

Chapter One

Introduction

1.1 Historical background

Nanotechnology is science, engineering, and technology conducted at the nanoscale, which is about 1 to 100 nanometers. Nanoscience and nanotechnology are the study and application of extremely small things and can be used across all the other science fields, such as chemistry, biology, physics, materials science, and engineering. Nanoscience and nanotechnology involve the ability to see and to control individual atoms and molecules. Everything on Earth is made up of atoms—the food we eat, the clothes we wear, the buildings and houses we live in, and our own bodies. But something as small as an atom is impossible to see with the naked eye. In fact, it's impossible to see with the microscopes typically used in a high school science class. The microscopes needed to see things at the nanoscale were invented relatively recently about 30 years ago. Once scientists had the right tools, such as the scanning tunneling microscope (STM) and the atomic force microscope (AFM), the age of nanotechnology was born. Although modern nanoscience and nanotechnology are quite new, nanoscale materials were used for centuries. Alternate-sized gold and silver particles created colors in the stained glass windows of medieval churches hundreds of years ago. The artists back then just didn't know that the process they used to create these beautiful works of art actually led to changes in the composition of the materials they were working with. Today's scientists and engineers are finding a wide variety of ways to deliberately make materials at the nanoscale to take advantage of their enhanced properties such as higher strength, lighter weight, increased control of light spectrum, and greater chemical reactivity than their larger-scale counterparts [1].

1.2 Objective of Research

The objective of this research was to identify the phenomenon of nanotechnology and its applications, especially iron element.

1.3 Problem of Research

The problem of research is the possibilities to study the properties of the specific element at its nanoscale and to provide a suitable environment and wide applications prospects for it.

1.4 Previous Studies

Some of previous studies in Nanotechnology was done the first one done by G. Yu. Yurkova, A. S. Fionovb, Yu. A. Koksharovc, V. V. Kolesovb, and S. P. Gubina, d, 2006: when have prepared nanocomposites consisting of narrowly sized metal-containing nanoparticles embedded in a polyethylene matrix and have established conditions for the fabrication of thick films and bulk materials from the synthesized polymer powders. Dielectric permittivity and resistivity measurements demonstrate that the electrical properties of the nanocomposites depend significantly on the nanoparticle size and content. The microwave absorption and permittivity of the materials are shown to vary little in a broad frequency range. The magnetization (including the remanent one) of the cobalt-containing nanomaterials is higher than that of the iron-containing samples [2].

The Second one done by Kehan Yu & Junhong Chen, 2008: The current global energy problem can be attributed to insufficient fossil fuel supplies and excessive greenhouse gas emissions resulting from increasing fossil fuel consumption. The huge demand for clean energy potentially can be met by solar-to-electricity conversions. The large-scale use of solar energy is not occurring due to the high cost and inadequate efficiencies of existing solar cells. Nanostructured materials have offered new opportunities to design more efficient solar cells, particularly one-dimensional (1-D) nanomaterials

for enhancing solar cell efficiencies. These 1-D nanostructures, including nanotubes, nanowires, and nanorods, offer significant opportunities to improve efficiencies of solar cells by facilitating photon absorption, electron transport, and electron collection; however, tremendous challenges must be conquered before the large-scale commercialization of such cells. This review specifically focuses on the use of 1-D nanostructures for enhancing solar cell efficiencies. Other nanostructured solar cells or solar cells based on bulk materials are not covered in this review. Major topics addressed include dye-sensitized solar cells, quantum-dot-sensitized solar cells, and p-n junction solar cells [3].

The third one done by Manzoor Ahmad Gato, Sufia Naseem, Mir Yasir Arfat, Ayaz Mahmood Dar, Khusro Qasim, and Swaleha Zubair, 2014:

Nanotechnology has emerged as one of the leading fields of the science having tremendous application in diverse disciplines. As nanomaterials are increasingly becoming part of everyday consumer products, it is imperative to assess their impact on living organisms and on the environment. Physicochemical characteristics of nanoparticles and engineered nanomaterials including size, shape, chemical composition, physicochemical stability, crystal structure, surface area, surface energy, and surface roughness generally influence the toxic manifestations of these nanomaterials. This compels the research fraternity to evaluate the role of these properties in determining associated toxicity issues. Reckoning with this fact, in this paper, issues pertaining to the physicochemical properties of nanomaterials as it relates to the toxicity of the nanomaterials are discussed[4].

1.5 Logout Research

This research contains five chapters: chapter one Introduction, chapter two Nanotechnology, chapter three application of Nanotechnology in various fields. chapter four contains the magnetism of the materials and chapter five

contains the practical part, discussing and analyzing, conclusions and recommendations.

Chapter Two

Nanotechnology

2.1 Introduction

The history of nanotechnology traces the development of the concepts and experimental work falling under the broad category of nanotechnology. Although nanotechnology is a relatively recent development in scientific research, the development of its central concepts happened over a longer period of time. The emergence of nanotechnology in the 1980s was caused by the convergence of experimental advances such as the invention of the scanning tunneling microscope in 1981 and the discovery of fullerenes in 1985, with the elucidation and popularization of a conceptual framework for the goals of nanotechnology beginning with the 1986 publication of the book *Engines of Creation*. The field was subject to growing public awareness and controversy in the early 2000s, with prominent debates about both its potential implications as well as the feasibility of the applications envisioned by advocates of molecular nanotechnology, and with governments moving to promote and fund research into nanotechnology. The early 2000s also saw the beginnings of commercial applications of nanotechnology, although these were limited to bulk applications of nanomaterials rather than the transformative applications envisioned by the field [5].

2.2 Structural Nanotechnology

It is concerned with very small structures, such as nanocrystals and complicated molecules. Structural nanotechnology became an accepted field of research only a few years ago, but has already divided into a huge number of different threads of research. It is driven largely by commercial applications: as soon as it is found that a nanocrystal emits light with certain properties, it is immediately adapted by biotechnology, computer, or other companies. There is certainly pure research going on, but it is largely hidden

behind the avalanche of products and possibilities created by the new properties of nano-scale materials and structures [5].

2.3 Nanophysics

Chemistry and Biochemistry are in many ways nanotechnologies working with nanoscale structures. In physics the classical laws of motion are not always valid on the nanoscale but a quantum mechanical model often is more suitable, and there are often a wealth of forces that are important and do not consider very much in classical physics the surface forces [5].

2.4 Nanomaterials

Nanomaterials describe, in principle, materials of which a single unit is sized (in at least one dimension) between 1 to 1000 nanometres (10^{-9} meter) but usually is 1 to 100 nm. (the usual definition of nanoscale) [6].

2.5 Classification of nanomaterials

Nanomaterials have been divided into three major groups according to their morphology and structures.

2.5.1 one-dimensional nanomaterials

Under this category are all substances with a scale of less than 100 nm. For Examples of such materials are thin films and thin layers [1].

2.5.2 Two-dimensional nanomaterials

In this class of nanomaterials, a two dimension less than 100 nm is required. For example of such materials are nanotubes and nanowires [1].

2.5.3 Three-dimensional nanomaterials

This is materials on the three axis X, Y, Z less than 100 nm, for examples such as nanoparticles, as well as metal powder and ultra-soft Ceramic materials. this class of very important technological [1].

2.6 Properties of nanomaterials

Nanomaterials have very important properties that distinguish them from others, these properties: Mechanical Properties, Optical Properties, Fusibility of Point, Magnetic Properties, Electrical Properties [7].

2.7 Preparation Methods nanomaterials

There are two ways to produce nanomaterials:

2.7.1 Bottom – up Technology

These start from atoms or molecules to be separated from one another and then assembled using chemical reactions or using the material exchange method [4], these Method: Sol-gel Method, Aerosol Method, Chemical Vapour Deposition (CVD) Method [1].

2.7.2 Top –down Technology

This method starts from the bulk (the material is in its natural state when it is solid). After that, it is broken down or reduced until it reaches very small pieces (for thenanoscale), using mechanical methods or chemical methods, these methods: Crashing method, Etching method, Electrochemical method, Laser ablation method, Sputtering method [1].

2.8 Forms of nanomaterials

Nanomaterials have different forms that distinguish them from each other.

2.8.1 Nanoparticles

They are the simplest form of structures with sizes between 1 and 100 nanometers in size. For example elements, iron nanopowder [8].

