Electronic Supplementary Information

A Facile low temperature method for synthesis of $CoFe_2O_4$ nanoparticle having excellent microwave absorption property

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Materials Used

$Co(NO_3)_2.6H_2O$, $Fe(NO_3)_3.9H_2O$ and sodium hydroxide (NaOH) were purchased from Merck, India and used without further purification. Deionized water was used throughout the experiment.

Characterization Details

Room temperature powder X-ray diffraction (XRD) pattern of the synthesized nanopowder was recorded using a powder X-Ray diffractometer (Mini Flex II, Rigaku, Japan) with Cu K_α(λ= 0.15405 nm) radiation at a scanning speed of 2°/ min. High Resolution Transmission Electron Microscopy (HRTEM) images of samples were obtained using JEOL JEM 1400, Japan. Particle size of the synthesized material was determined by dynamic light scattering (DLS) study employing a particle size analyser (Delsa Nano S, Beckman Coulter, USA). EDAX spectra of the synthesized material was recorded using Carl-Zeiss EVOMA15 (Carl-Zeiss, Germany) electron microscope. Room temperature magnetization with respect to external field was measured by using Vibrating Sample Magnetometer (VSM) (EV5, ADE technology, USA). Multiple point BET surface area was measured with a surface area and porosity analyser (MicromeriticsTristar 3000, USA).Before the analysis, the sample was degassed at 100 °C for 6 h.

For measurement of microwave absorption of the synthesized $CoFe_2O_4$ in X-band (8.2 - 12.4 GHz range), HP 8510 vector Network Analyzer (USA) was used and reflection loss (RL) was calculated using the measured values of complex permittivity and permeability. To prepare the samples for this purpose, $CoFe_2O_4$ powders were first mixed with aqueous solution of 10 wt. % polyvinyl alcohol (PVA), which acted as binder and the mixture was dried. This mixture was further ground to powders and then compressed under a pressure of 10 tons and shaped into

rectangular pellets with size of 10.16 mm x 22.86 mm x 2 mm, so as to fit exactly into a rectangular waveguide of X-band.

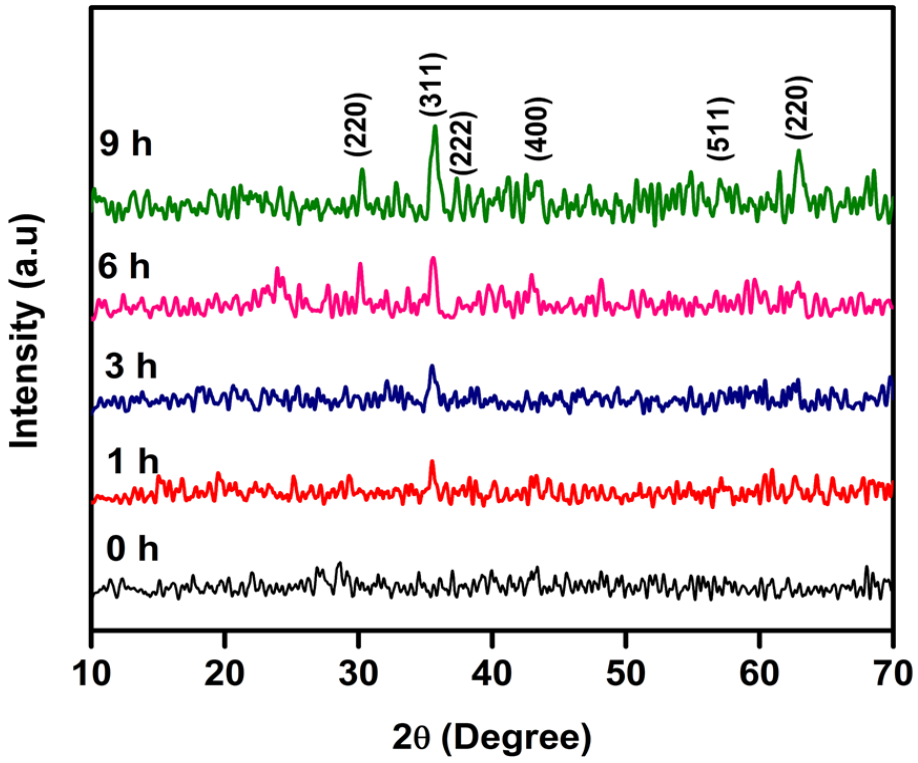

Fig.S1 Room temperature wide angle powder XRD pattern of the precipitates refluxed at 120 C at different time (0 h to 9h).

