# Nanotechnology Center for Biomedical and Energy-Driven Systems & Applications
# NSF Award Nº HRD 0833112 CREST Program


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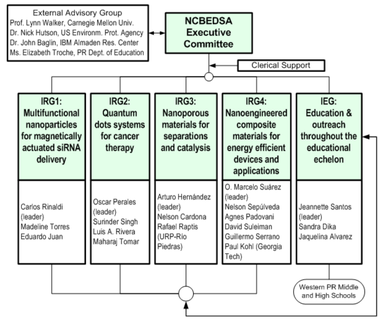
## University of Puerto Rico - Mayaguez


This Center is the largest NSF grant currently active at the University of Puerto Rico–Mayaguez (UPRM). It is structured in four interdisciplinary research groups (IRGs) and an interdisciplinary education group (IEG). The figure on the right presents the organizational chart of the Center, as established in 2008. Twenty-four researchers from UIPRM and other institutions are part of the Center as well as 30 graduate students and 30 undergraduates. The number of students actually impacted by support provided the Center to the researchers is more than twice as high. From its formal foundation on September 1, 2008 until August 31, 2013, the Center is scheduled to receive $5.2M from NSF, which includes two supplemental funds provided to expand the project activities linking it with U. Minnesota, MD Anderson Cancer Center, Ohio State U. (OSU) and Northwestern U (NU). This later UPRM-OSU-NU collaboration is helping establishing the seeds for a new IRG dedicated to simulation and modeling.





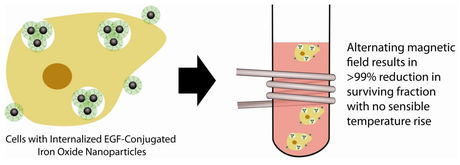
Center researchers during the first Center meeting in 2008

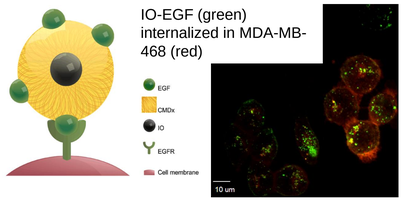

Nanotechnology Center students during an NSF site visit.

## RESEARCH HIGHLIGHTS

### IRG1

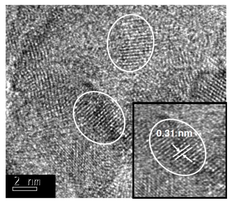
The enhanced therapeutic efficacy of anti-cancer drugs such as cisplatin when administered in combination with heat delivered by magnetic nanoparticles was demonstrated. The researchers also revealed that significant reductions in cell survival can be achieved without a macroscopic perceptible temperature rise when using receptor targeted magnetic nanoparticles. Colloidally stable IO NPs that targeted the EGFR, are efficiently internalized and result in significant reduction in cell survival. The team also designed and built a prototype dynamic magnetic susceptometer capable of frequencies of 10 kHz to 1 MHz at a constant excitation field.



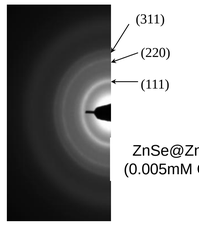




### IRG2

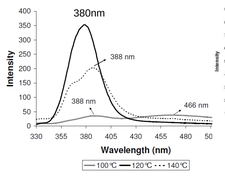
In this group, the reproducible microwave-assisted synthesis of pure and doped water-soluble ZnSe@ZnS core-shell QDs was achieved. Functional properties were found to be strongly dependent on the type of thiol (MPA vs TGA) and the type/amount of dopant. In Cu-doped QDs, the strong emission band (515 nm) is attributed to the recombination of an excited electron in the conduction band of the core and the hole from the d-orbital of a Cu ion.

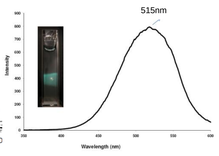


Bare ZnSe@ZnS



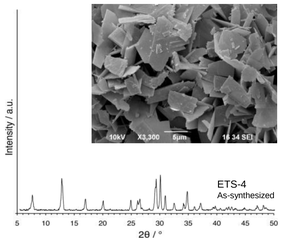
ZnSe@ZnS (0.005mM Cu)

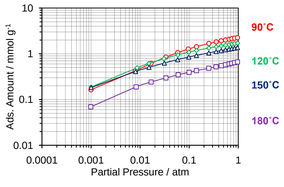


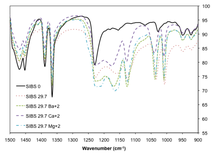




### IRG3

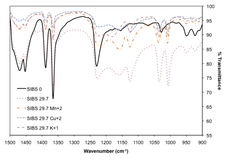
By employing a templated assembly approach the team is producing nanoporous titanium silicates with sand-clock shaped channels as selective and high adsorption capacity flexible frameworks. These are large, accessible void volume and flexible frameworks for superior $CO_2$ selective adsorption from light gas mixtures. The team has also developed redox-active metal organic frameworks (MOFs) based on aryl and aralkyl linkers in conjunction with metal-pyrazolates that could be used for gas storage. Loading and unloading of the gas will be accomplished upon changing the redox state of the framework, a novel approach for regeneration.

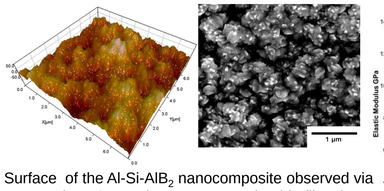


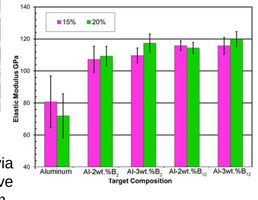



Low sulfonated cross-linked SIBS spectrums where the counter ion substitution increases the intensity of the bands and shifts the asymmetric stretching vibrations band to a higher wavenumber.





