Sudan University of Science and Technology

College of Graduate Studies

Effect of Change of Aluminum Nanosize In Its Paramagnetic Permeability

تأثير تغير حجم النانو لمادة بارامغناطسية (الالمونيوم) في النفاذية المغناطسية

Thesis Submitted for Partial Fulfillment of the Requirement for Degree of Master in (General Physics)

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November 2016

الآيـــــــــــة

قال تعالى:

بسم الله الرحمن الرحيم

(لَا يُكَلِّفُ اللَّهُ نَفْسًا إِلَّا وُسْعَهَا ۚ لَهَا مَا كَسَبَتْ وَعَلَيْهَا مَا اكْتَسَبَتْ ۗ رَبَّنَا لَا تُؤَاخِذْنَا إِن نَّسِينَا أَوْ أَخْطَأْنَا ۚ رَبَّنَا وَلَا تَحْمِلْ عَلَيْنَا إِصْرًا كَمَا حَمَلْتَهُ عَلَى الَّذِينَ مِن قَبْلِنَا ۚ رَبَّنَا وَلَا تُحَمِّلْنَا مَا لَا طَاقَةَ لَنَا بِهِ ۖ وَاعْفُ عَنَّا وَاغْفِرْ لَنَا وَارْحَمْنَا ۚ أَنتَ مَوْلَانَا فَانصُرْنَا عَلَى الْقَوْمِ الْكَافِرِينَ)

صدق الله العظيم

سورة البقرة الأية (286)

Dedication

To whom he strives to bless comfort and welfare and never stints what he owns to push me in the success way who taught me to promote life stairs wisely and patiently, to my dearest father

To the Spring that never stops giving, to my mother who weaves my happiness with strings from her merciful heart

To whose love flows in my veins, and my heart always remembers them, to my brothers ,sisters and my fiends

To those who taught us letters of gold and words of jewel of the utmost and sweetest sentences in the whole knowledge. Who reworded to us their knowledge simply and from their thoughts made a lighthouse guides us through the knowledge and success path, To our honored teachers and professors.

Acknowledgement

Before of all, the praise and thanks be to Allah whom to be ascribed all perfection and majesty. The thanks after Allah must be to my virtuous teacher professor : **Mubark Dirar Abd Allah** who supervised this research and guide me in patience until the results of this research are obtained. I wish to express my thanks to Sudan university of science and technology and department of physics. My humble thanks to everyone help and encourage me during this work. I also would like to thanks my friends and classmates for any support that make me complete this research.

Abstract

A magnetic property of matter plays an important role in modern technology. This need intensive research to satisfy technology need for new magnetic properties of matter. This motivates to do this research on the effect of change of nano size of Aluminum on its permeability. Three different nano sizes were prepared. It was found that increase of Aluminum nano size increases its magnetic permeability

مستخلص البحث

تلعب الخواص المغناطيسية للمادة دورامهما في مجال التقنية الحديثة . هذه تحتاج الى اجراء ابحاث مكثفة لتلبية حاجة التقنية لخصائص مغناطسية جديدة للمواد.هذا ما حفز على عمل هذا البحث في تأثير تغير الحجم النانوي للالمونيوم على النفاذية المغناطسية أعدت ثلاثة ابعاد نانوية مختلفة . ووجدان زيادةالحجم النانوي يزيد النفاذية المغناطسية للالمونيوم .

Cotenant

Chapter One

Introduction

(1.1)Magnetic Field

Magnetic field is one of the oldest discovered. It was discovered that some stones can attract iron. This stone is called magnet .recently it was discovered that the motion of metallic coils can produce electric current [1].

It was also found that electric current produces magnetic field. This relation between electric and magnetic field encourages Maxwell to formulate the well-known famous electromagnetic field ($e.m.f$) equation. Using these equations leads to prediction of possibility of generating $e.m$ waves by oscillating charges[2].

Magnetic field is used widely in generating electricity, and storing information in magnetic Discs.

The electric current is used in operating different electronic and home devices.

The electromagnetic field has wide scope of application in mobile phone, internet, radio and television [1].

(1.2) Research Problem

There research problem is related to the fact that there are not enough experimental studies explaining the effect of nano size on magnetic permeability of the paramagnetic materials

(1.3) Literature Review

In a research done by some researchers.

Low pressure chemical vapor deposition device is used to synthesize carbon nanotubes (CNTs) of iron nanoclusters [3].

In another work the self-magnetization for Iron filling samples was investigated by the experimental work which shows that the self-magnetization increasing dependent on size nanoparticles for the samples c(x^1 , x^2 and x^3) which x^1denote the hard sample x^2 is the mid-size and x^3 is soft one for Iron filling the magnetization of sample x^3 was greater than sample $x^2$and sample x^1 [4].

