Effect of Molecular Coating on Magnetic Properties of Spinel Ferrite Nanoparticles: XANES study

M. Abdolrahimi[1,2], D. Peddis[2,3], G. Varvaro[2] , C. Meneghini[1] and S. Ammarmerah[4]

[1]Dipartimento di Scienze, Università degli Studi Roma Tre, Via della Vasca Navale 84, 00146 Roma - RM, Italy
[2]Istituto di Struttura della Materia – Consiglio Nazionale delle Ricerche, via Salaria Km 29.300, 00015 Monterotondo Scalo (Rm), Italy
[3]Dipartimento di Chimica e Chimica Industriale, Università di Genova, Via Dodecaneso 31, I-16146 Genova, Italy
[4]Universite Paris Diderot, Sorbonne Paris Cite, Laboratoire ITODYS, CNRS UMR-7086, 75205 Paris, Frence

mabdolrahimi@os.uniroma3.it

Rome (Italy), 08/09/2020

Staff & Location

E. Agostinelli
ISM-CNR
Senior Researcher

A. Capobianchi
ISM-CNR
Researcher

A. Di Trolio
ISM-CNR
Researcher

D. Fiorani
ISM-CNR
Ass. Researcher

S. Laureti
ISM-CNR
Researcher

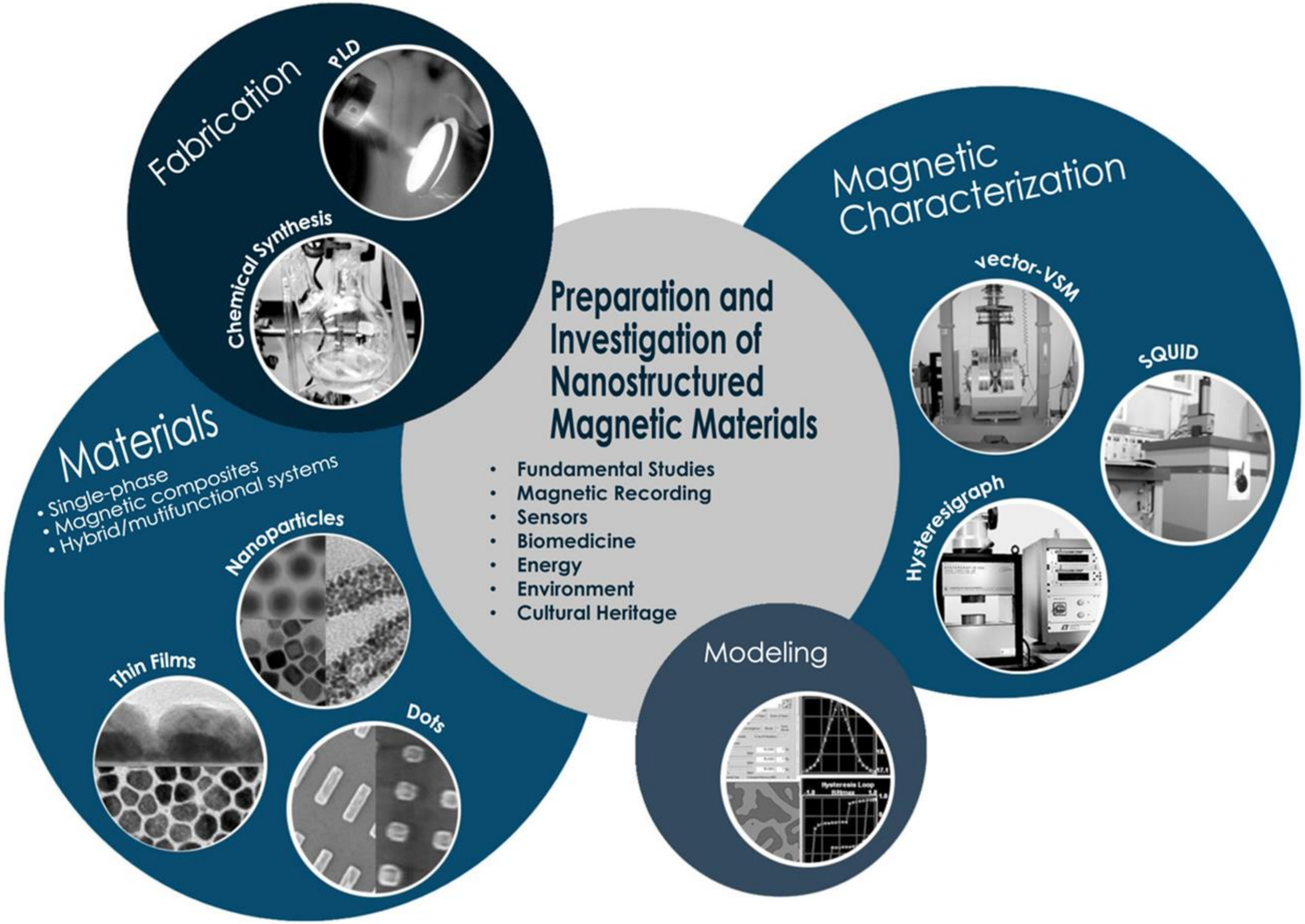
D. Peddis
Uni-Ge, Ass. Professor
ISM-CNR, Ass. Researcher

