Magnetic heating of iron oxide Nanoparticles with alternating magnetic field for hyperthermia applications

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Objective: The nanoparticle can be made to heat up, which leads to their use as hyperthermia agents, delivering toxics amounts of thermal energy to tumours. Moderate degree of tissue worming results in more effective cell destruction.

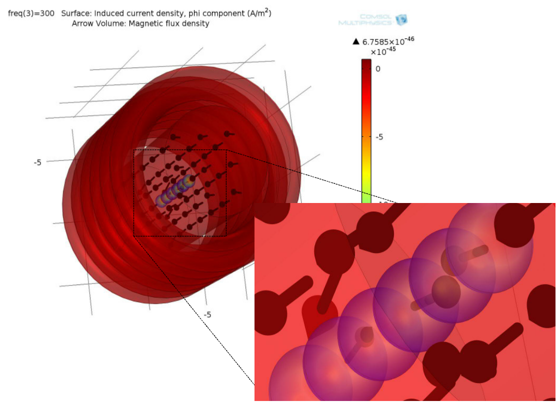


Figure 1. Iron oxide Nanoparticle in Magnetic Field

Physics of Magnetism

- The magnetic induction is given by

$$B = \mu_0(H + M)$$

- Equilibrium magnetization of the [M] system is described by Langevin equation

$$(M) = N\mu_{ef}\,[cth(\mu_{ef}H/K_BT) - (K_bT/\mu_{ef}H)]$$

- As the external magnetic field is enhanced, the blocking temperature decreases by a power law

$$T_b(H) = t_b(0)\,(1 - H/Hc)^k$$

- Magnetic relaxation

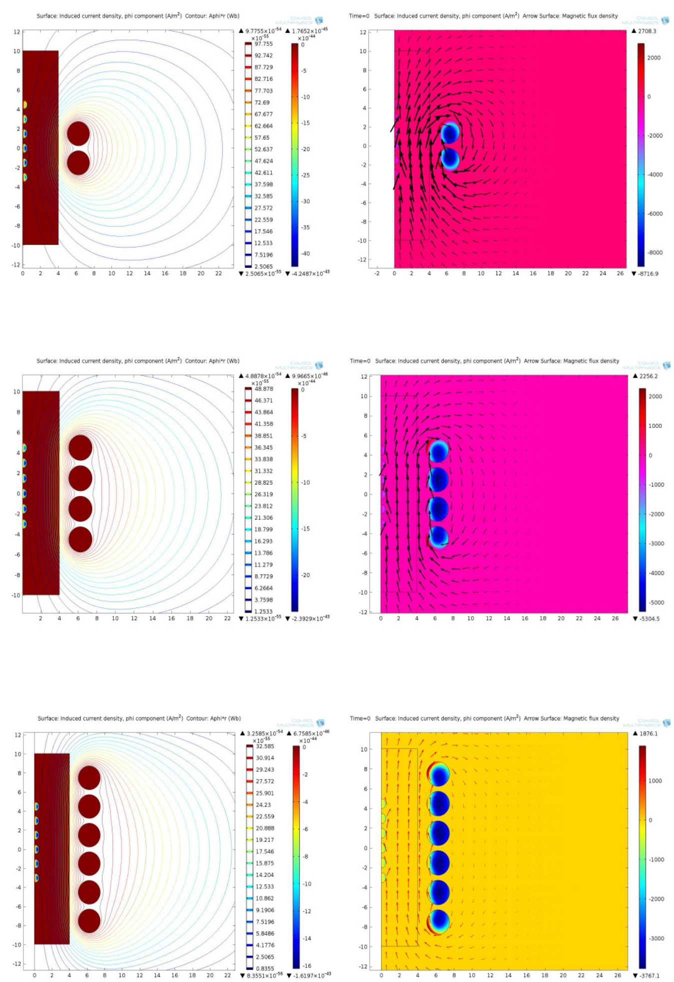
$$SAR = 4.1868\pi\mu_0^2\,\varphi Ms^2V/1000kT\,H_0^2V\,(2\pi VT/1 + (2\pi vT)^2$$

- The Neel and Brownian magnetic relaxation times of a particle are given by

$$\tau_N = \tau_0\, e^{(KV\,M/kT)}$$
$$\tau_B = 3nV_H/kT$$
$$\tau = \tau_B\,\tau_N/\tau_B + \tau_N$$

size (nm)	M_s	H_c	(T_b) °C	M_R	Reference
4	90	-	25	-	L.A Cano et al., 2010
4.2	75	318 G	19	-	Guardia et al., 2011
6.6	71	16 G	203	-	Caruntu et al., 2007
8.1	65	70 G	49	-	Guardia et al., 2011
8.5	31	0	100	0	Zhen et al., 2011
10	8.4	0	-	-	H Lu et al., 2004
11.6	77	15 G	264	low	Caruntu et al., 2007
12.5	60	0	245	-	J.Devkota et al., 2014
14	62.1	0	-	0	N.Arsalani et al., 2010
17	82		>275	-	Guardia et al., 2011
20	70	negligible	-	1.19	Sara Gil et al., 2013

Table 1. Particle size vs Magnetic properties



Reference

R.E Rosensweig ,“Heating magnetic fluid with alternating magnetic field”, Journal of Magnetism and Magnetic Materials, Vol.252, pp. 370-374 (2002)