Two types of highly ordered TiO_2nanotubes were grown by anodic oxidation on titanium foil and titanium films deposited by rf-sputtering onto transparent conducting glass

Highly ordered TiO_2 nanotubes were grown by anodic oxidation on titanium foil and titanium films deposited by rf-sputtering onto transparent conducting glass (TiO) and their photo-electrochemical parameters were characterized and compared to each other [5].

(1.4)Aims of Work

The aim of the work is to see how the magnetic permeability is affected by different nano sizes of Aluminum which is paramagnetic material

(1.5)This is Layout

The thesis consists of four chapters chapter one is the introduction chapter two is concerned with magnetic properties of matter while chapter three is devoted for nano science. The contribution is in chapter four

Chapter Two

Magnetic Properties of Matter

2.1 Introduction

Magnetic field is very important for people. This chapter is concerned with the magnetic properties of matter this includes magnetic susceptibility magnetic classification of materials on the basis of atomic properties of matter

2.2 Magnetic Moment and Susceptibility

The magnetic moment of matter result from that of atoms. The magnetic moment p is defined in terms of the current $i$and area Aenclosed by it to be in the form

$$p = iA \tag{2.1}$$

But the current generated by the electron of charge –e moving around a nucleus in a circular orbit of radius is given by

$$i = -ef = \frac{e\omega}{2\pi} \tag{2.2}$$

f is the frequency

The area of a circle in closed by the electron orbit is given by

$$A = \pi r^2 \tag{2.3}$$

One the other hand the orbital angular momentum L is given by

$$L = mvr = m\omega r^2 \tag{2.4}$$

Where m is the mass electron and $v$is the electron speed

Inserting (2.2.2), (2.2.3) and (2.2.4) in (2.2.1) yields the magnetic moment in the form

$$p = iA = -\frac{e\omega}{2\pi}(\pi r^2) = \frac{-e\omega r^2}{2}$$

$$p = \frac{-em\omega r^2}{2m} = -\frac{e}{2m}L \tag{2.5}$$

Similarly the spin magnetic moment P_s is related to the spin angular momentum according to the relation

$$\vec{P}_s = -\frac{e}{m}\vec{S} \tag{2.6}$$

The total magnetic moment P_m resulting from spin and orbital motion is given by

$$\vec{P}_m = \frac{e\hbar}{2m}\mathrm{g}_J\vec{J}$$

$$\vec{P}_m = -\mu_\mathrm{g}\mathrm{g}_J\vec{J} \tag{2.7}$$

$\vec{J}$ Is the quantum number, $\mathrm{g}_J$is the g factor and μ_g is the susceptibility hence

$$\vec{P}_m = -\mu_B\langle\vec{L} + 2\vec{S}\rangle \tag{2.8}$$

Where

$$\mathrm{g}_J\vec{J} = \langle\vec{L} + 2\vec{S}\rangle \tag{2.9}$$

$$\mu_\mathrm{B} = \frac{e\hbar}{2m} \tag{2.10}$$

The parameter g_J can simply by given by

$$\mathrm{g}_J = \frac{\frac{3}{2}\vec{J}^2 + \frac{1}{2}\vec{S}^2 - \frac{1}{2}\vec{L}^2}{\vec{J}^2} \tag{2.11}$$

$$= \frac{3}{2} + \frac{S(S+1) - L(L+1)}{2J(J+1)} \tag{2.12}$$

$$\vec{J} = \hbar\sqrt{J(J+1)}$$

This relation can be found by setting

$$\vec{J} = \vec{L} + \vec{S} \tag{2.13}$$

$$J^2 = L^2 + S^2 + 2\vec{L}.\vec{S} \tag{2.14}$$

$$\langle\vec{L} + 2\vec{S}\rangle = \vec{L} + 2\vec{S} \tag{2.15}$$

To get

$$\mathrm{g}_J\vec{J}.\vec{J} = \left(\vec{L} + 2\vec{S}\right).\left(\vec{L} + \vec{S}\right) = L^2 + 2S^2 + +3\vec{L}.\vec{S} \tag{2.16}$$

Then

$$\mathrm{g}_J J^2 = L^2 + 2S^2 + 3L.S \tag{2.17}$$

Form (2.14)

$$L.S = \frac{J^2 - L^2 - S^2}{2}$$

$$= \frac{1}{2}J^2 - \frac{1}{2}L^2 - \frac{1}{2}S^2$$

$$g_J J^2 = L^2 + 2S^2 + \frac{3}{2}J^2 - \frac{3}{2}L^2 - \frac{3}{2}S^2$$

$$= \frac{3}{2}J^2 - \frac{1}{2}L^2 + \frac{1}{2}S^2$$

Hence

$$G_J = \frac{\frac{3}{2}J^2 + \frac{1}{2}S^2 - \frac{1}{2}L^2}{J^2} \quad (2.18)$$

