† Electronic Supplementary Information (ESI)

Insights into the Structural and Microscopic Origin of Magnetic and Optical Properties of monodispersed γ-Fe_2O_3, ZnO, γ-$Fe_{2-2x}Zn_{2x}O_3$ and γ-Fe_2O_3@ZnO nanostructures

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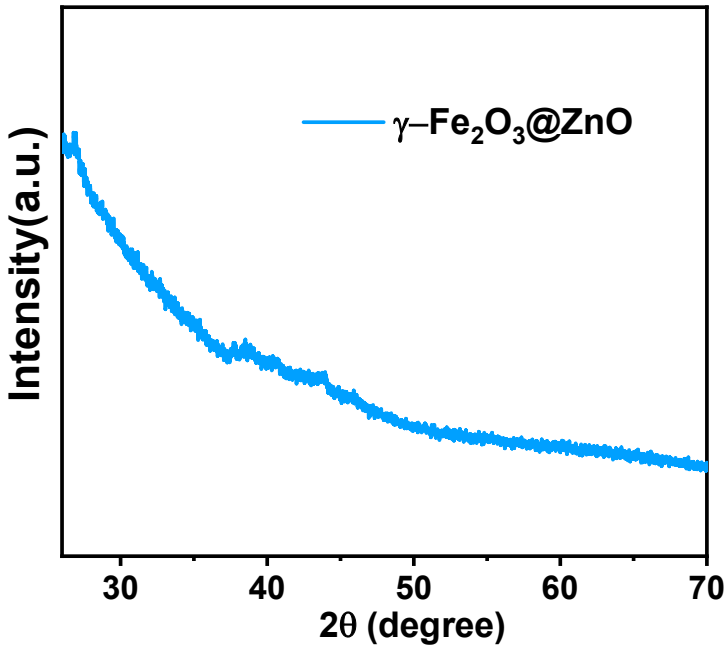

Fig. S1 Typical XRD pattern ofγ-Fe_2O_3@ZnO (CS).

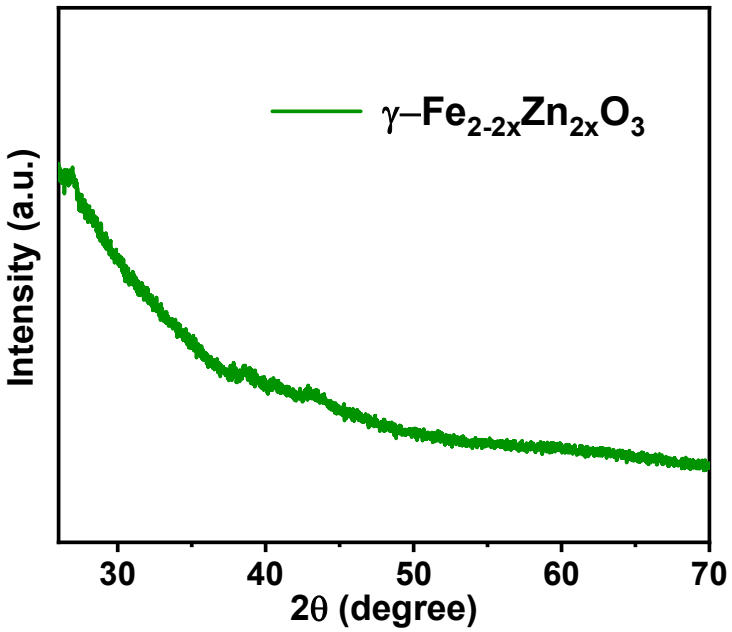

Fig. S2 Typical XRD pattern ofγ-$Fe_{2-2x}Zn_{2x}O_3$(SUB).

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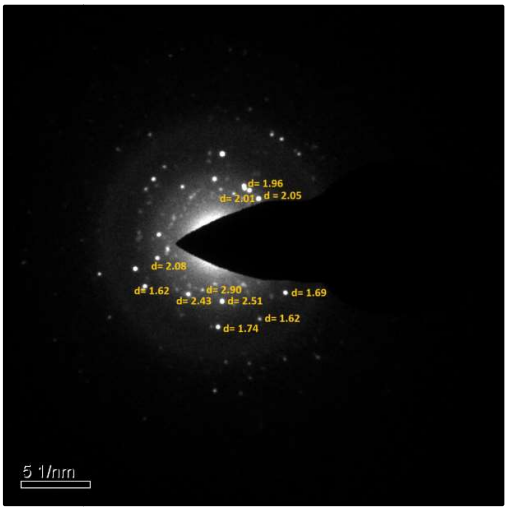

Fig. S3 AnotherSAED pattern of γ-Fe_2O_3.

