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The Investigation of Smart Magnetic Nanoparticles for Use in the Hyperthermia Treatment of Cancer

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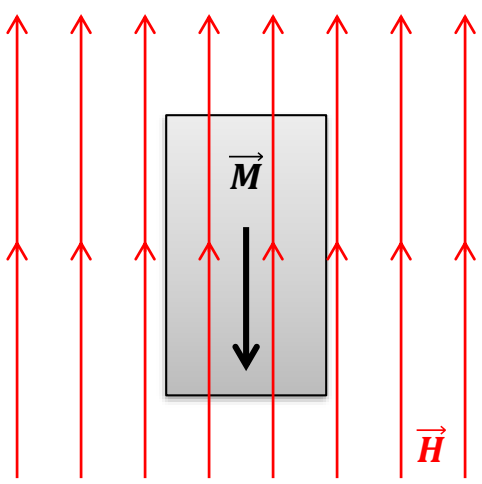
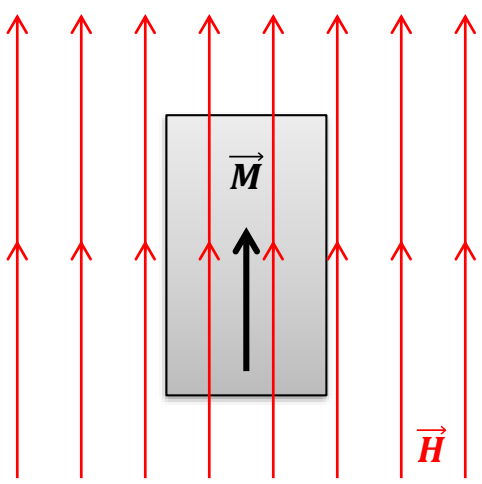
To understand magnetic nanoparticles, we must first understand some basics of magnetism in general.

Diamagnetism



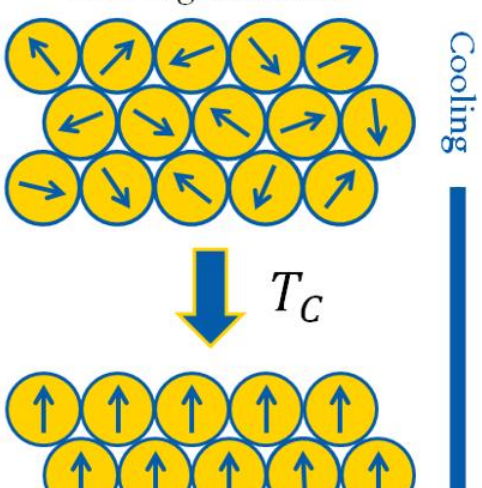
$$\chi = \frac{|\vec{M}|}{|\vec{H}|} \sim -10^{-5}$$