If n atoms per unit volume align themselves along the x-ray thus the component of x is given by

$$M_x = nP_m = -n\mu_B g_J \vec{J} \quad (2.19)$$

Where M_x change from 0 to max value during a time T

The electron revolving around a nucleus can produce a magnetic field of flux density B if the electron revolves with frequency *f* in circular orbit of radius *r* then according to Bio-Savart law it produces a magnetic field of flux density

$$B_e = \frac{\mu_0 i}{2r} \quad (2.20)$$

$$B_e = \frac{\mu_0 fe}{2r} \quad (2.21)$$

$$i = fe$$

The magnetic moment produced by such an electron is given by

$$P_m = iA = i(\pi r^2) = \pi i r^2 \quad (2.22)$$

Where A is the area enclosed by the current i

$$A = \pi r^2 \quad (2.23)$$

For z electron with mean radius r,the magnetic flux density of the atom (B_a) is given by

$$B_a = \frac{\mu_0 zfe}{2r} \quad (2.24)$$

Thus the internal atomic field generated by one electron is $B_i = \frac{\mu_0 fe}{2r}$ and is related to the magnetic moment through the relation

$$B_e = \frac{\mu_0 P_m}{2\pi r^3} \tag{2.25}$$

Since the current for the whole atom is

$$i = zfe$$

Hence the field of the atom is related to the magnetic moment also as follows

$$B_a = \frac{\mu_0 P_m}{2\pi r^3} \tag{2.26}$$

Bu the magnetic moment M is defined in terms of the number of dipoles N divided by the volume V to be

$$M = \frac{NP_m}{V} \tag{2.27}$$

If the atomic radius is r, thus one atom exists in a volume $V_a$is given by

$$\frac{N}{V} = \frac{1}{V_a} = \frac{1}{\frac{4}{3}\pi r^3} = \frac{3}{4\pi r^3} \tag{2.28}$$

This

$$M = \frac{3P_m}{4\pi r^3} \tag{2.29}$$

Using (2.25), (2.27) and (2.28) in (2.29) yields

$$M = \frac{3}{4\pi r^3}\frac{B_a}{\mu_0}(2\pi r^3) = \frac{3B_a}{2\mu_0} \tag{2.30}$$

Assume the proton is affected by nuclear force $F_e$beside internal magnetic field B_i and a resistive force γv_0 thus the proton equation of motion

$$ma = F_e - B_i e v_0 - \gamma v_0$$

$$ma = \frac{m{v_0}^2}{r} = F_e - eB_i\omega_0 r - \gamma\omega_0 r$$

$$m{\omega_0}^2 r = F_e - eB_i\omega_0 r - \gamma\omega_0 r$$

$$F_e = m{\omega_0}^2 r + eB_i\omega_0 r + \gamma\omega_0 r \tag{2.31}$$

When an external magnetic field B_e is applied the frequency becomes ω thus one gets

$$m\omega^2 r = F_e - eB_i\omega r - \gamma\omega r + Bev$$

$$= m{\omega_0}^2 r + eB_i\omega_0 r + \gamma\omega_0 r - eB_i\omega r - \gamma\omega r + B_e\omega r$$

$$m(\omega + \omega_0)(\omega - \omega_0)r =$$

$$eB_i r(\omega_0 - \omega) + \gamma r(\omega_0 - \omega) + B_e\omega r \tag{2.32}$$

If the frequency ω is greater slightly than ω_0 it follows that

$$\omega_L = \omega - \omega_0\omega \approx \omega_0 \tag{2.33}$$

$$-2m\omega_0\omega_L = eB_i\omega_L + \gamma\omega_L + B_e\omega_0$$

$$-[2m\omega_0 + \gamma + eB_i]\omega_L = B_e\omega_0$$

$$\omega_L = -\frac{B_e\omega_0}{2m\omega_0+\gamma+eB_i} \tag{2.34}$$

The magnetic susceptibility can be found by using

$$i = -zef = \frac{ze\omega_L}{2\pi}$$

$$P_m = Ai = \pi r_0^2 ef = -ze\omega_L r_0^2 \tag{2.35}$$

Where

$$x = y = z$$

$$x^2 = y^2 = z^2$$

Thus

$$r^2 = x^2 + y^2 + z^2$$

$$z^2 + z^2 + z^2 = 3z^2$$

Hence

$$z^2 = \frac{1}{3}r^2$$

$$r_0^2 = r^2 - z^2 = 3z^2 - z^2 = 2z^2 = \frac{2}{3}r^2 \tag{2.36}$$

$$M = nP_m = -\frac{2znner^2\omega_L}{3}$$

$$M = -\frac{2ze^2nr^2\omega_0 B}{3(2m\omega_0 + \gamma + eB_i)}$$

$$M = -\frac{2ze^2n\omega r^2\mu_0}{3(2m\omega_0+\gamma+eB_i)}H = x_m H \tag{2.37}$$

