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Research Interests:

1. The catalytic activity of inorganic ionic crystals in many organic reactions is determined by low-coordinated surface ions (LCSI). Areas of atomic disorder formed at the interface of crystal grains – grain boundaries (GB) are considered as a source of LCSI playing a role of active sites in solid catalysts.
   This phenomenon is being investigated using MgO and γ-Al_2O_3 as ionic crystals with basic and acidic surface functionality, where the GB area between nanocrystal grains was controlled by materials densification.
   The formation of LCSI, surface basicity and acidity of a series of Mg- and Al-oxides with different aggregation ratio of their nanocrystals was correlates with catalytic activity in base and acid catalyzed reactions.
2. Fe-Carbide-Oxide-Carbon phases in Catalyst for Hydrogenation of CO_2 to Liquid Fuels - At present, the development of a highly efficient process for the conversion of CO_2 and hydrogen mixtures selectively into liquid fuels at high yields requires both novel catalytic materials and process innovation. The most efficient Fe-based catalyst system tested in fixed-beds and other reactor types is potassium-promoted bulk mixed oxide K-Fe-Cu-Al-O. <u>Iron carbide catalysts</u> are self-organizing $Fe_xC/Fe_xO/C$ systems whose phase composition, dispersion and morphology – and hence whose performance – depend both on nature of its mixed oxide precursor and on the actual process conditions and reactor configuration. The efficient precursor, spinel-type were discovered in our studies. Our research comprises three interrelated phases: preparation and characterization of a family of catalysts based on Fe-containing mixed oxides, testing the catalysts in fixed-bed reactors at optimal configuration, modeling of the catalysts' morphology and phases and the catalytic process. Focus is placed on developing the knowledge for: (i) controlling the active phases of the catalyst as a function of selected mixed oxide precursors, the operating conditions and the promoters, (ii) controlling the morphology and pore structure of the materials comprising the catalyst system, and (iii) defining the optimal reaction environment for improved catalyst performance.
3. Study of the potential catalytic paths for converting vegetable oils (triglycerides or fatty acids) to an organic liquid that consists of compounds (*iso*- and normal paraffins, naphthenic and mono-aromatic hydrocarbons) present in jet and diesel liquid fuels. This includes synthesis of novel materials with the proper catalytic functions and their combination in catalytic processes. The structure and composition of triglycerides requires hydrodeoxygenation (HDO) to paraffinic/olefinic hydrocarbon

chains C_{15}-C_{18}, reforming to normal- and *iso*-paraffins, aromatic and cyclic compounds along with mild hydrocracking to lower molecular weight. One path is to use Pt/alumina/SAPO-11 catalyst.

4. Catalytic wet hydrogen peroxide oxidation (CWHPO) of organic wastewater contaminants using hydrogen peroxide as the oxidant is an attractive technology for treating wastewater. This technology deals with the removal of organic carbon at atmospheric pressure and temperatures of $<100^{o}C$. The research deals with testing and understanding the effect of varying the rare earth (RE) metal in perovskites with the formula RE-FeO_3 on the catalytic activity in CWHPO of phenol, to find a more efficient and stable catalyst for CWHPO.