Paramagnetism



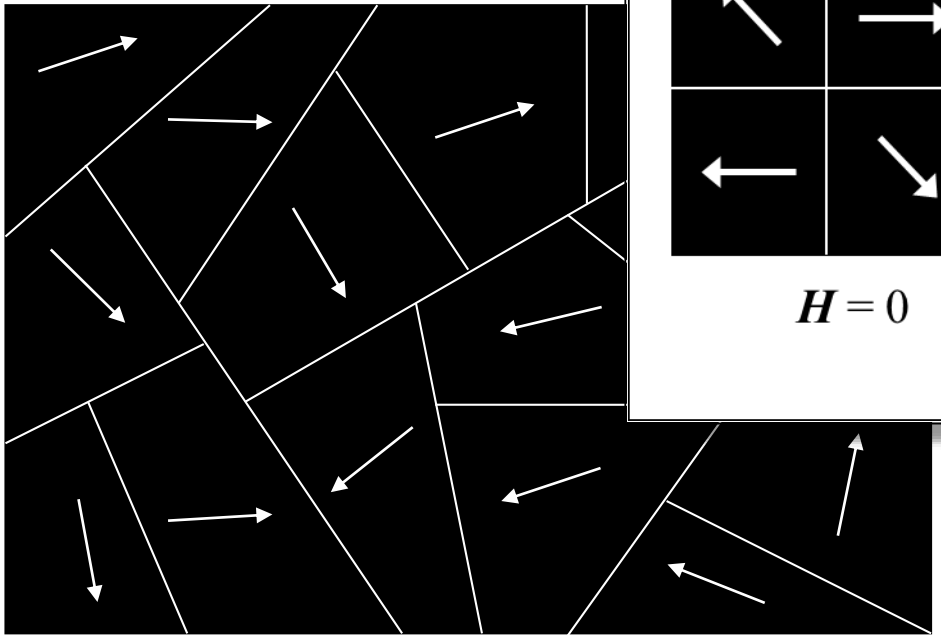
$$\chi = \sim 10^{-2} - 10^{-5}$$

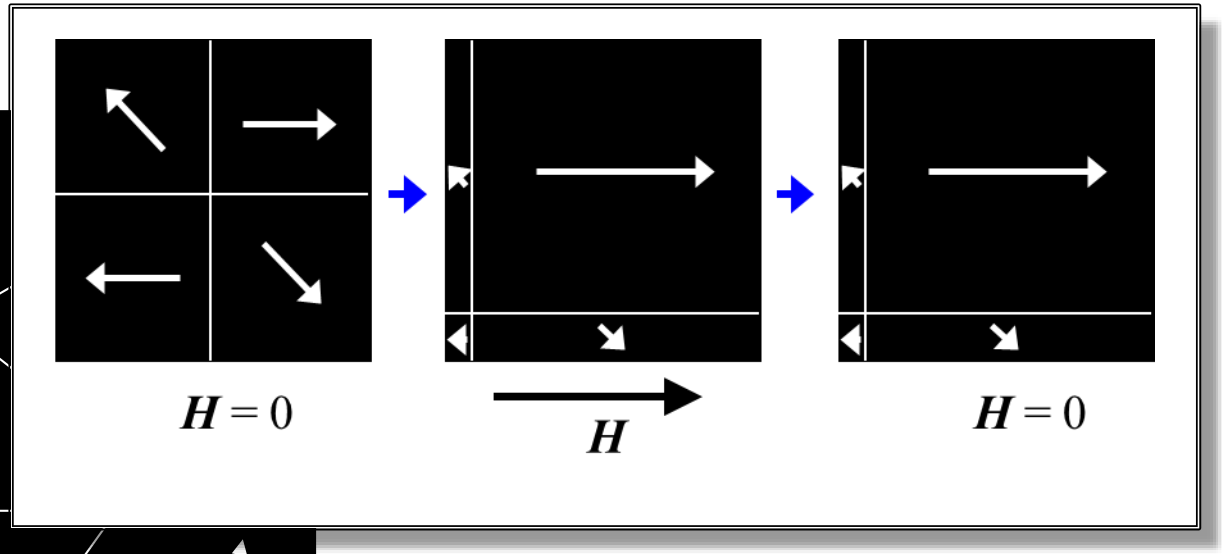
Ferro(Antiferro-)magnetism



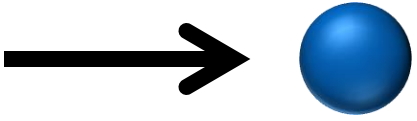
$$\chi = \sim 50 - 10^4$$

In ferromagnetic materials energy considerations favor the formation of domains and domain dynamics governs their behavior.



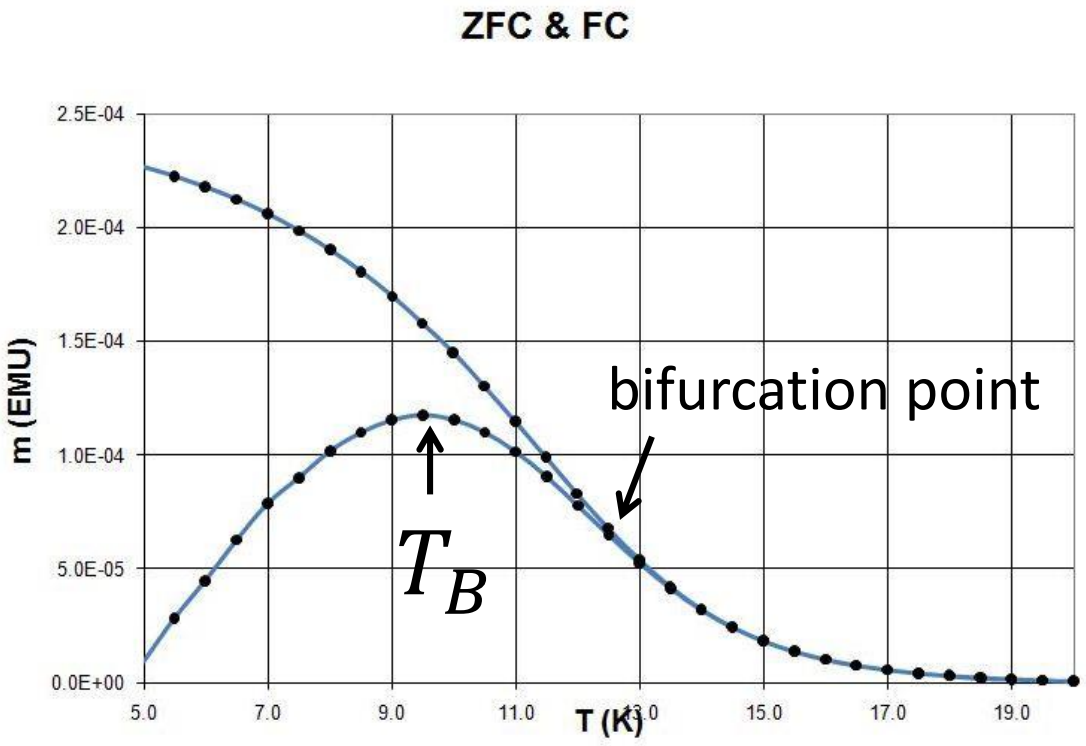


Magnetic Nanoparticle

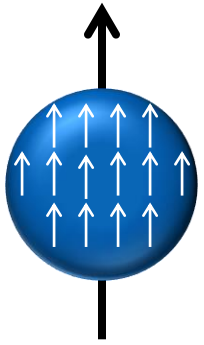


Pieces of magnetic materials whose dimensions are smaller than a typical domain size (~100 nm) will be “single domain”

The behavior of magnetic nanoparticles is governed not by domain dynamics but by thermally activated moment reversal.