2.8.2 Nanowires

A nanowires is a structure that has two lateral sizes constrained to tens of nanometers or less and one unconstrained longitudinal size, and it is often

referred to as a type of one-dimensional material. For example, semiconductor nanowires [1].

2.8.3 Nanorods

In nanotechnology, nanorods are one morphology of nanoscale objects. Each of their dimensions range from 1–100 nm. They may be synthesized from metals or semiconducting materials. Standard aspect ratios (length divided by width) are 3–5. Nanorods are produced by direct chemical synthesis. A combination of ligands act as shape control agents and bond to different facets of the nanorod with different strengths. This allows different faces of the nanorod to grow at different rates, producing an elongated object, for example, element nanorods [7].

2.8.4 Nanofibers

A nanofiber is a fiber with a diameter of 100 nanometers or less. The properties of nanofibers have caused researchers and companies to consider using this material in several fields, for example, carbon nanofiber [9].

2.8.5 Quantum dots

By definition, quantum dots are a nano-scale crystalline structure made from cadmium selenide that absorbs white light and then reemits it a couple of nanoseconds later in a specific color [5].

2.8.6 Fullerenes

Fullerenes are pure carbon molecules composed of at least 60 atoms of carbon. Because a fullerene takes a shape similar to a soccer ball or a geodesic dome, it is sometimes referred as a buckyball after the inventor of the geodesic dome, Buckminster fuller, for whom the fullerene is named [5].

2.8.7 Nanoballs

The nanoballs belong to the class of C_{60} fullerenes with a slight difference in structure. This is because they are multi-crusted and center-free, because of their onion-like structure, scientists have called them “bucky” and may have a diameter of more than 500 nanometers [10].

2.8.8 Nanotubes

Nanotubes are a sequence of nanoscale C_{60} atoms arranged in a long thin cylindrical structure. They are related to two other carbon crystal forms, graphite and diamonds. They are often described as looking like rolls of graphite chicken wire, but as member of the fullerene family they are essentially buckballs expanded from the center in to cylinders. Nanotubes are also called buckytubes in some references books [5].

2.8.9 Nanocomposites

A plastic nanocomposites is being used for “step assists” in the GM safari and Astro Vans. It is scratch-resistant, light-weight, and reductions in weight, which lead to fuel savings and increased longevity. And in 2001, Toyota started using nanocomposites in a bumper that makes it 60% lighter and twice as resistant to denting and scratching [5].

2.9 Equipment of Zoom

Are equipment used to enlarge the small objects that can not be seen with the naked eye and to show the exact details and to discover the structure and study. These equipment are known as microscopes and have many types, for example: the Electron Microscopes.

2.10 Electron Microscopes

This is Microscopes used to beam from the electrons instead of light checking the behavior and structure of the material.

2.11 Types of Electron Microscopes

Electronic Microscopes are classified by operating method and sample preparation.

2.11.1 Scanning Electron Microscopes (SEM)

The scanning electron microscope (SEM) uses a focused beam of high-energy electrons to generate a variety of signals at the surface of solid specimens. The signals that derive from electron-sample interactions reveal information about the sample including external morphology (texture), chemical composition, and crystalline structure and orientation of materials making up the sample. In most applications, data are collected over a selected area of the surface of the sample, and a 2-dimensional image is generated that displays spatial variations in these properties. Areas ranging from approximately 1 cm to 5 microns in width can be imaged in a scanning mode using conventional SEM techniques (magnification ranging from 20X to approximately 30,000X, spatial resolution of 50 to 100 nm). The SEM is also capable of performing analyses of selected point locations on the sample; this approach is especially useful in qualitatively or semi-quantitatively determining chemical compositions (using EDS), crystalline structure, and crystal orientations (using EBSD) [7].

The design and function of the SEM is very similar to the EPMA and considerable overlap in capabilities exists between the two instruments.

Principles of Scanning Electron Microscopy (SEM): Accelerated electrons in an SEM carry significant amounts of kinetic energy, and this energy is dissipated as a variety of signals produced by electron-sample interactions when the incident electrons are decelerated in the solid sample [7]. Essential components of all SEM include the following: Electron Source ("Gun"), Electron Lenses, Sample Stage, Detectors for all signals of interest, Display / Data output devices, Infrastructure Requirements (Power Supply,

Vacuum System, Cooling system, Vibration-free floor, Room free of ambient magnetic and electric fields) [7].

2.11.2 Transmission Electron Microscopes(TEM)

Operating principle of Transmission Electron MicroscopeThe original form of electron microscope, the transmission electron microscopeuses a high voltage electron beam to illuminate the specimen and create an image. The electron beam is produced by an electron gun, commonly fitted with a tungsten filament cathode as the electron source. The electron beam is accelerated by an anode typically at +100 keV(40 to 400 keV) with respect to the cathode, focused by electrostatic and electromagnetic lenses, and transmitted through the specimen that is in part transparent to electrons and in part scatters them out of the beam. When it emerges from the specimen, the electron beam carries information about the structure of the specimen that is magnified by the objective lens system of the microscope. The spatial variation in this information the"image" may be viewed by projecting the magnified electron image onto a fluorescent viewing screen coated with a phosphor or Scintillator material such as zinc sulfide. Alternatively, the image can be photographically recorded by exposing a photographic film or plate directly to the electron beam, or a high-resolution phosphor may be coupled by means of a lens optical system or a fibre optic light –guide to the sensor of a digital camera. The image detected by the digital camera may be displayed on a monitor or computer.The resolution of TEM is limited primarily by spherical aberration, but a new generation of aberration correctors have been able to partially overcome spherical aberration to increase resolution. Hardware correction of spherical aberration for the High-Resolution Transmission Electron Microscopy(HRTEM) has allowed the production of images with resolution below 0.5angstrom(50picometres) and magnifications above 50 million times. The ability to determine the positions of atoms within materials has made the HRTEM an important tool for nanotechnologies researchand development. Transmission electron microscopes are often used in electron

diffraction mode. The advantages of electron diffraction over X-ray crystallography are that the specimen need not be a single crystal or even a polycrystalline powder, and also that the Fourier transform reconstruction of the object's magnified structure occurs physically and thus avoids the need for solving the phase problem faced by the X-ray crystallographers after obtaining their X-ray diffraction patterns of a single crystal or polycrystalline powder. The major disadvantage of the transmission electron microscope is the need for extremely thin sections of the specimens, typically about 100 nanometers. Biological specimens are typically required to be chemically fixed, dehydrated and embedded in a polymer resin to stabilize them sufficiently to allow ultrathin sectioning. Sections of biological specimens, organic polymers and similar materials may require special treatment with heavy atom labels in order to achieve the required image contrast [11].

2.11.3 Reflection Electron Microscope (REM)

In the Reflection Electron Microscope (REM) as in the TEM, an electron beam is incident on a surface but instead of using the transmission (TEM) or Secondary Electrons Microscope (SEM), the reflected beam of elastically scattered electrons is detected. This technique is typically coupled with Reflection High Energy Electron Diffraction (RHEED) and Reflection High-Energy Loss Spectroscopy (RHELs). Another variation is Spin-Polarized Low-Energy Electron Microscopy (SPLEEM), which is used for looking at the Microstructure of magnetic domains [11].

2.11.4 Scanning Transmission Electron Microscopes (STEM)

The STEM raster a focused incident probe across a specimen that (as with the TEM) has been thinned to facilitate detection of electrons scattered through the specimen. The high resolution of the TEM is thus possible in STEM. The focusing action (and aberrations) occur before the electrons hit the specimen in the STEM, but afterward in the TEM. The STEM use of SEM-like beam rastering simplifies annular dark-field imaging, and other analytical

techniques , but also means that image data is acquired in serial rather than in parallel fashion . Often TEM can be equipped with the scanning option and then it can function both asTEM and STEM [11].

2.12 Advantages of Electron Microscopes

It has a very high magnification Force, the lighting source is a beam of electrons, use of electromagnetic lenses [11].

2.13 Disadvantages of Electron Microscopes

Electron microscopes are expensive to build and maintain, Very sensitive to vibration and external magnetic fields, Requires high-level electronic training and skill to work on, Possible the observation of non-conductive specimens without coating [11].

2.14 Challenges and risks of nanotechnology

Although nanotechnology has many important advantages, it also has risks.

