Nanotechnology Center at the University of Puerto Rico - Mayagüez (CREST – NSF Award Nº 1345156)

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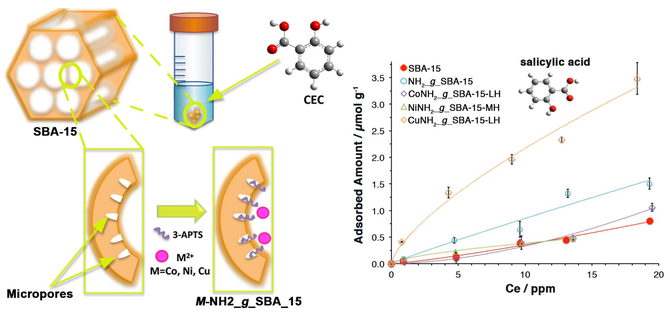
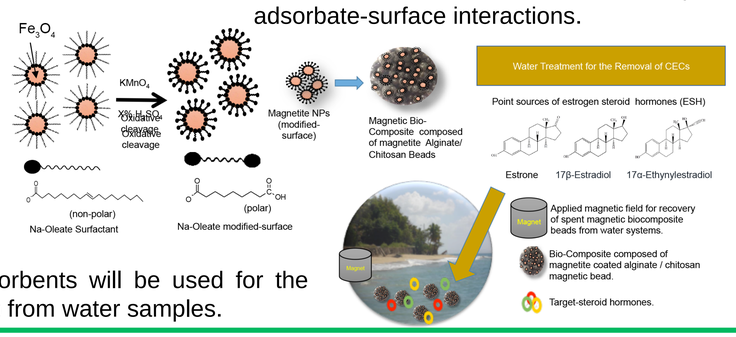
Abstract: The Nanotechnology Center of the University of Puerto Rico – Mayagüez was established in 2008 and is currently in its Phase II dedicated to transformational research on novel nanomaterials for biomedical, environmental and sustainable applications. Two of the interdisciplinary research groups are dedicated to develop new nanostructured materials to remove contaminants of emerging concern and for efficient applications with smaller carbon footprints, such as novel construction materials. The Center includes an educational group dedicated to coordinate students' training as well as the outreach to public middle and high schools located in Western Puerto Rico. The overall goal of the latter group is the recruitment of mostly low-income students by engaging them in highly-instructive activities as members of Materials Science and Engineering Clubs.

Nanostructured Materials for Remediation of Recalcitrant and Emerging Contaminants Present in the Environment

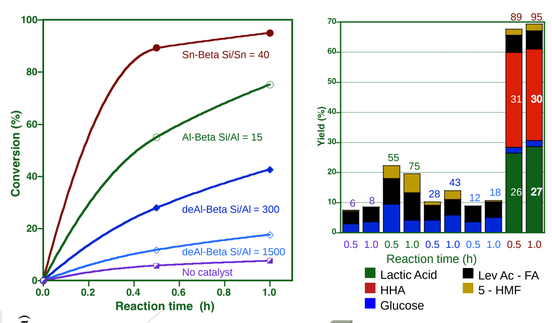


Nanoporous silica SBA-15 was modified to develop adsorbents with affinity toward contaminants of emerging concern (CECs) in water sources. By grafting with amines and immobilizing transition metals (Co^{2+}, Ni^{2+} or Cu^{2+}), we achieved blockage of surface micropores and minimized hydration levels to avoid depolymerization of the silica wall. This approach also brought enhanced textural properties and superior adsorption capacity. At neutral pH and ambient temperature, the $CuNH_2$_g_SBA-15 variant displayed the best overall adsorption working capacities, probably due to enhanced steric conditions and specific adsorbate-surface interactions.

