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RESEARCH ARTICLE

SELF MAGNITIZATION DEPENDENCE OF IRON FILLINGS ON NANO PARTICLE SIZE

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ABSTRACT

The main objective of the present work was investigated the self-magnetization for Iron filling samples. The experimental shown that the self-magnetization increasing dependent on size nanoparticles for the samples (x^1,x^2 and x^3), which x^1 denote the hard sample, x^2 is the mid-size and x^3 is soft one for Iron filling. The magnetization of sample x3 was greater than sample $x^2$and sample x^1.

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INTRODUCTION

Diverse technological applications of magnetic nanoparticles in recording tape, flexible disk recording media, permanent magnets, microwave oscillators as well as bio medical materials and catalysts, provides an impetus for extensive research in nanometre scale magnets (Bennett, 2013; Pufall *et al.,* 2004; Chappert, 2007). Most of these applications rely on the stability of magnetic ordering with time. In nanometre scale magnets, the thermal fluctuations randomize the magnetic moment by overcoming the anisotropy energy barrier leading to unstable state of Ferromagnetic.There has been a frenzy of activity in recent years into the investigation of nanoparticlesand their possible applications, or as celebrated physicist and Nobel laureate Richard Feynman put it the problem of manipulating and controlling things on a small scale" (Barber and Freestone, 1990). The list of applications includes drug delivery, catalysis, food production, cosmetics and the many further applications of Nano materials engineered with specific properties. The use of nanoparticles, however, goes back several millennia although those using this seemingly modern technology were unaware of it. There are examples of Roman glasswork over 2000 years old given their color using glasses coloured with nanoparticles (Faraday, 1857). Faraday (Faraday,1857) presented his gold sold to the Royal Society in London over 150 years ago (Feynman, 1960). Even the development of photography throughout the 19th century can be viewed as containing elements of nanotechnology and the use of nanoparticles by Hornyak et al. (Wakayama, 1995). The experimental observation of ferromagnetic moment formation at the nanoscale in Iron filling nanoparticles is an interesting departure from the bulk behavior of gold, which is ferromagnetic. The measured magnetization is strongly size dependent, increasing with particle diameter at the smaller nanoparticle sizes, peaking at approximately 500 nm for Iron filling nanoparticles, and subsequently decreasing with increasing nanoparticle size.

In this paper, experimental investigation of the self-magnetization for Nano size Iron Filings was studied.The experimental magnetic moment is calculated from the following formula (Hori, 2004).

$$\eta = \frac{MWXM_S}{558\ 5} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where MW is molecular weight of the sample and Ms is saturation magnetization in emu/g.When the size of magnetic nanoparticles reduces below a critical value (13nm for magnetite), such magnetic anisotropy increases the thermal

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energy (KBT) more than the energy barrier. Hence, the KBT is able to reorient the domains, diminishes hysteresis and coercive field to zero (which are characteristic features of SPM regime). When the particle size of a magnetic phase is reduced, the coercivity increases, goes through a maximum, and then tends towards zero (Neel, 1956). Hysteresis data are used to characterize the domain state and infer the average magnetic grain size. Bean *et al.* proposed firstly to determine the size distribution from the measurements of magnetization curve based on the theory of SPM (Cullity, 1972). In many cases, an accurate knowledge on the average size and size distribution of nanoparticles are crucially important for the proper working of the particular application. The particle moment may be determined by magnetic measurements, from which the particle volume may be obtained as *m*0/*Ms,* if *Ms*is known [Bean and Jacobs, 1956]. One can estimate Keff particle volume and particle size (diameter) by using the following relations (Chen *et al.,* 2009; Goya *et al.,* 2003).

$$\text{Keff} = \frac{\text{HCxMS}}{2} \quad \ldots\ldots (2)$$

$$V = \frac{25\text{KB TB}}{K_A} \quad \ldots\ldots (3)$$

$$V = \frac{4\pi r^3}{3} \quad \ldots\ldots (4)$$

Where, Keff and KA are effective magnetic anisotropy constant, HC is coercivity, MS is saturation magnetization, KB is Boltzmann constant (1.38 *10-23), TB is blocking temperature (303 K), V is particle volume and r is radius of particle. We estimated the values that Keff = 2502 J.m-3, particle volume = 4.2*10-23 m3, radius = 2.15*10-8 m and particle size (diameter) = 44 nm for lead SPM nanoparticles. The transition temperature from a magnetism state to SPM state with no hysteresis behaviour is referred as TB. Bulk materials have magnetic anisotropic energies much larger than the thermal energy (kT).

