Solvent-free SOL-GEL synthesis: pushing back the boundaries of eco-responsible metal oxide synthesis

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- **Viernes 4 de octubre a las 13:30 hs.**
- **Aula RFP - 3er piso, DQIAQF/INQUIMAE**

Resumen

Sol-gel synthesis strategy of metal oxides is by essence eco-friendly. Indeed, most part of time, it uses for solvent only water or cheap alcohol solvents, requires low or moderate temperatures for achieving the formation of metal oxide structures. Moreover, it is easy to use, coupled with numerous processing techniques aiming at orienting the reactivity of polycondensation, or the size and the shape of final materials. Nowadays, it used extensively in industry for preparing at large scale, thin films, monoliths, gas adsorbant, heterogeneous catalysts, etc.. Yet, actual constrains of climate change urgently impose that worldwide industry evolves for more sustainable production processes. This implies that production methods target now drastic economy of atoms, and energy, while decreasing chemical waste production. In order to reach such ambitious goal, we developed some years ago a research dedicated to the development of sol-gel syntheses without any solvent.

This presentation will focus on the recent history of solvent-free sol-gel synthesis. The first part will be devoted to the case study of the production of heterogeneous catalysts (silica, alumina, zirconia and porous titanium), which industry produces in large quantities but still uses multi-stage processes that are often energy-consuming and polluting. By way of comparison, we will present the principles, advantages and disadvantages of a solvent-free approach using the example of the preparation of bohemite (γ-AlOOH) which, after calcination, leads to large-area mesoporous alumina (γ-Al2O3). Their catalytic properties and environmental impact will be presented in a comparative manner. By extension, the potential of solvent-free sol-gel syntheses will be discussed with several examples, including the synthesis of doped oxides and mixed functional metal oxides. Finally, the industrial coupling of this new synthesis approach using various processing techniques (batch mixing, reactive extrusion and spraying) will be discussed.