Then magnetic susceptibility is given by [6].

$$x_m = -\frac{2ze^2n\omega r^2\mu_0}{3(2m\omega_0+\gamma+eB_i)} \tag{2.38}$$

(2.3) Classification of Mantic Materials

All materials can be classified in terms of their magnetic behavior. The two most common types of magnetism are diamagnetism and paramagnetism which account for the magnetic properties of most of the periodic table of elements at room temperature these elements are usually referred to as nonmagnetic whereas those which are referred to as magnetic are actually classified as ferromagnetic the only other type of magnetism observed in pure elements at room temperature is antiferromagnetism

Finally, magnetic materials can also be classified as ferromagnetic although this is not observed in any pure element but can only be found in compounds such as the mixed oxides known as ferrites from which ferrimagnetism derives its name the value of magnetic susceptibility falls into a particular range for each type of material [7].

(2.4) Diamagnetism and Langevin Equation

In a diamagnetic material the atoms have no magnetic moment. Under the influence of an applied field the spinning electrons generates electric current which produces a magnetization (M) in the opposite direction to that of the applied field. The value of susceptibility is independent of temperature [7].

The diamagnetic susceptibility can be found by using langevin equation

The magnetic moment of atom is given by

$$U_m = iA = \frac{-e\omega}{2\pi} \times \pi r^2 = -\frac{e\omega r^2}{2} \tag{2.39}$$

For electron moving with velocity $v_0$the centrifugal force is given by

$$F_c = \frac{mv_0^2}{r} \tag{2.40}$$

Where

$$v_0 = \omega_0 r \tag{2.41}$$

$$\therefore F_c = m\omega_0^2 r \tag{2.42}$$

When only electric force F_e and centrifugal force act on electrons

$$F_e = F_c = m\omega_0^2 r \tag{2.43}$$

But when magnetic force act on electrons

$$F_c = \frac{mv^2}{r} = m\omega^2 r = F_e + Bev$$

$$= m\omega_0^2 r + Be\omega r \qquad (2.44)$$

Thus

$$\omega^2 - \omega_0^2 = -\frac{eB\omega r}{m} \qquad (2.45)$$

By adopting the approximation

$$\omega - \omega_0 = \Delta\omega$$

$$\therefore \omega \approx \omega_0 \qquad (2.46)$$

Hence

$$\omega^2 - \omega_0^2 = (\omega + \omega_0)(\omega - \omega_0) = (2\omega)(\Delta\omega) \qquad (2.47)$$

From equations (2.45) and (2.47)

$$\therefore \Delta\omega = \frac{eB}{2m} \qquad (2.48)$$

Thus the larmor frequency is given by

$$\omega_l = \Delta\omega = \frac{eB}{2m} \qquad (2.49)$$

Therefore the current take the form

$$i = -ezf = -\frac{\omega_l eZ}{2\pi} = \frac{\left(-\frac{eB}{2m}\right)eZ}{2\pi} \qquad (2.50)$$

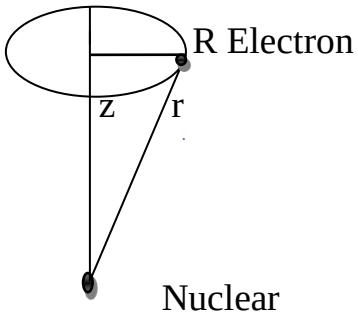
Where Z is the atomic number

Thus the atomic magnetic moment is given by

$$M_a = iA = -\frac{\omega_l eZ}{2\pi}\pi R^2 = -\frac{\omega_l eR^2 Z}{2} \qquad (2.51)$$

$$M_a = \Delta M = -\frac{eR^2\Delta\omega Z}{2} \qquad (2.52)$$

$$M_a = -\frac{e^2R^2B}{4m} \qquad (2.53)$$



When

$$r^2 = x^2 + y^2 \tag{2.54}$$

Hence

$$R^2 = \frac{2}{3}r^2 \tag{2.55}$$

Thus

$$M_a = -\frac{e^2 B r^2 Z}{6m} \tag{2.56}$$

Where

$$r^2 = x^2 + y^2 + z^2$$

$$\therefore x = y = z$$

$$\therefore R^2 = \frac{2}{3}r^2 \tag{2.57}$$

But the magnetic moment per unit volume is given by

$$M = nzM_a = -\frac{nze^2r^2B}{6m} = -\frac{nze^2r^2\mu_0 H}{6m} \tag{2.58}$$

Where

$$B = \mu_0 H$$

n Is number of atoms per unit volume

The diamagnetic susceptibility is given by

$$X_D = \frac{M}{H} == -\frac{\mu_0 nze^2r^2}{6m}$$

Or

$$X_D = \frac{\mu_0 nze^2R^2}{4m} \tag{2.59}$$

[10].