A.M. Testa
ISM-CNR
Senior Researcher

G. Varvaro
ISM-CNR
Researcher

E. Patrizi
ISM-CNR
Technician

P. Rocchi
ISM-CNR
Technician


Fabrication
PLD
Chemical Synthesis
Materials
• Single-phase
• Magnetic composites
• Hybrid/mutifunctional systems
Nanoparticles
Thin Films
Dots
Preparation and Investigation of Nanostructured Magnetic Materials
• Fundamental Studies
• Magnetic Recording
• Sensors
• Biomedicine
• Energy
• Environment
• Cultural Heritage
Magnetic Characterization
Vector-VSM
SQUID
Hysteresigraph
Modeling

Content

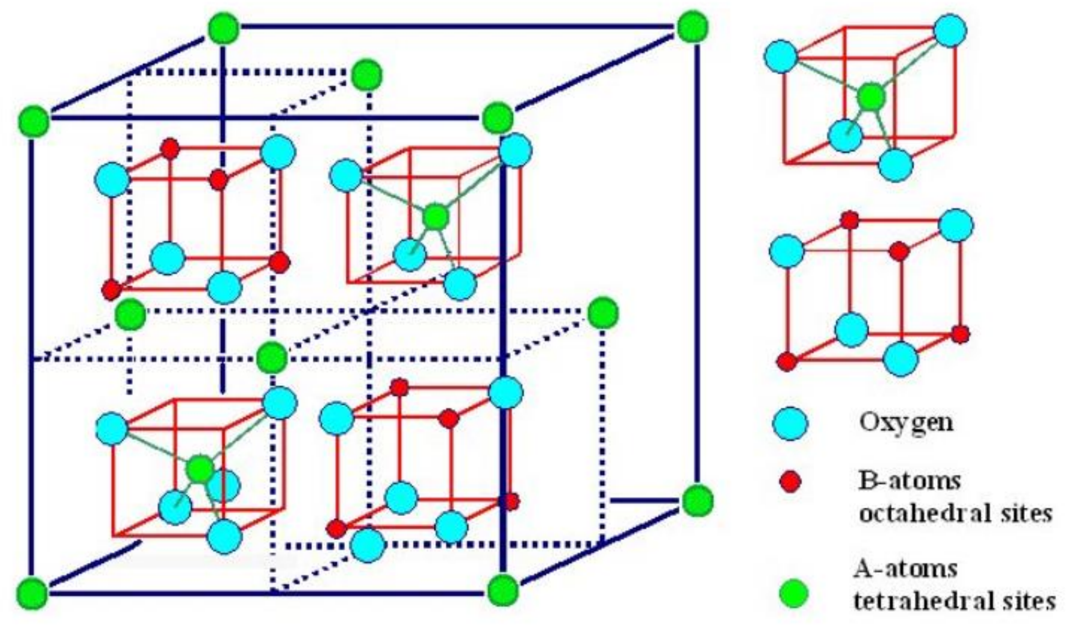
Introduction
Spinel ferrite structures
Molecular coating

Experimental section
Synthesis of nanoparticles
Ligand exchange process

Results and discussion

INTRODUCTION

Spinel ferrite structures



AB_2O_4 **spinel** The red cubes are also contained in the back half of the unit cell

MFe_2O_4

M: Fe^{2+} ,Ni^{2+} , Cu^{2+} ,Mg^{2+} ,Mn^{2+} ,Zn^{2+}

$Mn_xZn_{1-x}Fe_2O_4$

Due to the hight saturation magnetization
Applications in electrical motors

very important in biomedicine as magnetic carriers, such as in bioseparation, enzyme and protein immobilization.

Due to the high permeability
Applications transformer cores and inductors

Introduction

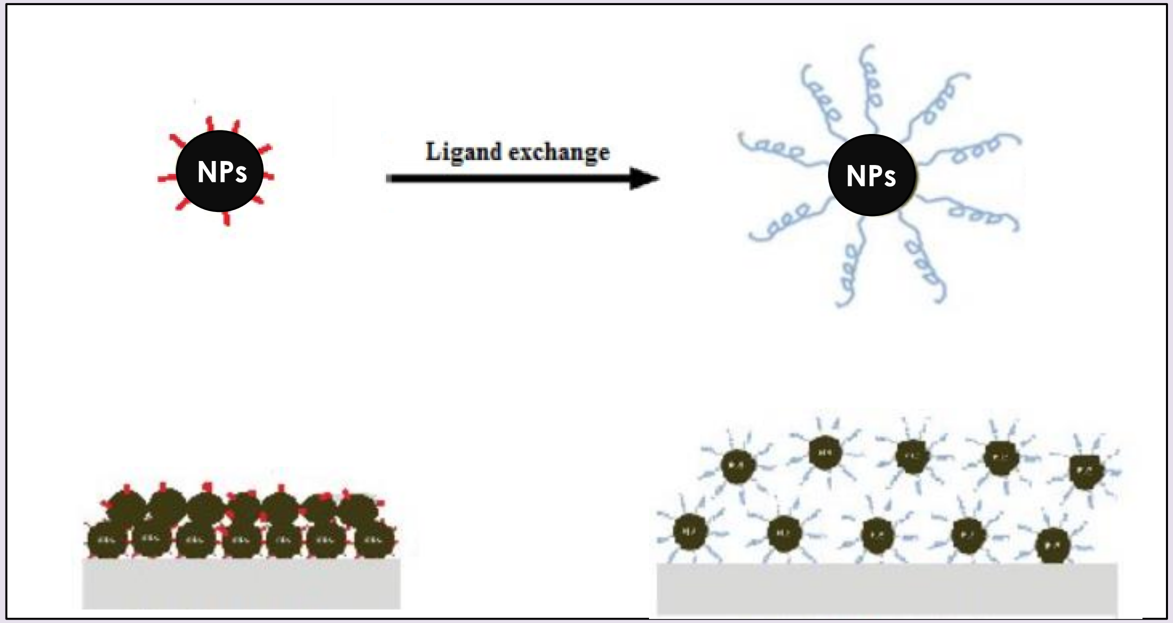
Magnetic properties of spinel ferrite NPs can be tailored by chemical manipulations

