SYNTHESES IN POLYOL MEDIUM OF INORGANIC OXIDES WITH VARIOUS SMART OPTICAL PROPERTIES

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Summary: At the interface of the studies performed by 4 ICMCB's PhD students: Shian Guan (2017-2020),[1] Marie Bourdin (2016-2019),[2] Ines Andron (2017-2020),[3] Isabelle Trenque (2012-2015),[4] a single synthesis route: polyol mediated synthesis, was used with success for different inorganic oxides; the application field being smart optical compounds in both cases. This synthesis route has allowed us to develop nanoparticles of zinc oxide, vanadium oxide or tungsten oxide. This route is with easy implementation, inexpensive and with large scale production potentialities and leads to materials of high purity. Additionally, polyol route allows the obtaining of nano-crystalline oxides with uniform particle size distribution, tunable oxygen sub-stoichiometry thanks to the reducing properties of the polyol solvents. Then, the as-prepared NPs can be used in suspensions to be coated for the elaboration of transparent thin films from dip or spin-coating processes. The obtaining by this route of nanometric particles, however perfectly crystalline, has notably led to the possibility of doping these matrix materials with high doping ion concentrations (high solubility limits).

Thus, as first example, Al^{3+} or Ga^{3+} doped-ZnO powder, with high doping rate in comparison with the literature, exhibits remarkable infrared absorption properties thanks to their high free carrier density. Note also that due to the narrow particle size distribution of the as-prepared nanometric doped-ZnO powder, original correlation between crystallite size and unit-cell parameters have been established.

Also, in a second example, depending on the annealing atmosphere use to treat vanadium precursors, VO_2, V_2O_3 or V_2O_5 oxides with thermochromic or electrochromic properties can be obtained without any impurity, despite the versatility of the oxidation state of vanadium. This is of more particularly interest on vanadium dioxide, a relatively difficult-to-prepare oxide, whose first-order metal-insulator phase transition is widely explored in the literature for its thermochromic behavior (in smart windows with optimal thermal insulation).

Finally, polyol synthesis routes were performed to prepare some nanoparticles (NPs) of WO_{3-x}, MoO_{3-x} and $Zn_{1+\varepsilon}O$ oxides. The photochromic properties of WO_{3-x} as powder or thin films show improved optical contrasts between colored and bleached state with a self-bleaching behavior allowing their use them as smart films for solar control on glass windows. The mixing of molybdenum and zinc oxides, thanks to the creation of Schottky barriers at the solid / solid interface, lead to exceptional photochromic effect thanks to the possibility to activate under UV-light excitation of a self-closed redox reaction at this interface. Details on their optical spectra, the kinetic aspects through coloring or bleaching half-cycle and the cycling possibilities of the enhanced photochromic effects on WO_{3-x} oxides and ZnO/MoO_3 mixtures will be presented. Correlations between the optical properties of these nanoparticles and their micro-structural behavior (surface chemical composition vs bulk chemical composition) structural modifications, electronic transport: "polaronic" vs "plasmonic" effects, etc…) will be emphasized.

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