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Comparison Characteristics of Nanoiron Colloid in Different Duty Cycle by Electrical Spark Discharge Method

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Abstract

In nano technology field, the preparation can be divided to two, chemical method and electrical method consider as physical method. The study fabricates the nanoiron colloid with electrical method called Electrical Spark Discharge Method (ESDM). By analyzing different Ton-Toff which relates to duty cycle to determine the characteristic of Ton-Toff in 10-10, 10-30, 10-50, 10-70 and 10-90. The wavelength represents the different colloid locates around 190-210nm with Ultraviolet-visible spectroscopy (UV-Vis). To verify the size, Zetasizer is used to measure the zeta size, distribution and zeta voltage. The results received from Ton-Toff in 10-90 has the smaller particle size. During the experiment, less suspension time was found and assumed the magnesium was the reason. Vibrating Sample Magnetometer (VSM) was used to discover the magnetic property. After many attempt, Ton-Toff in 10-30 was used to determine the magnetic characteristic and the plot result was different from the other kind of the sample which took the same analyze and it is also unlike the Hysteresis curve we have learned.

Keywords: Electrical Spark Discharge Method, nanoiron, Ultraviolet-visible spectroscopy, Vibrating Sample Magnetometer, Zetasizer

1. Introduction

Nano technology has applied to various industry, from factory to medication it has a great improvement nowadays. Such nano particle mostly fabricate with chemical method which adds chemical compound to the solution to stabilize the colloid condition [1]. The study uses Electrical Spark Discharge Method to fabricate nanoiron. From the same method but different metal material result, nanoiron suspension was less than any other kind. The magnetic characteristic was assumed to be analyzed. Later, different duty cycle was assumed to be the reason to receive different wavelength and zeta size was doubt to have different size.

Nano technology has rapid growth in recent years [2]. The innovation of industry necessity and application has been growing fast. Metal nanoparticle is widely applied in semi-conductor [3], bio medication [4] and daily essentials. Comparing to normal status, the properties of each metal nanoparticle has its individual characteristic, such as the increase of vapor pressure, decrease of melting point, surface and interface effect increases and quantum effect.

The chemical reaction to diffusion and sintering and the transformation in optics, electrics, mechanics and magnetics from their physical characteristics. Application such as metal catalyst, absorber, biomarkers and cancer treatment in medication are well known.

2. Materials and Methods

The preparation of metal nanoparticle material can be divided to physic or chemical methods [5] from their synthetic process. Chemical method is commonly used for commercial purpose with the substance electrolysis or oxidation-reduction reaction method to obtain massive nanoparticle. The chemical compound is necessary in the process [6] and the pollution to sample is also a concern. The result sample usually come with chemical sub product. The Electrical Spark Discharge Method (ESDM) using electric field to evoke spark melt metal material surface, take apart its particle and rapidly collect in dielectric fluid and there will be no other chemical product added. The ESDM hence produce high pure substance with simple process and there are many reference taking such method to prepare magnetic nano colloid solution, Plasma solution control the synthetic nano gold particle [7], prepare titanium dioxide nano particle to observe its formation and characteristic with discharge spark method [8].

The study fabricates magnetic nano colloid by ESDM, with the combination of resistance and capacitor to RC circuit in Electrical Electronics techniques and switch fast to generate high frequency discharge pulse to reach the electrical discharge effect. With high energy discharge spark Etching high solidity conductive material, its discharge circuit has improvement recently. Develop in transistor way and circuit with resistant capacitor parallel transistor combination make pulse voltage operating frequency reach megahertz level. The study group take such discharge spark method and nano technology combination to produce various metal nano colloid and analyze the result with professional equipment to testify the result match the standard of metal nano colloid characteristics, such as Ultraviolet-visible spectroscopy (UV-Vis) to observe colloid wavelength; with Zetasizer to obtain metal nano particle surface electric potential and distribution. The result indicated such method preparation of result was metal nano colloid.