The decrease in size

Change in the cation distribution between the two sublattices

Molecular coating

Molecular coating



INTRODUCTION

	M_S (emu/g)	M_r (emu/g)	H_c (Oe)
$Mn_{0.3}Zn_{0.7}Fe_2O_4$	17.3 24.56	0.000674 0.5175	17.01 28.58
$Mn_{0.5}Zn_{0.5}Fe_2O_4$	19.41 25.81	0.2369 0.629	39.33 22.03
$Mn_{0.6}Zn_{0.4}Fe_2O_4$	52.61 43.23	0.8723 0.713	24.41 19.48
$Mn_{0.8}Zn_{0.2}Fe_2O_4$	59.08 50.31	3.55 0.6558	17.55 23.73
$Mn_{0.9}Zn_{0.1}Fe_2O_4$	53.6 37.36	0.9645 1.802	13.02 6.186

Hessien, M. M., Rashad, M. M., El-Barawy, K., & Ibrahim, I. A. (2008). Influence of manganese substitution and annealing temperature on the formation, microstructure and magnetic properties of Mn-Zn ferrites. *Journal of Magnetism and Magnetic Materials*, *320*(9), 1615–1621. https://doi.org/10.1016/j.jmmm.2008.01.025

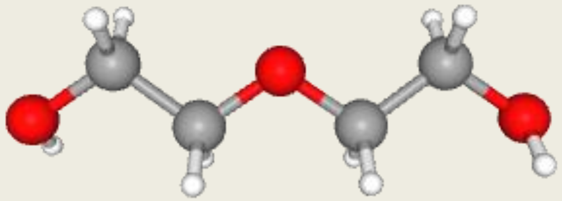
SAMPLE PREPARATION