(2.5) Paramagnetism Quantum Susceptibility

For some atoms that have even number of electron spin is associated with each atom when a magnetic field is applied the dipoles align with the field causing a positive magnetization. Large magnetic fields are required to align all atoms in the field direction. Atoms return back to random motion as soon as the magnetic field is removed this effect called paramagnetism is found in metals such as aluminum titanium and alloys of copper the magnetic susceptibility (X_m) of paramagnetic materials is positive and lies between $10^{-4}$and 10^{-5} [8]

If a magnetic field of strength H causes the energy E to change by on amount

$$\Delta \mathrm{E} = g\beta \mathrm{H} m_s \tag{2.60}$$

Where

g : Landi factor

β: Bohr magneton

m_s: Magnetic spin quantum number

The energy split into two sub states E_1 and E_2 where the number of particles in them is given by

$$n_1 = e^{\Delta \mathrm{E}/kT} \tag{2.61}$$

$$n_2 = e^{-\Delta \mathrm{E}/kT} \tag{2.62}$$

Thus

$$\therefore n = n_1 + n_2 = e^{\Delta E/kT} + e^{-\Delta E/kT} \tag{2.63}$$

$$\frac{n_1}{n} = \frac{e^{\Delta E/kT}}{e^{\Delta E/kT} + e^{-\Delta E/kT}} \tag{2.64}$$

And

$$\frac{n_2}{n} = \frac{e^{-\Delta E/kT}}{e^{\Delta E/kT} + e^{-\Delta E/kT}} \tag{2.65}$$

The magnetic moment is given by

$$M = g\beta m_s(n_1 - n_2) \tag{2.66}$$

$$M = g\beta m_s \left(\frac{e^x - e^{-x}}{n}\right) n = \frac{e^x - e^{-x}}{e^x + e^{-x}} g\beta m_s n \tag{2.67}$$

Setting

$$x = \frac{\Delta E}{KT} \tag{2.68}$$

Inserting (2.60) in (2.68) yields

$$x = \frac{g\beta m_s H}{KT} \tag{2.69}$$

For small x one gets

$$\therefore e^x \approx 1 + x \quad , x \ll 1$$

$$\frac{e^x - e^{-x}}{e^x + e^{-x}} = \frac{(1+x)-(1-x)}{(1+x)+(1-x)} = \frac{2x}{2} = x \tag{2.70}$$

Inserting (2.70) in (2.67) yields

$$M = xg\beta m_s n \tag{2.71}$$

Inserting (2.69) in (2.71) yields

$$M = g\beta m_s n \times \frac{g\beta m_s \mathrm{H}}{KT}$$

$$M = \frac{ng^2 m_s^2 \beta^2 H}{KT} \tag{2.72}$$

When $g = 2$, $m_s = \frac{1}{2}$

$$M = \frac{n\beta^2 H}{KT} \tag{2.73}$$

Thus the paramagnetic susceptibility takes the

$$X = \frac{M}{H} = \frac{n\beta^2}{KT} \tag{2.74}$$

[11].

(2.6)Ferro and Antiferromagnetic

When an atom has odd number of electrons it acts as tiny magnet. Individual atomic magnetic moments are then thermally disordered at any finite temperature they point in random directions yielding a zero net moment for the solid as a whole. When an external field is applied it leads to an ordering of all magnetic moments at sufficiently low temperatures as schematically however a similar effect could also be obtained by coupling the different magnetic moments by having an interaction that would favor parallel alignment for example Already quite short-ranged interactions for example only between nearest neighbors would already lead to an ordered structure Such interactions are often generically denoted as magnetic interaction although this should not be misunderstood as implying that the source of interaction is really magnetic in nature materials that exhibit an ordered magnetic structure in the absence of an applied external field are called ferromagnets (or permanent magnets) and their resulting magnetic moment is known as spontaneous magnetization. The complexity of the possible magnetically ordered states exceeds the simple

parallel alignment case in another common case the individual local moments sum to zero and no spontaneous magnetization is present to reveal the microscopic ordering such magnetically ordered states are classified as antiferromagnetic and one possible realization.