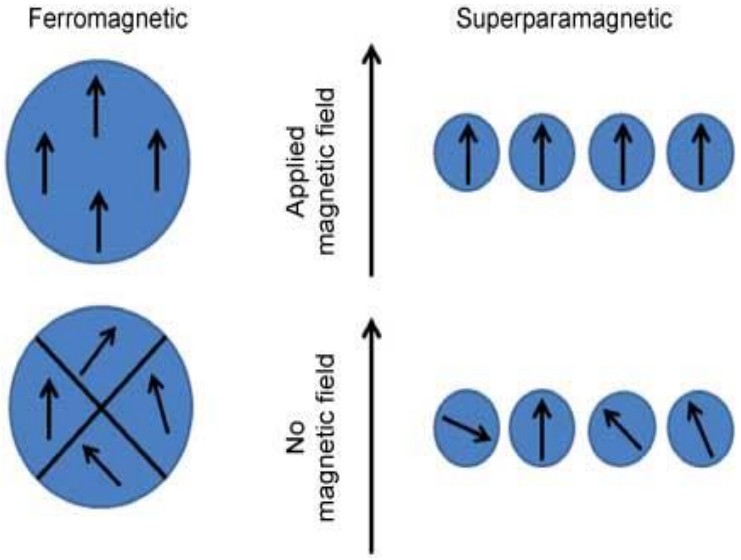


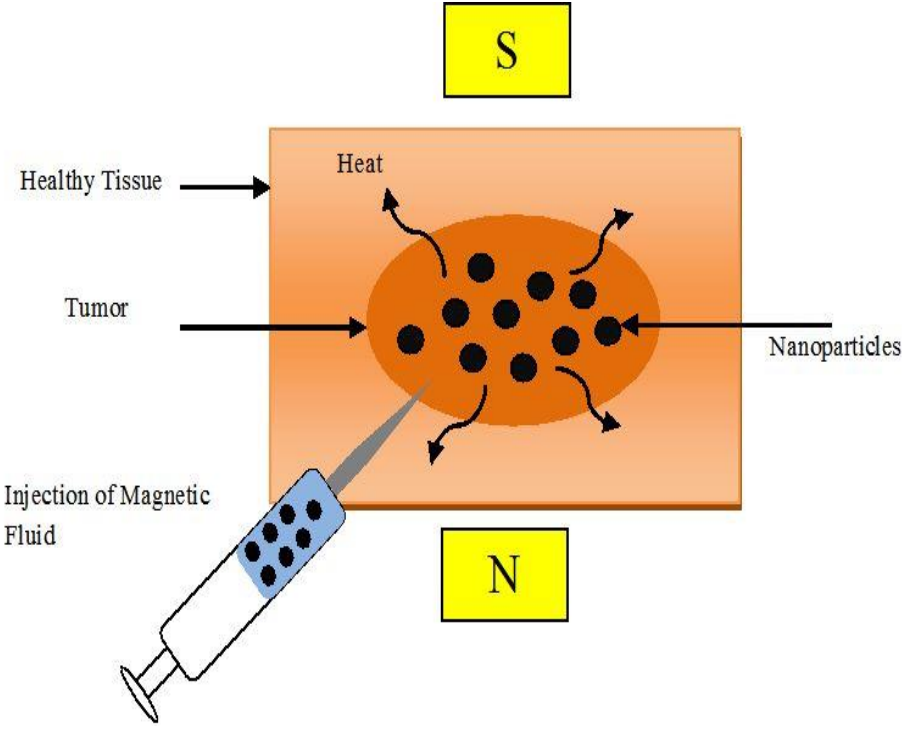
Thermally activated moment reversal



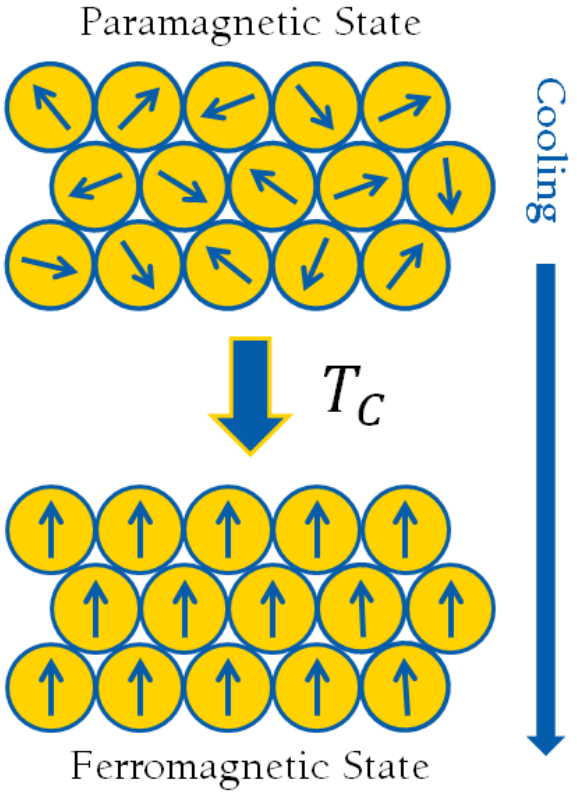
This behavior is known as ***SUPERPARAMAGNETISM***