Table S1 The d-values and corresponding planes of **Fig. S3**.

γ-Fe_2O_3	d-value (Å)	Plane
	2.90	**220**
	2.51	**311**
	2.05, 2.01, 2.08	**400**
	1.69, 1.74	**422**
	1.62, 1.62	**511**

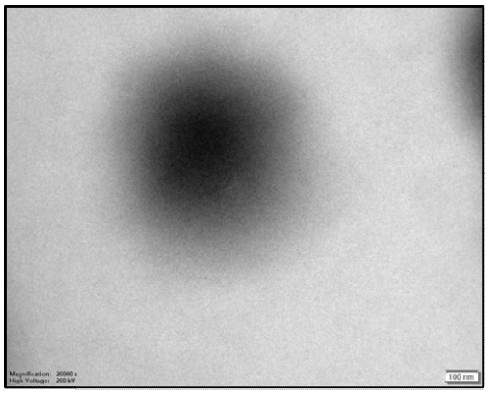

Fig. S4 TEM image of ZnO-300 (scale = 100 nm).

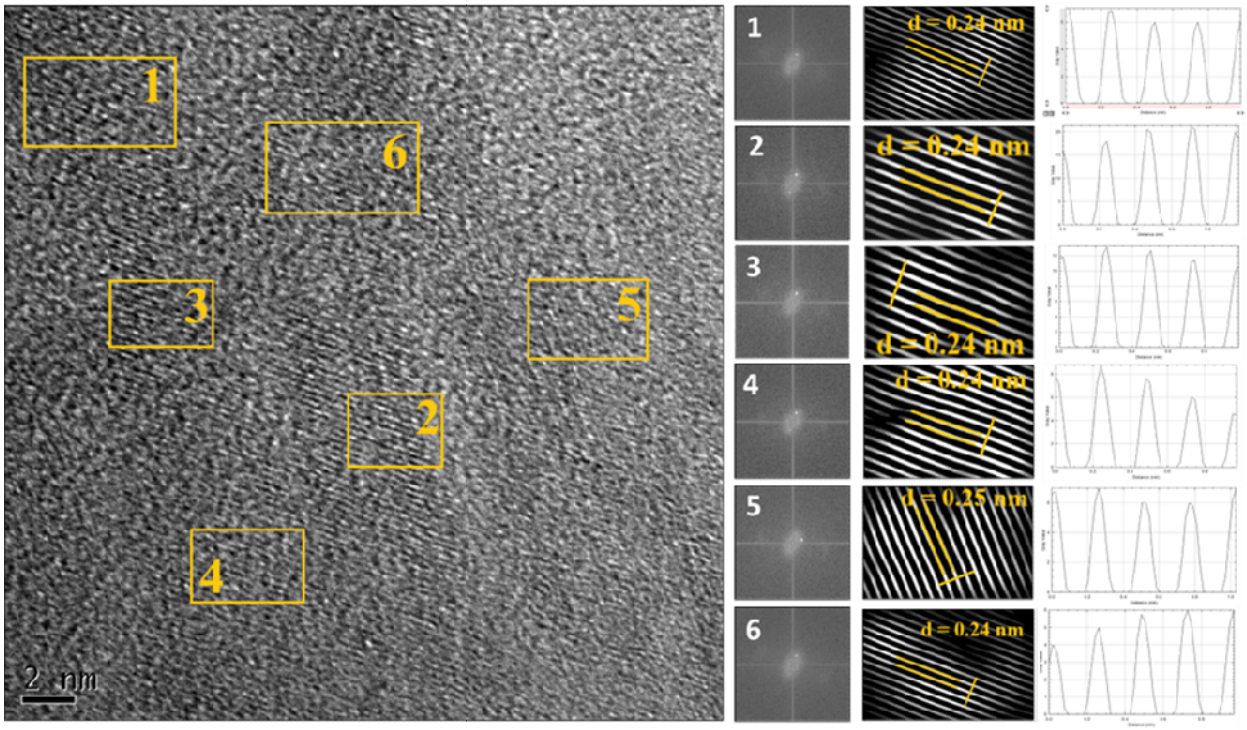

Fig. S5 Another HR-TEM image of CS: 6 different spots (1, 2, 3, 4, 5, 6) and their corresponding FFT images, inverse FFT and line profile images.