In antifromagnet, individual atoms align themselves such that their magnetic moments are opposite to each other. Thus the net magnetic [9].

Chapter Three

Nanoscience

(3.1) Introduction

Nanoscience is one of the most recent branches of science the applications of nanoscience includes medicine and industry therefore this chapter is concerned with the physics of nanomaterials.

(3.2) What is Nanoscience

Nanoscience is the phenomena that occur in systems with nanometer dimensions some of the unique aspects of nano systems arise solely from the tiny size of the systems.

Nano is about as small as it gets in the world of regular chemistry materials science and biology the diameter of a hydrogen atom is about one tenth of nanometer so the nanometer scale is very smallest scale one which we might consider building machines of the basis of the principles we learn from every day mechanics on the using the 1000 or so hydrogen atoms we could pack into a cube of size $1nm \times 1nm \times 1nm$ if this all that there was to nanoscience it would still be remarkable because of the incredible difference in scale between the nano world and regular macroscopic world.

In nanostructures we have layered on top of quantum mechanics the statistical behavior of a large collection of interacting atoms from this mixture of quantum behavior and statistical complexity many phenomena emerge they span the gamut from nano scale physics to chemical reactions to biological processes .the value of this rich behavior is enhanced when on realizes that the total number of atoms in the systems is still small enough that many problems in nanoscience are amenable to modern computational techniques .thus studies at the nanometer scale have much in common whether they are carried out in physics materials science chemistry or biology just as important at the technological implication[12].

(3.3)Advantages and Disadvantages of Nanomaterials

Nanomaterials are formed when bulk matter is fragment to small tiny nano isolated particles.

The strength and the durability of structure of materials strongly depend on the structure and properties of grain boundaries and size. These nano particles need to be isolated by host material so as to prevent their interaction the behavior of these nano isolated particles obeys quantum laws. Thus one expects them to have physical properties different from that of buck matter. Despite these successes nano materials suffers from some disadvantages [13].

First of all fine metal particles act as strong explosives owing to their high surface area coming in direct contact with oxygen their exothermic combustion can easily cause explosion.

Secondly nano particles are highly reactive they inherently interact with impurities as well. In addition encapsulation of nanoparticles becomes necessary when they are synthesized in a solution (chemical route) The stabilization of nanoparticles occurs because of a non-reactive species engulfing the reactive nano-entities thereby these secondary impurities become a part of the synthesized nanoparticles and synthesis of pure nanoparticles becomes highly difficult. Formation of oxides nitrides etc can also get aggravated from the impure environment/ surrounding while synthesizing nanoparticles hence retaining high purity in nanoparticles can become a challenge hard to overcome.

Thirdly nanomaterials are usually considered harmful as they become transparent to the cell-dermis Toxicity of nanomaterials also appears predominant owing to their high surface area and enhanced surface activity Nanomaterials have shown to Cause irritation and have indicated to be carcinogenic If inhaled their low mass entraps those inside lungs and in no way they can be expelled out of body their interaction with liver/blood could also prove to be harmful (though this aspect is still being debated on).

Fourthly difficulty in synthesis isolation and application it is extremely hard to retain the size of nanoparticles once they are synthesized in a solution hence the

nanomaterials have to be encapsulated in a bigger and stable molecule/material. Hence free nanoparticles are hard to be utilized in isolation and they have to be interacted for intended use via secondary means of exposure Grain growth is inherently present in nanomaterials during their processing. The finer grains tend to merge and become bigger and stable grains at high temperatures and times of processing [14].

(3.4) Nanosaize and Nanoshapes

The funelamental particle properties such as particle diameter particle shape of nanosized or fine particles influence the character of the particle packed bed in these particle properties the particle diameter measurement equipment based on various principles can be marketed and it is easy to measure particle diameter distribution but a particle shape analyzer for nano particle cannot be easily found and the shape index of nano particle can be calculated from particle imageges observed using various types of microscope:

1. Two dimensional particle image:

In order to measure the particle shape of two dimensional projection images captured from microscope photograph is analyzed since the diameter of nano particle is smaller than the wave length of visible light a nano size particle cannot be observed by an optical microscope

2. Three dimensional particle image:

Particle shape measurement of flaxy particle or porous particle including hole or space inside the particle he shape analysis of two dimensional particle projection picture is inadequate and three dimensional shape analysis is necessary

3. Particle shape index using particle diameter ratio: once the microscope particle image is captured quantification of particle shape can be performed by the some method as a coarse even if is a nano particle