The preparation of this study has successfully produced nanoiron colloid, despite the method mentioned above Vibration Sample Magnetometer was used to analyze the sample magnetic characteristic and Hysteresis curve and result showed it is able to be magnetize [9]. Nowadays, magnetic nano particle has widely purpose such as fighter jet invisible painting which cannot be traced by radar. In medical field, contrast media application is used to detect cancer cell [10]. Generally chemical compound is used to stabilize magnetic nano particle during the fabricating process [11]. For instance, the iron magnetic nano particle with chemical process is edible with compound to kill cancer cell by heat and it can be digest with no safety concern [12]. With discharge spark method, the produced nanoiron colloid can be preserve in di-water with no other chemical compound. The method to prepare nano colloid has great potential on bio-artificial.

2.1 Electrical Discharge Spark Method

Electrical Spark Discharge Method principle is to put two electrode into dielectric water (di water) and gives high speed circular DC pulse voltage. Through control servo system to control two electrode's gap within micro-distance. When the intensity of voltage is greater than two electrode di water resistant value, the resistance will be broken and cause spark. The discharge process comes with high temperature, the surface temperature of two electrode can reach 6000-10000 Celsius degree. Such high temperature melt tiny particle on the electrode surface due to the magnetic characteristic, instead of magnetic blending, ultrasonic blending method is more ideal to use in this study. The ultrasonic blending machine makes metal nano particle suspension on di water. When pulse stops, the two electrode di water return to insulation condition and waits until next discharge. The two electrode spark figure can be seen in Figure 1. V and I means two electrode voltage and current. Ton and Toff represents pulse voltage turn on and off.

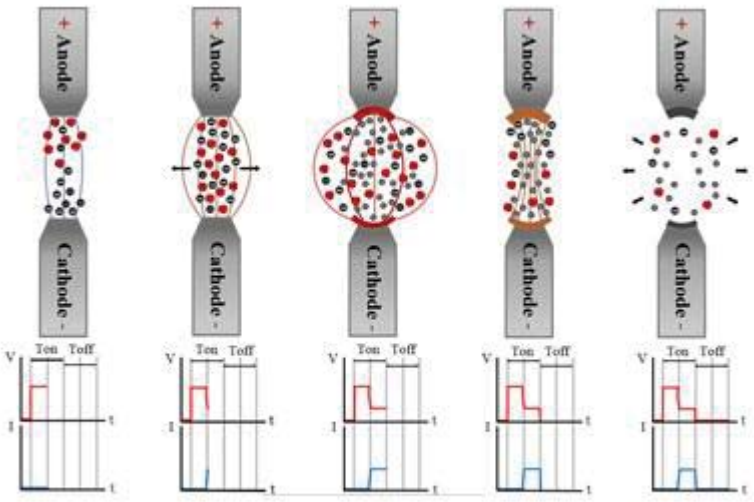


Figure 1. Electrical Spark Discharge Method

By using Electrical Spark Discharge Method to fabricate metal nano colloid. Figure 1 is the structure of ESDM can be used under standard experiment environment (with 25 Celsius degrees and 1atm). The system can be divided into four parts as following:

1. System parameter control box

Discharge system parameter setup, includes DC power value, discharge current adjustment, pulse modulates width (Ton-Toff), capacitor setup, servo motor control speed and sensibility setting, initial electrode up and down adjustment.

2. Servo Control System

Through controlling motor electrode up and down, makes two electrode stay within 10-30um distance to stabilize the discharge process.

3. Discharge fabricate platform

According to the needs, the metal nano material should be 99.99% metal electrode, anode diameter should be 1mm and cathode diameter should be 1mm. Due to discharge spark goes from anode to cathode leads to anode material fades rapidly，take the less fade cathode enlarge it to make more accurate when discharge.

4. Sample Storage and blending System

Put 80ml di water into beaker (Conductivity is about 5us) as dielectric fluid and blend with ultrasonic blending machine to stir to make it distribute average. After fabricating, the metal nano particle directly preserve in di water.