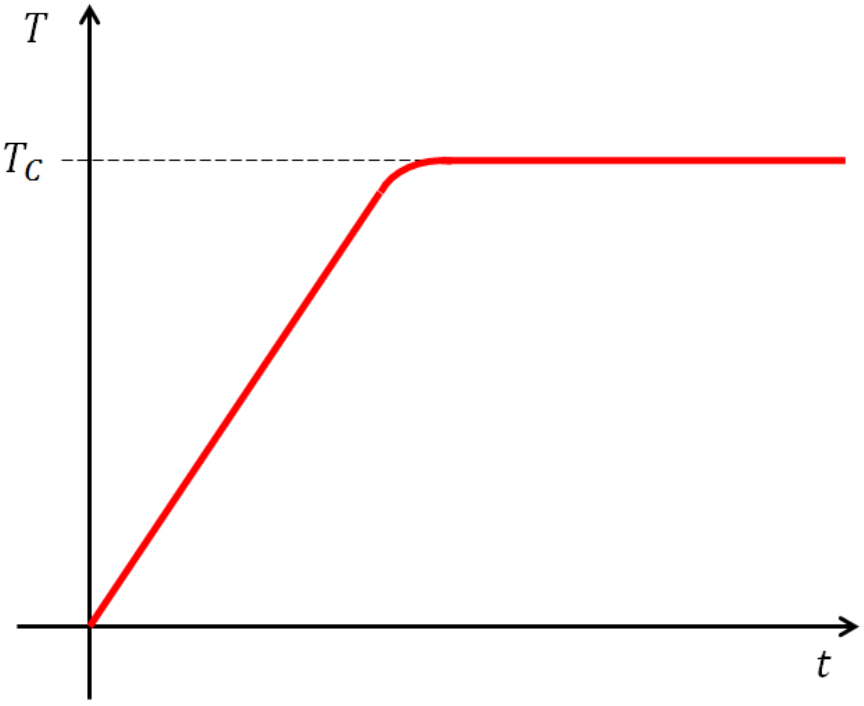
Magnetic Hyperthermia works through the reversal of magnetization that occurs inside the nanoparticles when exposed to RF magnetic field.



