DEVELOPMENT OF NANOSTRUCTURED MAGNETIC COMPOSITES USED AS NANO-ADSORBENTS AND NANO-CATALYSTS WITH HIGH PERFORMANCE IN ENVIRONMENTAL APPLICATIONS

Goal of the project:

Developing new efficient synthesis variants of oxide nanoparticles in order to obtain nanomaterials, magnetic nanostructures based on iron oxides (gamma-Fe_2O_3, Fe_3O_4, ferrites spinels MFe_2O_4) with tailored properties for their use as nano-adsorbents and nano-catalysts for remediation of water.

Short description of the project:

Water pollution by heavy metals and organics has become a serious problem because of their extremely hazardous effects on humans and the ecological systems.

The present project is focused on the developing of nanostructured magnetic materials based on iron oxides (magnetite, maghemite, spinel ferrites) with special properties (magnetic properties, specific surface area and morphology) that can be used as high performance nano-adsorbents and nano-catalyst for the removal of inorganic (metals ions: Cd(II), Pb(II), Cr(VI), Cu(II), Co(II), Zn(II)) and organic (dyes and phenols) pollutants from wastewaters. In order to achieve this we will develop new, original versions of the two unconventional synthesis methods of nanopowders and nanocomposites: solvothermal method and thermal decomposition of precursors. In order to develop high performance nanostructured magnetic oxides (iron oxides and ferrites) with high specific surface area, porosity and adequate magnetic properties composites like magnetic oxides/carbon will be synthesized by these methods, using different common carbon precursors in order to obtain low cost final materials. Also, the functionalization of surface will be performed with different organic modifiers in order to make the nanoparticles specific for certain applications.

Finally, the obtained iron oxides based magnetic nanostructures materials (oxides, ferrites and composites) will be tested as nanoadsorbants and catalyst for the removal of water pollutants.

Project implemented by

University Politehnica Timisoara

Implementation period:

01.10.2015-30.09.2017

Main activities:

I. Synthesis of magnetic oxide nanopowders (Fe_xO_y, MFe_2O_4) by new, original variants of solvothermal method and of thermal decomposition of the precursors and powders characterization.

A.I.1 Study of the influence of organic solvents' nature on the structure and morphology of the oxide particles obtained by solvothermal method. Determination of the most appropriate solvent for the synthesis of a series of solvents which have not been reported in the literature.

A.I.2 Study of the influence of polyols nature and polyol: metal nitrates ratio and of the presence of surfactants on the structure, morphology, magnetic properties of nanopowders synthesized by the method of decomposition of precursors.

A.I.3 Characterization of materials obtained by thermal analysis, FT-IR spectroscopy, X-ray diffractometry, specific surface area and porosity measurements, Mosbauer spectroscopy, X-ray diffractometry, SEM, TEM electron microscopy, magnetic measurements.

A.I.4 Writing scientific report and disseminate the results through participation in an international conference. Making the project web page

II. Synthesis of the nanocomposites type Fe_xO_y / C and MFe_2O_4 / C by original synthesis methods and their characterization

A.II.1 Study of the influence of process parameters: temperature and autoclaving time on the structure, morphology and properties of synthesized nanocomposites

A.II.2 Study of the influence of organic solvents' nature on the structure and morphology of the oxide particles obtained by solvothermal method. Determination of the most appropriate solvent for the synthesis of a series of solvents which have not been reported in the literature

A.II.3 Study of the influence of initial oxide precursor: carbon precursor ratio on the carbon content of the composite.

A.II.4 Study of the influence of carbon precursor nature on the carbon content of composites with carbon and their morphology

A.II.5. The obtaining of composites by thermal decomposition of precursor method: influence of decomposition atmosphere, calcination temperature and time and of the presence of other carbon precursors in addition beside the polyol used as a reductant.

A.II.6 Characterization of the obtained nanocomposites by thermal analysis, FT-IR, X-ray diffractometry, the specific surface area and porosity measurements, Mössbauer spectroscopy, X-ray diffractometry, electron microscopy, SEM, TEM, magnetic measurements.