Table S2 The d-values and corresponding planes of **Fig. 5(c), Fig. 5(d)** and **Fig. S5**.

SAED	d-value (Å)	Plane	
	3.37	211	γ-Fe_2O_3
	2.58	311	$ZnFe_2O_4$
	2.4	222	$ZnFe_2O_4$
	1.7	422	γ-Fe_2O_3/ $ZnFe_2O_4$
	1.5	440	$ZnFe_2O_4$
HR-TEM	d-value (Å)	Plane	
Spot 1	2.5	311	γ-Fe_2O_3/$ZnFe_2O_4$
Spot 2	2.5	311	γ-Fe_2O_3/$ZnFe_2O_4$
Spot 3	3.0	220	γ-Fe_2O_3/ $ZnFe_2O_4$
HR-TEM	d-value (Å)	Plane	
Spot 1	2.4	222	$ZnFe_2O_4$
Spot 2	2.4	222	$ZnFe_2O_4$
Spot 3	2.4	222	$ZnFe_2O_4$
Spot 4	2.4	222	$ZnFe_2O_4$
Spot 5	2.5	311	γ-Fe_2O_3/$ZnFe_2O_4$
Spot 6	2.4	222	$ZnFe_2O_4$

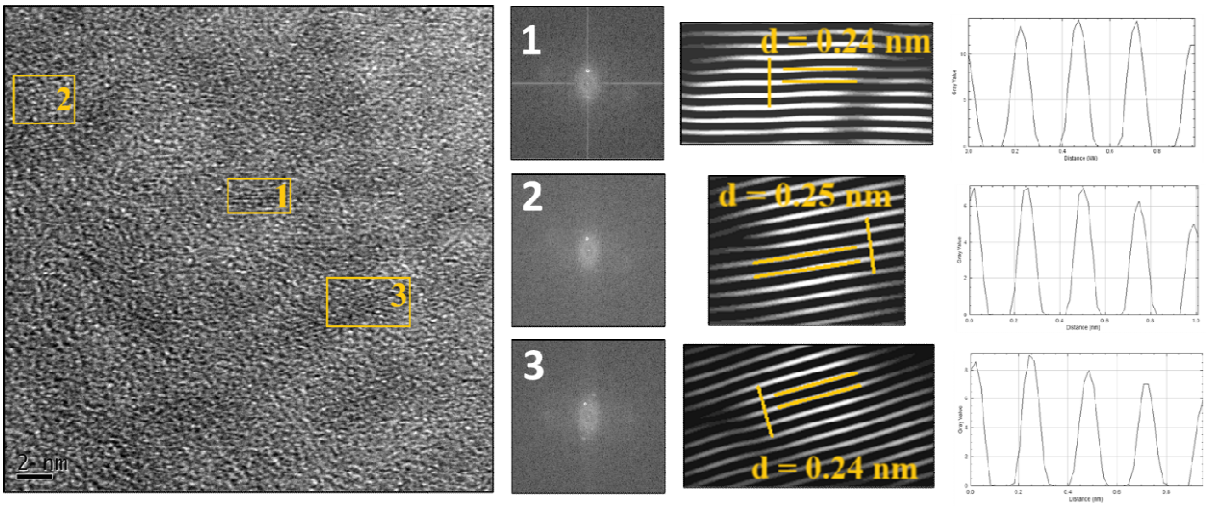

Fig. S6 Another HR-TEM image of SUB: 3 different spots (1, 2, 3) and their corresponding FFT images, inverse FFT and line profile images.

Table S3 The d-values and corresponding planes of **Fig. 6(c), Fig. 6(d)** and **Fig. S6**.

γ-$Fe_{2-2X}Zn_{2X}O_4$ (SUB)			
SAED	**d-value (Å)**	**Plane**	
	3.0	**220**	**γ-Fe_2O_3/$ZnFe_2O_4$**
	2.58	**311**	**$ZnFe_2O_4$**
	2.2	**400**	**$ZnFe_2O_4$**
	1.6	**511**	**$ZnFe_2O_4$**
	1.5	**440**	**$ZnFe_2O_4$**
HR-TEM	**d-value (Å)**	**Plane**	
Spot 1	**2.4**	**222**	**$ZnFe_2O_4$**
Spot 2	**3.0**	**220**	**γ-Fe_2O_3/$ZnFe_2O_4$**
Spot 3	**1.5**	**440**	**$ZnFe_2O_4$**
HR-TEM	**d-value (Å)**	**Plane**	
Spot 1	**2.4**	**222**	**$ZnFe_2O_4$**
Spot 2	**2.5**	**311**	**γ-Fe_2O_3/$ZnFe_2O_4$**
Spot 3	**2.4**	**222**	**$ZnFe_2O_4$**

