Supplementary Material

Impact of colloidal stabilization of MnZn-ferrite nanoparticles by oleic acid on their magnetothermal properties

1 Supplementary Data

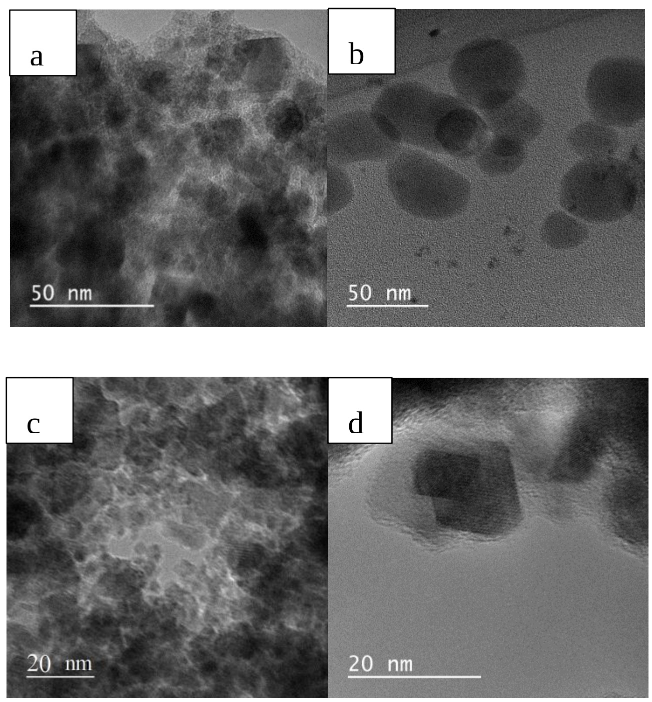


Fig. A1 TEM images of $Zn_xMn_{1-x}Fe_2O_4$ MNPs: a: x=0.15, oleic acid stabilized, b: x=0.15, bare MNPs, c: x=0.2, oleic acid stabilized, d: x=0.2, bare MNPs.