2.14.1 Challenges

Nanotechnology may be the ultimate enabling technology, since it deals with the fundamental building blocks of matters and lives. Almost every field of industry will be deeply affected by the progress in nanotechnology. The most important impact of this nanotechnology revolution may be the new synergy among scientists, engineers, industrialists, financiers and economic development specialists. The nanotechnology creates both challenges and opportunities. The major challenges of nanotechnology mainly include technology challenge, societal and ethical challenge, business driven economy, risk and uncertainty, and military implications [1].

2.14.2 Risks

Nanotechnology could well pave the way for the next revolution to take place. It is often remarked that it is easier to make destructive use of a technology rather than use it constructively. The risk and uncertainty of nanotechnology should be taken very seriously by both the developed world and the

developing world. Nanotechnology could enable new weapons in more than one way [1].

First, using nanotechnology, existing drugs could be delivered more effectively. Many pharmaceutical companies are working on nanoparticles that could make drugs effectively absorbed by the body. Nanotechnology could be used to develop viable medicines, and meanwhile it can also be used to boost the power of compounds for the development of chemical weapons. For example, delivering nicotine in lethal amounts is quite difficult due to the barriers of the body. Maybe using nanotechnology, something can be developed that could assist nicotine to get through the barriers of the body. In this way, weapons can be made based on something that is not lethal [1].

Second, due to the rapid progress in biology, it is possible to use nanotechnology to develop new weapons that are not recognized by existing weapons inspectors. For example, since there are well-established means for the synthesis of cyanide, it could be detected at a very early stage by following the production process. However, using nanotechnology, new agents could be developed to attack very specific functions in the body, for example, the central nervous system. As the amount of agent needed is usually quite small, its synthesis does not require big industrial bases, and tracing such agents is very difficult. Some of the above issues have been outlined by pardo-Guerra, at the college of Mexico, in the Nanotechnology low and Business Journal [1].

Chapter Three

Applications of Nanotechnology

3.1 Introduction

The understanding Nanotechnology website is dedicated to providing clear and concise explanations of nanotechnology applications. Scan the listings below to find an application of interest, or use the navigation bar above to go directly to the page discussing an application of interest [12].

3.2 Medicine

Researchers are developing customized nanoparticles the size of molecules that can deliver drugs directly to diseased cells in your body. When its perfected, this method should greatly reduce the damage treatment such as chemotherapy does to a patients healthy cells. Check out our Nanotechnology Applications in Medicine page to see how nanotechnology is being used in medicine [12].

3.3 Electronics

Nanotechnology holds some answers for how we might increase the capabilities of electronics devices while we reduce their weight and power consumption. Check out our Nanotechnology Applications in Electronics page to how nanotechnology is being used in electronics [12].

3.4 Food

Nanotechnology is having an impact on several aspects of food science, from how food is grown to how it is packaged. Companies are developing nanomaterials that will make a difference not only in the taste of food, but also in food safety, and the health benefits that food delivers. Check out our Nanotechnology Applications in Food page for the details [12].

3.5 Fuel Cells

Nanotechnology is being used to reduce the cost of catalysts used in fuel cells to produce hydrogen ions from fuel such as methanol and to improve the

efficiency of membranes used in fuel cells to separate hydrogen ions from other gases such as oxygen. Check out our Nanotechnology Applications in Fuel Cells page for the details [12].

3.6 Solar Cells

Companies have developed nanotech solar cells that can be manufactured at significantly lower cost than conventional solar cells. Check out our Nanotechnology Applications in Solar cells page for the details [12].

3.7 Batteries

Companies are currently developing batteries using nanomaterials. One such battery will be as good as new after sitting on the shelf for decades. Another battery can be recharged significantly faster than conventional batteries. Check our Nanotechnology Applications in Batteries page for details [12].

3.8 Space

Nanotechnology may hold the key to making space-flight more practical. Advancements in nanomaterials make lightweight spacecraft and a cable for the space elevator possible. By significantly reducing the amount of rocket fuel required, these advances could lower the cost of reaching orbit and traveling in space. Check our Nanotechnology Applications in Space page for details [12].

3.9 Fuels

Nanotechnology can address the shortage of fossil fuels such as diesel and gasoline by making the production of fuels from low grade raw materials economical, increasing the mileage of engines, and making the production of fuels from normal raw materials more efficient. Check our Nanotechnology Applications in Fuels page for details [12].

3.10 Better Air Quality

Nanotechnology can improve the performance of catalysts used to transform vapors escaping from cars or industrial plants into harmless gasses. That is because catalysts made from nanoparticles have a greater surface area to

interact with the reacting chemicals than catalysts made from larger particles. The larger surface area allows more chemicals to interact with the catalyst simultaneously, which makes the catalyst more effective. Check our Nanotechnology and Air Quality page for details [12].

3.11 Cleaner Water

Nanotechnology is being used to develop solutions to three very different problems in water quality. One challenge is the removal of industrial wastes, such as a cleaning solvent called TCE, from groundwater. Nanoparticles can be used to convert the contaminating chemical through a chemical reaction to make it harmless. Studies have shown that this method can be used successfully to reach contaminants dispersed in underground ponds and at much lower cost than methods which require pumping the water out of the ground for treatment. Check out our Nanotechnology and Water Quality page for details [12].

3.12 Chemical Sensors

Nanotechnology can enable sensors to detect very small amounts of chemical vapors. Various types of detecting elements, such as carbon nanotubes, zinc oxide nanowires or palladium nanoparticles, can be used in nanotechnology-based sensor. Because of the small size of nanotubes, nanowires, or nanoparticles, a few gas molecules are sufficient to change the electrical properties of the sensing elements. This allows the detection of a very low concentration of chemical vapors. Check out our Nanotechnology Applications in Chemical Sensors page for details [12].

3.13 Sporting Goods

If you're a tennis or golf fan, you'll be glad to hear that even sporting goods has wandered into the nano realm. Current nanotechnology applications in the sports arena include increasing the strength of tennis racquets, filling any imperfections in club shaft materials and reducing the rate at which air leaks

from tennis balls. Check out our Nanotechnology Applications in Sporting Goods page for details [12].

3.14 Fabric

Making composite fabric with nano-sized particles or fibers allows improvement of fabric properties without a significant increase in weight, thickness, or stiffness as might have been the case with previously-used techniques. For details see our Nanotechnology in Fabrics page [12].

Chapter Four

Magnetization

4.1 Introduction

The magnetization of a magnetized material is the local value of its magnetic moment per unit volume, usually denoted M , with units A/m . It is a vector field, rather than just a vector (like the magnetic moment), because different areas in a magnet can be magnetized with different directions and strengths[7].

4.2 Magnet

A magnet is a material or object that produces a magnetic field. This magnetic field is invisible but is responsible for the most notable property of a magnet: a force that pulls on other ferromagnetic materials, such as iron, and attracts or repels other magnets[7].

4.3 Magnetic Materials

Magnetic materials are materials studied and used mainly for their magnetic properties. The magnetic response of materials is largely determined by the magnetic dipole moment associated with the intrinsic angular momentum, or spin, of its electrons. A material's response to an applied magnetic field can be characterized as diamagnetic, paramagnetic, ferromagnetic or antiferromagnetic [13].

4.4 Classes of Magnetic Materials

The magnetic behavior of materials can be classified into the following five major groups:

4.4.1 Diamagnetic

Diamagnetic appears in all materials, and is the tendency of a material to oppose an applied magnetic field, and therefore, to be repelled by a magnetic field. However, in a material with paramagnetic properties (that is, with a

tendency to enhance an external magnetic field), the paramagnetic behavior dominates. Thus, despite its universal occurrence, diamagnetic behavior is observed only in a purely diamagnetic material. In a diamagnetic material, there are no unpaired electrons, so the intrinsic electron magnetic moments cannot produce any bulk effect [13].

4.4.2 Paramagnetic

In a paramagnetic material there are unpaired electrons, i.e. atomic or molecular orbitals with exactly one electron in them. While paired electrons are required by the Pauli exclusion principle to have their intrinsic ('spin') magnetic moments pointing in opposite directions, causing their magnetic fields to cancel out, an unpaired electron is free to align its magnetic moment in any direction. When an external magnetic field is applied, these magnetic moments will tend to align themselves in the same direction as the applied field, thus reinforcing it [13].