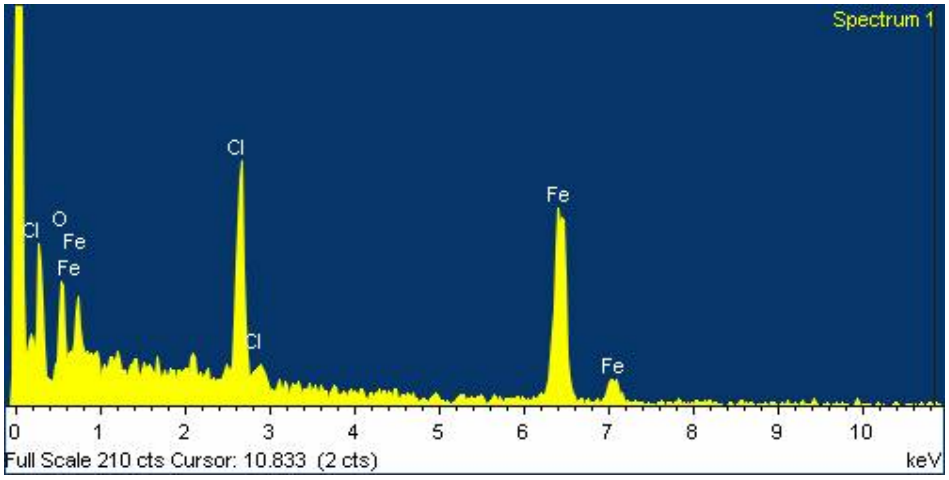

Fig. S7 EDX spectrum of γ-Fe_2O_3.

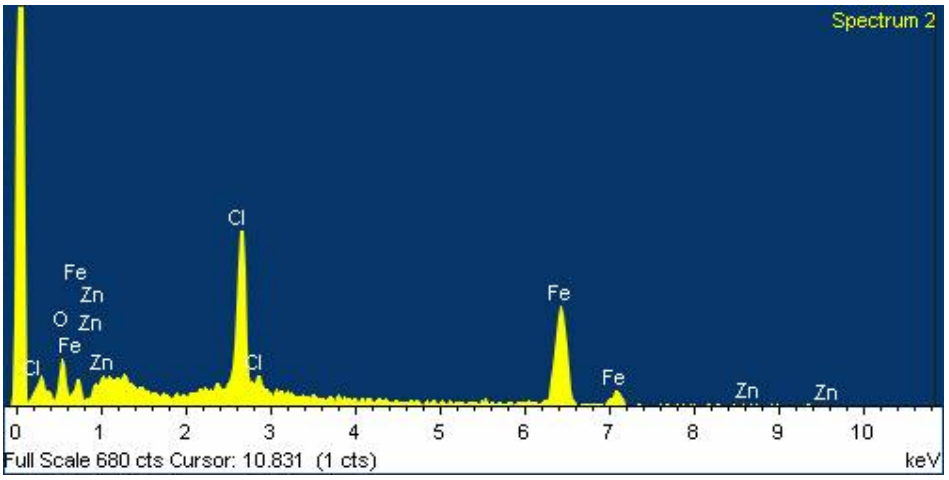

Fig. S8 EDX spectrum of γ-Fe_2O_3@ZnO (CS).