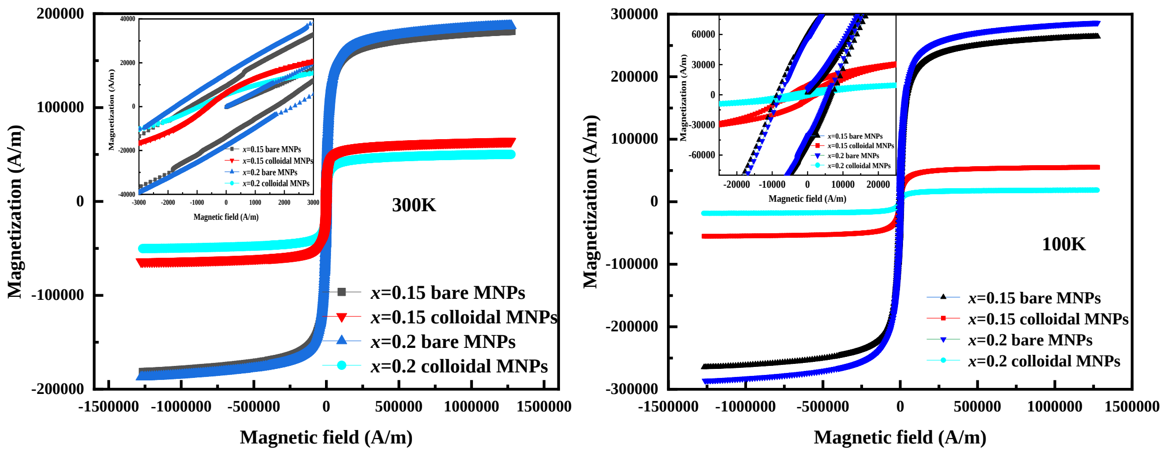
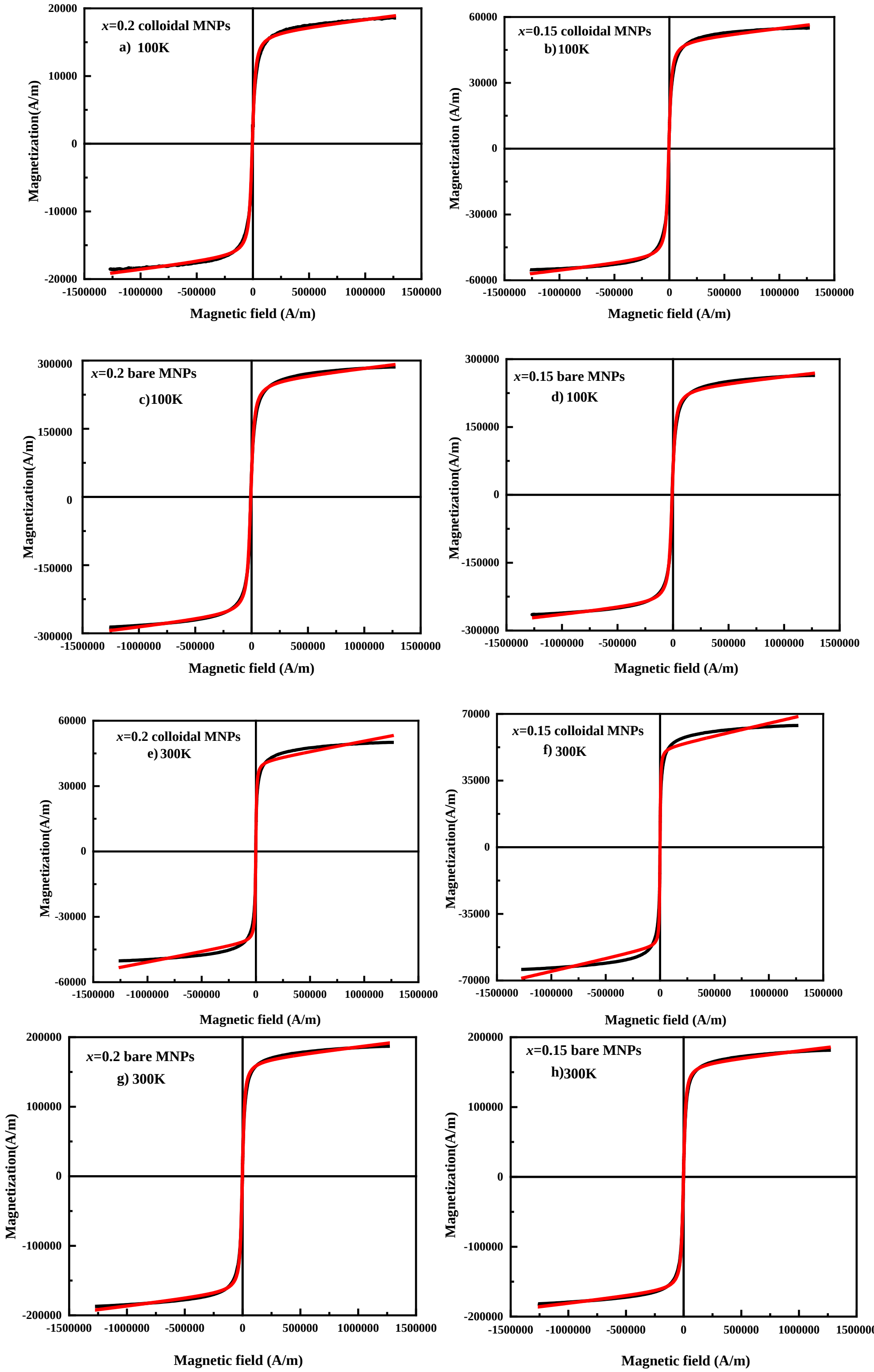


Fig. A2 Hysteresis loops of $Zn_xMn_{1-x}Fe_2O_4$ (x=0.15, 0.2) MNPs and colloidal MNPs at temperature 300K and 100K.

Fig.A3 presents hysteresis loops of $Zn_xMn_{1-x}Fe_2O_4$ (x=0.15, x=0.2)colloid and bare MNPs (the red line is the fitting curve of Langevin function). The values of the magnetic parameters obtained by Langevin function fitting are listed in Table 2.