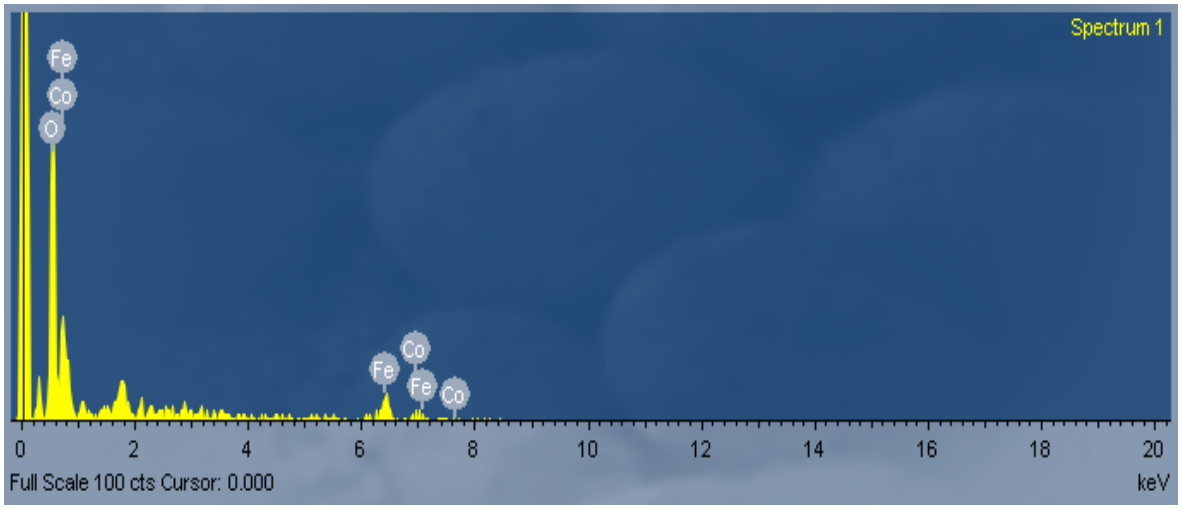

Fig.S2 EDAX spectra of synthesized $CoFe_2O_4$ nanoparticles.

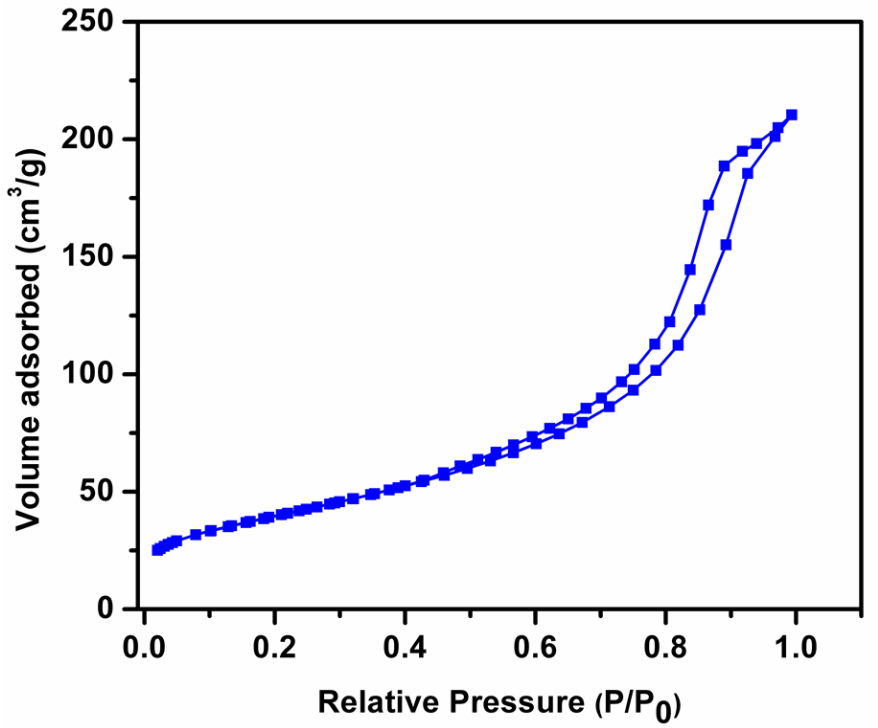

Fig. S3 N_2 adsorption-desorption isotherms of the synthesized $CoFe_2O_4$ nanoparticles.