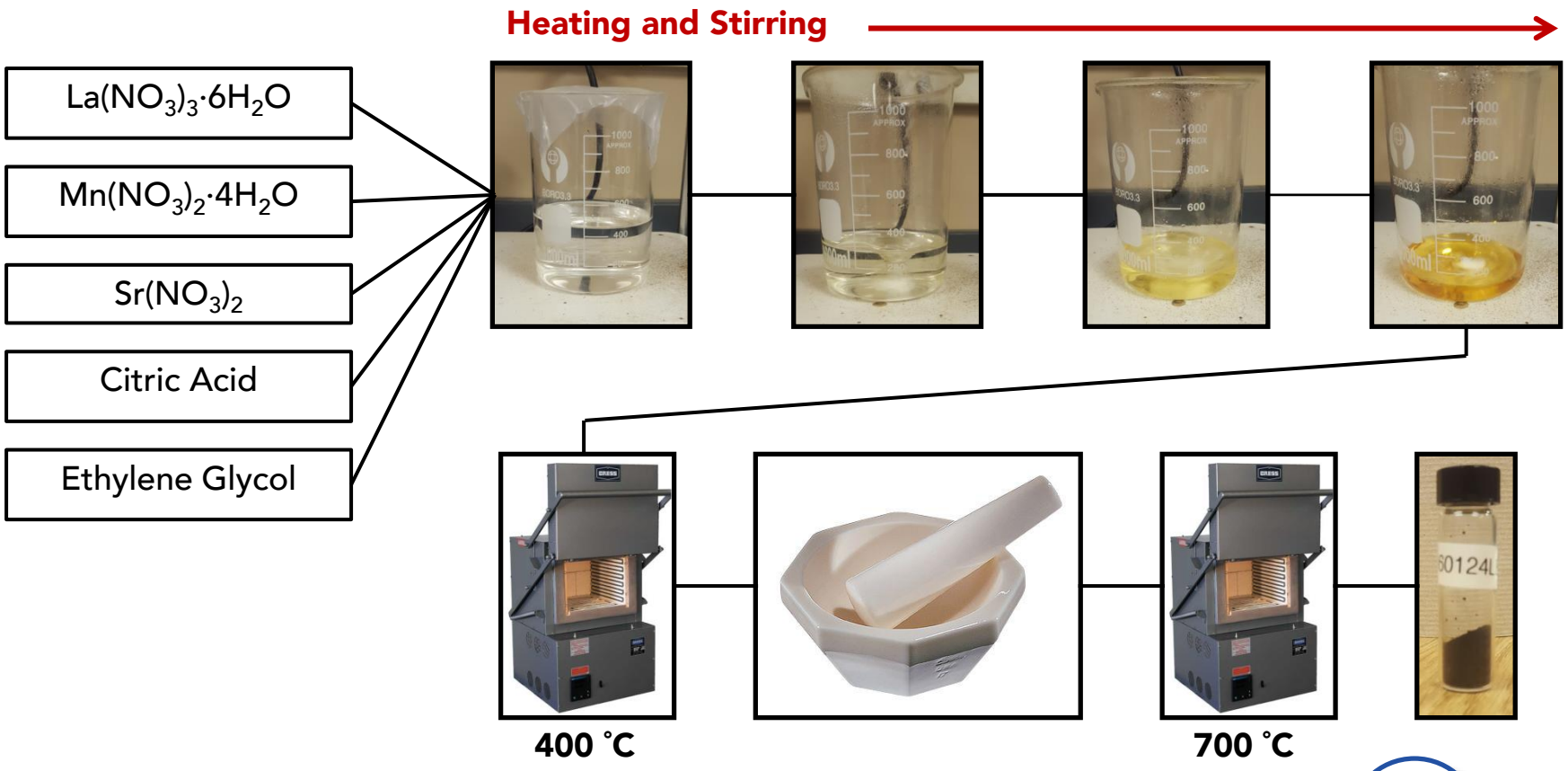


Self-temperature controlled nanoparticles allow constant magnetic field application without fear of over heating.

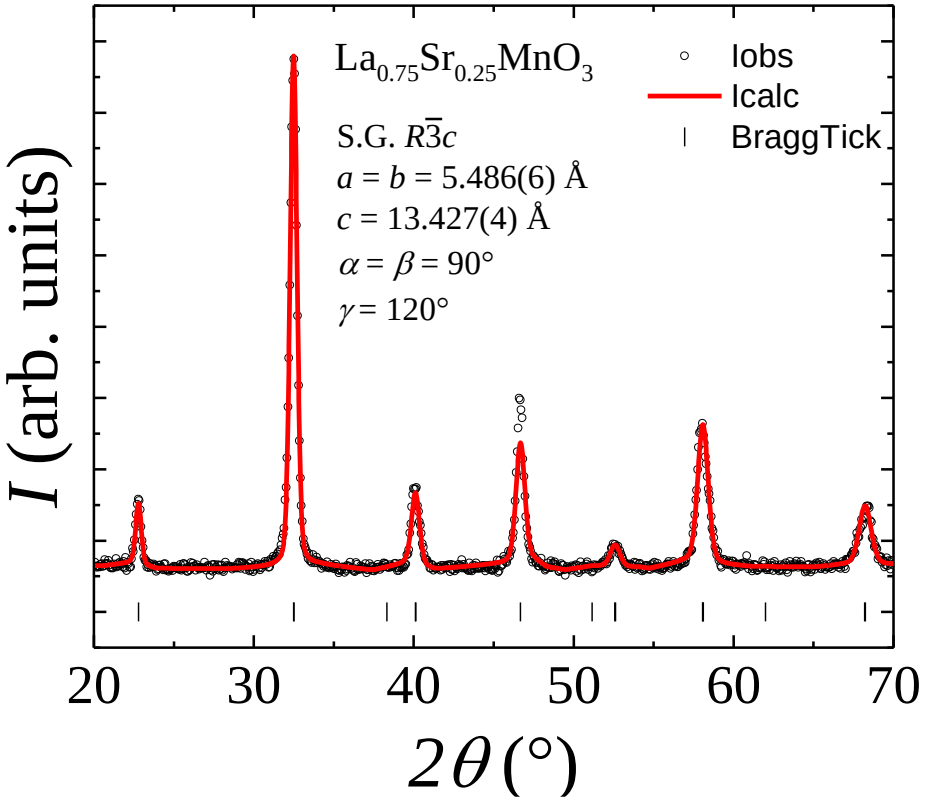


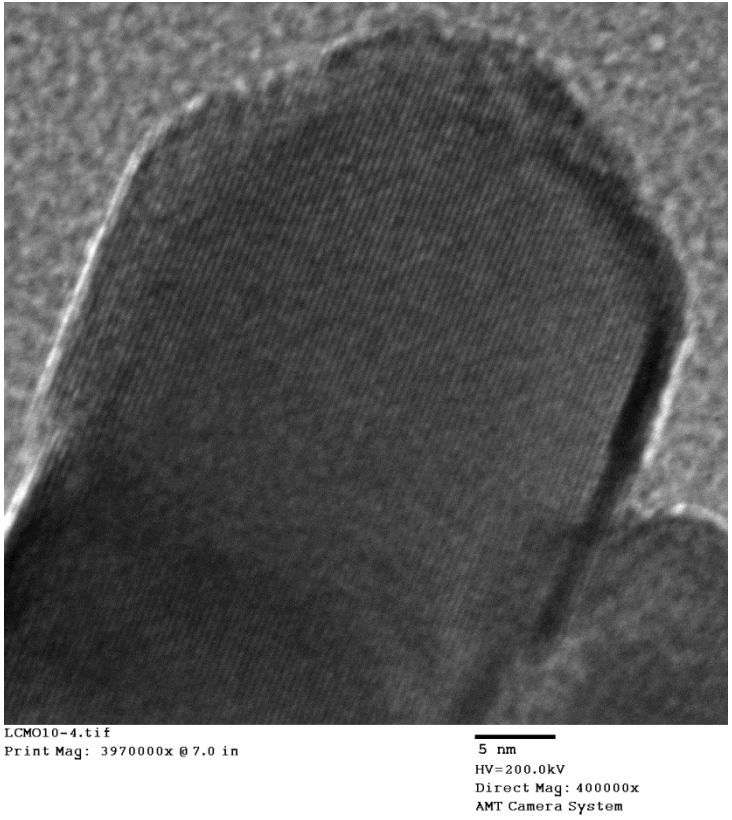


Synthesis of $La_{1-x}Sr_xMnO_3$ was performed via a standard sol-gel method.

