 IC/2010/065

United Nations Educational, Scientific and Cultural Organization
and
International Atomic Energy Agency

THE ABDUS SALAM INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS

THE FIRST STEP IN STUDYING THE INFLUENCE OF GAMMA RADIATION ON MAGNETIC PROPERTIES OF $CoFe_2O_4$ NANO-PARTICLES

Nguyen Mong Giao[1]
Hung Vuong University, 342Bis Nguyen Trong Tuyen Street, Tan Binh District, Hochiminh City, Vietnam
and
The Abdus Salam International Centre for Theoretical Physics, Trieste, Italy,

Nguyen Lam Thu Trang
Hung Vuong University, 342Bis Nguyen Trong Tuyen Street, Tan Binh District, Hochiminh City, Vietnam

and

Nguyen Thi Ai Thu
Transport College, 189 Kinh Duong Vuong Street, District 6, Hochiminh City, Vietnam.

MIRAMARE – TRIESTE
August 2010

[1] Senior Associate of ICTP.

Abstract

The influence of radiation on magnetic material has been investigated in some researches and the results proved that the magnetic properties of hard magnetic were unchangeable under radiation effect [1,2,3] Our works were aimed at studying the influence of gamma radiation on the nano-size magnetic materials. The gamma radiation with 1332 keV and 1174 keV energy was emitted on $CoFe_2O_4$ nano-particles with various doses. The comparison of properties of the materials before and after emitting was analyzed by hysteresis loop VSM. The change of magnetic properties of $CoFe_2O_4$ nano-particles after radiating appeared.

INTRODUCTION

Some previous researches had proved that magnetic properties are unchangeable under the effect of radiation [1,2,3].

In this work the influence of gamma radiation on $CoFe_2O_4$ nano-magnetic particles is studied.

We performed the study as follows: the ^{60}Co gamma radiation with 1332 and 1774 keV energy was irradiated on magnetic nano-particles. Properties of this system before and after emitting, were measured by hysteresisgraph.The magnetic properties were tested by measurements of magnetization curves using vibrating sample magnetometer (VSM) after irradiating with doses from 500 kGy to 2500 kGy. The result of the measurements shows that the change of (B-H) loop is about 10%.

EXPERIMENTAL

A mixture of 0.05M $CoCl_2.6H_2O$ 11.9g and 0.1M $FeCl_3.6H_2O$ 27g [Co^{2+}: Fe^{3+} = 1:2] were mixed with 50ml H_2O in 142ml NaOH solution. The chemical reaction of $CoFe_2O_4$ precipitation is expected as follows:

$$2FeCl_3.6H_2O + CoCl_2.6H_2O + 8NaOH \rightarrow CoFe_2O_4 + 8NaCl + 22H_2O$$

The detailed experiment is processed as follows:

First, $FeCl_3$ and $CoCl_2$ were mixed in distilled water. Next, mixture solution precipitated with NaOH and stirred by ultrasonic agitation at room temperature. Black precipitate products will be washed by distilled water in magnetic field several times. Finally, products had uniform sphere size about 5-180nm of diameter and were dried in vacuum at 70^0C for 48 hours.