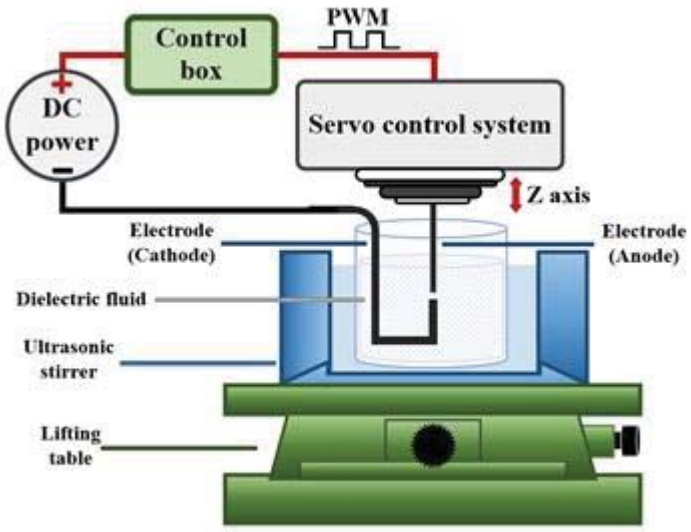


Figure 2. Electrical Discharge Machine

The metal nano preparation process can be seen in Figure 2. First put metal material on discharge fabricating platform electrode. Put 80 ml di water into beaker, point both anode and cathode correctly. Set system parameter control box and turn on ultrasonic blending machine to stir quickly. Then discharge begins, setup 5 minutes every time. When the discharge is done, take the result sample to analyze.

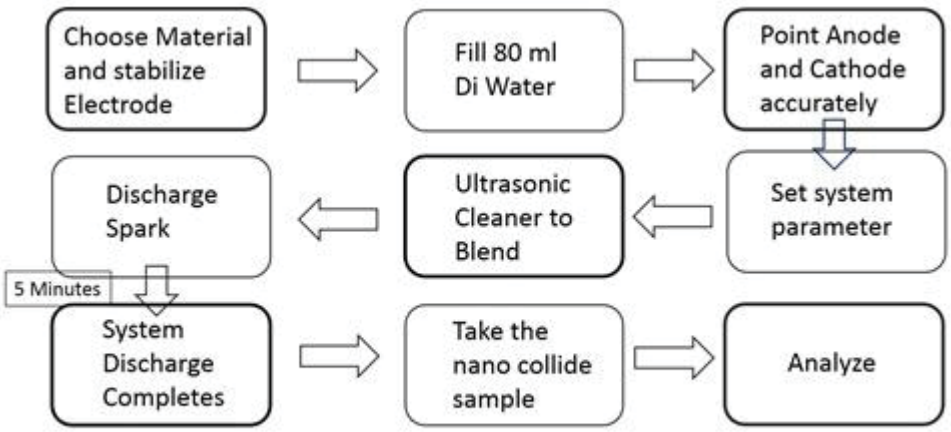


Figure 3. Process Flow Chart

5. Nanoiron colloid analyze

The study fabricates nanoiron colloid in the di water with metal electrode by the methods mentioned above. By changing the discharge parameter (pulse modulation width, Ton-Toff) to determine the difference of concentration on fabricated nanoiron colloid.

