INCA
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Macro-area III - Materials

Catalytic Materials

Heterogeneous catalysis is a powerful tool for the invention of synthetic processes with reduced or no environmental impact. Functional material chemistry represents an extremely wide and diversified sector of chemistry. It shows correlations with and overlaps both other thematic research areas of INCA Consortium and those of other national academic consortia.

The preparation and characterization of catalytic materials as well as surface technologies strongly require a deep knowledge of nano-sciences, this is particularly relevant to process optimization.

In the last century the preparation of catalytic materials was essentially based on their activity, meant as the production of the highest number of molecules per area and time units. This was made possible by the low costs for the disposal of by-products at that time. Nowadays, the situation has drastically changed: the high costs for the treatment of by-products, as well as the problems connected to their environmental impact, has shifted the focus on selectivity. The latter is the main objective of chemists who devise new catalyst, even at the expense of activity.

The application on wide scale is the final objective of any investigation on catalysts. Therefore the design of a new catalyst must also consider the type of plant in which it will be used.

According to a supra-molecular approach, a catalytic site supported on a surface is similar to a nano-reactor. Here the chemical transformation is the result of the synergic cooperation between the active site itself and the chemistry of the surrounding region, just like what happens with enzymes.
Trying to imitate natural processes, we can devise sequential pathways which take place in very limited spaces and are structurally connected in a cascade: the product of a reaction is the substrate of the following one, or acts as its catalyst. Such cascaded processes are raising more and more interest, since they represent a valid tool for increasing the efficiency of the scaling-up from the laboratory to the productive plant scale.

A fundamental objective is represented by the realization of combined catalytic systems allowing for cascaded multistep continuous processes in which experimentation and production may take place simultaneously. It is to be stressed that such an approach represents also a primary tool for Process Intensification (see Macro-area II).

One of the most recent research topics about catalytic materials concerns the construction of multifunctional catalysts able to promote processes which need the coexistence of active sites with opposite characteristics (e.g. acid/base or reduction/oxidation), with high efficiency and selectivity. The technical problem is to build them in such a way to inhibit the reciprocal neutralization of the diverse active sites. Such sophisticated catalytic materials are becoming more and more similar to enzymes. Therefore, their preparation and characterization requires strict collaboration among experts from different disciplines.

Thematic research areas concern heterogeneous catalysis for :

- eco-sustainable processes;
- processes in eco-compatible media;
- solvent-free processes;
- multi-step and multi-component processes;
- continuous flow processes
- preparation and use of multi-functional catalysts.