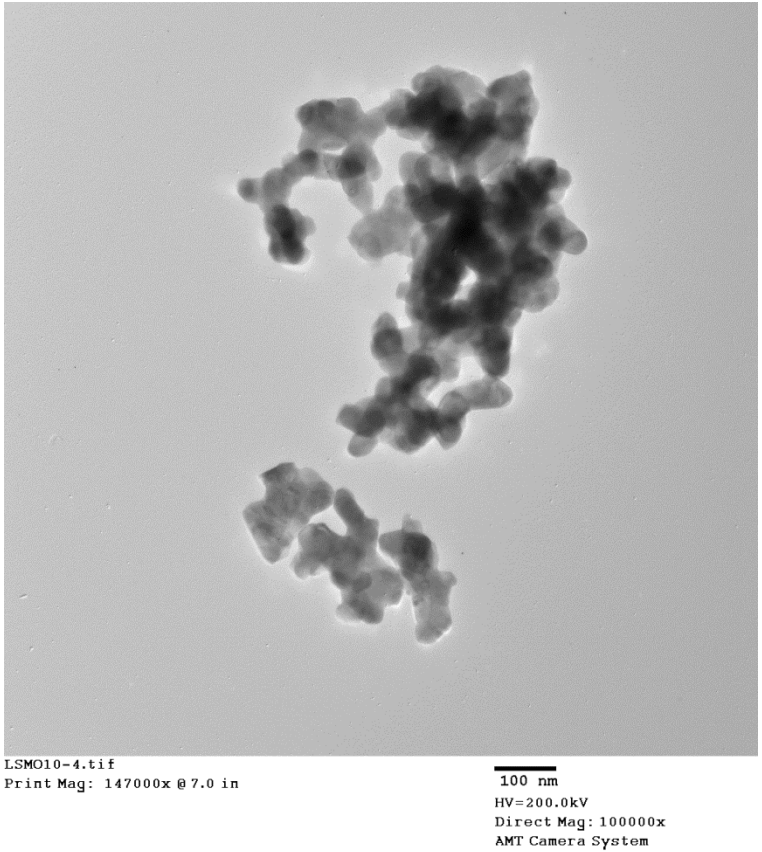


Structural characterization of the nanoparticles was performed using powder x-ray diffraction and transmission electron microscopy.





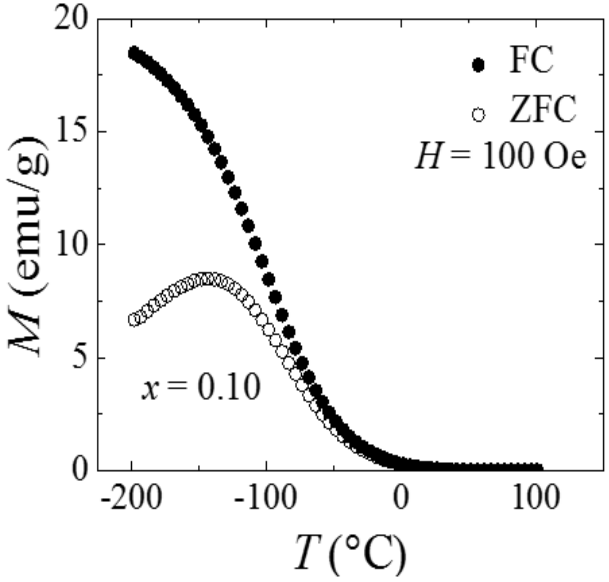
TEM analysis was used to determine size distribution of nanoparticles

