Advanced catalysts and materials for sustainable chemistry and energy

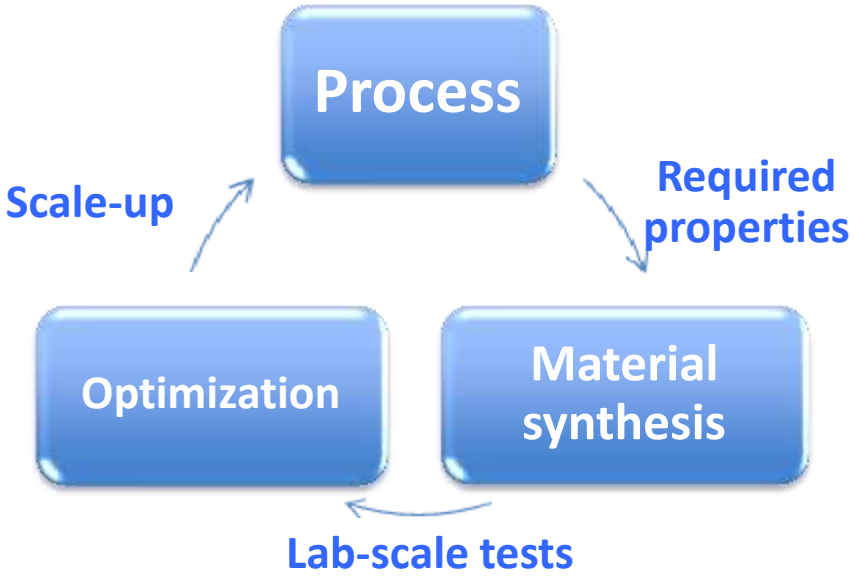
An invisible revolution

"***Materials*** can enable industrial and commercial success for both existing and not-yet existing products and processes: they may introduce new functionalities and improved properties adding value to existing products and process, thus representing **an invisible revolution**; at the same time, the engineered production of materials by design might allow the development of products and processes under **a really sustainable systemic approach**."

From the European Commission web site
http://ec.europa.eu/research/industrial_technologies/materials_en.html

CHALLENGE

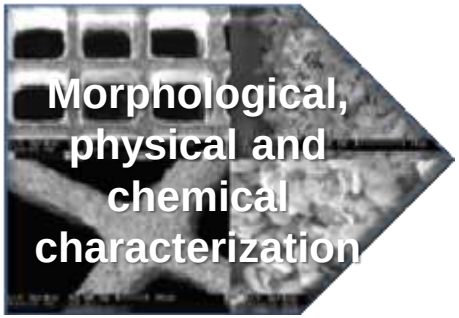
Development of novel and advanced materials/catalysts for process intensification and/or new alternative processes compared to traditional ones.



Fields of interest

- Low C technologies
- Environmental control
- Electronics
- Bio-materials

Steps of development of innovative materials/catalysts



SKILLS, METHODOLOGIES AND INSTRUMENTS

Skills

Development of new formulations of catalysts/nano-materials
Synthesis of nano-dispersed active phases on structured catalytic systems
Synthesis of nano-structured and nano-dispersed materials
Synthesis of composite and hybrid compounds
Synthesis of bio-materials
Basic and functional characterization

Methodologies

Bottom-up

- Synthesis from precursors in solution or suspension
- Synthesis from vapour phase precursors (flame synthesis)

Top-down

Controlled demolition of carbonaceous NP

Dispersions

Dispersion of nano-particles on different substrates

Instruments

Synthesis: rotating evaporators, electrical and MW ovens, stoves.
Morphological, physical and chemical characterization : ICP-MS, SEM/EDS, XRD, GC-MS, HPLC, DLS, laser-granulometer, elemental analyser, analyser for surface area and pores, TPD/TPR/TPO system, in –situ FTIR /DRIFT, UV-Vis and fluorescence spectrofotometers , TGA, MALDI/ESI/APPI/IT spectrometer.
Functional characterization: Plants for operating catalytic tests or testing special properties (adsorption, electrical conductivity)

Researchers

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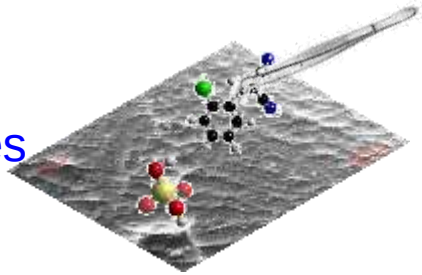
Project lines