A.II.6 Writing scientific report and disseminate the results through participation in an international conference and publication of an ISI

article.
III. Testing of magnetic powders synthesized as adsorbent materials and catalysts for removal of inorganic and organic pollutants in water
A.III.1 Testing of oxide nanopowders Fe_3O_4, Fe_2O_3, MFe_2O_4 compared to the corresponding nanocomposite Fe_3O_4 /C, Fe_2O_3 /C, MFe_2O_4 /C as a metal ion adsorbents: Cd (II), Cr (VI), Pb (II), Cu (II), Ni (II), Co (II
A.III.2 Testing of oxide nanopowders Fe_3O_4, Fe_2O_3, MFe_2O_4 compared to the corresponding nanocomposites Fe_3O_4 /C, Fe_2O_3 /C, MFe_2O_4 /C as adsorbents for organic contaminants: colorants and phenolic compounds.
A.III.3 Testing of functionalized oxide powders as adsorbents for inorganic and organic pollutants studied. Study on the influence of nature of surface functional groups on pollutant removal efficiency
A.III.4 Testing of Fe_xO_y and MFe_2O_4 magnetic powders as catalysts for catalytic oxidative degradation of organic pollutants: dyes and phenolic compounds
A.III.5 Study the possibility of regeneration of the adsorbent material by controlled desorption of adsorbed species in different solvents or by changing the pH.
A.III.6 Study of adsorbent material reuse on its performance (maximum capacity of adsorption of pollutant removal efficiency). Proposing a technological schemes for use in remediation of water nanopowders
A.III.7 Preparing final scientific report. Dissemination of results: patent proposal preparation and submission and publication of 2 ISI papers..

Results:

Published papers:
1. Stoia M., Istratie R., Pacurariu C., Investigation of magnetite nanoparticles stability in air by thermal analysis and FTIR spectroscopy, Journal of Thermal Analysis and Calorimetry (2016) 125, 1185–1198
2. Stoia M., Pacurariu C., Istratie R., Barvinschi P, Locovei C., Thermoanalytical techniques: Excellent tools for the characterization of ferrite/SiO2 nanocomposites and their precursors, Journal of Thermal Analysis and Calorimetry (2016) 125, 1249–1263,
3. Stoia M., Pacurariu C., Muntean E.C., Thermal stability of the solvothermal-synthesized MnFe2O4 nanopowder, Journal of Thermal Analysis and Calorimetry,
Conferences
1. Cornelia Muntean: The XXXVIII National Congress on Calorimetry, Thermal Analysis and Applied Thermodynamics (AICAT-GICAT 2016) Ischia (Naples), Italy, September 25-28, 2016
Cornelia Muntean, Marcela Stoia, Geza Bandur: Thermal evolution OF MnFe2O4 precursors obtained by co-precipitation in organic medium
2. Eliza Muntean: 25-th Symposium on Thermal Analysis and Calorimetri - Eugen Segal, Bucuresti, Romania, Ferbuarie, 2016
Stoia M, Muntean Eliza, Pacurariu C, Study on thermal evolution of MnFe2O4 /C composites synthesized by solvothermal method
3. Muntean Eliza: "New trends and strategies in the chemistry of advanced materials with relevance in biological systems, technique and environmental protection" 9th Edition, June 09-10, 2016
Muntean E., Stoia M., Pacurariu C. Solvothermal synthesis of manganese ferrite nanopowders using different surfactants

Applicability and transferability of the results:

This project will develop innovative and original solutions, both in terms of getting nanomaterials used as nano-adsorbents or nanocatalysts in wastewater treatment processes and in terms of regeneration of adsorbents / catalysts and their reintroduction in the process of treatment the waste water, so as to minimize the impact on the environment.
The project aims to find effective solutions as easy to achieve as practical and cheap for treatment of effluents loaded with ions of heavy metals and organic pollutants (dyes and phenols) using as adsorbents the magnetic oxide nanopowders to be obtained.

Financed through/by

Executive Agency for Higher Education Research, Development and Innovation Funding (UEFISCDI)

Research Center

Research Institute for Renewable Energy , University Politehnica Timisoara

Research team

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