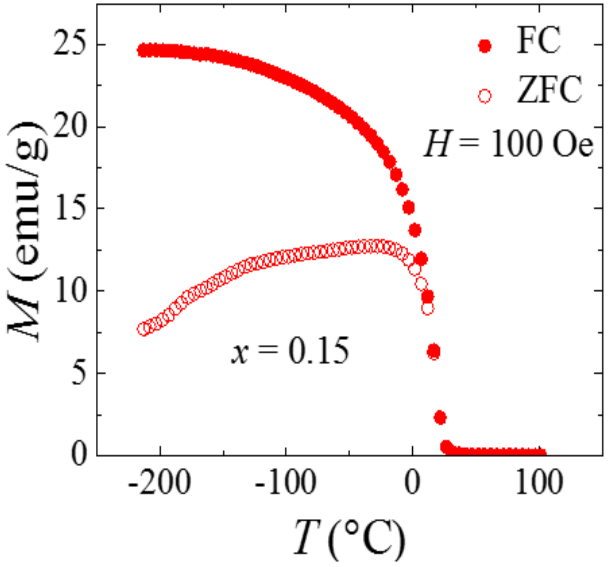


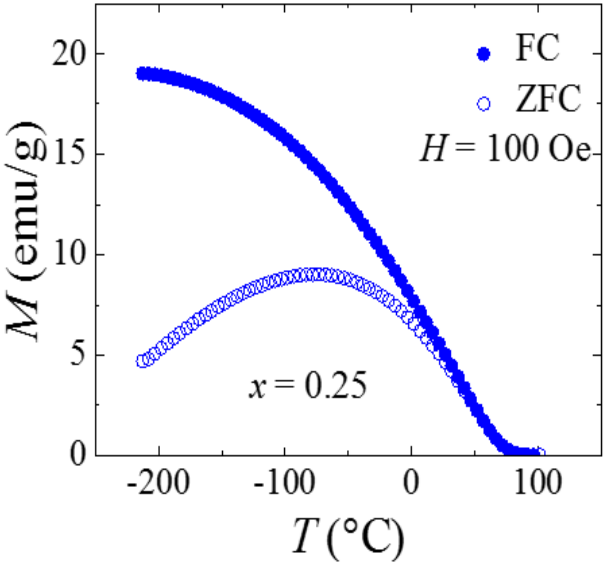
	D_S (nm)	D_L (nm)	CC
$x = 0.10$	43 ± 10	60 ± 17	1.4 ± 0.37
$x = 0.15$	19 ± 4	25 ± 7	1.3 ± 0.55
$x = 0.25$	26 ± 5	39 ± 11	1.5 ± 0.43

$$CC = \frac{D_L}{D_S}$$

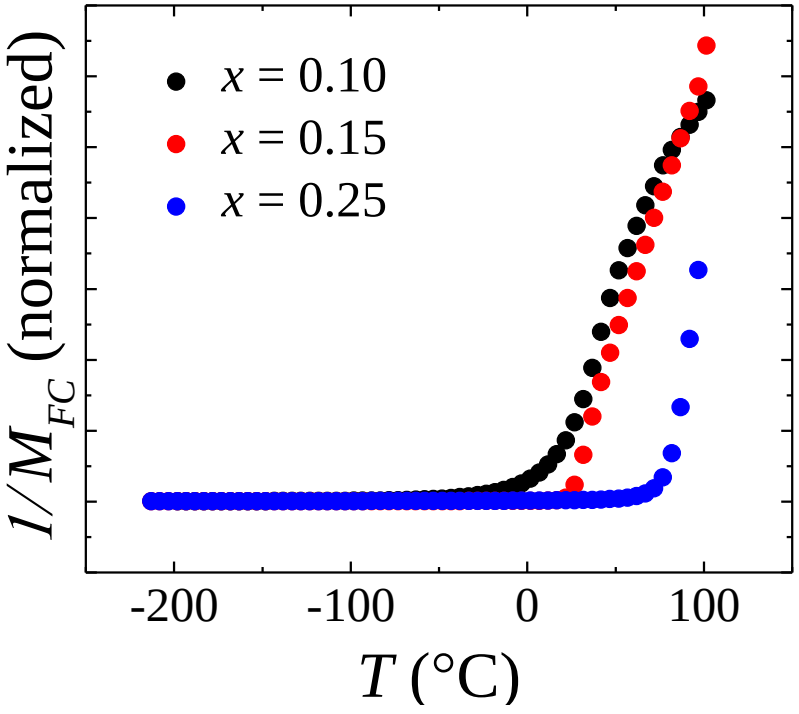
Zero-field-cooled and field-cooled magnetization measurements on these samples show a standard superparamagnetic signature.

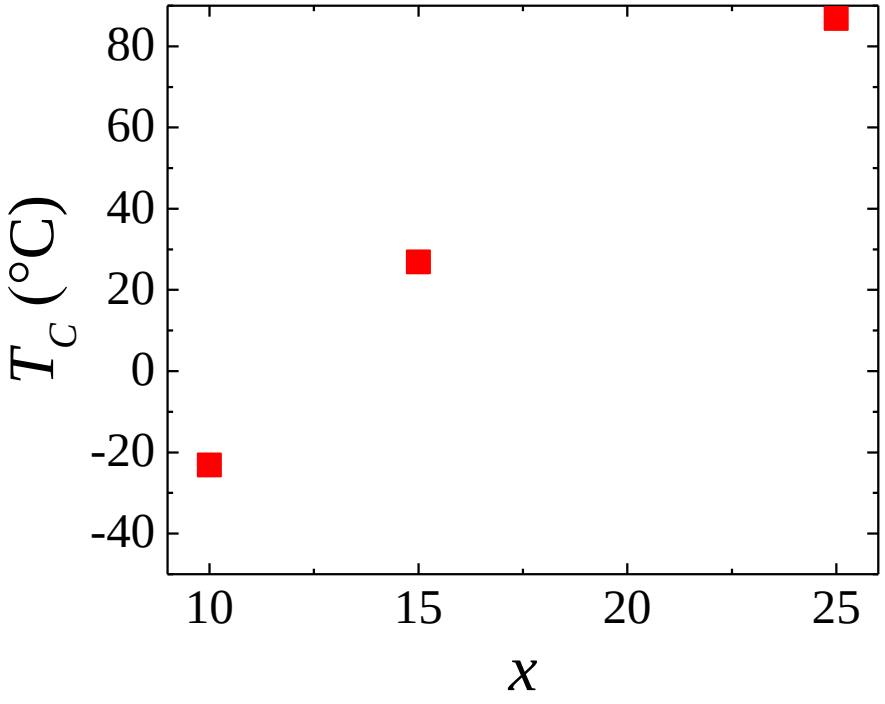






The Curie temperature for each sample can be determined by plotting the inverse of the field-cooled magnetization versus temperature.