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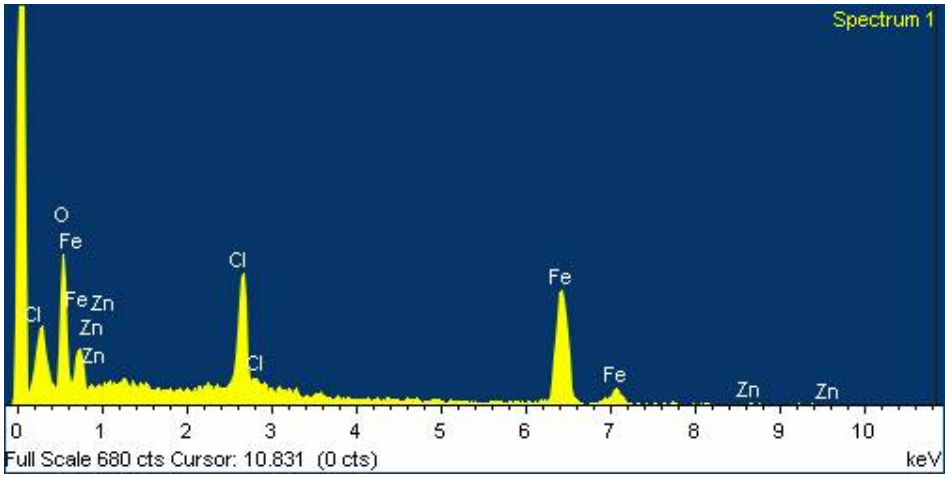

Fig. S9 EDX spectrum of γ-$Fe_{2-2x}Zn_{2x}O_3$ (SUB).

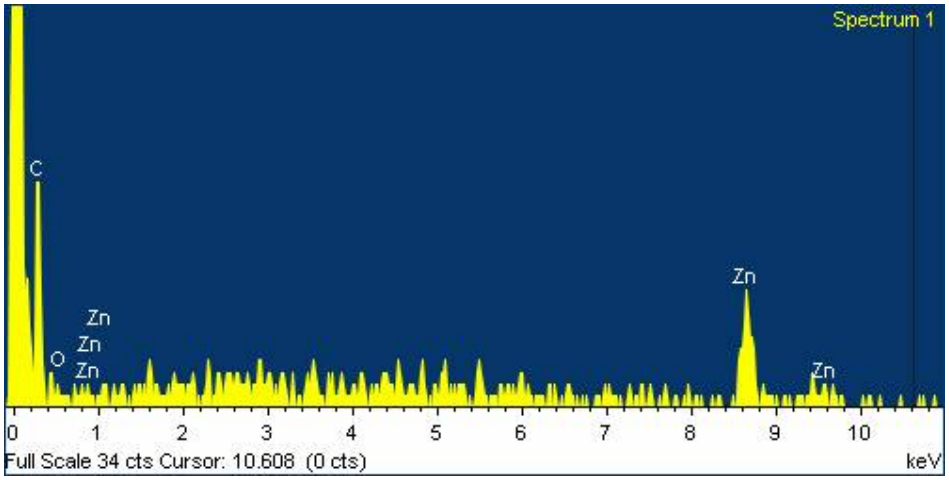

Fig. S10 EDX spectrum of ZnO.

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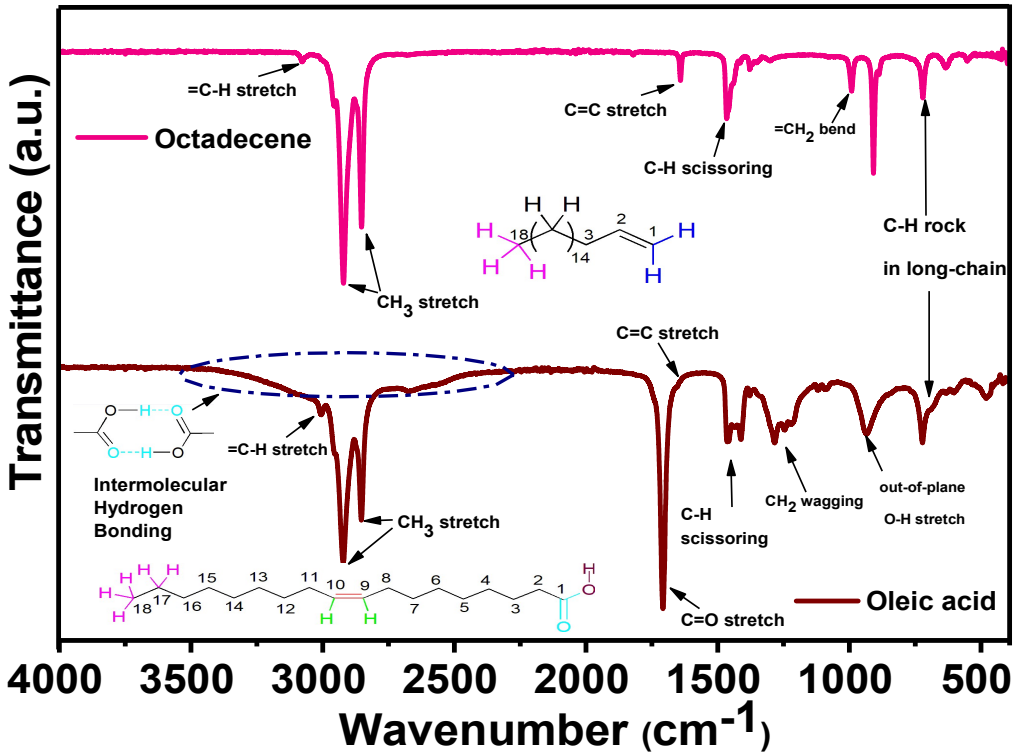