Main challenges of the project

HORIZON 2020

- New materials with chemical and physical properties and functionalities tailored for specific applications



- Lowering costs and enhancing performances of currently used materials

- Development of properties of resistance to severe operating conditions

- Toxicity mitigation of common materials

Activity lines of the project:

1 – Development of innovative catalytic systems

2 – Development of advanced materials

Details of activity lines

Development of innovative catalytic systems

- Partial oxidation (production of syngas and olefins from methane or biogas);
- Total oxidation (hybrid or high pressure catalytic combustion for gas turbine);
- Gas upgrade (reforming of tar biomass pyrolysis, purification of hydrogen stream for fuel-cell);
- Abatement of NO_x (low temperature SCR for diesel application, NO decomposition) and soot from diesel engines;
- CO_2 valorisation through methanation and methanol synthesis.

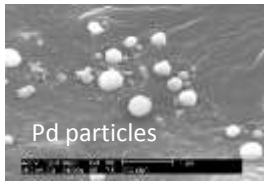
Development of advanced materials

- CO_2 capture;
- Sensors;
- Selective photo-oxidation;
- Water remediation (metals capture);
- CLC/CLR processes;
- Bio-compatible and bio-inspired materials (ex. drug delivery, biomimetics).

Catalysts developed at IRC

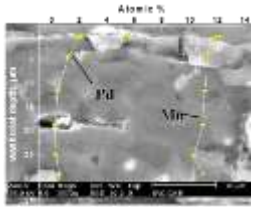
By active phase

Noble metals



Nano-particles dispersed onto several supports; doping by hetero-atoms in order to improve metal dispersion and tolerance to poisoning.

Bi-functional



Noble metals nano-particles dispersed onto catalytically active matrix; two active phases for different catalytic functions; matrix provides high dispersion and resistance to sintering of the noble metals.

Transition metals oxides

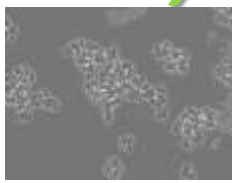
Bulk and supported

Pure/mixed oxides, phosphates, zeolites.

Doping by hetero-atoms for chemico-physical properties modification

Enzymatic bio-catalysts

CLEA (Cross Linked Enzyme Aggregates): carbonic anhydrase immobilization on functionalized supports.



By structure

Powder

Structured

Monoliths and foams

Highly mechanical resistant spheres

Slubs

Materials developed at IRC

Carbon-based

Graphene-like film
Ultrathin conductive films (< 20 nm) with flatness at atomic level

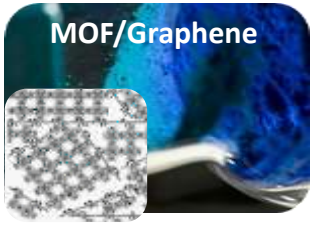
Modified soot and carbon black
Carbon-based nanoparticles bearing amino and carboxyl groups, magnetic iron oxides; hydrophilic nanoparticles, supported ionic liquid phase (SILP).

C nano-disk
Flame-formed carbon based nanoparticles

Graphene-like layers
Hydrophilic flat graphene-like nanoparticles (4 nm height)

Hybrids and composites

Hybrid ferromagnetites
graphene-like and CB/ferromagnetite hybrids

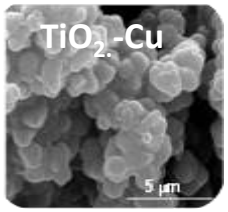


MOF/graphene-like hybrids
Metal organic framework HKUST-1 type hybridated with graphene-like layers

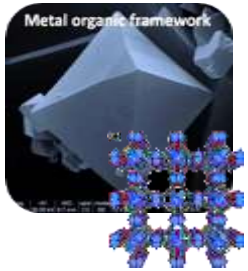
eumelanin/graphene-like hybrids
Biocompatible and conductive eumelanin/graphene-like hybrids

Inorganics

TiO_2 and MgO
Flame-formed nano metal oxides



TiO_2 .Cu
TiO_2 doped with Cu oxide from MOF precursor



MOF
Metal organic framework HKUST-1 type

CL carriers
New doped lanthanum oxysulphates

COLLABORATIONS/PROJECTS

Academic/Research partnerships

- Main collaborations:
  - University of Naples Federico II
  - University of Udine
  - Politecnico of Turin
  - University of Rome «la Sapienza»
  - Elettra Sincrotrone Trieste
  - Politecnico of Milan
  - Wageningen University and Research Centre

Industrial partnerships

- Collaborations:
  - ENI-Snamprogetti
  - Riello
  - E.G.O.