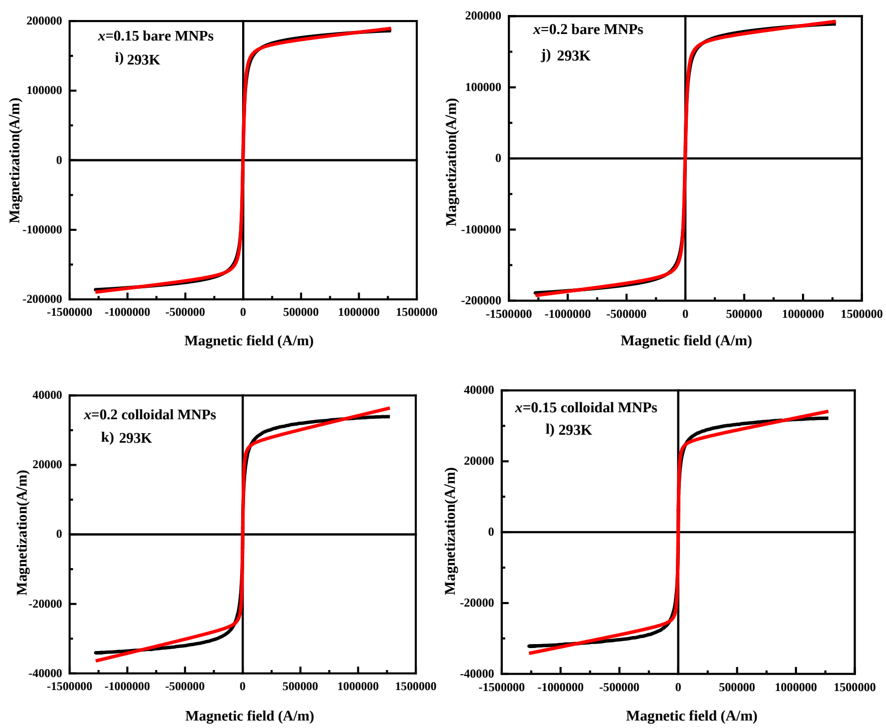


Fig.A3. Hysteresis loops of $Zn_xMn_{1-x}Fe_2O_4$ (x=0.15, x=0.2)colloidal and bare MNPs (the red line is the fitting curve of Langevin function): a)-d):100K, e)-h):300K, i)-l):293K.

Table 2. Magnetic parameters of $Zn_xMn_{1-x}Fe_2O_4$ (x=0.15, x=0.2) colloid and bare MNPs at 300K, 293K and 100K.

	Saturation magnetization (kA/m)	LF Susceptibility	Coercivity (kA/m)	Linear contribution	Offset	R^2	Temperature
x=0.2 bare MNPs	167.5 ±0.3	(1.35±0.01) E-4	-2.01 ±0.03	(2.53 ±0.05)E-2	-300 ±150	0.99	300K
x=0.15 bare MNPs	162.6 ±0.3	(1.35±0.01) E-4	-1.52 ±0.03	(2.52 ±0.04)E-2	-260 ±130	0.99	300K
x=0.2 colloidal MNPs	41.4 ±0.2	(3.05 ±0.04)E-4	-1.12 ±0.03	(1.05 ±0.03)E-2	-0 ±100	0.99	300K
x=0.15 colloidal MNPs	52.0 ±0.2	(4.15 ±0.05)E-4	-0.65 ±0.03	(1.05 ±0.04)E-2	0 ±100	0.99	300K
x=0.2 bare MNPs	168.2 ±0.3	(1.25 ±0.01)E-4	-1.5±0.05	(2.05 ±0.04)E-2	-0 ±100	0.99	293K
x=0.15 bare MNPs	166.4 ±0.3	(1.35 ±0.01)E-4	-1.95 ±0.05	(2.05 ±0.04)E-2	-0 ±100	0.99	293K
x=0.2 colloidal MNPs	26.4 ±0.2	(2.95 ±0.05)E-4	0.05 ±0.01	(1.05 ±0.03)E-2	-0 ±90	0.99	293K
x=0.15 colloidal MNPs	25.7 ±0.1	(3.15 ±0.05)E-4	-0.79 ±0.05	(1.03 ±0.02)E-2	-0 ±80	0.99	293K
x=0.2 bare MNPs	258.1 ±0.5	(8.55 ±0.05)E-5	-7560 ±60	(3.02 ±0.07)E-2	-1600 ±200	0.99	100K
x=0.15 bare MNPs	238.5 ±0.5	(8.95 ±0.05)E-5	-8280 ±70	(3.02 ±0.07)E-2	-1600 ±200	0.99	100K
x=0.2 colloidal MNPs	16.57 ±0.04	(9.25 ±0.07)E-5	-5360 ±60	(3.05 ±0.06)E-3	-120 ±20	0.99	100K
x=0.15 colloid-oleic acid	49.8 ±0.1	(1.05 ±0.01)E-4	-5360 ±60	(0.62 ±0.02)E-2	-320 ±60	0.99	100K