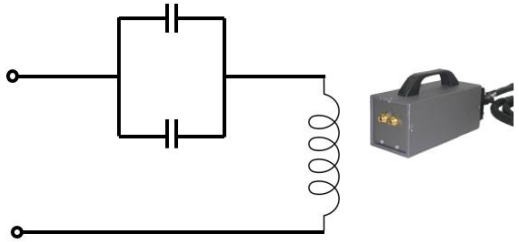
Future research includes application of principles learned from experimental data, increased biocompatibility of nanoparticles, and hyperthermia testing.

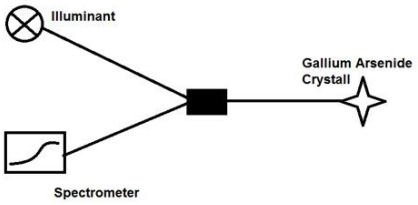
$$SAR = \frac{\text{Power Absorbed } (P)}{\text{Mass of Nanoparticles } (m_{NP})}$$

$$P = \frac{Q}{\Delta t} = \frac{M_{sample} c_{fluid} \Delta T}{\Delta t}$$

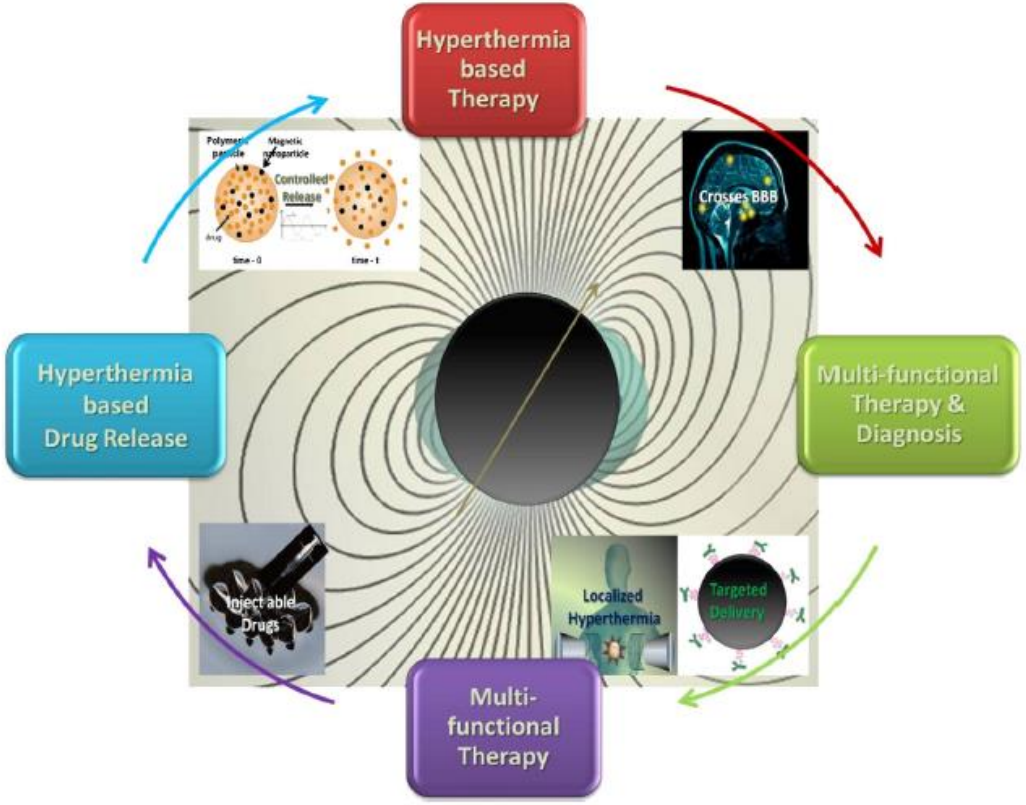
$$SAR = \frac{M_s}{m_{NP}} c_f \frac{\Delta T}{\Delta t}$$

Max. output = 2.4 kW





The investigation of self-controlled temperature nanoparticles as a form of hyperthermia treatment could open new doors in the fight against cancer.



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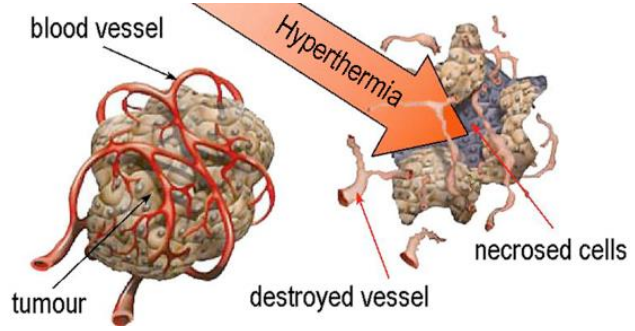

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