochemical measurements

Electrochemical properties of the prepared powders were analyzed by fabricating a 2032-type coin cell. The anode was prepared from a mixture of the active material, carbon black, and sodium carboxymethyl cellulose (CMC) in a weight ratio of 7:2:1. Li metal and microporous polypropylene film were used as counter electrode and separator, respectively. The

electrolyte was composed of 1 M $LiPF_6$ dissolved in a mixture of fluoroethylene carbonate/dimethyl carbonate (FEC/DMC; 1:1 v/v). Discharge/charge characteristics of the samples were investigated by cycling in the voltage range of 0.001–3 V at various current densities. Cyclic voltammograms (CVs) were measured at a scan rate of 0.1 mV s^{-1}.

Table. S1 Electrochemical properties of $CoFe_2O_4$ materials prepared by various processes.

Electrode	Current rate	Initial C_{dis}/C_{cha} [mA h g^{-1}]	Coulombic Efficiency [%]	Discharge capacity [mA h g^{-1}]	Cycle number	Ref
three-dimensional ordered macroporous $CoFe_2O_4$	0.2 mA cm^{-2}	1782/~1150	65	702	30	[25]
$CoFe_2O_4$ nanorod	1000 mA g^{-1}	1694/1298	77	800	300	[26]
hollow $CoFe_2O_4$ nanosphere	90 mA g^{-1}	2264/~1250	~55	1185	50	[29]
$CoFe_2O_4$/C composite fiber	2 C	1004/-	-	494	700	[14]
mesoporous $CoFe_2O_4$ nanosphere/CNT	200 mA g^{-1}	1517.4/1123.6	74	1045.6	100	[27]
wintersweet-flower like $CoFe_2O_4$/MWCNTs	45 mA g^{-1}	1016/740	73	823	50	[28]
$CoFe_2O_4$/graphene sandwich	800 mA g^{-1}	-/735	-	565	300	[13]
$CoFe_2O_4$/graphene nanocomposite	100 mA g^{-1}	1388/906	65	910	50	[30]
carbon-encapsulated $CoFe_2O_4$/graphene nanocomposite	100 mA g^{-1}	1453.1/917	63	925.6	100	[31]
$CoFe_2O_4$ yolk-shell microsphere	1000 mA g^{-1}	1158/902	78	751	200	this work

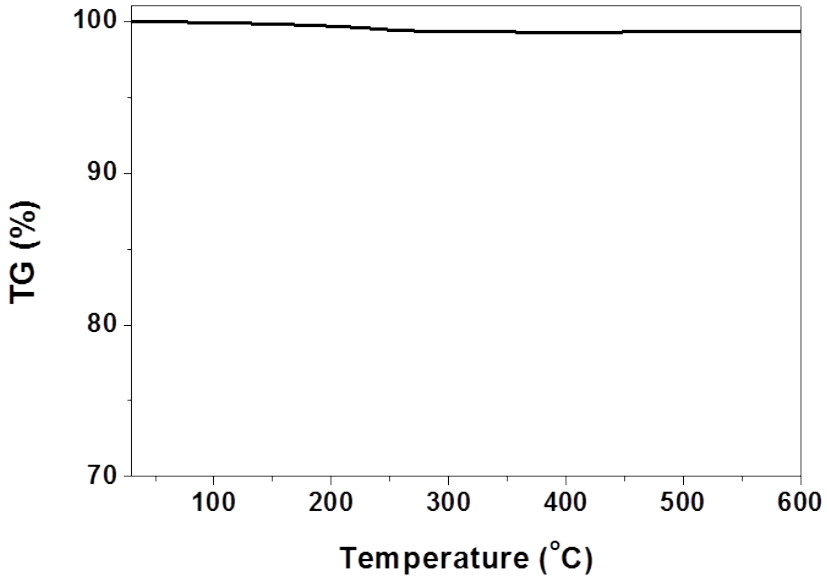

Fig. S1 TG analysis of the yolk-shell $CoFe_2O_4$ powders.