RESULTS AND DISCUSSION

Figures 1-5 and table 1 show results of our experiment

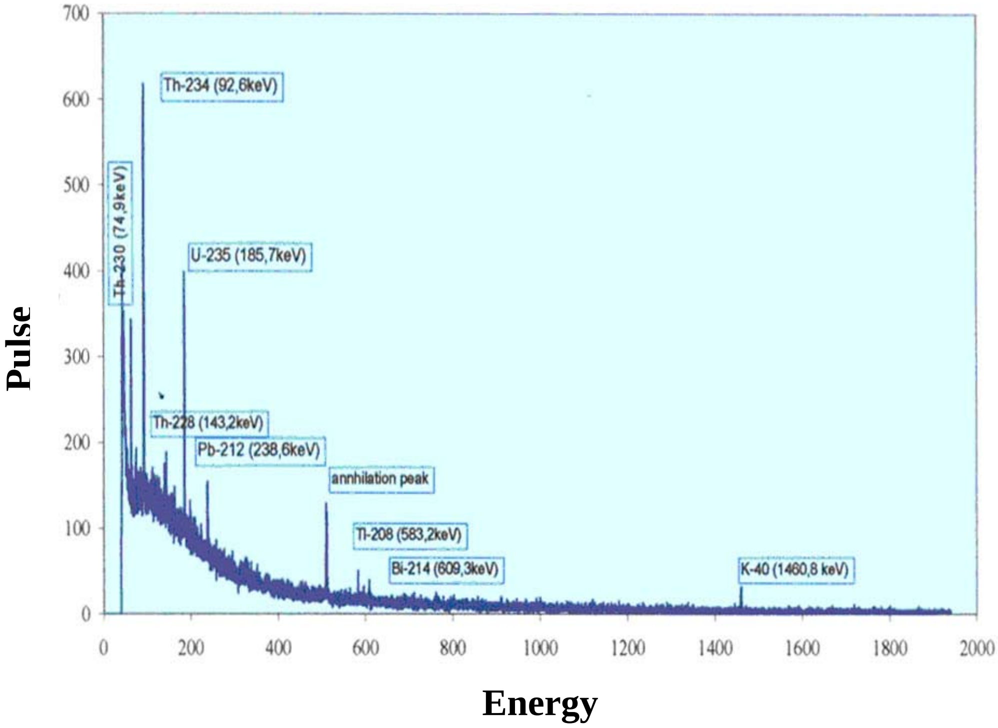

Figure 1: Gamma spectra of irradiated samples with dose in 2500 kGy

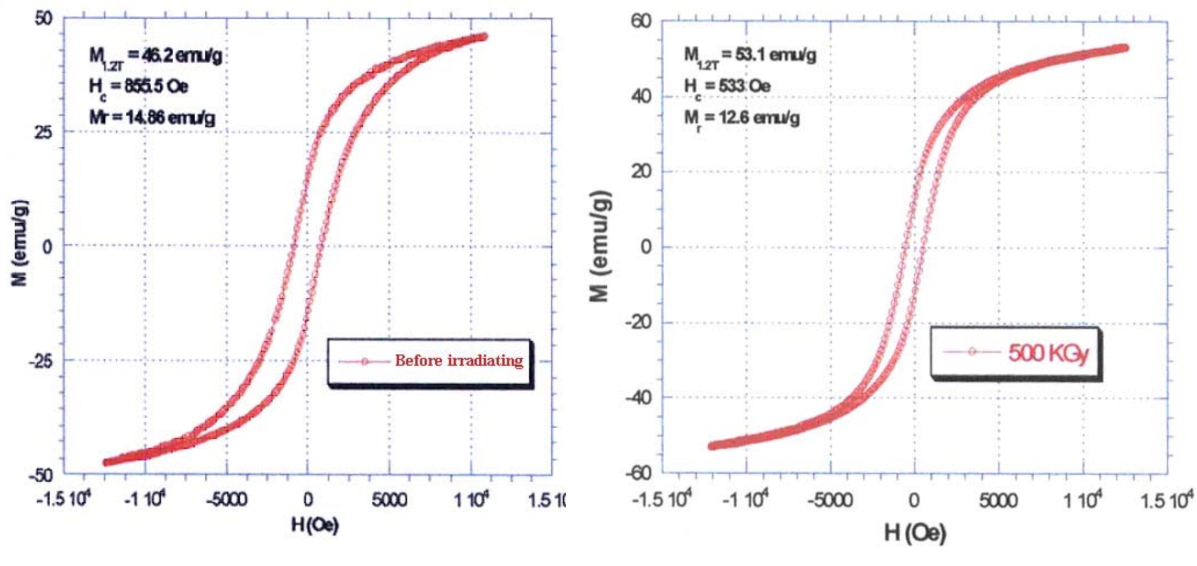

Figure 2: Magnetization curves of $CoFe_2O_4$ sample before and after irradiating with dose in 500 kGy