Experimental

Apparatus

DC power supply, Two Digital AVO-meter, plastic cylinder wounded by wires in the form of solenoid, Tesla-meter and three samples of Iron filling (soft,medium and hard).

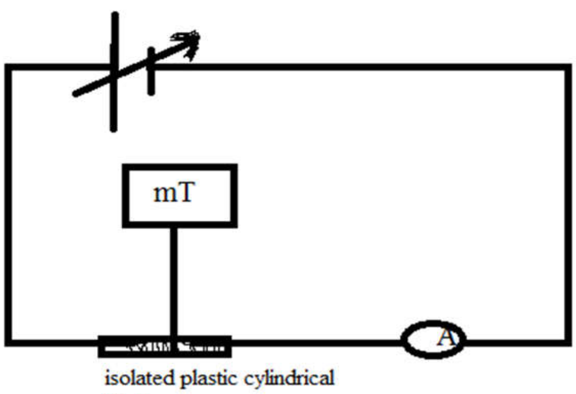

Figure 1. The setup of experiment

Procedure

The circuit which is shown in the Fig. (1) had been connected. The Iron filling was putted in isolated plastic cylindrical Coil. The initial value of magnetic inductance was recorded when current (I) is zero. The current I was increased in steps of 25mA, and the corresponding to magnetic field induction. This experiment was carried out in Omdurman Islamic University physic lab, Sudan.

RESULTS AND DISCUSSION

From Figure 2. It is clear that the linear relations between magnetic flux B and the current I for different size of iron fillings (X_1,X_2,X_3), where X_1 represent hard sized of iron filling with diameter (1-5)x10^3nm,X_2 is mid-sized iron fillings with diameter(0.5-1)x10^3nm and while X_3 soft sized iron fillings with diameter (0.05-0.1) x10^3nm. By the fitting three linear curves, equations (1), (2) and (3) were conducted as below;

For hard sized iron fillings:

$$B = 0.32484 + 0.00156i \quad \ldots\ldots (5)$$

And for mid-sized iron fillings:

$$B = 0.38747 + 0.00236i \quad \ldots\ldots (6)$$

Whereas the soft sized iron fillings:

$$B = 0.51626 + 0.0039i \quad \ldots\ldots (7)$$

Where B is magnetic flux and current I for different size of iron fillings (X_1,X_2,X_3).

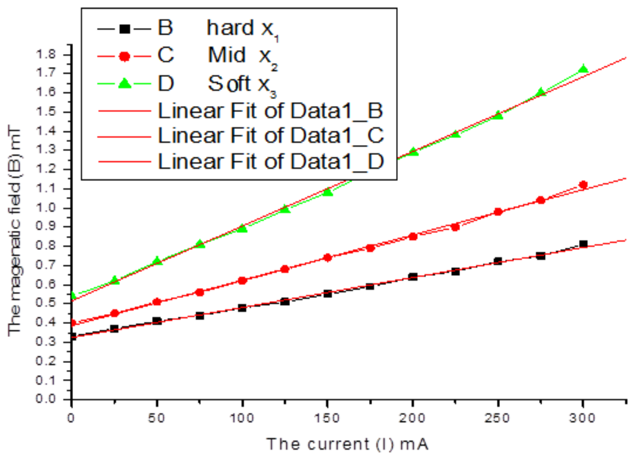

Figure 2. The relation between magnetic flux B and Current Ifor different size Iron Fillings

From Figure 2 and equations (1-3), it clear that the magnetic flux density increases when the current increases. This agrees with the relation:

$$B = \mu ni + B_0 \ldots\ldots (8)$$

Where μ is magnetic permittivity for Solenoid where the iron powder was inserted inside a solenoids and n is number of turns per unit length, i is current and B_0 is back ground flux.The back ground flux$B_0$are 0.3, 0.4 and 0.55 respectively hard, Mid and soft powders. The increase of B for fixed $\boldsymbol{i}$ with the decrease of Nano size may be due to the fact that the size decrease increases the density of nano particles which acts as small magnets. This increases of course B. The size decrease also decreases the mass of particles thus giving them more freedom to align the in selves easily in the direction of the external field.

Conclusion

The magnetic properties of matter for bulk iron and nano iron powder are different. The change of nano size change of nano size changes the flux density. The decrease of nanosize, increases the flux density.

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