4. Particle shape expression by fractal dimension: The fractal dimension is a dimension taking a veal numerical value proposed by Mandelbrot and is also used for Particle shape expression the divider particle projection image

perimeters if the relation between r and $N(r)$ shows straight line on log.log paper as shown the value corresponding to the inclination of this straight line is defined as the fractal dimension

$$N(r) \propto r.D \tag{3.1}$$

5. Particle shape analysis by Fourier analysis:

In the Fourie analysis method the particle shape is given as a function of the radius from the center of mass to perimeter as shown the Fourie analysis is carried out by the following equation

$$\int(0) = a_0 + \sum_{n=1}^{\infty}(a_n \cos\frac{2n\pi}{1}0 + b_n \sin\frac{2n\pi}{1}0) \tag{3.2}$$

6. Particle shape analysis of nanoparticle:

A particle shape analyzer is not available for nanoparticle and so a method based on the microscopic particle image is used usually in order to obtain the average result about many particles the ratio of two particles diameters obtained by deferent kinds of method such as a particle size by dynamic light scattering method and the specific surface diameter by gaud sorption is used [15].

(3.5) Quantum Dots

Nano materials are isolated nano particles that can be described by quantum laws. Usually Schrodinger equation is used by imposing some restriction and generalization the lagrangeing to describe electron-electron interaction, lattice-electron interaction beside pin-pin interaction.

The dot plane is generally calculated by considering the following Hamiltonians:

$$\widehat{H} = \sum_{i=1}^{N}\left\{\frac{1}{2m}\left[\vec{p}_i + e\vec{A}(\vec{r}_i)\right]^2 + V(\vec{r}_i)\right\} + \frac{1}{4\pi\varepsilon_0\varepsilon_r}\sum_{i>j}^{N}\frac{e^2}{|\vec{r}_i - \vec{r}_j|} + g\mu_B B_z S_z \tag{3.3}$$

Where:

The first term is one-electron term the second term is coulomb potential energy the last term is the Zeeman energy

$V_{(r)}$ Is the one electron confinement potential

The vector potential in a symmetric gauge is written as follows

$$\vec{A}(\vec{r}) = \frac{B_z}{2}(-y, x, 0) \tag{3.4}$$

Where:

$\vec{r} = (x, y)$ Is the 2D position vector

$-e(e > 0)$ Is electron's charge

m Is electron's mass

g Is electron's g-factor

μ_B Is Bohr's magneton

ε_r Is the dielectric constant

S_z Is the z-component of the total spin

To obtain the mang-electron energy spectrum and wave function one must solve the station Schrodinger equation for the Hamiltonian given by

$$\widehat{H}\psi(\vec{r}_1, \dots, \vec{r}_n) = E\psi(\vec{r}_1, \dots, \vec{r}_n) \quad (3.5)$$

$$V(r) = \frac{m}{2}{\psi_0}^2 r^2 \quad (3.6)$$

Where

$\hbar\omega_0$ Is the parabolic confinement energy

$$r^2 = x^2 + y^2$$

$$\frac{V(r)}{\hbar\omega_0} = \frac{1}{2}(\alpha r)^2 \quad (3.7)$$

Where

$$\alpha = \sqrt{\frac{m\omega_0}{\hbar}} \quad (3.8)$$

Is the inverse quantum oscillator length

If we neglect the coulomb interaction between electrons's the Hamiltonian in equation (3.5.1) without the Zeeman term can be written:

$$\widehat{H}(\vec{r}) = \frac{1}{2m}\left[\hat{\vec{p}} + e\vec{A}(\vec{r})\right] + \frac{m}{2}{\omega_0}^2 r^2 \quad (3.9)$$

[16]

Chapter Four

The Effect of Nano Size on Magnetic Permeability

(4.1)Introduction

The aim of this work is to measure the magnetic flux density of AL powder of different size to see how the changes of particles nano size affect the magnetic permeability.

(4.2)Instruments

Testometer, Am meter, Aluminum powder with large, medium and small sizes, Power supply, Copper wire, glass tubes, Wires.

(4.3) Methodology and Experimental Procedures

1. Three tubes were prepared the tubes are made of glass
2. The copper wires is wounded around each tube
3. The diameter of the tube and the number of turns are found
4. The three powder samples were put inside three tubes
5. Each tube wire were connected to an electric power source
6. The electric current and magnetic flux density were measured where 5 readings were taken
7. The flux density is given by

$$B = \frac{\mu n}{r} I \tag{4.1}$$

$$\mu = \frac{Br}{nI} \tag{4.2}$$

B = magnetic flux density

μ= magnetic permeability

n =number of turns

r =radius

I =electric current

(4.4) Results

Table (4.1): magnetic flux density change with current for soft powder

I_A	$B_{mT_{\text{soft}}}$	$\mu_{\text{soft}} \times 10^{-7}$
0	0.03	0
0.4	0.06	0.087
1.5	0.18	0.0699
2.8	0.30	0.0624
3	0.43	0.0835