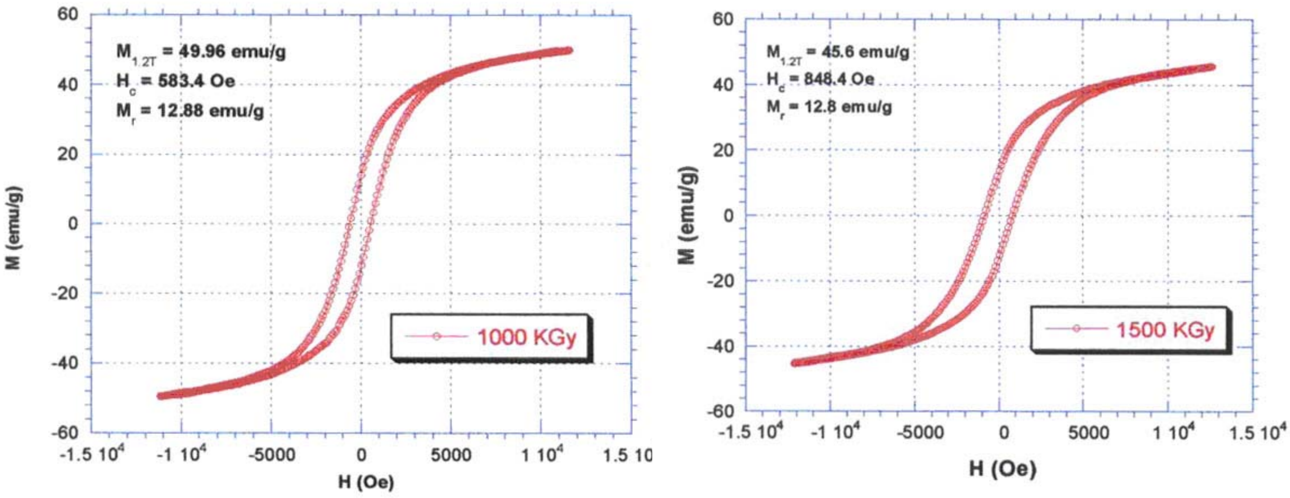

Figure 3: Magnetization curves of $CoFe_2O_4$ sample after irradiating with doses in 1000 kGy and 1500 kGy

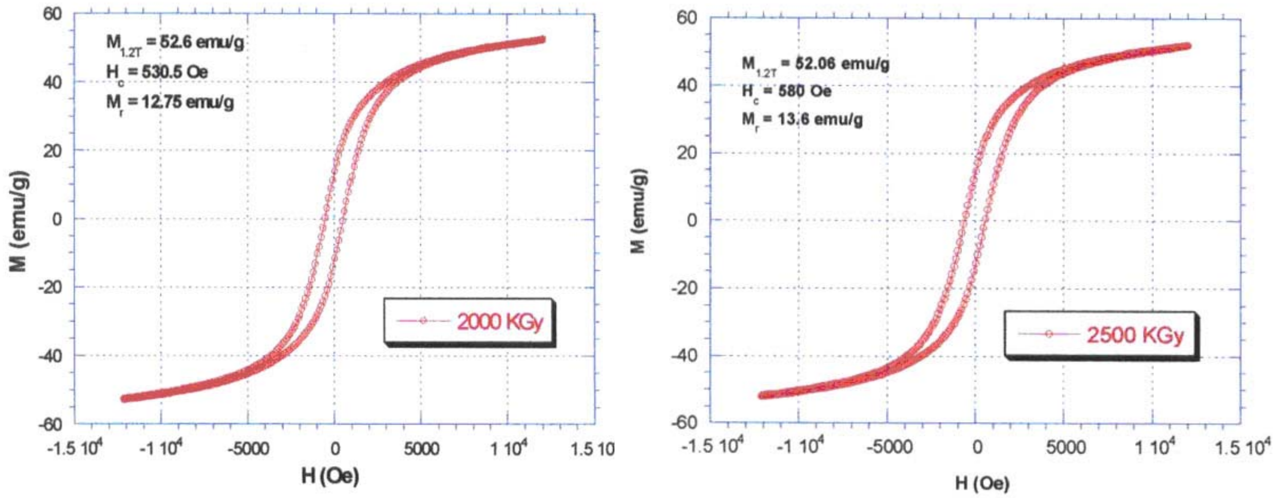

Figure 4: Magnetization curves of $CoFe_2O_4$ sample after irradiating with doses in 2000 kGy and 2500 kGy