Detail equations for calculation of reflection loss (RL)

The reflection loss (RL) was calculated from the complex relative permeability and permittivity at a given frequency and specimen thickness using a model of single-layered plane wave absorber, proposed by Naito and Sutake.[51]

$$Z_{in} = Z_0(\mu_r/\varepsilon_r)^{1/2}\tan h\left[j\left(\frac{2\pi fd}{c}\right)(\mu_r.\varepsilon_r)^{1/2}\right] \quad \text{(S1)}$$

$$RL = 20\ log\left|\frac{Z_{in} - Z_0}{Z_{in} + Z_0}\right| \quad \text{(S2)}$$

Where, $\mu_r = \mu' - j\mu''$ and $\varepsilon_r = \varepsilon' - j\varepsilon''$ are the relative complex permeability and permittivity of the absorber medium, respectively, f is the frequency of the electromagnetic wave, d is the absorber thickness, c is the velocity of light, Z_0 is the free space impedance, and Z_{in} is the absorber impedance. In order to analyze the variation of microwave absorption properties with thickness of the absorber, the reflection loss was calculated using equations (S1) and (S2) for different absorber thickness.

Table S1: Methods of preparation of different $CoFe_2O_4$ and $CoFe_2O_4$ based composites and their microwave absorption property.

$CoFe_2O_4$ and $CoFe_2O_4$ based composites	**Preparation Method**	**Required Processing /calcination temperature**	**Minimum Reflection loss (absorber thickness), % of absorption**	**Effective absorption band width (GHz)(RL< -10 dB)**	**Reference**
$Ni_{0.5}Co_{0.5}Fe_2O_4$	Co-precipitation	85 °C	-18 dB (1.5 mm) (98.42 %).		[6]
Rugby Shaped $CoFe_2O_4$	Vapour diffusion	550 °C	-34.1 dB (2.5 mm) (99.96 %).	2.6 GHz	[9]
a)EG/PANI/ $CoFe_2O_4$ with m_{CF}/ m_{EG}/ $m_{PANi}$of 0.8	Co-precipitation method	300 °C	a) -19.13 dB (0.5 mm), (98.74 %).	a) 3.37GHz	[10]
b) $CoFe_2O_4$			b) -13.58 dB (1 mm), (95.00 %).	b) 3.6 GHz at RL < -8 dB)	
Polyaniline - $CoFe_2O_4$	Precursor based method followed by situ emulsion polymerization	1000 °C	-21.5 dB, (99.25 %)		[11]
a).$CoFe_2O_4$nanorod/Graphene b). $CoFe_2O_4$nanorod	Hydrothermal	150°C	a) -25.8 dB (2.0 mm), (99.75 %). b) -14.9 dB (2.0 mm), (96.84 %)	a) 4.5 GHz b) 1.6 GHz	[14]
a) $CoFe_2O_4$ hollow/Graphene b) $CoFe_2O_4$ hollow	Vapour diffusion	550 °C	a) -18.5 dB (2 mm), (98.5 %). b) -11.7 dB (2 mm), (93.69 %)	a) 3.7 GHz b) 1.3 GHz	[15]
60 wt %ZnO/ $CoFe_2O_4$	Co-precipitation method	90°C	-28.3 dB (--), (99.86 %)	--	[22]
$CoFe_2O_4$/ SBA-15	Double solvent technique and incipient impregnation method	800 °C	-18 dB (2 mm), (98.42 %)	4.5 GHz	[25]

$CoFe_2O_4$ and $CoFe_2O_4$ based composites	**Preparation Method**	**Required Processing /calcination temperature**	**Minimum Reflection loss (absorber thickness)**	**Effective absorptionband width (GHz) (RL< -10 dB)**	**Reference**
Hollow glass microsphere/ $CoFe_2O_4$	Co-precipitation method	80 °C	-8.3 dB (1.5 mm), (84.3 %)	0 GHz	[28]
$SrFe_{12}O_{19}$/ $CoFe_2O_4$	Modified flux method (co-precipitation	1200 °C	-27.6 dB (---), (99.82%)		[32]
80 wt% $CoFe_2O_4$-Co_3Fe_7-Co and 20 wt % epoxy resin composite	Thermal reduction Process	600°C to 800°C	-34.4 dB (4 mm), (99.96 %).		[33]
10 wt % CBC/ $CoFe_2O_4$	Solvothermal		-45 dB (2 mm), (99.99 %).		[40]
Hollow $CoFe_2O_4$-Co_3Fe_7	solvothermal	600 °C (annealing under H_2/N_2)	-41.6 dB (2 mm), (99.99 %).	3 GHz (from 7.4 to 10.4 GHz).	[41]
CNT/ $CoFe_2O_4$	Chemical Vapor Deposition		-18 dB (2 mm), (98.42 %)		[42]
$CoFe_2O_4$	Co-precipitation method	120 °C	-55dB (2 mm), (99.99 %). -30 dB (1.8 mm), (99.90 %)	2.6 GHz 3.06 GHz	Present work