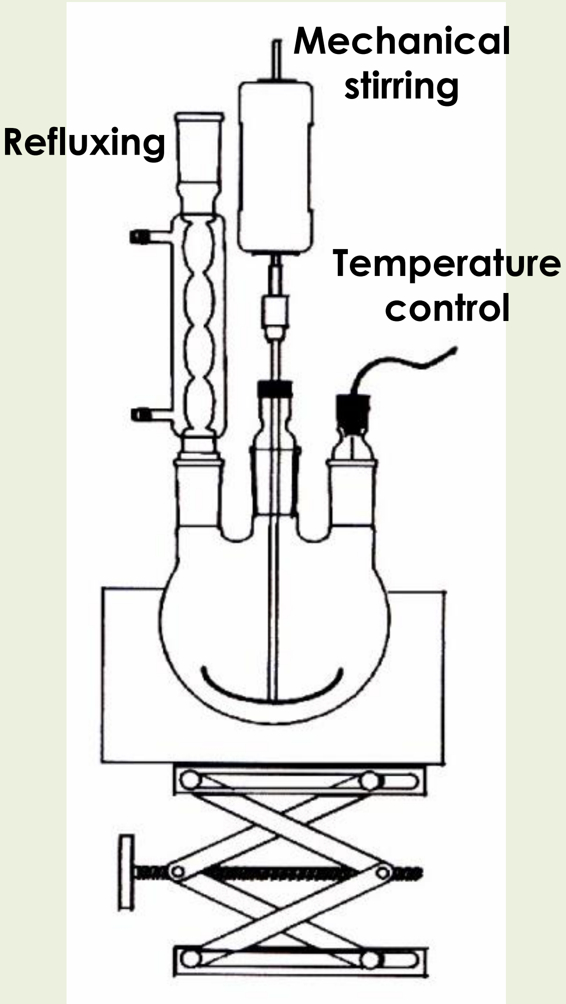
$Mn_{0.6}Zn_{0.4}Fe_2O_4$

MZFO

$Mn(CH_2CO_2)_2.4H_2O$
$Zn(CH_2CO_2)_2.2H_2O$
$Fe(CH_3CO_2)_2$

Diethylene Glycol

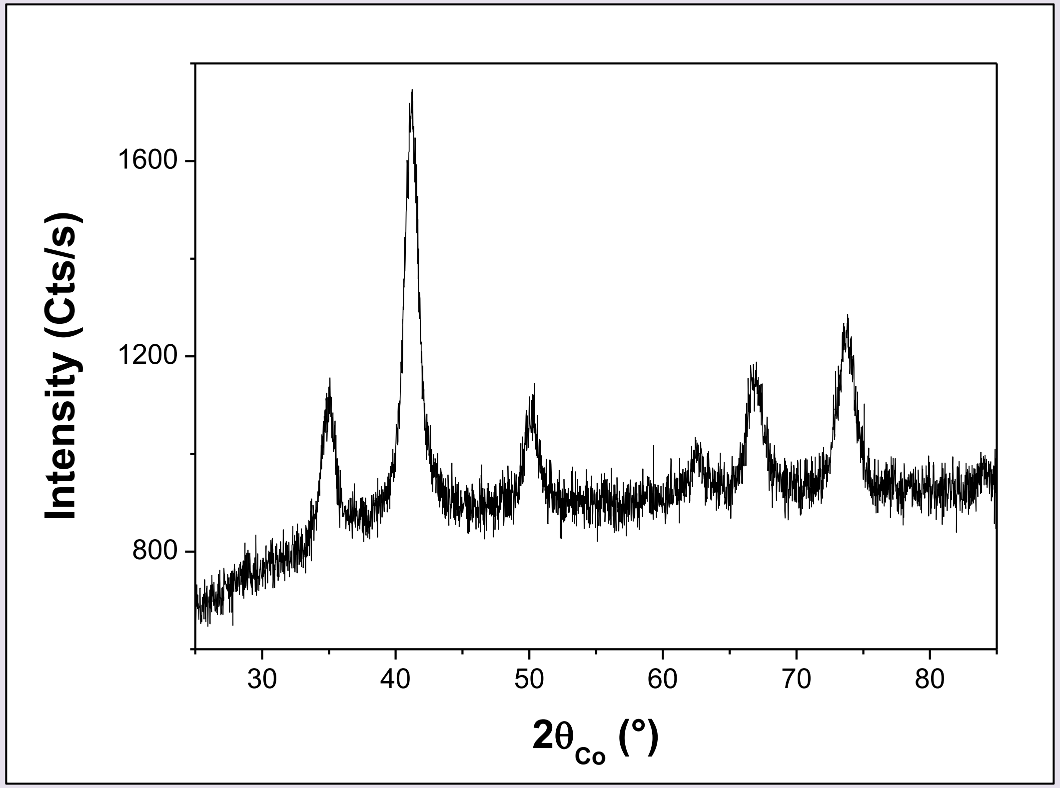




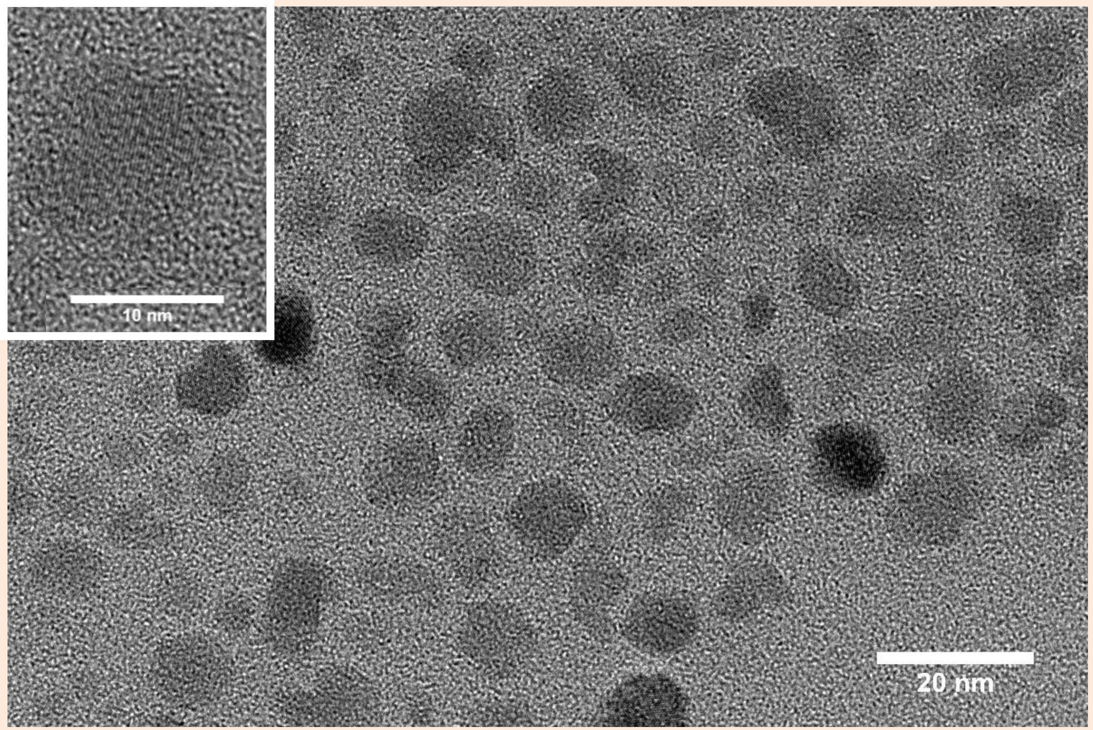
MORPHOLOGICAL AND STRUCTURAL FEATHERS

XRD and TEM

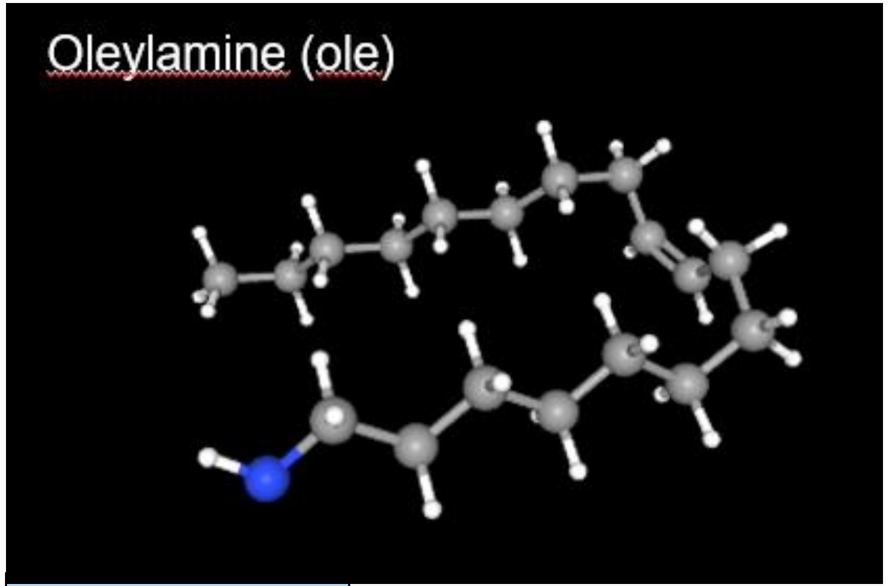
XRD



TEM

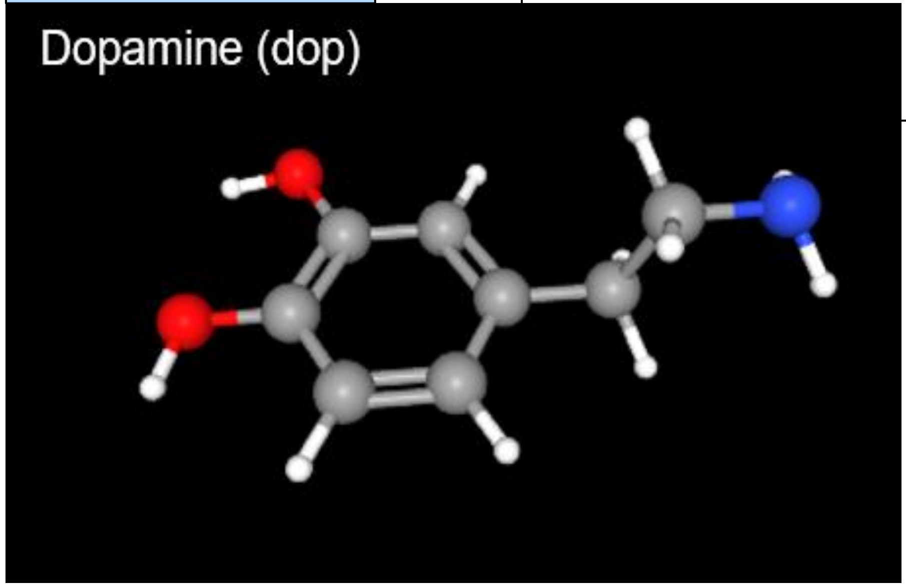


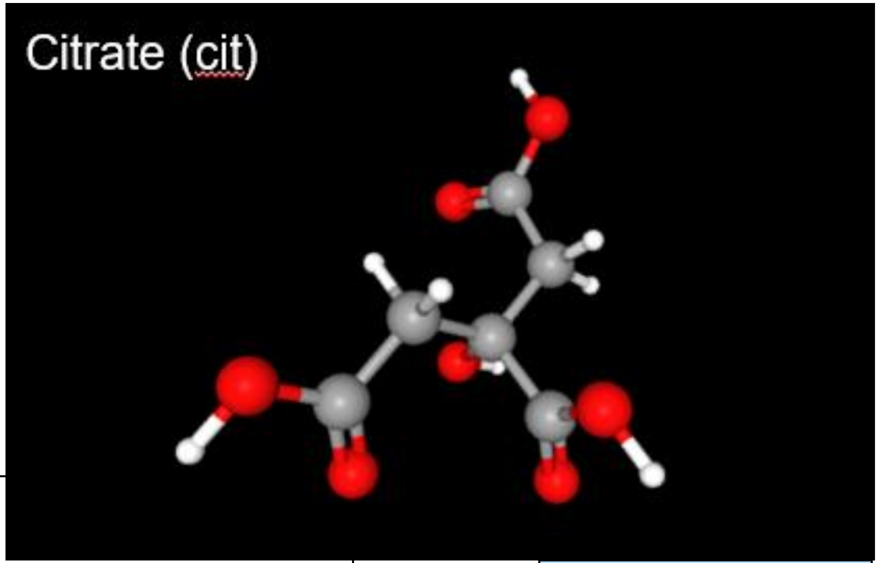
SAMPLE PREPARATION



MZFO_ole