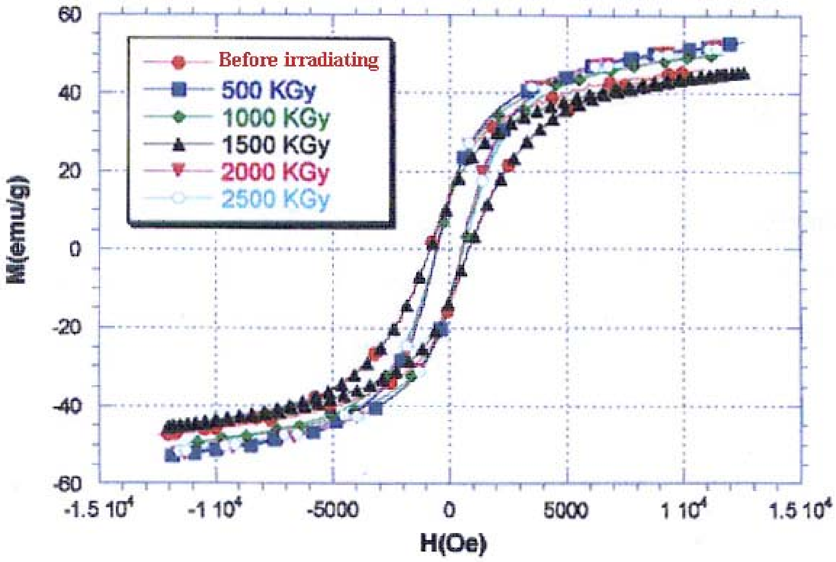

Figure 5: Magnetization curves of 7 samples of $CoFe_2O_4$
after irradiating with doses in 500 kGy ÷ 2500 kGy

Table 1. Results of measurements the coercivity, magnetization and remanent magnetization