Fig. S11 FTIR spectra of pure oleic acid and 1-octadecene.

Table S4 FT-IR peak assignments of 1-octadecene and oleic acid.

1-Octadecene (cm^{-1})	Oleic acid (cm^{-1})	Peak assignments	References
3076	3005	=C-H stretch	2, 3
2919	2921	C-H stretch (asymmetric)	1, 2, 3
2851	2851	C-H stretch (symmetric)	1, 2, 3
-	2250-3500	O-H stretch Intermolecular hydrogen bonding	3
-	1709	C=O stretch	1, 3
1643	1643	C=C stretch	2

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-	1462	In plane O-H stretch	1, 3
-	1284	C-O stretch	1, 3
-	931	Out-of-plane O-H stretch	2, 3
1380-1460	1380-1460	C-H scissoring	2, 3
-	1200-1300	C-H wagging	2
990	-	$=CH_2$ bend	2
720	725	C-H rocking in long chain alkanes	2, 3

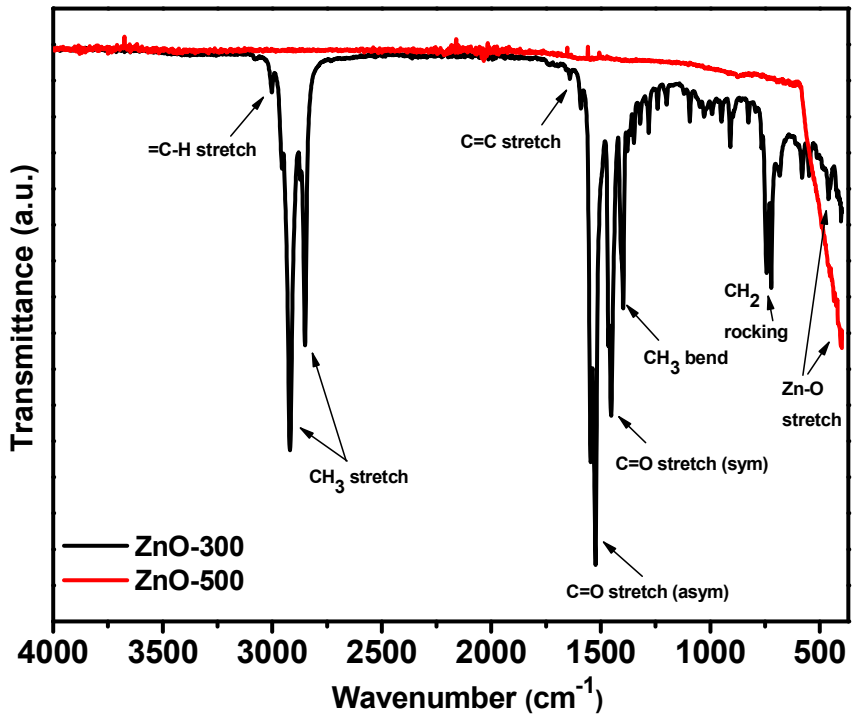

Fig. S12 FTIR spectra of ZnO-300 and ZnO-500 nanoparticles.

References:

(1) J. Ibarra, J. Melendres, M. Almada, M. G. Burboa, P. Taboada, J. Juárez and M. A. Valdez, *Mater. Res. Express*, 2015, **2**, 095010.

(2) R. Joshi, B. P. Singh, C. L. Prajapat, Y. Kashyap, C. Nayak, D. Bhattacharyya and R. S. Ningthoujam, *J. Phys. Chem. C*, 2021, **125**, 17971–17982.

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(3) N. Wu, L. Fu, M. Su, M. Aslam, K. C. Wong and V. P. Dravid, *Nano Lett*., 2004, **4**, 383–386.

Table S5 Optical band gap energy of all the samples.