4.4.3 Ferromagnetic

A ferromagnetic, like a paramagnetic substance, has unpaired electrons. However, in addition to the electrons' intrinsic magnetic moment's tendency to be parallel to an applied field, there is also in these materials a tendency for these magnetic moments to orient parallel to each other to maintain a lowered-energy state. Thus, even in the absence of an applied field, the magnetic moments of the electrons in the material spontaneously line up parallel to one another. Every ferromagnetic substance has its own individual temperature, called the Curie temperature, or Curie point, above which it loses its ferromagnetic properties. This is because the thermal tendency to disorder overwhelms the energy-lowering due to ferromagnetic order [13].

4.4.4 Ferrimagnetic

Like ferromagnetism, ferrimagnets retain their magnetization in the absence of a field. However, like antiferromagnets, neighboring pairs of electron spins tend to point in opposite directions. These two properties are not contradictory, because in the optimal geometrical arrangement, there is more magnetic moment from the sublattice of electrons that point in one direction, than from the Sublattice that points in the opposite direction. Most ferrites are ferrimagnetic. The first discovered magnetic substance, magnetite, is a ferrite and was originally believed to be a ferromagnet; Louis Néel disproved this, however, after discovering ferromagnetic [13].

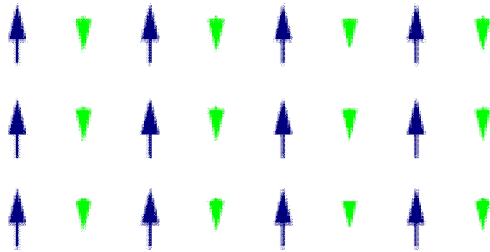


Figure (4.1): The Ferrimagnetic ordering [14]

4.4.5 Antiferromagnetic

In an antiferromagnet, unlike a ferromagnet, there is a tendency for the intrinsic magnetic moments of neighboring valence electrons to point in opposite directions. When all atoms are arranged in a substance so that each neighbor is "anti-aligned", the substance is antiferromagnetic. Antiferromagnets have a zero net magnetic moment, meaning that no field is produced by them. Antiferromagnets are less common compared to the other types of behaviors and are mostly observed at low temperatures. In varying temperatures, antiferromagnets can be seen to exhibit diamagnetic and ferromagnetic properties. In some materials, neighboring electrons prefer to point in opposite directions, but there is no geometrical arrangement in which

each pair of neighbors is anti-aligned. This is called a spin glass and is an example of geometrical frustration [13].

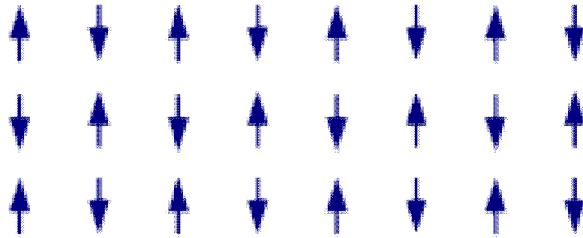


Figure (4.2): The Antiferromagnetic ordering [14]

4.5 Magnetic Nanoparticles

The category of nanoparticle that can be influenced with magnetic field gradients is termed as Magnetic nanoparticles. These particles generally comprise of magnetic elements such as nickel, iron, cobalt and their chemical compounds. The nanoparticles have diameters less than 1 micrometre, the larger microbeads diameter ranges from 0.5-500 micrometre. Several individual magnetic nanoparticles together form a magnetic nanoparticle cluster that are termed as magnetic nano beads their diameter ranges from 50-200 nanometres [13].

4.6 Nano-structured magnets

Some nano-structured materials exhibit energy waves, called magnons, that coalesce into a common ground state in the manner of a Bose–Einstein condensate [13].

Chapter Five

Experimental Work

5.1 Introduction

The experiment was conducted at the physical laboratory at Omdurman Islamic University.

5.2 Equipments and Artifacts

The circuit designed to study the magnetic properties of the iron metal it consists of Voltmeter, Ameter, milli-Tesla (mT), Voltage source (Power Supply), Sensor, Samples(bulk, crashing at one minute and three minute), X-Met 5000, Sample holder and Conduction Wires.



Figure (5.1): The Detector of element(X-Met 5000)[17].

5.3 Method

The samples were prepared by crashing(one minute and three minute). The circuit was connected as shown below, the samples was placed on a holder and it was coiled by insulated wire at 50 turns, and inside a sensor connected to the Milli-Tesla device to read the external magnetic flux by using different values of current and then recorded for the voltage source and reading it at the Voltmeter. Thus, the values of the magnetic flux and the outflow current(in Ameter)of each sample were recorded separately, the weight of the samples 3g. The results were recorded in the table below. The values were graphically plotted between the voltage and the magnetic flux as well as the voltage and current, and then the voltage and the magnetic flux and current together.

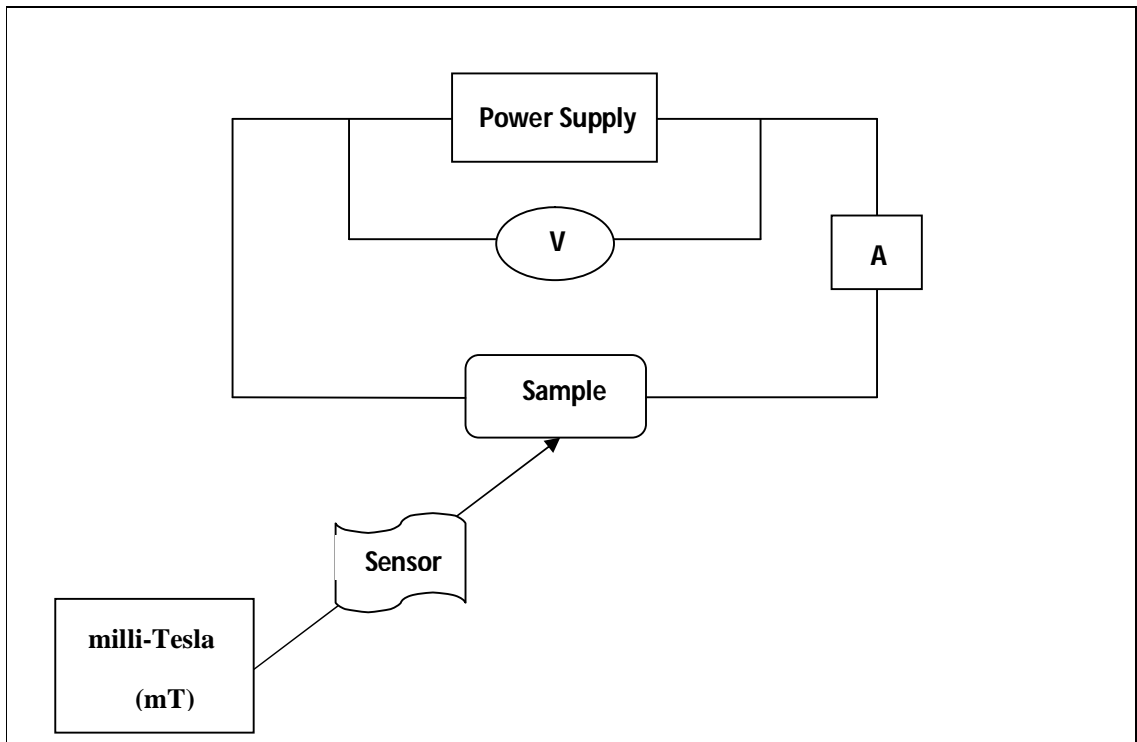


Figure (5.2): The designed to study the magnetic properties of the iron metal.

5.4 Results

The Experiment was carried out and the results of the current and the magnetic flux values were observed when the voltage value was changed monitored in the following tables:

Table (5.1): Bulk sample for different number of turns(insulated wire at 50 turns).