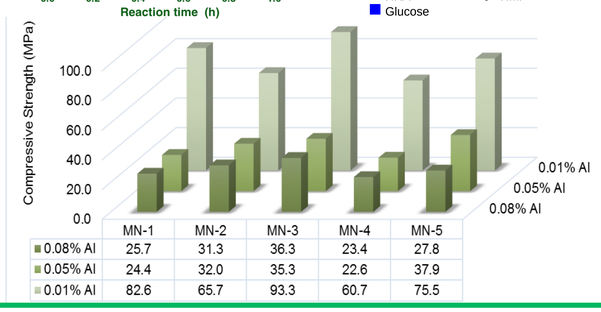
A chemical co-precipitation method was used to integrate functional groups to magnetite (Fe_3O_4) nanoparticles. The ability to modify the surface of nanoparticles covered with sodium-oleate in a one-step process improved colloidal stability, agglomeration, and the size - shape relationship. These bio-composite adsorbents will be used for the removal of steroid hormones (i.e., CEC) from water samples.



Nanostructured Composites and Catalysts for Sustainability



The combination of a Sn-β zeolite with mainly Lewis acidity prepared using a post-synthetic procedure and a solution of GVL and water as solvent is an effective catalytic process for the production of lactic acid from fructose. The figures to the left show the effect of different levels of dealumination of a commercial Al-Beta zeolite and the incorporation of Sn on the activity and selectivity for fructose conversion to lactic acid.

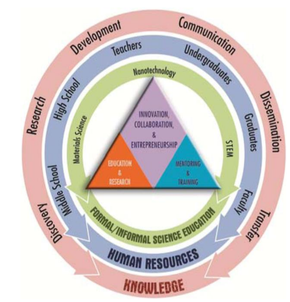


	MN-1	MN-2	MN-3	MN-4	MN-5
0.08% Al	25.7	31.3	36.3	23.4	27.8
0.05% Al	24.4	32.0	35.3	22.6	37.9
0.01% Al	82.6	65.7	93.3	60.7	75.5

Air entrained concrete needed for cold regions were simulated by adding aluminum powder. The expected strength loss was, nonetheless, counteracted by cement partial replacement with nanostructured silica and fly ash. The modified concrete can therefore be used for structural purposes. Another set of statistically-optimized nanomodified mixes proved to be qualified as high-performance concretes

Working Towards Impacting and Developing a More Globally-Oriented Nanotechnology Workforce

The Interdisciplinary Education Group (IEG) aims at training a new generation nanotechnology workforce through the development of critical skills and technical and educational competencies that will ultimately lead to students becoming highly competitive and successful professionals in a global economy. It also aims at expanding the number of Hispanic youth engaged and actively pursuing careers in science, engineering, and/or other STEM-related fields. The latter involves a plethora of initiatives that range from public outreach events to more targeted activities with pre-college students.



Undergraduate and graduate student training focuses on the development of a critical skill set that includes, amongst others: written and oral communication skills, research and engineering best practices, as well as the development of an entrepreneurial and innovative mindset.

At the pre-college level, efforts revolve around the yearly support of an average 17 Materials Science & Engineering (MSE) Clubs that have developed in the public middle schools and high schools throughout Western PR (totaling over 600 students). Bi-semester visits to the MSE Clubs highlight educational modules with fundamental nanotechnology and MSE concepts that include hands-on experiments aimed at increasing the students' interest towards STEM. Once a year, at the Annual MSE Club Meeting, the students gather for a technical presentation and the construction of a large-scale scientific model using air balloons. Highly creative and complex models have been developed based on the Center's research topics.

Public outreach events at local venues (e.g. libraries, shopping malls) highlight nanotechnology demonstrations aimed at raising awareness of the multiple benefits of exploring the NanoWorld. These events have also targeted focus groups such as Girl Scout Troops and Summer Camps.

Publications (Partial List):

- Ortiz-Martínez, K.; Reddy, P.; Cabrera-Lafaurie, W.A.; Román, F.R.; Hernández-Maldonado, A.J. Single and Multi-component Adsorptive Removal of Bisphenols from Aqueous Solutions with Transition Metal Modified Inorganic-Organic Pillared Clay Composites: Effect of pH and Presence of Humic Acid. *J. Hazard. Mater.* **2016**, *312*, 262–271.
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