Table (4.2) magnetic flux density change with current for medium powder

I_A	$B_{mT_{\text{medium}}}$	$\mu_{\text{medium}} \times 10^{-7}$
0	0.03	0
0.4	0.09	0.131
1.5	0.28	0.108
2.8	0.47	0.0977
3	0.65	0.126

Table (4.3) magnetic flux density change with current for rough powder

I_A	$B_{mT\,\mathrm{large}}$	$\mu_{\mathrm{large}} \times 10^{-7}$
0	0.03	0
0.4	0.12	0.174
1.5	0.36	0.139
2.8	0.60	0.124
3	0.82	0.159

$$\mu_r = \frac{\mu}{\mu_0} \tag{4.3}$$

μ_r =relative permeability

μ_0= vacuum permeability

Table (4.4) magnetic permeability for different nano sizes

$\mu_{r\,\mathrm{soft}}$	$\mu_{r\,\mathrm{medium}}$	$\mu_{r\,\mathrm{large}}$
0	0	0
0.00692	0.0104	0.0138
0.00556	0.00859	0.01106
0.00496	0.00727	0.00987
0.0664	0.01002	0.0126

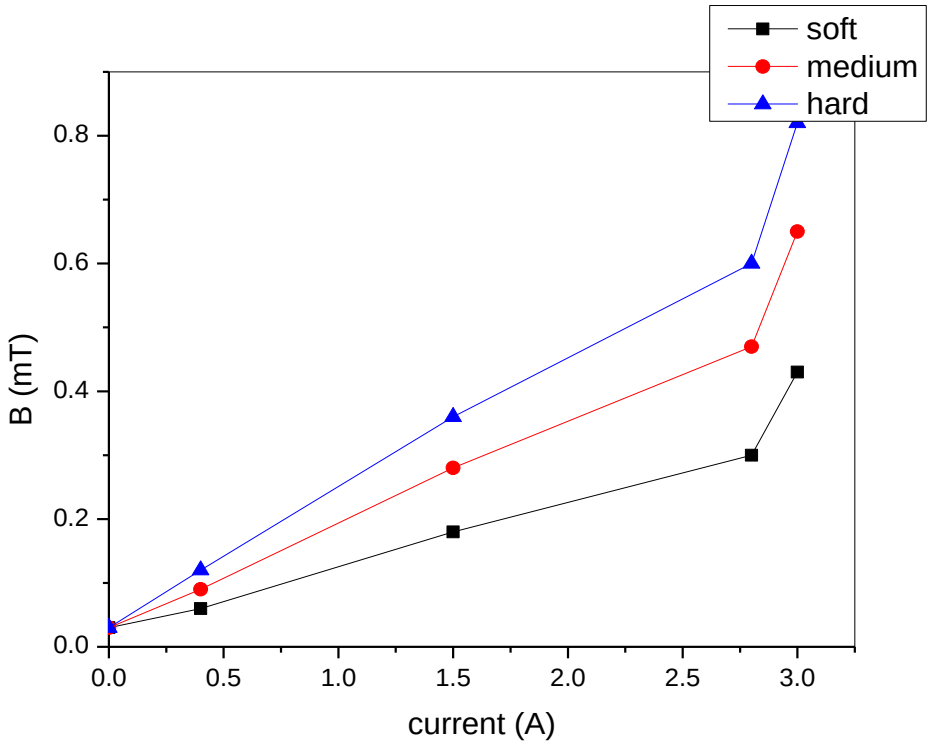


Figure (4.1) explains magnetic flux density versus current for three different nano Aluminum sizes.

(4.5) Discussion

In view of table (4.4) and figure (4.1) one can observe easily that the magnetic permeability of Aluminum which is a paramagnet increases when the nano size increases this can be attributed to the fact that increasing nano size increases the mass thus make it less sensitive to random thermal motion which causes magnetic field of nano particles align themselves randomly even in the presence of external field this random orientation decreases the medium field strength thus decreases the magnetic permeability however for large nano size the particles does not respond to random thermal motion easily thus large number of them align themselves in the direction of the external field causing the internal field and magnetic permeability to increase.

(4.6) Conclusion

The increase of Aluminum nano particle size increase the magnetic permeability where the Aluminum is a paramagnet.

(4.7) Recommendations

1. The effect of change of nano size should be extended for other material
2. The electrical permeability of nano particles needs to be investigated also
3. The result obtained in this work should be applied and used in producing useful techniques

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