V/volt	I/mA	B/mT
0.2	1	0.1
0.4	3	0.2
0.6	4	0.3
0.8	5	0.4
1	6	0.6
1.2	8	0.7
1.4	9	0.8
1.6	10	0.9
1.8	12	1
2	13	1.2

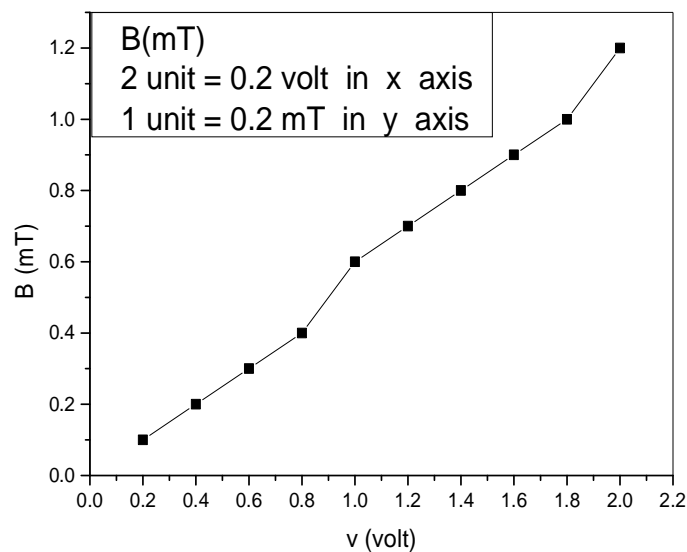


Figure (5.3): The relation between magnetic field induction vs potential difference V for bulk sample (insulated wire at 50 turns).

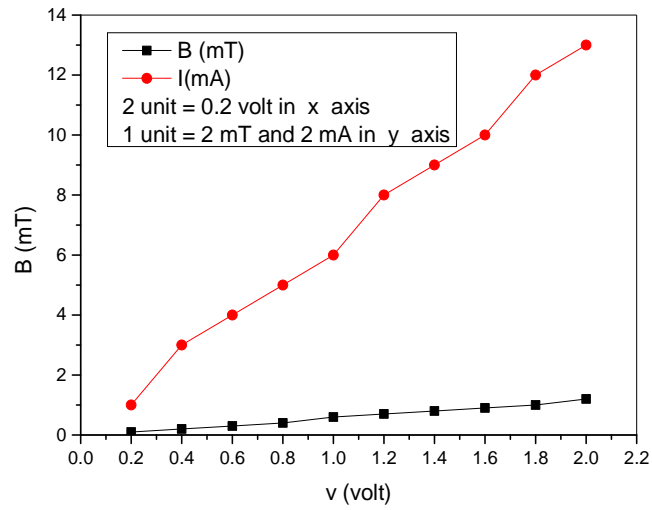


Figure (5.4): The relation between magnetic field induction and current I vs potential difference V for bulk sample (insulated wire at 50 turns).

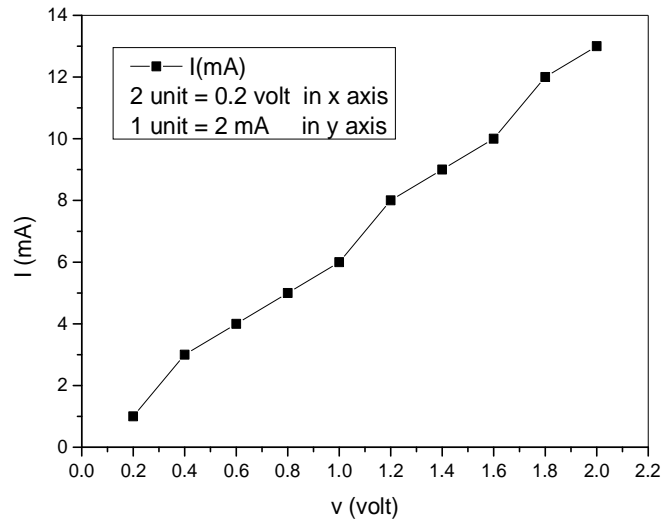


Figure (5.5): The relation between current I vs potential difference V for bulk sample (insulated wire at 50 turns).

Table (5.2): Bulk sample for different number of turns(insulated wire at 100 turns).

V/volt	I/mA	B/mT
0.2	1	0
0.4	1.5	0.1
0.6	2	0.3
0.8	3	0.4
1	3	0.5
1.2	4	0.7
1.4	5	0.9
1.6	5.5	1.1
1.8	6	1.2
2	7	1.4

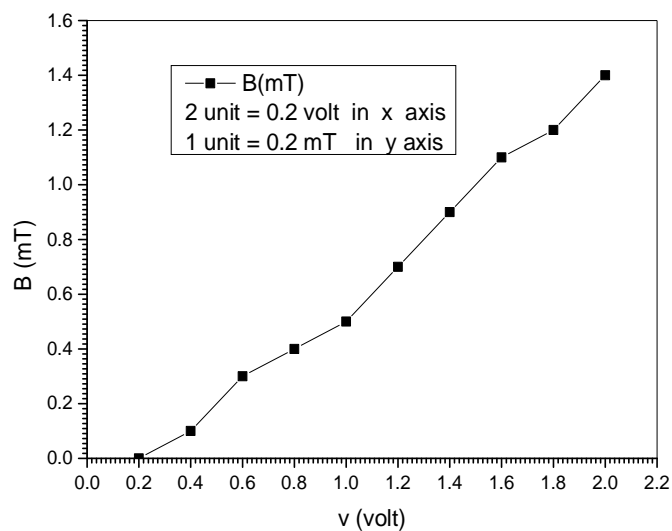


Figure (5.6): The relation between magnetic field induction vs potential difference V for bulk sample (insulated wire at 100 turns).

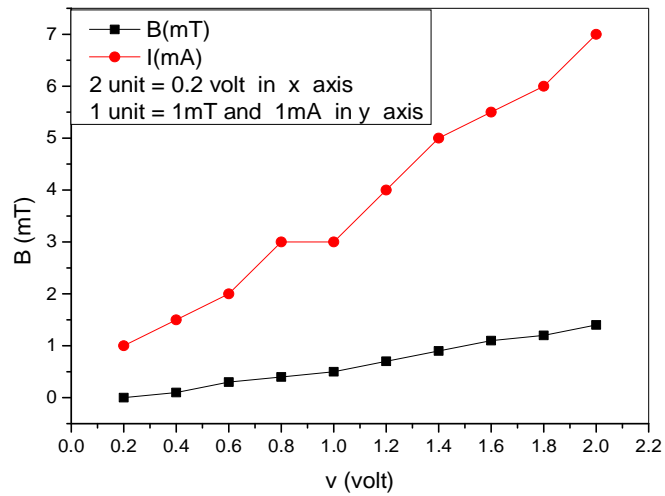


Figure (5.7): The relation between magnetic field induction and current I vs potential difference V for bulk sample (insulated wire at 100 turns).

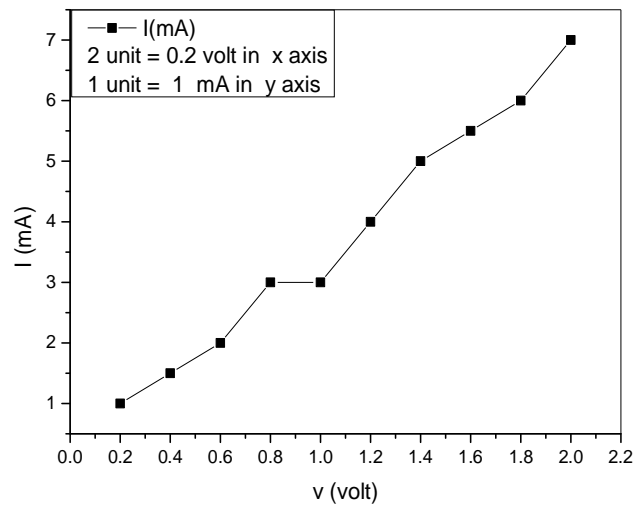


Figure (5.8): The relation between current I vs potential difference V for bulk material (insulated wire at 100 turns).

Table (5.3): Crashed sample for one minute (insulated wire at 50 turns).

