TEACHING GUIDE ON:

NANOMATERIALS DESIGN AND CHARACTERIZATION

MASTER MODULE	SEMESTER	CREDITS	COURSE TYPE
NANOTECHNOLOGY: PHYSICS AND APPLICATIONS	2	6	Optional

PROFESSOR(S)	CONTACT DETAILS
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MASTER DEGREE
University Master in Physics: Radiations, Nanotechnology, Particles and Astrophysics, University of Granada
TEACHING DATES AND TIMES
Second Semester. Start: February 2020. TEACHING TIME: MON (16.00-18.00); WED (17.00-18.00)
PRE-REQUISITES FOR REGISTRATION
Only those required for Master access.
BRIEF CONTENTS DESCRIPTION
Generalities on existing methods for nanoparticle production. The role of the surface. Electrical, magnetic and surface properties and their implications thereof. Characterization techniques. Electromechanics and magnetomechanics of particles. Technological applications of nanomaterials.
PROGRAM
I. INTRODUCTION

I.1. Introduction
I.2. History and Present Challenges
I.3. Contents and Basic Bibliography

II. SYNTHESIS AND CHARACTERIZATION
- II.1. Introduction
- II.2. Mechanisms of Nanoparticles Formation
  - A) Homogeneous Nucleation
  - B) Heteronucleation
  - C) Nuclei formation and Growth
  - D) Formation of Secondary Particles by Aggregation
  - E) Ostwald Ripening
  - F) Hydrothermal Methods

III. NANOPARTICLES: EXAMPLES
- III.1. Metal Oxides
  - A) General Features
  - B) Al, Cr, Zr Oxides
  - C) Iron Oxides
  - D) Hydrolysis of Metal Alcoxides
  - E) Phase Transformations in Solid State
  - F) Confined Reactions
- III.2. Metallic Particles
  - A) Synthesis in Homogeneous Solution
  - B) Non-spherical Symmetry
- III.3. Quantum Dots
- III.4. Polymeric Particles

IV. OTHER NANOMETRIC STRUCTURES
- IV.1. Nanowires
- IV.2. Carbon Nanotubes
- IV.3. Thin Films
- IV.4. Composite Systems. Nanostructures

V. THE ROLE OF THE SURFACE
- V.1. Introduction. Importance of the Surface in Nanomaterials
- V.2. The Origin of Surface Energy
- V.3. Mechanisms of Surface Free Energy Reduction
- V.4. Surface Electrical Charge: The Electrical Double Layer
- V.5. Charge Determination: Electrokinetics
- V.6. Interactions between Particles in Suspension
- V.7. Total Potential Energy of Interaction. DLVO Theory

VI. MAGNETIC SYSTEMS
- VI.1. Methods of Magnetic Nanoparticles Synthesis
- VI.2. Magnetic Interactions
- VI.3. Magnetometry

VII. NON-DLVO INTERACTIONS
VII.1. Thermodynamic Aspects. Wettability
VII.2. Forces due to Polymers in the Dispersion Medium

VIII. ENVIRONMENTAL IMPLICATIONS
VIII.1. Risks Associated to the Use of Nanoparticles
VIII.2. Natural and Anthropogenic Sources of Nanoparticles in the Environment

BIBLIOGRAPHY

1. Hosokawa M. Nanoparticle technology handbook. Elsevier, Amsterdam, 2007.
2. Sugimoto T. Fine Particles: Synthesis, Characterization, and Mechanisms of Growth. Surfactant Science Series, Vol. 92. Marcel Dekker, New York, 2000.
3. Albella JM, Cintas AM, Miranda T, Serratosa JM. Introducción a la Ciencia de Materiales, CSIC, Madrid, 1993.
4. Rahman M, Laurent S, Tawil N, Yahia L, Mahmoudi M. Protein-Nanoparticle Interactions: The Bio-Nano Interface. Springer, Berlín, 2013.
5. Handy RD, Shaw, BJ. Toxic effects of nanoparticles and nanomaterials: Implications for public health, risk assessment and the public perception of nanotechnology. Health, Risk & Society 9(2007)125.
6. Gouw TH, Guide to Modern Methods of Instrumental Analysis, Wiley, NY, 1972.
7. Brittain H.G., Physical Characterization of Pharmaceutical Solids, Marcel Dekker, New York, 1995.
8. Jiles D, Introduction to Magnetism and Magnetic Materials, Chapman & Hall/CRC, New York, 1998.
9. Lamber JP, Mazzola EP. Nuclear magnetic resonance spectroscopy : an introduction to principles, applications, and experimental methods. Pearson Education, Upper Saddle River, 2004.
10. Prasad PV. Magnetic Resonance Imaging [Recurso electrónico]: Methods and Biologic Applications. Humana Press, Totowa, 2006.
11. Jones TB. Electromechanics of particles. Cambridge University Press, Cambridge, 1995.

RECOMMENDED LINKS

Journal: Nature Nanotechnology. www.nature.com/nnano/
Journal: Nanomaterials. http://www.mdpi.com/journal/nanomaterials
Journal: Nanoscale. https://www.rsc.org/journals-books-databases/about-journals/nanoscale/
Journal: ACS Nano. https://pubs.acs.org/journal/ancac3
Journal: Nano Letters. https://pubs.acs.org/journal/nalefd
UK Institute of Nanotechnology: http://www.nano.org.uk/
Nanomaterials news: http://phys.org/nanotech-news/nano-materials/
US National Nanotechnology Initiative: http://www.nano.gov/

TEACHING ACTIVITIES

- Theoretical lessons
- Laboratory: group activities in the synthesis of some of the following aspects:
  1. Nanoparticles and nanowires;
  2. Materials characterization (structural, electrical, magnetic, thermodynamic);
  3. Analysis of posible applications: hyperthermia, rheology, drug transport, of the prepared materials;

4. Computer simulations of complex systems behavior: stability, rheology.
- Seminars and presentations by students
- Academic tutorials

EVALUATION

1. Final written exam or problem solving: 20%-50%
2. Lab. Work: 15%-40%
3. Presentations and seminars: 15%-40%