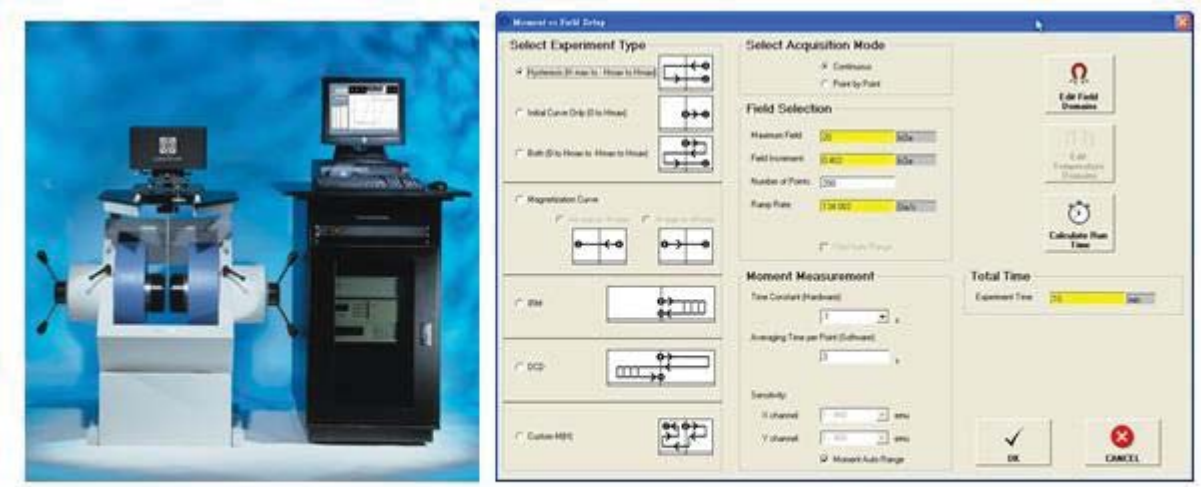
Ultraviolet-visible spectroscopy use the wave length from UV to VIS and observe the specific wave length in the certain interval to see if the spectrum resonance. With such process to find the wavelength.

2.2 Zetasizer

Zetasizer use Non-Invasive Back Scattering (NIBS), NIBS to detect scattering light. Gives opposite electrical field at the both sides of the sample, the nano colloid carries dielectric when the electric field gains, it pushes particle to a direction. By the movement of particle speed rate to calculate Zeta-Potential and particle size analyze result.

2.3 Vibrating Sample Magnetometer

Vibrating Sample Magnetometer analyze magnetic field with different given magnetic value to obtain sample Hysteresis curve. Generally the sample is powder and vibrates the particle with high speed which makes it average distribute. The sample of this study is liquid, due to the holder size is small and the surface tension also is one thing needs to conquer. By giving different magnetic field to discover under different duty cycle, the magnetic field variation to see if can fabricate different characteristic magnetic nano particle. The machine and function can be seen in Figure 4.



(a) (b)

Figure 4. (a) Vibrating Sample Magnetometer (b) Parameter Setting

3. Results and Discussion

During the whole preparation and experiment, anode electrode and cathode electrode attached when capacitor value set to 0.1uF. When capacitor value set to 0.5, no matter the Ton-Toff value was, the two electrode did not attach to influence the discharge process. The discharge condition stayed the most stable when the Ton-Toff set to 10-30, hence main analyzing focus on Ton-Toff at 10-30.

By analyzing different Ton-Toff value within 10-10, 10-30, 10-50, 10-70 which 10-30 was discovered to have the more stable status while preparing nanoiron colloid. UV-Vis was used to analyze such different Ton-Toff value to observe which would obtain the better wavelength. From the process and attempting, wavelength and intensity can be the consequence of suspension time and from the previous experiment we have known, nanoiron colloid gathers fast because of its characteristic. The UV-Vis result can be seen in Figure 5. the preparation time was set to three minutes and five minutes testified by many experiment result, within five minutes, the prepared colloid would receive the saturation condition. The wavelength characteristic result can been seen in Figure 5 (d). The climbing trend of wavelength showed the highest wavelength at 10-50. The absorbance intensity result can be seen in Figure. 5 (a), (b) and (c). For three minutes and five minutes preparation, both of result indicated when the Ton-Toff was given to 10-70, the ascending trend went lower though the different time has different absorbance intensity.

