10:45 CF-08. Magneto-plasmonic properties of hybrid Au-Fe oxide heterodimers. C. de Julian Fernandez1,2, F. Pineider3,2, G. Campo2, L. Cabrera2, P. Ghigna4, D. Cozzoli5, C. Sangregorio1,2, A. Caneschi2 and D. Gatteschi2 1. CNR- ISTM, Milano, Italy; 2. INSTM-Univ. Florence, Florence, Italy; 3. CNR- ISTM, Padova, Italy; 4. INSTM- Univ. Pavia, Pavia, Italy; 5. Univ. of the Salento & NNL – CNR, Lecce, Italy

11:00 CF-09. Formation of columnar structures by the magnetically directed assembly of cobalt ferrite nanoparticles. D. Lisjak1, P. Jenuš1 and M. Droženik1,2 1. Department for Materials Synthesis, Jozef Stefan Institute, Ljubljana, Slovenia; 2. Faculty for Chemistry and Chemical Technology, University of Maribor, Maribor, Slovenia

11:15 CF-10. Shape-dependent cation occupancy in Fe3O4 nanoparticle based on Mössbauer spectroscopy analysis. S. Yoon1, S. Kim1, C. Kim1 and I. Shim1 1. Department of Physics, Kookmin University, Seoul, Republic of Korea

11:30 CF-11. Magnetization drop at high temperature in oleic acid-coated magnetite nanoparticles. C. Rodriguez1, Y. Kolen’ko1, M. Bañobre-López1, B. Rodríguez1, P. Freitas1 and J. Rivas1 1. International Iberian Nanotechnology Laboratory (INL), Braga, Portugal

11:45 CF-12. Preparation and magnetic properties of porous NiO nanoplates. T. Li1,2, H. Bi1,2 and S. Li1 1. College of Chemistry and Chemical Engineering, Anhui University, Hefei, China; 2. AnHui Province Key Laboratory of Environment-friendly Polymer Materials, Hefei, China; 3. College of Physics Science, Qingdao University, Qingdao, China
Shape-dependent cation occupancy in Fe$_3$O$_4$ nanoparticle based on Mössbauer spectroscopy analysis.

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INTRODUCTION
Ferrite materials with excellent electromagnetic properties such as high electric resistivity, magnetic permeability have been studied in the past decade. Also ferrite nanoparticles have been used in bio-applications such as drug delivery system, treatment of hyperthermia, and magnetic resonance imaging contrast media [1] due to its physical/chemical properties depending on the particle size. Recently, studies on the synthesis of Fe$_3$O$_4$ nanoparticle was focused on the shape control [2], because nanoparticle showed various physical/chemical properties depending on not only size of particle but also shape of particle. C.-H. Ho et al. [3] synthesized the Fe$_3$O$_4$ nanoparticles by hot-injection method and measured x-ray magnetic circular dichroism (XMCD). They reported that cation site occupancy of Fe$_3$O$_4$ nanoparticles depends on the shape of particle. In this study, we have prepared Fe$_3$O$_4$ nanoparticles under hot-injection method and investigated crystal structure and electromagnetic properties. Especially, we investigated the occupancy of cation site in the spinel structure by measuring Mössbauer spectroscopy at various temperatures.

EXPERIMENT PROCEDURES
Fe$_3$O$_4$ nanoparticles were synthesized by modified hot-injection method [4]. X-ray diffraction (XRD) with Cu-$K\alpha$ ($\lambda = 1.540546$ Å) radiation was measured to identify the crystal structure and lattice constant of Fe$_3$O$_4$ nanoparticle. The morphology of the Fe$_3$O$_4$ nanoparticles was examined with a JEOL JEM 2010 high resolution-transmission electron microscope (HR-TEM). Magnetic properties were measured by vibrating sample magnetometer (VSM). Also we measured Mössbauer spectroscopy to determine occupancy of cation site in spinel structure of Fe$_3$O$_4$ nanoparticle.

RESULTS AND DISCUSSION
The crystal structure of Fe$_3$O$_4$ nanoparticles was determined to be inverse spinel structure. The lattice constant $a_0$, calculated by Nelson-Riley extrapolation, decreases from 8.388 to 8.378 Å with increasing injection time. However, XRD measurement is not conclusive enough to distinguish the Fe$_3$O$_4$ and $\gamma$-Fe$_2$O$_3$ because they have a same crystal structure.

HR-TEM images show that when precursor solution was injected for 0.5 min, polyhedral Fe$_3$O$_4$ nanoparticle was synthesized (figure 1(A)). However, when precursor solution was injected for 60 min, cubic Fe$_3$O$_4$ nanoparticle was synthesized (figure 1(B)). According to HR-TEM images, the size of polyhedral Fe$_3$O$_4$ nanoparticle was estimated to 3.83 nm and that of cubic Fe$_3$O$_4$ nanoparticle was estimated to 17.20 nm.

From the VSM measurements, the saturation magnetization ($M_s$) and coercivity ($H_c$) under the applied field of 10 kOe at 295 K were determined to be 45.77 emu/g and 5.99 Oe for polyhedral Fe$_3$O$_4$ nanoparticle, and 64.98 emu/g and 13.5 Oe for cubic Fe$_3$O$_4$ nanoparticle. Crystallization depending on injection time rate could be one of the possible reasons of increasing saturation magnetization of Fe$_3$O$_4$ nanoparticle.

Mössbauer spectra of Fe$_3$O$_4$ were measured at various temperatures (figure 1). The magnetic hyperfine field decreased with increasing temperature. Also, Mössbauer spectra of polyhedral Fe$_3$O$_4$ nanoparticle indicate superparamagnetism, which agrees with VSM results. Fe$_3$O$_4$ has an inverse spinel structure with the formula of [Fe$^{3+}$]$^{3n}$[Fe$^{3+}$Fe$^{2+}$]$^{n}$O$_4$ and based on this, we have analyzed Mössbauer spectra as 3 sets with six-lines. The isomer shift values from Mössbauer spectra of Fe$_3$O$_4$ nanoparticles indicate the presence of Fe$^{3+}$ ion and Fe$^{2+}$ ion. This clearly suggests that the prepared nanoparticle was composed of Fe$_2$O$_3$. Both polyhedral and cubic Fe$_3$O$_4$ nanoparticle indicate that the occupancy of Fe$^{3+}$ ion is larger than occupancy of Fe$^{2+}$ ion is at B-site, which agrees with XMCD result of C.-H. Ho et al. However, in the case of polyhedral Fe$_3$O$_4$ nanoparticle, difference between the occupancies of cations (Fe$^{3+}$, Fe$^{2+}$) at B-site in inverse spinel structure is larger than that in the cubic Fe$_3$O$_4$ nanoparticle. It is noticeable that the occupancy of cation depends not only on the shape of nanoparticle but also on the nanoparticle size. We expect that the difference in the occupancy of cation at B-site is possibly from the terminated plane or the surface-to-volume ratio.