FLAME SYNTHESIS AND DIAGNOSTICS OF TITANIA, VANADIA AND SILICA NANOPOWDERS

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Nanostructured inorganic materials are routinely produced in manufacture industry by the gas-to particle conversion process using flame reactors. This route allows to obtain inexpensive, pure products with tailored characteristics for the different destination fields [1-2]. Catalysis, coatings, electronics, gas sensing, fuel cells and ceramics are just few meaningful examples of the potential application areas. For instance, carbon black, silica and titania are "historical" flame-made materials. In the last decades an increasing number of more and more sophisticated materials were obtained by flame synthesis.

In this work an investigation on the synthesis of oxides nanoparticles having very interesting applications is presented. TiO_2 from titanium tetraisopropoxide (TTIP), V_2O_5 from Vanadium oxytriethoxide and SiO_2 from Tetraethyl-orthosilicate were produced. The apparatus (see fig.1) consisted of a hybrid burner reactor [3-4] that allowed the injection of precursor vapours generating a diffusion flame in the middle of a premixed lean CH_4/air flame. Lean stoichiometry was adopted to guarantee the oxidizing environment. Powders samples were collected at different heights along the flame in two ways: sucking probe and rapid insertion technique (50 ms residence time). The samples were analyzed by X-Ray diffraction (XRD), Transmission Electron Microscopy (TEM) and Fourier Transform Infrared Spectroscopy (FTIR). Some comparisons between the sampling techniques are reported. Moreover, insights on reaction dynamics were pursued through flame emission spectroscopy in the spectral window from 231 nm to 847 nm. Spectra were recorded at the same height of the sampling locations, with the help of an alignment laser.

Overall results showed titania reaction to follow the expected dynamics, exhibiting a particle size increase and a change towards rutile in crystalline phase percentage along the flame. Vanadium oxides nanoparticles exhibited composite features: crystalline or amorphous, acicular or spherical. Analysis on silica revealed an amorphous structure and a high tendency of the nanoparticles to gather into aggregates. Light emission data of the three different flames showed as a common feature the typical spectral signatures of the post-burnt zone of premixed hydrocarbon-air flames and a signal at long wavelengths attributable to soot radiation. Beside this, data comparison from all flames made evident signatures peculiar to each of them, especially in the UV-blue spectral region from TiO_2 flame. A band in this region is particularly strong and becomes dominant in the higher part of the flame. Provided the similar nature of the precursors ligand, it seems to be reasonable to attribute this spectral behavior to species containing Titanium. Moreover, spectrum from isopropyl alcohol (being TTIP titanium isopropylate) injected in the premixed flame were recorded, and did not show any signature in the blue region, thus supporting the hypothesis. About titania peculiar flame characteristics, more efforts will be spent in the direction of a deeper interpretation. The investigation was carried out using the hybrid burner reactor, which proved to be well suited for reaction dynamics studies. The porous plug premixed flame produced a burnt gases region with smooth variations, and the precursor injection method allowed a stretched reaction flame and a separation of the two feeding systems. Moreover, reaction conditions could be changed by acting on several variables, such as flame composition, precursor concentration, region of injection in the burnt gases, according to the specific aim pursued.

References:
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Figures:

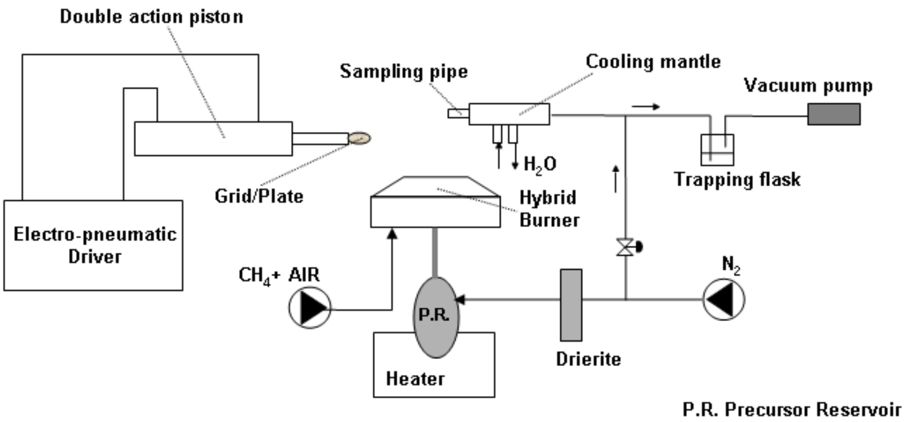
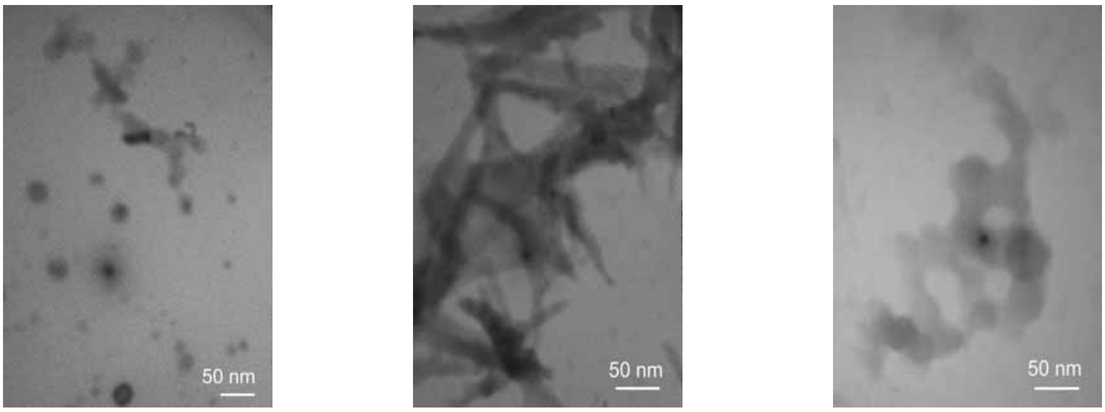


Fig.1 Experimental apparatus for nanopowders production and sampling.



TiO_2 **V_2O_5** **SiO_2**

Fig.2 TEM micrographs of nanoparticles synthesized in the hybrid flame reactor.