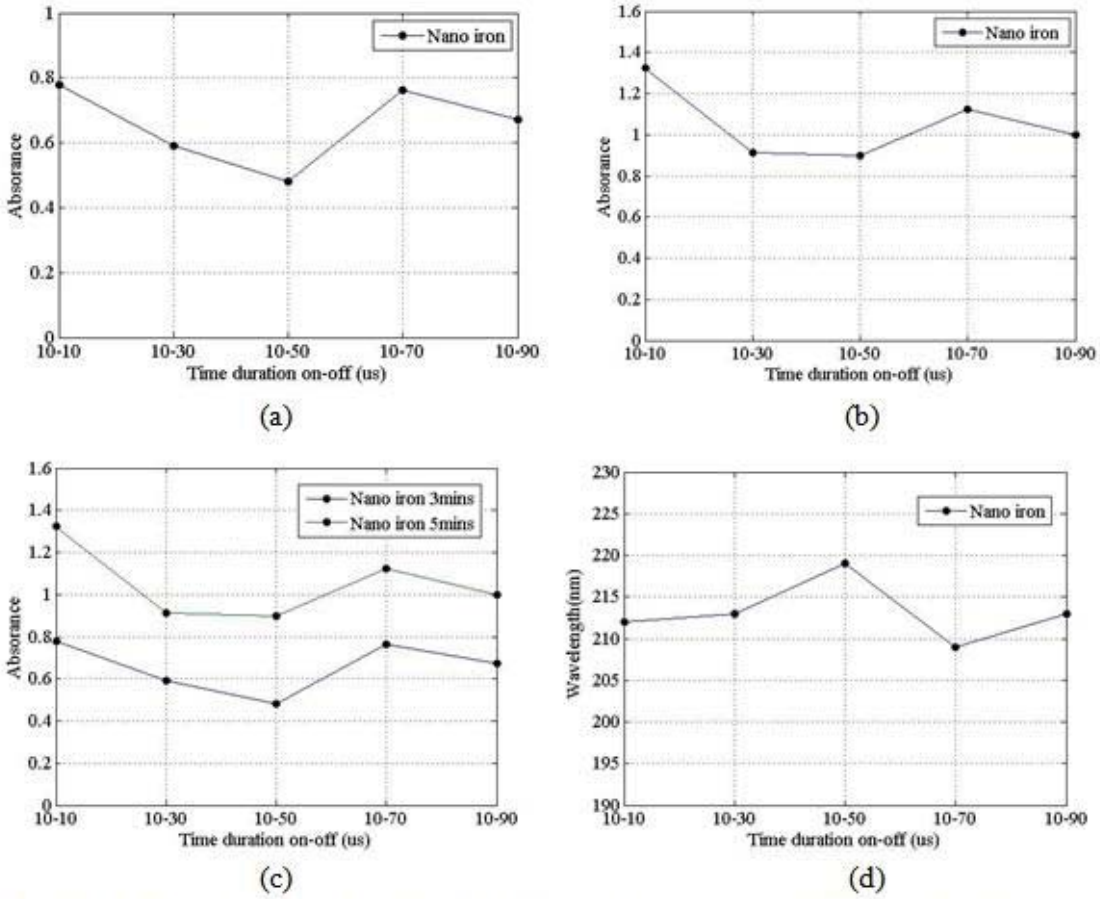


Figure 5. UV-Vis Result (a) Intensity of 3 Minutes (b) Intensity of 5 Minutes (c) Comparison of intensity (d) Comparison of Wavelength

The Zetasizer was used to measure zeta voltage and distribution size condition. The study analyze the Ton-Toff 10-30 and 10-90 which 10-30 has the more stability condition during preparation and 10-90 is testified to have the lowest concentration while the suspension time was longer compared to Ton-Toff of 10-10, 10-50 and 10-70. The result showed that 10-90 has smaller particle than 10-30 and the zeta distribution has the better result. The result can be seen in Figure 6.