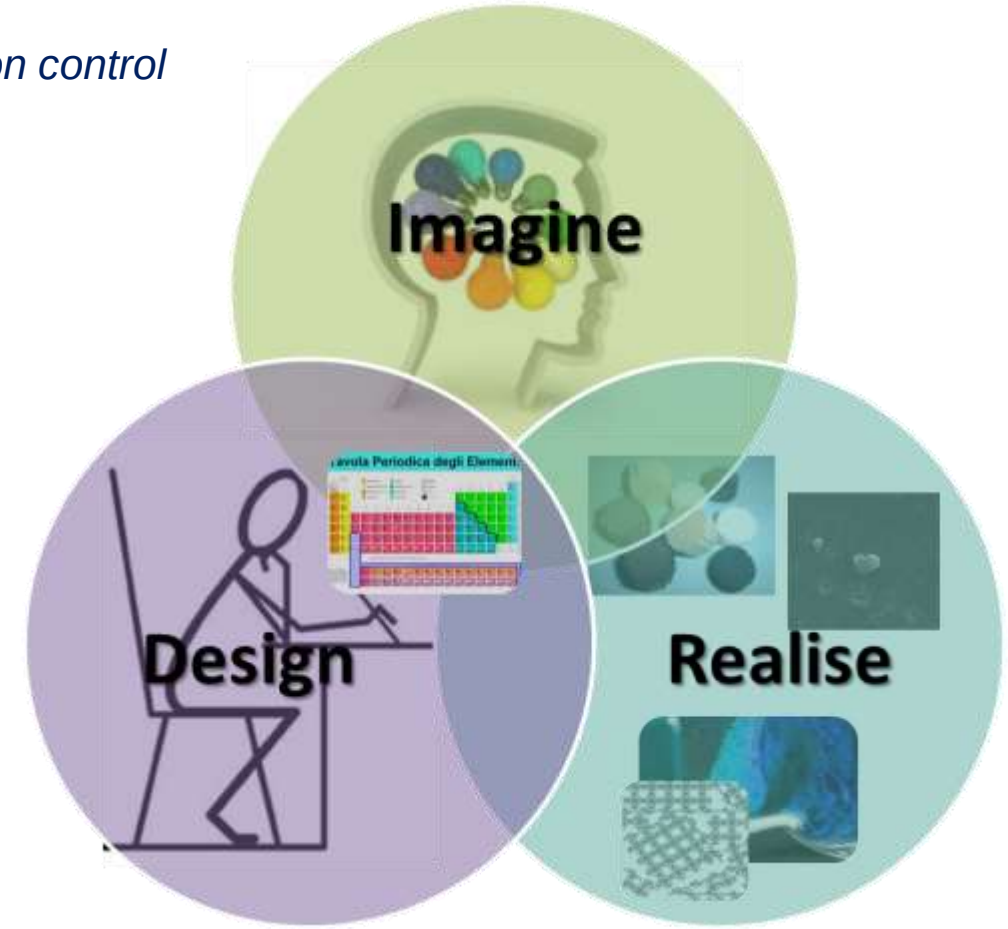
- Last Projects and Funding
  - DEECON
  - FIRB2010 «Futuro in ricerca» (MIUR)
  - PRIN2010/2011 (MIUR)
  - FIRB2012 «Futuro in ricerca» (MIUR)
  - Seed project IIT 2010
  - MiSe-CNR

PERSPECTIVES

Novel materials for energy and transports
"Low carbon" technologies
Novel processes for environmental pollution control

Nanomaterials for electronics
Sensors
Photovoltaic

Bio-inspired materials
(drug delivery, biomimetic)



Call Horizon 2020 relevant for the PL

Nanotechnologies, advanced materials and production
NMP-2015- two-stage-sub call: Novel materials by design for substituting critical materials

Nanotechnologies and advanced materials for low-carbon energy technologies and efficiency
NMP14-2015 ERA-NET on Materials (Materials for Energy)
NMP19-2015: Materials for severe operating conditions including added-value functionalities
NMP-PILOT-2015 sub call: Manufacturing and control of nanoporous materials