S.N.	Sample Name	Optical Band Gap Energy (eV)	
		Direct allowed transition	**Indirect allowed transition**
1	γ-Fe_2O_3	2.78	2.40
2	γ-Fe_2O_3@ZnO (CS)	3.15	2.88
3	γ-$Fe_{2-2x}Zn_{2x}O_3$(SUB)	3.12	2.84
4	ZnO	3.58	3.02

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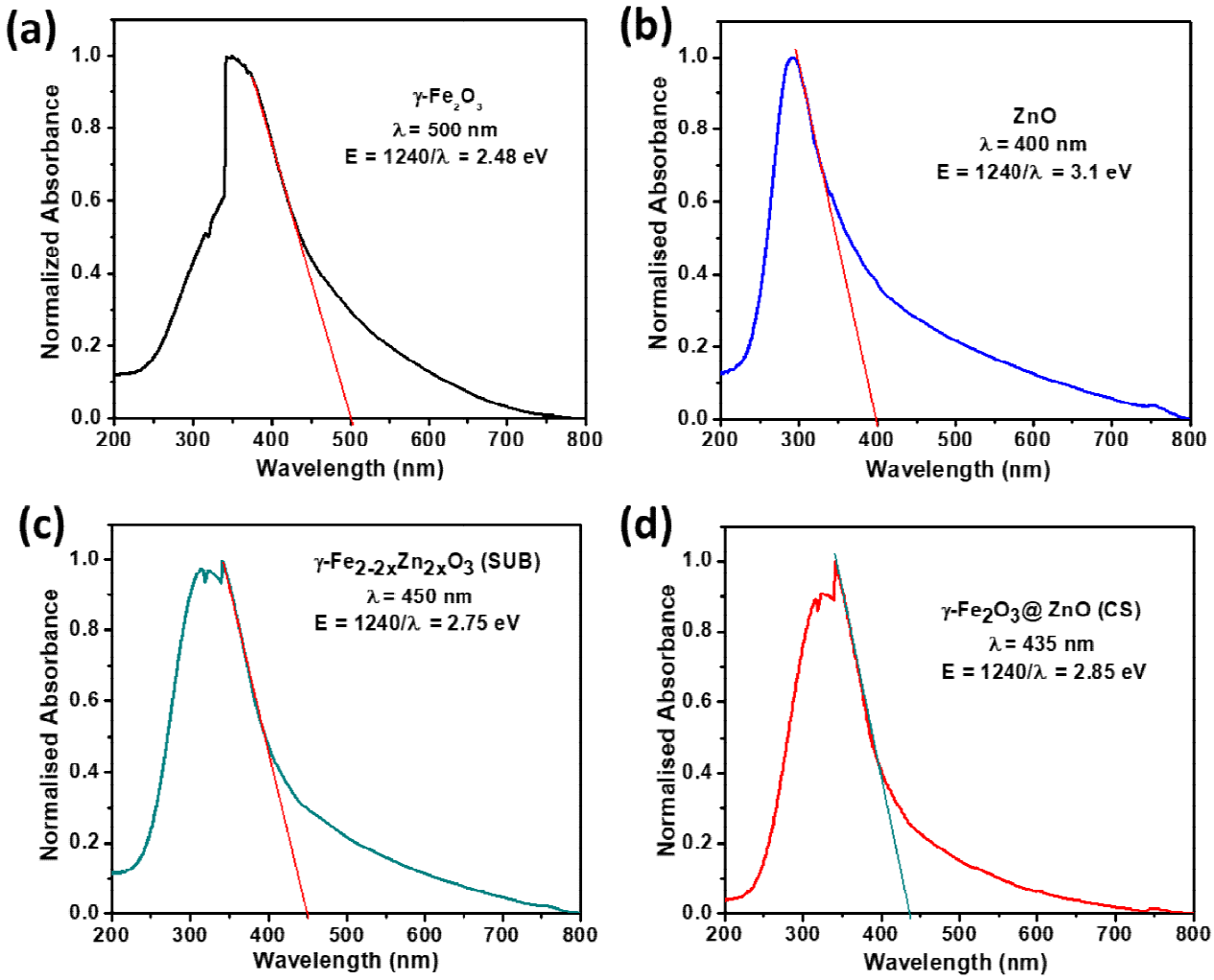

Fig. S13 Plotting of tangent/slope to UV-visible absorption curve of **(a)** γ-Fe_2O_3, **(b)** ZnO, **(c)** γ-$Fe_{2-2x}Zn_{2x}O_3$ (SUB) and **(d)** γ-Fe_2O_3@ZnO (CS).