MZFO_dop

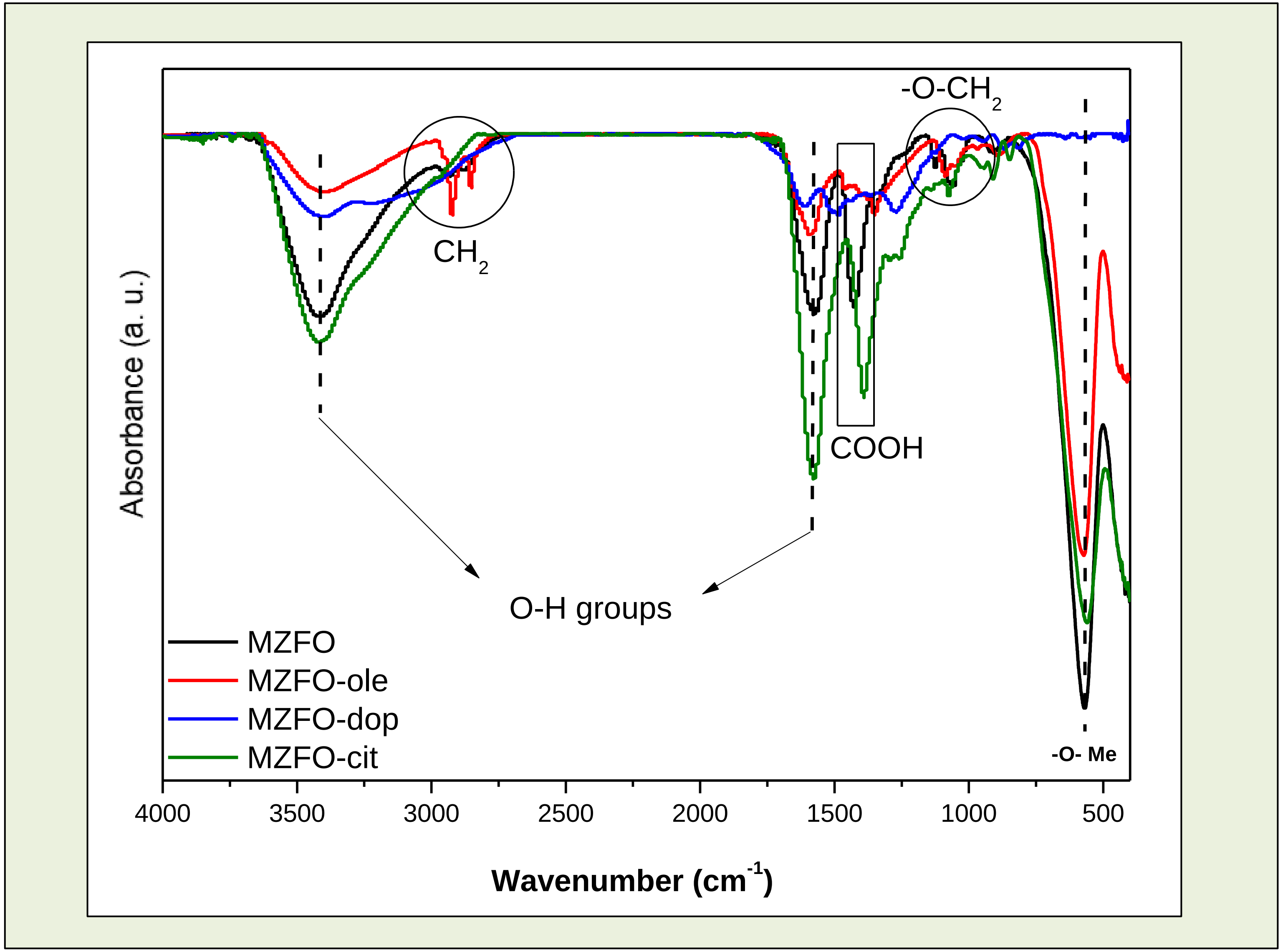




MZFO_cit

Morphological and Structural Feathers

FTIR



590 cm^{-1} and 400 cm^{-1}
attributed to the stretching vibrations of the metal with the oxygen
typical of the spinel ferrite structure

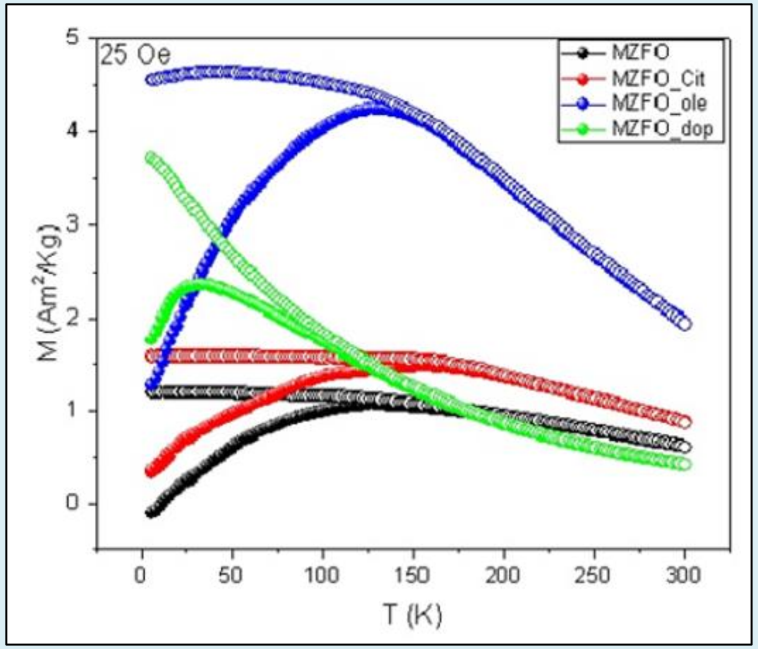
2922 and 2850 cm^{-1}
The symmetrical and asymmetrical stretching of C–H
typical of surfactants but their intensity increases with the molecular length