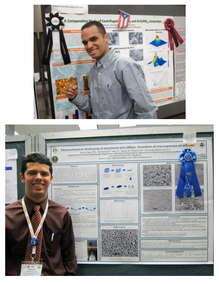

Surface of the Al-Si-$AlB_2$ nanocomposite observed via AFM and FE-SEM. The nanocomposite thin films have appreciably higher elastic moduli than pure aluminum as measured via nanoindentation

### IRG4

The team has worked on the synthesis and characterization of a new polymer nanocomposite, sulfonated poly(styrene-isobutylene-styrene) (S-SIBS), that can have applications in sensors and fuel cells. Critical transport properties such as methanol permeability and proton conductivity have been measured for the bulk membranes as a function of various cation substituents. Thin films of S-SIBS have also been fabricated using a spin-coating technique and the effects of processing parameters such as sulfonation level, casting solvent, and polymer concentration have been evaluated in order to understand morphological and/or nanomechanical differences in the films. Additional work has been completed in the development of Al-based nanocomposite deposited as thin films on different substrates.

## EDUCATION AND OUTREACH

The Nanotechnology Center established a robust partnership with Western Puerto Rico public schools (mostly serving low-income population) via the establishment of 13 Materials Science & Engineering clubs with more than 300 members. Every year they are convened to UPRM campus for an instructional and entertaining activity where they work on balloon constructs to learn about nanostructured materials. Through summer training in the Center-supported labs, science teachers of those schools develop instructional modules for their students. *Nanito*, a fictional character designed by students, represents a prominent vehicle for informal nanoscience education and outreach.

The highly trained cadre of the Center's students has been receiving an increasing number of prestigious awards and recognitions in international venues and conferences.

## Recent Representative Publications


- J.S. Lee, H.L. Rodríguez-Luccioni, A.K. Sood, G. Lopez-Berestein, C. Rinaldi, and M. Torres-Lugo, "Hyperthermia induced by magnetic nanoparticles improves the effectiveness of the anticancer drug *cis*-diamminedichloroplatinum." *Journal of Nanoscience and Nanotechnology*, **11**:4153-4157, 2011. [doi: 10.1166/jnn.2011.3821]
- M. Creixell, A.C. Bohorquez, M. Torres-Lugo, and C. Rinaldi, "EGFR-targeted magnetic nanoparticle heaters can kill cancer cells without a perceptible temperature rise." *ACS Nano*, **5**(9), 7124-7129, 2011. [doi: 10.1021/nn201822b]
- J. Tafur, C. Rinaldi, E.J. Juan, "Development and validation of a 10kHz-1MHz AC magnetic susceptometer with constant excitation field." *Journal of Applied Physics*, 2011. Under Review
- S. Bailon, L. Alamo, and O. Perales, "Synthesis and surface functionzalization of water-soluble CdSe@CdS," *Materials Science and Engineering, 2011.* Under Review.
- S. Bailon, and O. Perales, "Citotoxicity of functionalized CdSe@CdS quantums dots under photo-irradiation," *Journal of Nanotechnology*, 2011. Under Review.
- S. Urcia-Romero, O. Perales, O. N. C. Uwakweh, C. Osorio, and H. A. Radovan, "Tuning of magnetic properties in Co–Zn ferrite nanocrystals synthesized by a size controlled co-precipitation method," *Journal of Applied Physics*, **109**, 07B512, 2011.
- S. Singh, "Multifunctional magnetic quantum dots for cancer theranostics," *Journal of Biomedical Nanotechnology*, **7**, 95-97, 2011.
- J. N. Primera-Pedrozo, K. J. Guerrero-Medina, R. Fu, and A. J. Hernandez-Maldonado, "Sr(II)-UPRM-5 titanium silicate framework thermally induced contraction: In situ high temperature XRD and 29Si MAS NMR," *Dalton Transactions*, **40**(14), 3547-3552, 2011.
- J. N. Primera-Pedrozo, B. D. Torres-Cosme, M. E. Clardy, M. E. Rivera-Ramos, and A. J. Hernández-Maldonado, "Titanium silicate porous materials for carbon dioxide adsorption: Synthesis using a structure directing agent, detemplation and inclusion of alkaline earth metal cations," *Industrial & Engineering Chemistry Research*, **49**(16), 7515-7523, 2010.
- E. Merced, R. Cabrera, H. Coy, F. E. Fernandez, and N. Sepulveda, "Frequency tuning of $VO_2$-coated buckled microbridges," *Journal of Microelectromechanical Systems*, **20**(3), 558-560, 2011.
- E. Merced, R. Cabrera, R. Suarez, F. E. Fernández, and N. Sepúlveda, "Nanostructured $VO_2$ film coatings for tunable MEMS resonators," *Nanotechnology Materials and Devices Conference (NMDC)*, 2010 IEEE, 212-215, 2010.
- G. Ramos, and O.M. Suarez, "Characterization of sputtered Al-B-Si thin films produced with composite targets for device applications," *Science and Engineering of Composite Materials*, **18**, 2011. In Press.
- T. K. Adelakin, and O.M. Suarez, "Study of boride-reinforced aluminum matrix composites produced via centrifugal casting," *Materials and Manufacturing Processes,* **25**, 338-345, 2011.
- S. Dika, J. Alvarez, J. Santos, and O. M. Suárez, "School-based clubs as a mechanism to increase student interest in materials science engineering and nanotechnology among underserved groups*." Materials Research Society Proc.*, MRS Online Proceedings Library, Vol. 1320 rsf10-1320-xx01-04, doi:10.1557/opl.2011.592