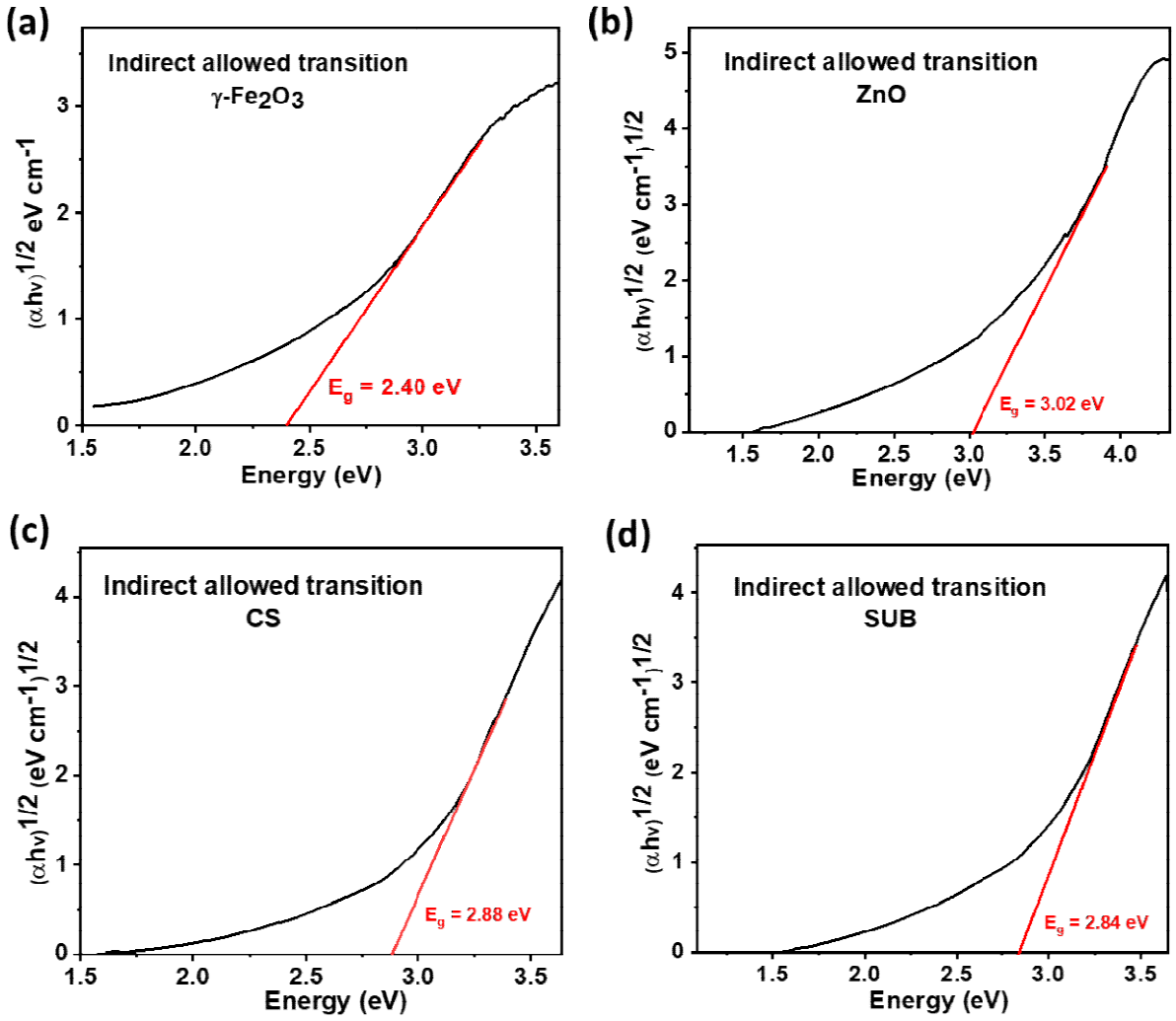

Fig. S14 The indirect optical band gap energies of **(a)** γ-Fe_2O_3, **(b)** ZnO, **(c)** γ-Fe_2O_3@ZnO (CS) and **(d)** γ-$Fe_{2-2x}Zn_{2x}O_3$ (SUB), respectively calculated using Tauc plot.