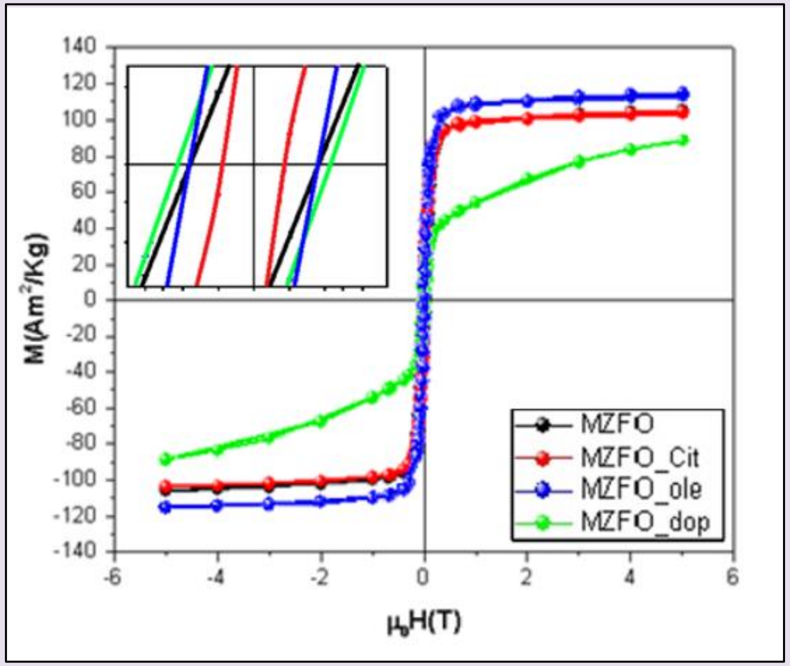
1100 cm^{-1}
The C–O stretching
confirms the presence of polyol

1500 cm^{-1} and 1400 cm^{-1}
The emergence of COOH stretching signals after the substitution with ligands

Magnetic Properties

ZFCFC and Hysteresis





	T_{max} (K)	T_b (K)
MZFO	128(6)	43(9)
MZFO_ole	130(3)	46(2)
MZFO_dop	35(5)	25(5)
MZFO_cit	155(9)	49(0)

Ms (Am^2/Kg)	Hc (Oe)
109(2)	179
117(4)	178
-	211
107(1)	99

XANES SPECTROSCOPY

Elettra Sincrotrone Trieste

Website

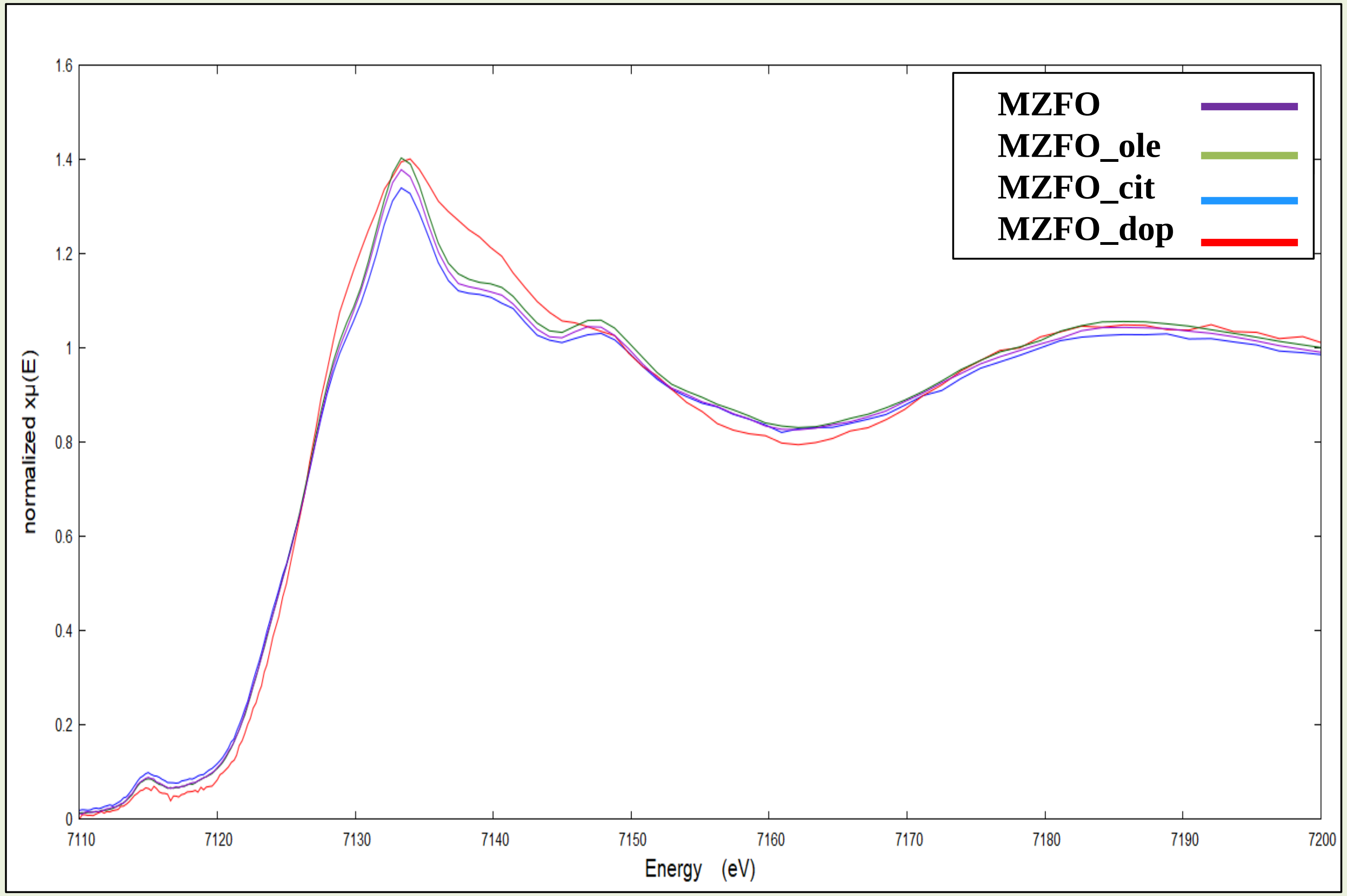
http://www.elettra.eu
/lightsources/elettra.html