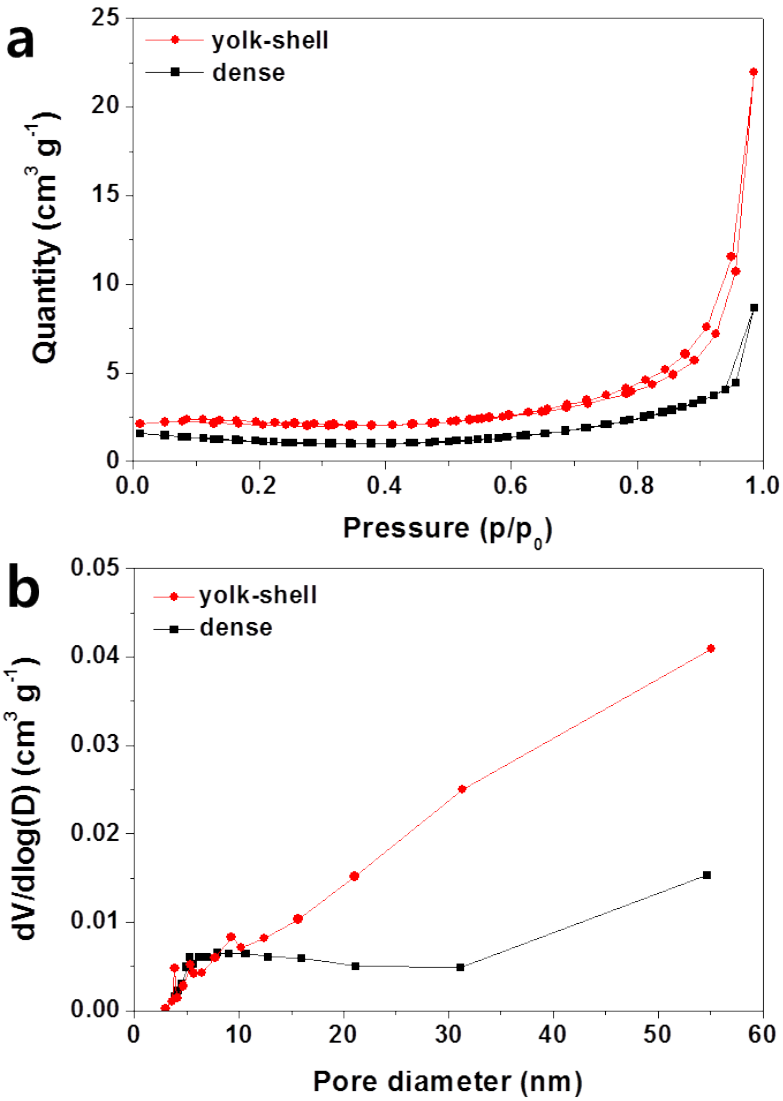

Fig. S2 (a) Nitrogen adsorption-desorption isotherms and (b) pore size distributions of the yolk-shell and dense $CoFe_2O_4$ powders.

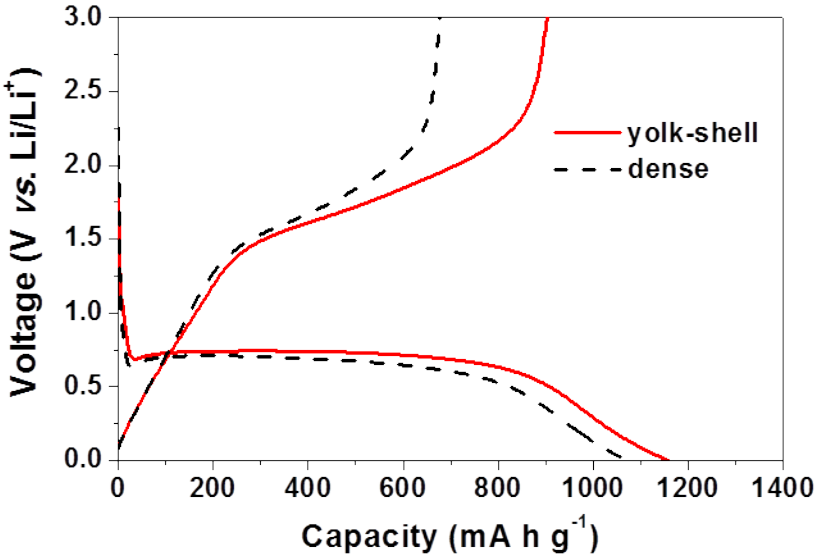

Fig. S3 Initial charge and discharge curves of the yolk-shell and dense $CoFe_2O_4$ powders at a constant current density of 1 A g^{-1}.