

TU1-1 Elaboration of inorganic materials

European Credits (ECTS): 6

Program / Sustainability

Time (hours) given to the students : 50.67

Student whole working time (hours) : 100

Goals and competencies

Goals:

This teaching corpus is devoted to the synthesis and elaboration of inorganic materials. In a first part, mining technologies (thermal and electrochemical metallurgy) are presented. A second part deals with the various synthesis routes of inorganic oxides and other ceramics. Co-sintering (solid state route), mechano-synthesis, and numerous solution routes (coprecipitation, autocombustion, spray pyrolysis, sol-gel processes and hydrothermal synthesis) are compared. A detailed focus is made on innovative sol-gel processes with the aim to elaborate nanomaterials with controlled morphology, this constitutes the third part. Finally, in a last part, the shaping processes, especially to design thin films (PVD, CVD) are presented. Hence, various competencies about the elaboration of inorganic materials are acquired from an adequate mixture of magisterial lessons, exercises and practical activities.

Main disciplinary competencies:

Fundamental knowledge: To know the different material classes and their main elaboration techniques, to apprehend these different classes and techniques basing on solid-state chemist approach: chemical bond description, structural behaviors, thermodynamic/kinetic competition....

From knowledge to know-how: To know how to prepare pure inorganic materials with one target chemical composition, one target crystallographic structure and one target morphology (size/shape).

Practical: To experiment the adequate scientific approach in order to reproduce an experiment of the literature (with the technical possibilities offered by the Practical' laboratories).

Lesson program:

I. The transformation processes in mineral chemistry (mining): (6 meetings * 1h20)

I.1- Bayer process: Alumina/Aluminum chemistry

I.2- Kroll proces: Rutile-Anatase/Titanium chemistry

I.3-Silicium; Process of silica transformation and purification: illustration besides electronic and photovoltaic requirements.

II. Synthesis of inorganic powder: (10 meetings * 1h20)

II.1- All-solid routes for inorganic oxide preparation: Solid-sate route, mechanosynthesis,

II.2- Solution routes for inorganic oxide preparation:

Autocombustion, spray-pyrolysis, Sol-Gel processes: Pechini & alkoxide precursors' routes, Precipitation, coprecipitation, hydrothermal synthesis

II.3- From oxides to other inorganic compounds:

III. Sol-Gel processes and diluted environments: (7 meetings * 1h20)

III.1- From colloids to sol-gel process

III.2- colloids vs Nanoparticles in sol "non-silica systems"

III.3- colloids vs Nanoparticles in sol "silica systems"

IV. From synthesis to shaping of inorganic materials: (9 meetings *1h20)

IV.1- Shaping techniques for thin films production (PVD-CVD), ionic implantation, thermal sprays and thermal diffusion.

Illustration of the applicative fields (films for optics, mechanical properties and surface coatings as protective barriers)

IV.2- Materials in industrial catalysis: Phenomenological description. Physico-chemical properties of solid catalysts: preparation and shaping. Focus on Zeolites and parent structures.

Practical (2 meetings * 4 h).

1- Synthesis of BaTiO₃ compound from two different routes,

2- Sol-gel synthesis: Silica particles with controlled hydrolysis-condensation in ammonia-based solution.

Evaluation

1st session examinations (0-20)

Final Exam (3h00): 0.9 coef.

Practical'reviews (made during the practical works): 0.1 coef.

2nd session examinations (0-20)

Final Exam (3h00): 0.9 coef.* (it can be oral examination depending on the workforce)

Practical reviews (made during the practical works): 0.1 coef. (report)

Recommended readings:

- W.D. Kingery, H.K. Bowen, D.R. Uhlmann, Introduction to Ceramics, A Wiley-Interscience Publication, 1975

- A. Earnshaw and N. Greenwood, "Chemistry of the Elements", 2 ed., Butterworths/Heinemann (1997)

TU' Coordinator

Manuel Gaudon

Teachers

Part I & II. Manuel Gaudon ; Part III. Rénal Backov ; Part IV. Francis Rebillat

Practical: Same team