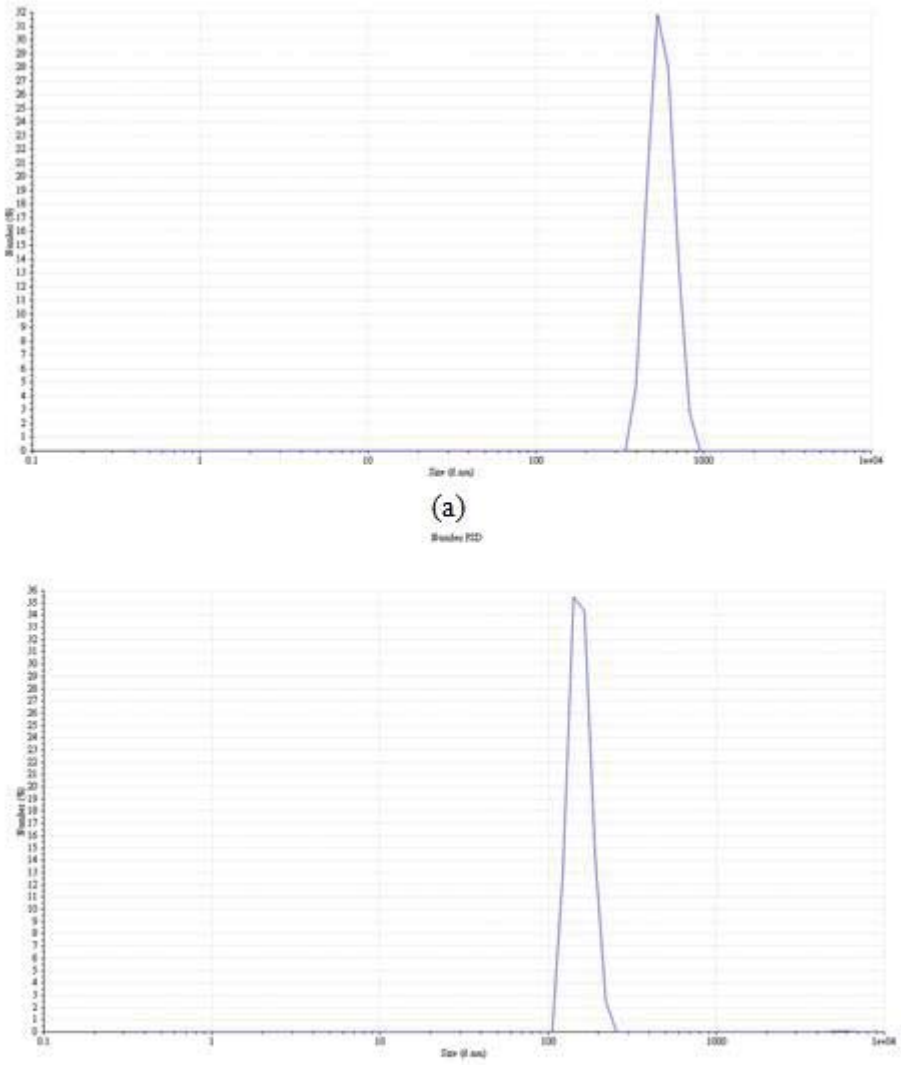
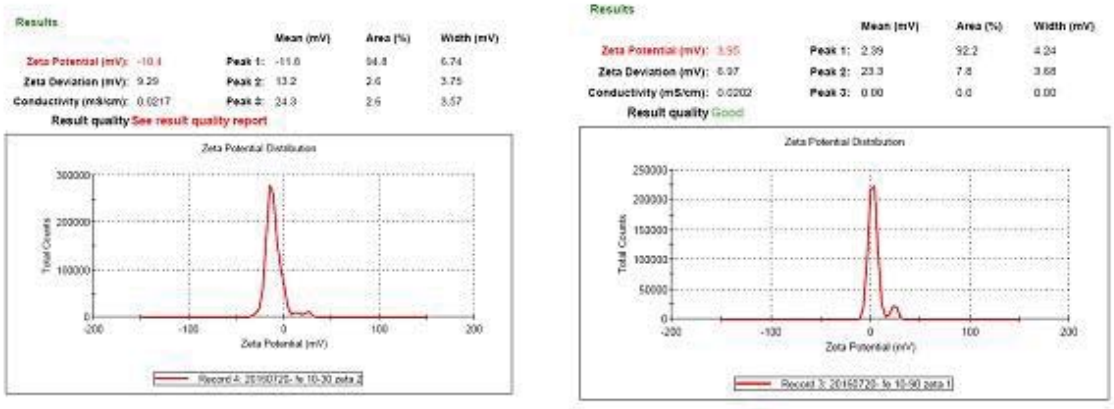