Location

Italy, Trieste

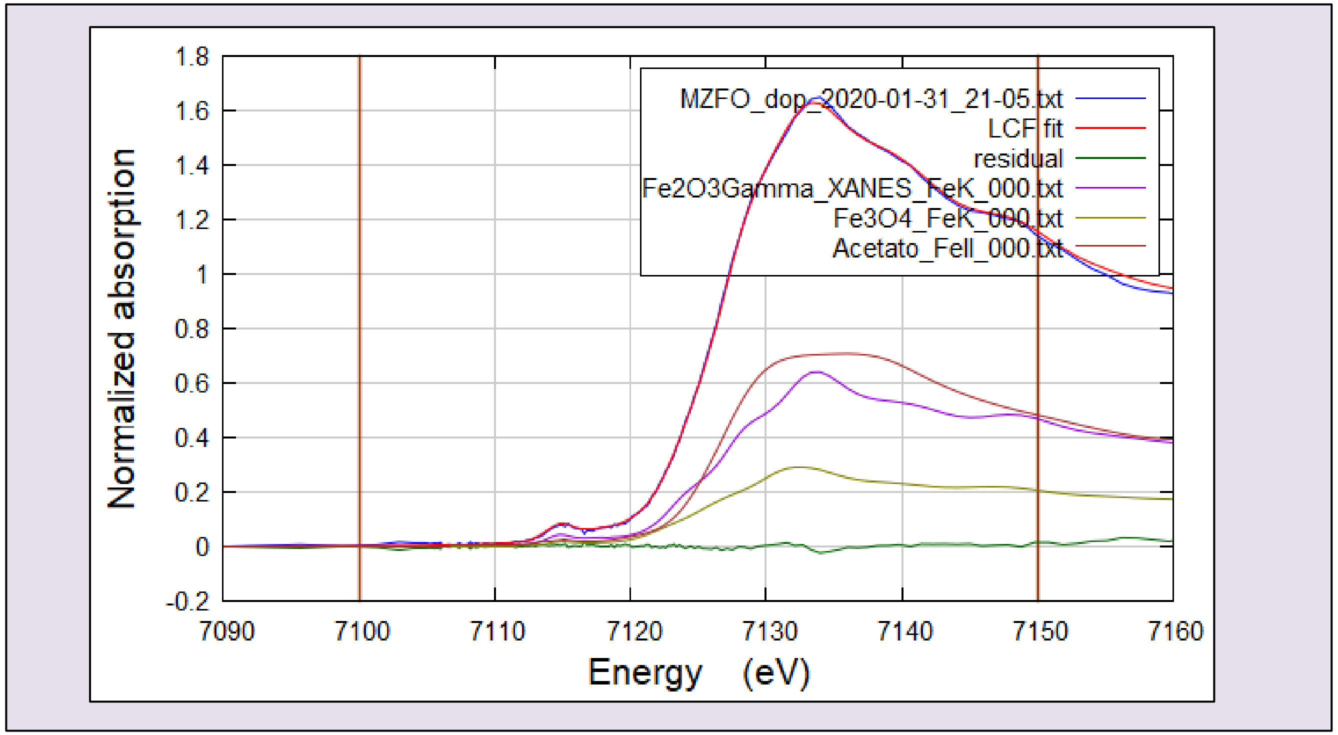
XANES SPECTRA

Fe k edge X ray absorption spectroscopy



LINEAR COMBINATION ANALYSIS (LCA)

Fe k edge X ray absorption



Sample	Fe_3O_4 (%)	Fe_2O_3Gamma (%)	Acetato_FeII (%)
MZFO	**21.8**	**72.6**	**-**
MZFO_ole	**28.5**	**67.9**	**-**
MZFO_cit	**19.5**	**74**	**-**
MZFO_dop	**30.5**	**27.9**	**39**

CONCLUSION

The effect of different ligands on the magnetic properties of MZFO nanoparticles is sturdied:

The hysteresis loops and the ZFC/FC magnetisation curves show that different ligands coated to the surface of the nanoparticles change saturation magnetisation and coercive field.

In case of the coating with dopamine completely different behaviour is observed respect to oleylamine and citrate. The XNES results shows that this behaviour could be due to the interaction between dopamine molecules with as produced magnetic nanoparticles.

Thank you!