V/volt	I/mA	B/mT
0.2	2	0.2
0.4	5	0.5
0.6	7	0.9
0.8	10	1.2
1	12.5	1.5
1.2	15	1.8
1.4	17	2.1
1.6	20	2.4
1.8	22	2.6
2	24	2.9

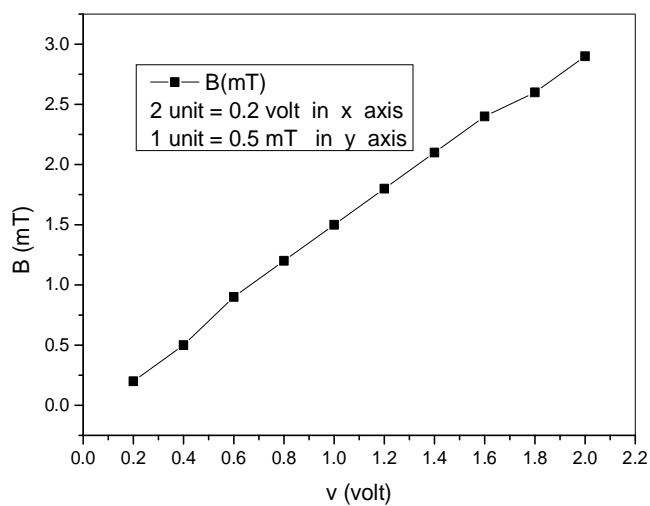


Figure (5.9): The relation between magnetic field induction vs potential difference V crashed sample for one minute (insulated wire at 50 turns).

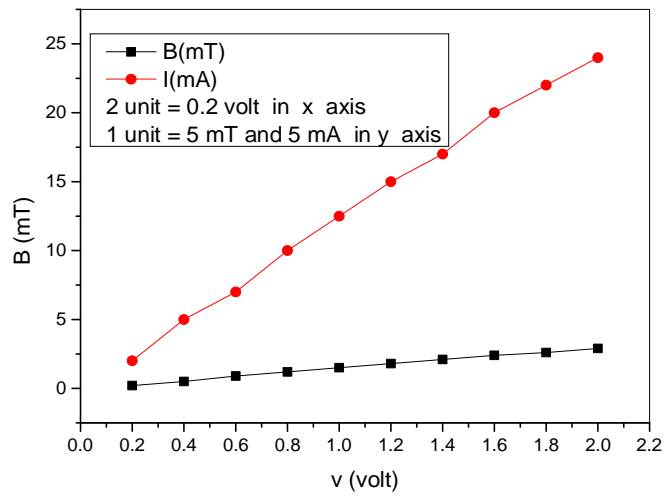


Figure (5.10): The relation between magnetic field induction and current I vs potential difference V crashed sample for one minute (insulated wire at 50 turns).

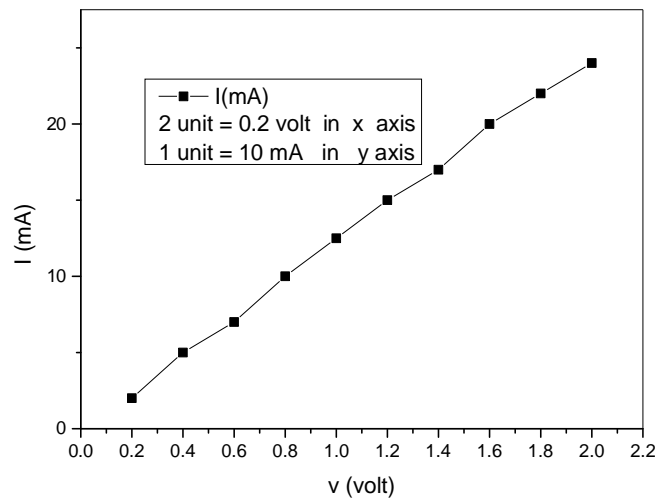


Figure (5.11): The relation between current I vs potential difference V crashed sample for one minute (insulated wire at 50 turns).

Table (5.4): Crashed sample for one minute (insulated wire at 100 turns).

V/volt	I/mA	B/mT
0.2	1	0.2
0.4	3	0.5
0.6	4	0.8
0.8	5	1.1
1	7	1.4
1.2	9	1.7
1.4	10	2
1.6	11	2.3
1.8	12	2.5
2	14	2.7

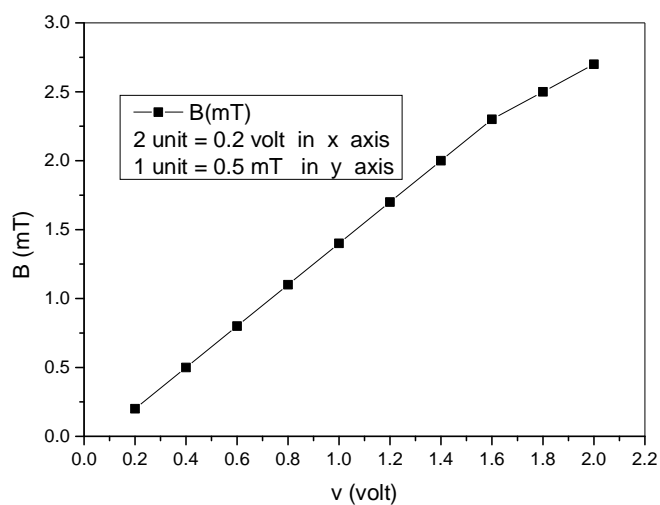


Figure (5.12): The relation between magnetic field induction vs potential difference V crashed sample for one minute (insulated wire at 100 turns).

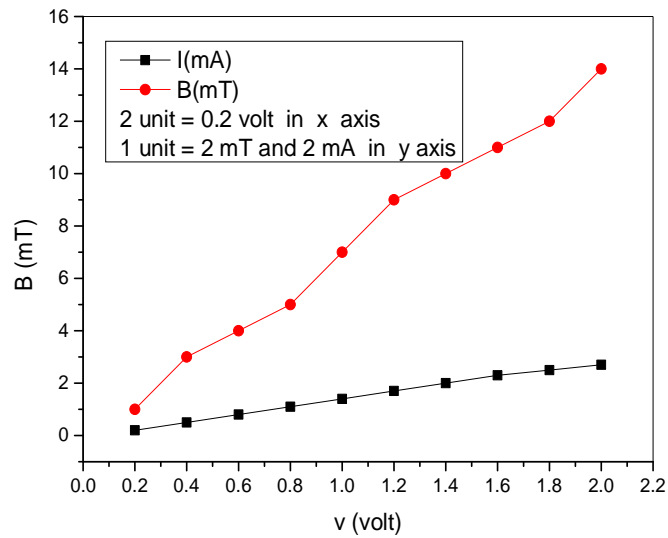


Figure (5.13): The relation between magnetic field induction and current I vs potential difference V crashed sample for one minute (insulated wire at 100 turns).

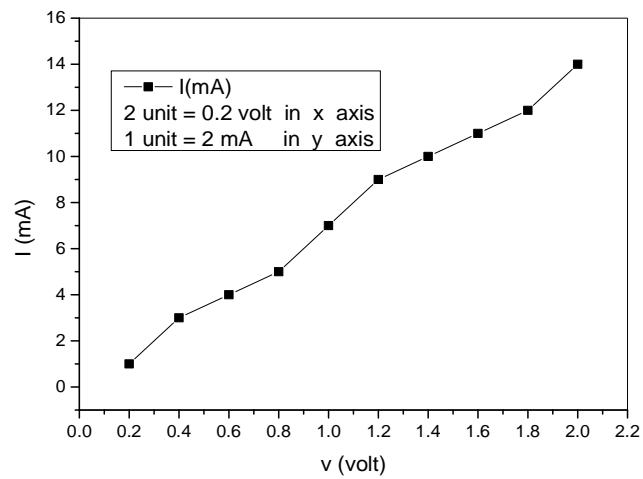


Figure (5.14): The relation between current I vs potential difference V crashed sample for one minute (insulated wire at 100 turns).

Table (5.5): Crashed sample for three minutes (insulated wire at 50 turns).

V/volt	I/mA	B/mT
0.2	2	0.3
0.4	5	0.7
0.6	8	1
0.8	11	1.4
1	13	1.8
1.2	15	2.1
1.4	18	2.4
1.6	20	2.8
1.8	22	3.1
2	25.5	3.4

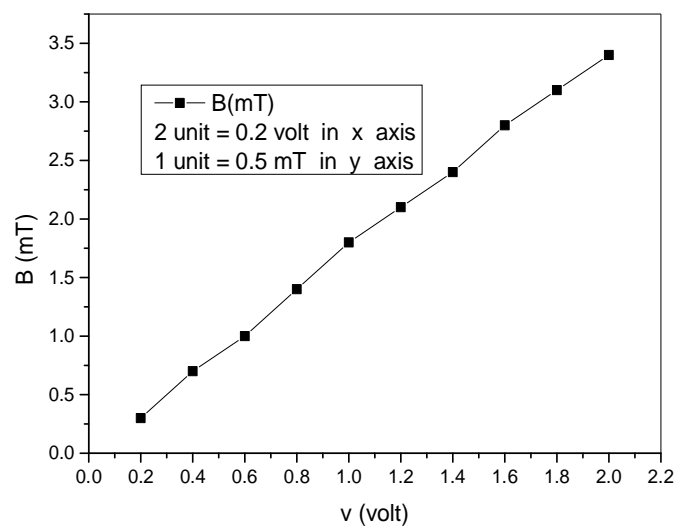


Figure (5.15): The relation between magnetic field induction vs potential difference V crashed sample for three minutes (insulated wire at 50 turns).