Figure 6. Zetasizer Size Result (a) Ton-Toff 10-30 (b) Ton-Toff 10-90

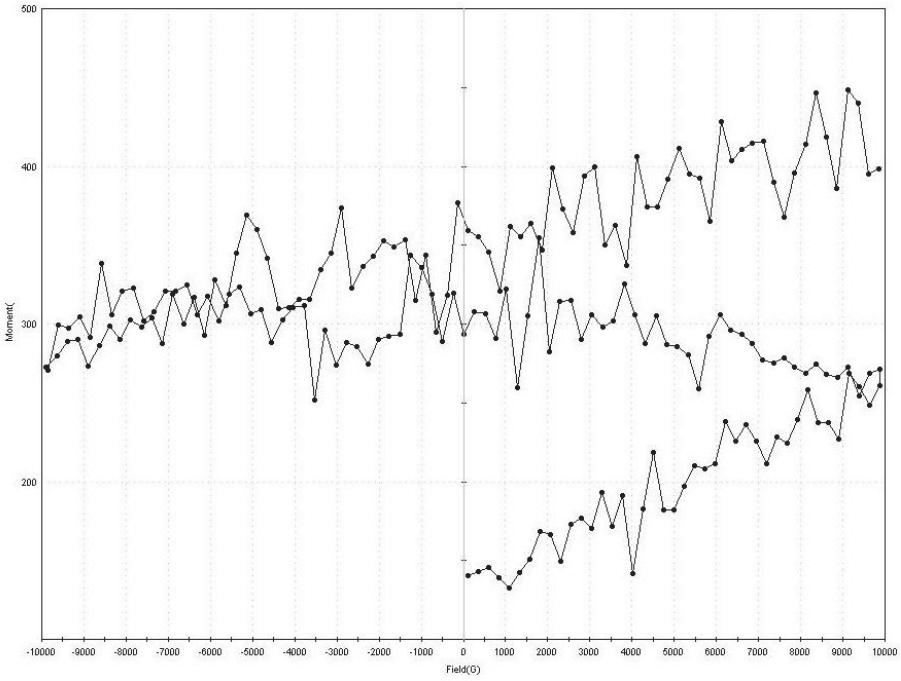


(a) (b)

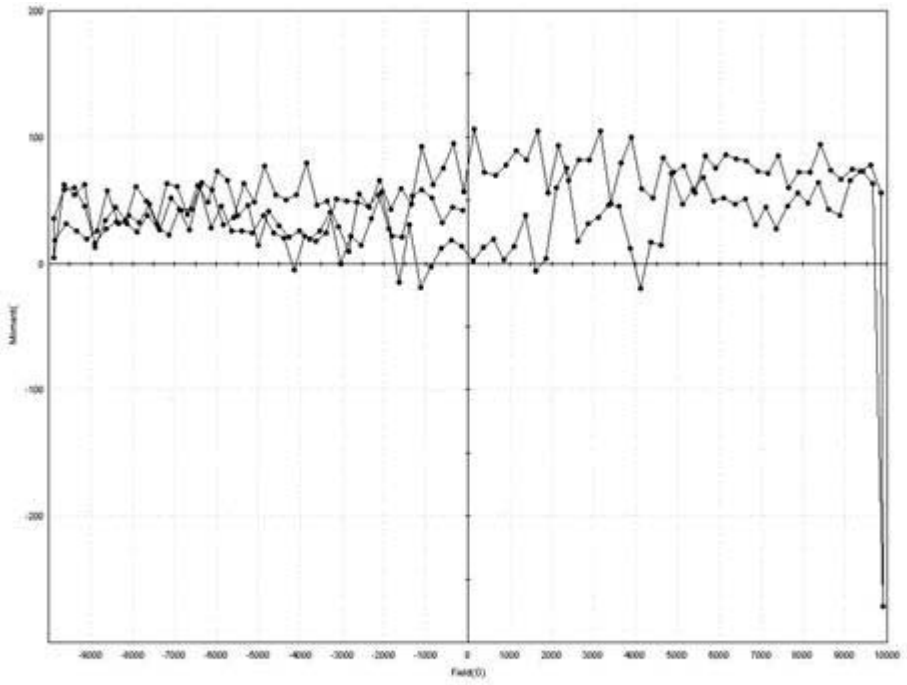
Figure 7. Zeta Potential Result (a) Ton-Toff in10-30 (b) Ton-Toff in 10-90

