HOW SMALL HOW LARGE THE MAGNETIC PARTICLE SHOULD BE IN THE FIXED DRUG DOSAGE

A. Yazdani, Z. Shadrokh, F. Karami
Dep. Physics, Tarbiat Modares University, P.O. Box: 14115-175, Tehran,Iran
yazdania@modares.ac.ir

Even though the small magnetic particles offer a proportionally larger surface area for absorption and therefore reducing the amount of magnetic carriers which are required to delivering fixed drug dosage, but increasing of the particle size would undoubtedly affect;
1) The external magnetic field, as it should be convenient for the high magnetic moment per unit volume and hence the higher magnetic saturation [1].
2) The larger particles are also more likely to be repelled from body very quickly [2,3].

However, while the fixed drug dosage for delivery should be exactly defined, the effect of size, chemical stability of structure and the number of particles in each convenient volume should be considered carefully by minimizing of the following internal materials' energy (potential) by three important controlling parameters of θ_i, $R_c=2k_f r_{ij}$ and σ_e. Where θ_i is the angle between the direction of the magnetic particle's moment and the line which joins the magnetic centers. R_c to be the effective correlation length between particles which are related to interatomic distance and the distance of the orbital and spin of electric charge and σ_e demonstrates the elastic shear constant which describes the effect of long range ion-ion oscillatory interaction which is proportional to $[\cos(2k_f r_{ij}+\varphi)]/(2k_f r_{ij})^3$.
As first the sharp and high magnetic moment in low external magnetic fields are functions of θ and R_c, as Crystal Field Effect, CFE, secondly the defined superparamagnetic structure where caused by the lack of anisotropy and thirdly controlling the chemical stability of nanoparticles distribution size as well as their hardness and softness, therefore for minimizing the following internal energies they play an important role;
1) the magnetic potential energy of a magnetic moment "μ_A" and its length "l" in the field of a similar magnet can be determined by:

$$U_p = -\frac{2\mu_A^2}{r_{ij}^3}\left[1.202P_2(\theta) + 1.038P_4(\theta)\left(\frac{l}{r}\right)^2 + \ldots\right]$$

Where $P_n(\theta)$s are Legendre functions.
2) the behavior of the linear moment when subjected to an external magnetic field "H" which can be defined by;

$$U_H = -H\mu_A\cos(\theta_0 - \theta)$$

3) the exchange interaction of the mean field approximation is given by:

$$\langle s_i \rangle = \frac{J\beta s_i \cdot H_i}{k_B T} \text{ where } H_i = \frac{2}{g\beta}\sum J_{ij} J_J \text{ results to}$$

$$U_{exchange} = \sum \frac{J(0)}{r_{ij}^3}\cos(\theta)\frac{J_{0j}}{J_{0i}}$$

Where J_{0i} and J_{0j} are the total quantum angular momentum and J(0) is the exchange interaction.
Consequently minimizing of the energy could be manifested by;

$$\frac{d}{d\theta}\left[U_P + U_H + U_{exchange}\right] = 0$$

$$\frac{d}{dR_c}\left[U_P + U_H + U_{exchange}\right] = 0$$

$$\frac{d}{d\sigma}\left[U_P + U_H + U_{exchange}\right] = 0$$

The minimizing energy equations have been applied to the size distribution of magnetic particles [4] experimentally which as shown in the fig. 1 satisfies the super paramagnetic conditions.

References:

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[3] Paula Gould, nanotoday, Vol. 1, Number 4 (2006) 34
[4] S.I. Denisov, et. Al. Physical Rev. Lett. 97 (2006) 227202

Figures:

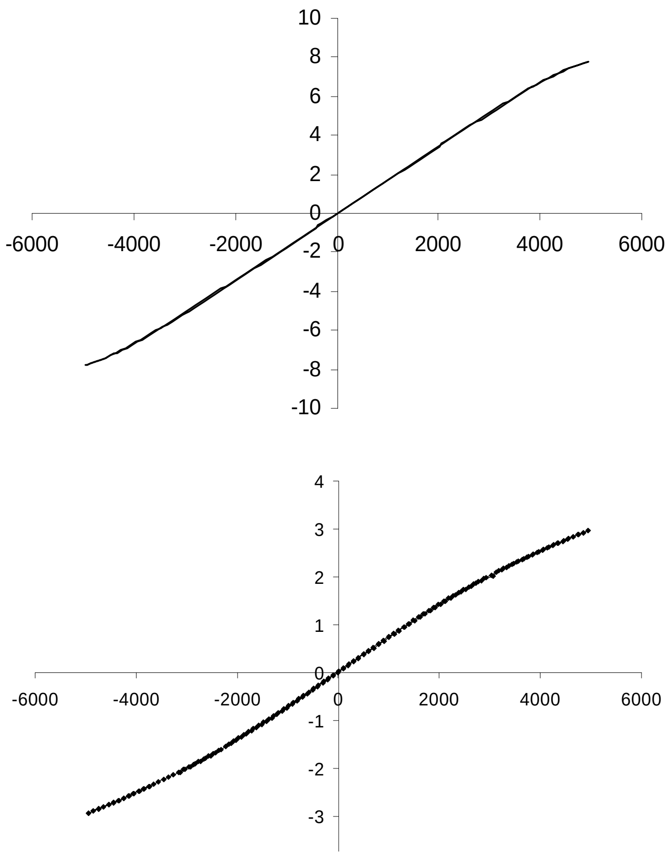

Fig. 1: Magnetization curve versus magnetic field strength for two different nanoparticle sizes