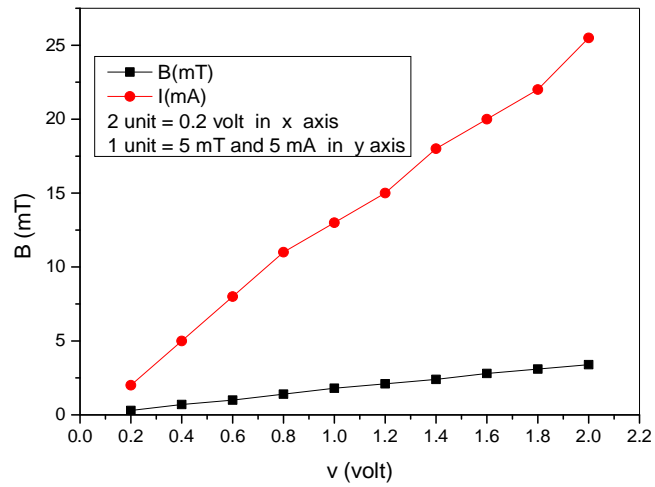


Figure (5.16): The relation between magnetic field induction and current I vs potential difference V crashed sample for three minutes (insulated wire at 50 turns).

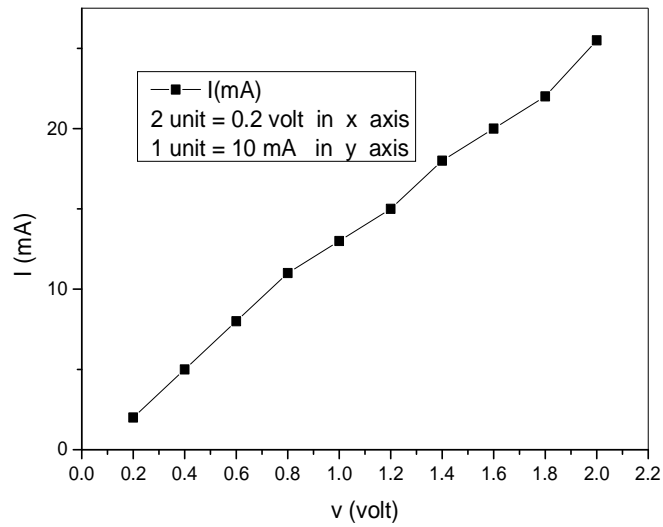
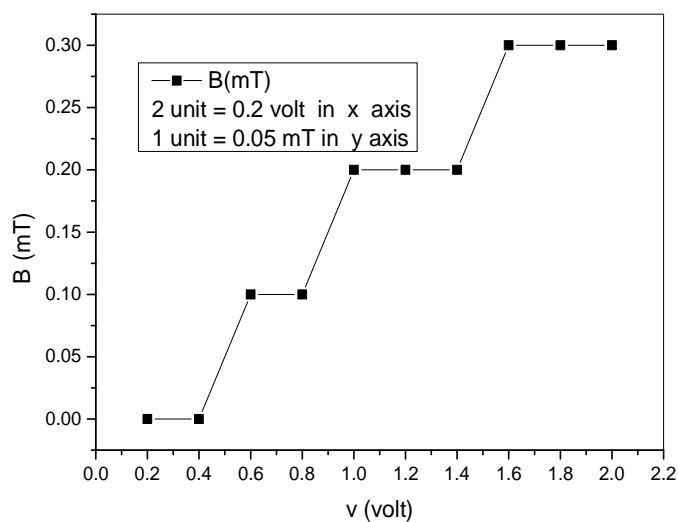


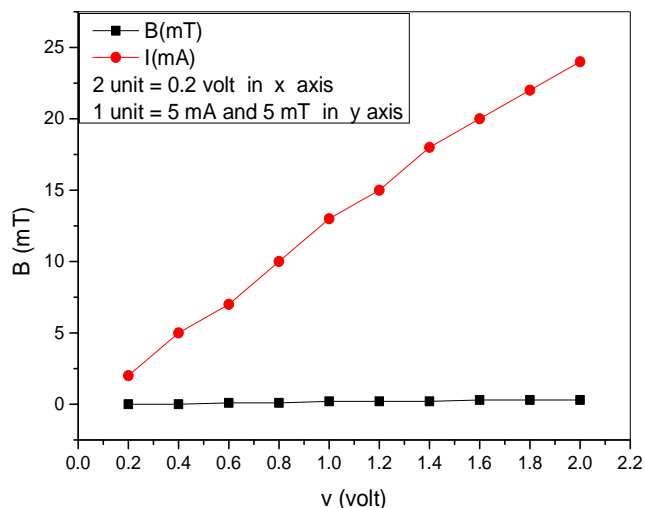
Figure (5.17): The relation between current I vs potential difference V crashed sample for three minutes (insulated wire at 50 turns).

Table (5.6): Crashed sample for three minutes (insulated wire at 100 turns).

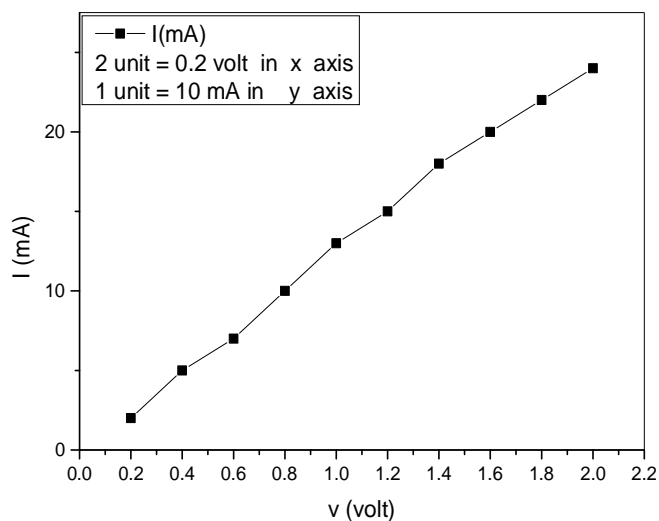
V/volt	I/mA	B/mT
0.2	2	0.0
0.4	5	0.0
0.6	8	0.1
0.8	11	0.1
1	13	0.2
1.2	15	0.2
1.4	18	0.2
1.6	20	0.3
1.8	22	0.3
2	25.5	0.3



Figure(5.18): The relation between magnetic field induction vs potential difference V crashed sample for three minutes (insulated wire at 100turns).



Figure(5.19): The relation between magnetic field induction and current I vs potential difference V crashed sample for three minutes (insulated wire at 100 turns).



Figure(5.20): The relation between current I vs potential difference V crashed sample for three minutes (insulated wire at 100 turns).

5.5 Detectors of Impurity in the Samples

The samples were placed under the detector device at Petroleum Technology Center (PTC) and some impurities appeared on the samples by X-Met 5000 (Principle of work by X-ray Fluorescent).

Table (5.7): Bulk Sample for different between elements and concentration (Conc) and stander deviation (STD).