During the preparation process, the suspension time was assumed to relate to the magnetic

property when the electrodes discharging. To analyze the property, Vibrating Sample Magnetometer (VSM) was used to analyze the magnetic characteristics by giving the magnetic field between -10000 Gauss to +10000 Gauss then observe the result curve. From we have learned, the result of Hysteresis curve is different. The given magnetic field was added from zero to +10000 Gauss to -10000 Gauss then back to zero. By giving the more magnetic field, the result increased while giving back to -10000 Gauss, the curve stayed stable until the magnetic field was given to positive trend, the curve increased again. The study even did the backward result and received the similar trend curve shown in Figure 8.



(a)



(b)

Figure 8. Vibrating Sample Magnetometer Result (a) Forward (b) Backward

4. Conclusions

The study analyze nanoiron by ESDM with Ton-Toff in 10-10, 10-30, 10-70, 10-90. The absorbance intensity received more high value than Ton-Toff at 10-30 and 10-90 when it is at 10-70. Nanoparticle size received smaller result when Ton-Toff at 10-90 and it is also related to the concentration. The condensation of nanoiron has magnetic characteristic, also the nanoiron particle prepared by ESDM has the same characteristic. The result of analyze the magnetic field is different from the Hysteresis Curve we have learned. The result locates above the third and the fourth quadrant. The result showed the nanoiron fabricated by ESDM has more magnetic characteristic to discover to apply to human benefit.

Acknowledgments and Legal Responsibility

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5. References

Xin Gao and K. M. Kerry Yu, "Colloidal stable silica encapsulated nano-magnetic composite as a novel bio-catalyst carrier," Chemical Communications, Issue 24, 2003.

Chang-gyu Hwang, "Nanotechnology enables a new memory growth model," Proceedings of the IEEE, Volume 91, pp. 1765-1771, 2003.

Kinam Kim, "Technology challenges for deep-nano semiconductor", 2010 IEEE International Memory Workshop, pp. 1-2, 2010.

Shrikant Patil, “Studies of the Atomic and Crystalline Characteristics of Ceramic Oxide Nano Powders after Bio field Treatment,” Industrial Engineering & Management, 2015.

P. Subramanya Herle and B. Ellis “Nano-network electronic conduction in iron and nickel olivine phosphates,” Nature Materials 3, pp. 147-152, 2004

S.F. Moustafa, “Synthesis of nano-sized Fe–Ni powder by chemical process for magnetic applications,” Journal of Materials Processing Technology, Volume 181, pp. 59-63, 2007.

K.-H. Su , Q.-H. Wei , and X. Zhang, “Interparticle Coupling Effects on Plasmon Resonances of Nanogold Particles,” Nano Letters, pp. 1087-1090, 2003

Walid A. Daoud, “Surface functionalization of cellulose fibers with titanium dioxide nanoparticles and their combined bactericidal activities,” Surface Science, Volume 599, pp. 69-75, 2005

Guillemin Rodary and Sebastian Wedekind, “Magnetic Hysteresis Loop of Single Co Nano-islands”, Japanese Journal of Applied Physics, Volume 47, Number 12R, 2008

Younsoo Bae and Woo-Dong Jang, “Multifunctional polymeric micelles with folate-mediated cancer cell targeting and pH-triggered drug releasing properties for active intracellular drug delivery,” Molecular BioSystems. 2005

Zhonghai Zhang and Yuan Yuan, “Preparation of photocatalytic nano-ZnO/TiO2 film and application for determination of chemical oxygen demand,” Talanta, Volume 73, Issue 3, pp.523-528, 2007

Amiri, “Nano Optical Tweezers Generation Used for Heat Surgery of a Human Tissue Cancer Cells Using Add/Drop Interferometer System,” Quantum Matter, Volume 2, pp. 489-493, 2013