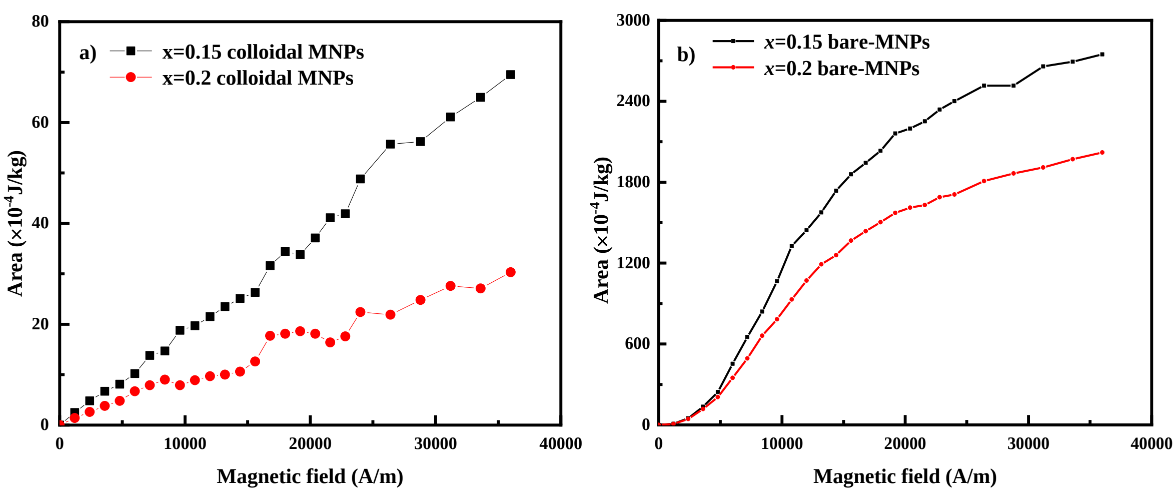


Fig. A5 The area of the hysteresis loop under different magnetic fields: a) colloid MNPs b) bare MNPs.

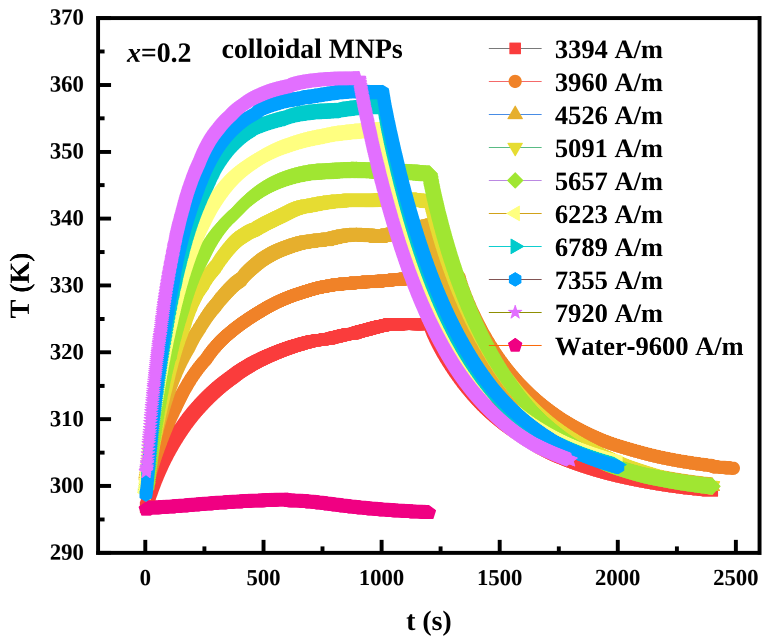


Fig. A6 The heating/cooling curve of colloidal $Zn_{0.2}Mn_{0.8}Fe_2O_4$ MNPs under different AC magnetic field and a frequency of 0.1MHz(The pink curve is the curve of deionized water under magnetic field of 9600A/m.).

Table 3. By approximation of the heating and cooling curves with the Box-Lucas law $y = y_0 +/- \Delta Te^{-x/\tau}$ one can obtain the the heating rate $dT/dt=\Delta T/\tau$.

Magnetic field (A/m)	ΔT	τ	ΔT/τ	SAR (×10^3 W/kg)
3394	28	200	0.14	3.00±0.03
3960	32	168	0.19	3.96±.964
4526	37	168	0.22	4.72±.725
5091	44	147	0.30	6.22±.226
5657	48	126	0.38	7.93±.938
6223	54	132	0.41	8.71±.719

6789	55	117	0.47	9.83±.839
7355	60	115	0.52	10.92±0.92
7920	61	103	0.59	12.32±0.12
Water (9600A/m)	1	381	0.004	-

Nomenclature section:

MNPs: Nanoparticles

FDA, EMA: European Medical Association - equivalent to FDA

SAR: specific absorption rate

TEM: Transmission Electron Microscopy

VSM: Vibrating Sample Magnetometer

ZFC-FC: zero-field-cooled

IRM: isothermal remanence

DCD: direct current demagnetization