***Sample* 1**	**Before radiating**	**After radiating**				
		500 kGy	***1000 kGy***	***1500 kGy***	***2000 kGy***	***2500 kGy***
$M_{1.2T}$	46.2	53.1	49.96	45.6	52.6	52.5
H_c	855.5	533	583.4	848.4	530.5	580
M_r	14.86	12.6	12.88	12.8	12.75	13.6
***Sample* 2**	**Before radiating**	**After radiating**				
		500 kGy	***1000 kGy***	***1500 kGy***	***2000 kGy***	***2500 kGy***
$M_{1.2T}$	46.51	52.8	49.18	44.9	52.66	52.0
H_c	855.6	534	583.6	848.6	530.7	581
M_r	14.88	12.7	12.89	12.9	12.76	13.7
***Sample* 3**	**Before radiating**	**After radiating**				
		500 kGy	***1000 kGy***	***1500 kGy***	***2000 kGy***	***2500 kGy***
$M_{1.2T}$	46.59	52.3	49.90	44.92	52.25	51.71
H_c	855.1	535	583.5	848.2	530.7	578
M_r	14.86	12.6	12.88	12.8	12.73	13.7
***Sample* 4**	**Before radiating**	**After radiating**				
		500 kGy	***1000 kGy***	***1500 kGy***	***2000 kGy***	***2500 kGy***
$M_{1.2T}$	45.59	52.4	49.93	44.96	52.24	51.72
H_c	855.1	535	583.7	848.3	530.6	578
M_r	14.86	12.6	12.85	12.5	12.76	13.3
***Sample* 5**	**Before radiating**	**After radiating**				
		500 kGy	***1000 kGy***	***1500 kGy***	***2000 kGy***	***2500 kGy***
$M_{1.2T}$	46.2	53.1	49.96	45.6	52.6	52.6
H_c	855.5	533	583.4	848.4	530.5	580
M_r	14.86	12.8	12.78	12.7	12.70	13.7
***Sample* 6**	**Before radiating**	**After radiating**				
		500 kGy	***1000 kGy***	***1500 kGy***	***2000 kGy***	***2500 kGy***
$M_{1.2T}$	46.2	53.1	49.96	45.6	52.4	52.6
H_c	855.5	533	583.4	848.4	530.5	580
M_r	14.85	12.6	12.86	12.68	12.71	13.3
***Sample* 7**	**Before radiating**	**After radiating**				
		500 kGy	***1000 kGy***	***1500 kGy***	***2000 kGy***	***2500 kGy***
$M_{1.2T}$	46.4	52.76	49.25	44.82	52.64	51.5
H_c	855.6	534	583.6	848.6	530.7	581
M_r	14.80	12.7	12.89	12.9	12.76	13.7
***Sample* 1,2,3,4, 5,6,7**	**Before radiating**	**After radiating**				
		500 kGy	***1000 kGy***	***1500 kGy***	***2000 kGy***	***2500 kGy***
$M_{1.2T}$	46.1±0.4	52.8±0.3	49.73±0.2	45.2±0.4	52.46±0.17	52±0.51
H_c	855.4±0.2	534±0.1	583.2±0.2	848.4±0.2	530.5±0.2	579±1.2
M_r	14.85±0.03	12.6±0.23	12.86±0.03	12.75±0.15	12.73±0.03	13.57±0.13

Magnetization curves of 7 samples before and after irradiating

The remanent magnetization and coercive nano-particles reduced in after irradiating (M_r reduced from 14.86 emu/g to 12.6 emu/ g,H_c reduced from 855.5 Oe to 533 Oe) but the saturation magnetization of nano-particles increased about 46.2 to 53.1 emu/g:

When gamma radiation emitted on matter, many effects appeared in which there is an effect that can change the shell structure and change the spin of atoms constitute materials. So with the change of the spin, magnetic properties also change. But what effects can change the atom properties? And then why aren't the changes seen if the irradiation was emitted on mass magnetic materials?

We consider that the impactions in both cases of the gamma radiation on magnetic materials induce the changes of magnetic properties. We denote ΔM and M are the change and the tested sample value, respectively. With the mass magnetic materials, M is very large, so the ratio of $\frac{\Delta M}{M}$ can't be observed, but with the nano materials, M is very small and $\frac{\Delta M}{M}$ ratio can be observed very well.

CONCLUSION

- We have made $CoFe_2O_4$ nanoparticles using the coprecipitation method.
- From testing the radioactivity, we can draw the conclusion that samples do not emit secondary radiation with 2500 kGy dose.
- Analysing magnetic properties of this system before and after irradiating by hysteresisgraph showed the change of (B-H) loop is insignificant. The result shows that the change is approximately 10%.

Acknowledgments

This work was done within the framework of the Associateship Scheme of the Abdus Salam International Centre for Theoretical Physics, Trieste, Italy.

References

[1] R.S. Gao et al., Journal of Magneticsm and Magnetic Materials 302 (2006) 156-159.

[2] J. Alderman, P.K. Job and J. Puhl, Nucl. Instrum. Methods A481 (2002) 9;
S. Roath, Journal of Magnetism and Magnetic Materials 122 (1993) 329;
C.M. Sorensen, in Nanoscale Materials in Chemistry, Ed. K.J. Klabundle (John Wiley and Sons, Inc., New York, 2001) p.169

[3] E.P. Wohlfarth, Journal of Magnetism and Magnetic Materials (1983) 39;
J. Popplewel and L. Sakhnini, Journal of Magnetism and Magnetic Materials 149 (1995) 72.