Element	Conc	STD
Cr	0.01%	0.037
Ni	0.00%	0.069
Mo	0.07%	0.015
Cu	0.01%	0.031
W	0.25%	0.103
V	0.01%	0.04
Mn	>2.12%	0.178
Fe	95.48%	0.325

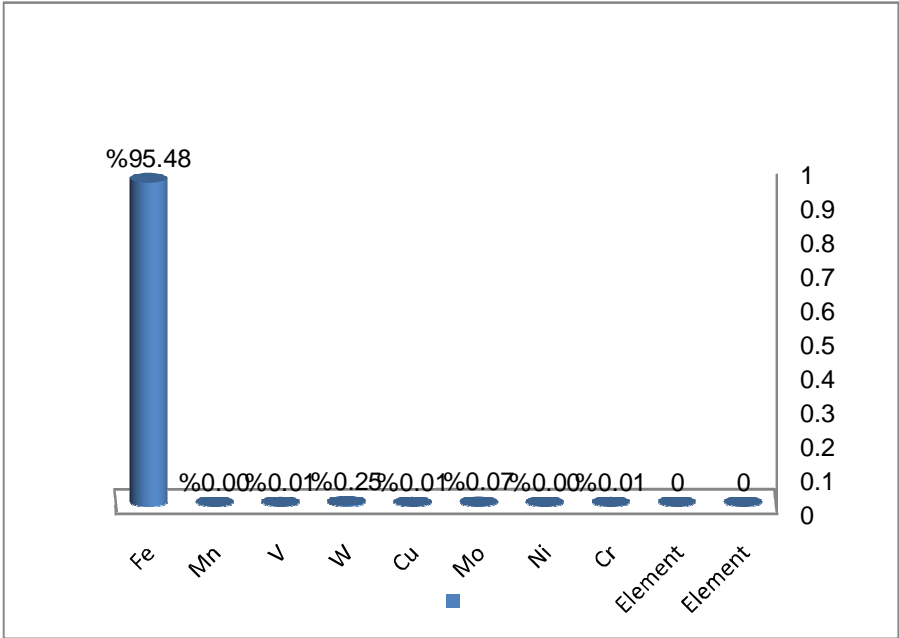
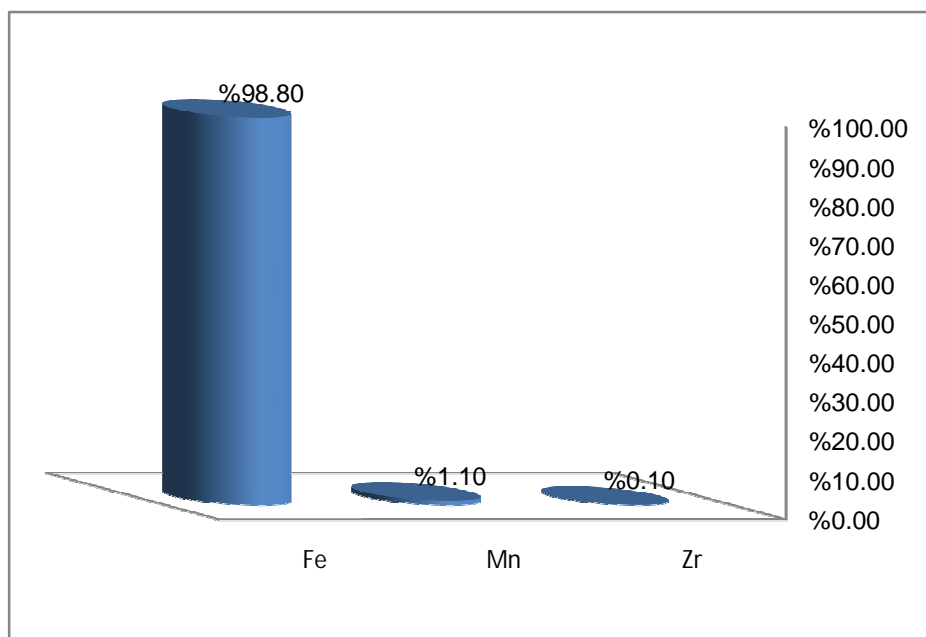


Figure (5.21): The bulk Sample for different between elements and concentration (Conc).

Table (5.8): Crashed sample for one minute, different between elements and concentration (Conc) and standerdeviation(STD).

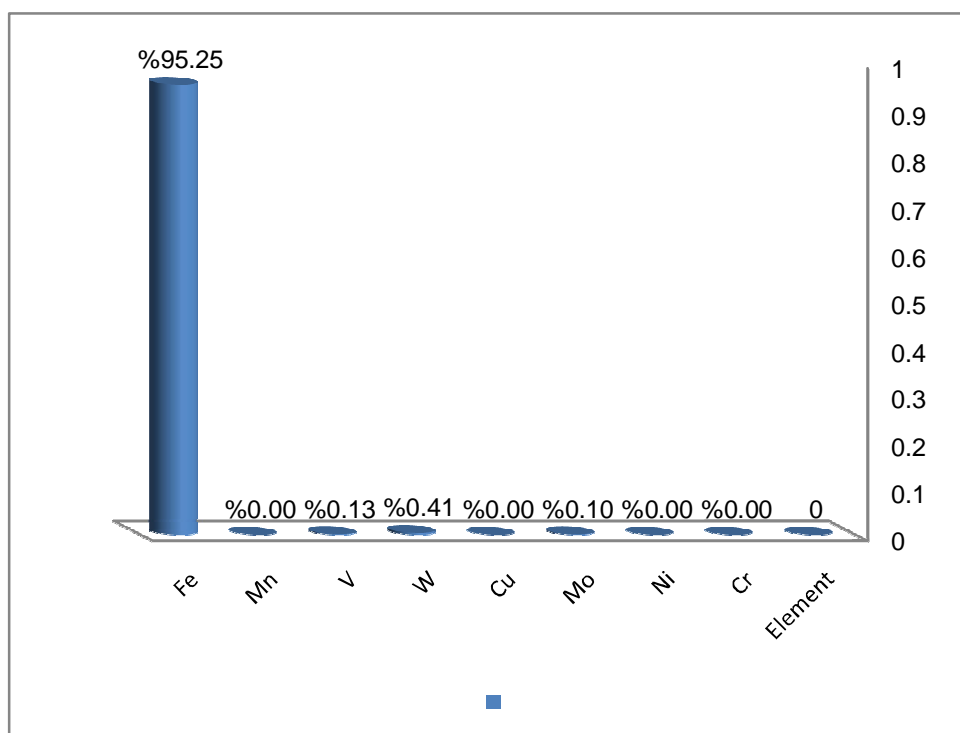
Element	Conc	STD
Zr	0.10%	0.03
Mn	1.10%	0.15
Fe	98.80%	1.06



Figuer(5.22): The crashed sample for one minute, different between elements and concentration(Conc).

Table (5.9):Crashed samplefor three minutes, different between elements and concentration (Conc) and Stander Deviation(STD).

Element	Conc	STD
Cr	0.00%	0.032
Ni	0.00%	0.066
Mo	0.10%	0.018
Cu	0.00%	0.022
W	0.41%	0.118
V	0.13%	0.059
Mn	>2.19%	0.176
Fe	95.25%	0.321



Figure(5.23): The crashed sample for three minutes, different between elements and concentration (Conc).

5.6 Discussion

It is evidenced from the figure(5.3), figure (5.6), figure(5.9), figure (5.12), figure (5.15) and figure (5.18): That is the magnetic flux increases by increasing of potential difference. And also of evidenced from the figure(5.4), figure(5.7),figure(5.10), figure (5.13), figure(5.16) and figure(5.19): That is the magnetic flux and current increases by increasing of potential difference. Also of evidenced from the figure(5.5), figure(5.8), figure(5.11), figure(5.14), figure(5.17)and figure(5.10): That is the magnetic flux and current increases by increasing of potential difference.

Note that the relationship between the magnetic flux and the number of turns is a direct relationship, when increasing the number of turns increasing the magnetic flux and also increasing the current, but the presence of impurities in the samples have different magnetic properties and classes, which led to oscillating in the values of magnetic flux and current outside.

It is evidenced from the figure (5.21) and figure (5.22) and figure (5.23): that is the percentage of the presence of iron element higher than percentages of the rest of the elements(Cr, Ni, Mo, Cu, W, V, Mn, Fe) and vary in each sample. In figure(5.22) disappeared some elements and back Zr element , and in the figure (5.23)the elements appeared again, resulting from different concentration element in the samples are different size.

5.7 Conclusion

The study shows how the properties of iron element at nanoscale size are altered by studying its magnetic properties and finding that the iron element's potential for the magnetic field increases at nanoscale size, But the presence of the impurity in the sample led to the oscillation in the values of currents and the magnetic flow outside.

5.8 Recommendations

It is necessary that the science researcher learn about nanotechnology and applications to benefit from it in variables fields. The researcher should divide the samples after the grind process to avoid the concentration of some impurities on a specific part of the sample, Thus giving better results.

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