Wisconsin - Puerto Rico Partnership for Research and Education in Materials

University of Wisconsin - Madison
Madison, Wisconsin

University of Puerto Rico - Mayagüez
Mayagüez, Puerto Rico

Institutional Overview and Student Population

Wi(PR)$_2$EM wiprem.uprm.edu

		Total	Female	Male
Total	**Total**	**13196**	**48%**	**52%**
	Sciences	3455	61%	39%
	Engineering	4859	31%	69%
UG	**Total**	**12092**	**49%**	**51%**
	Sciences	3148	62%	38%
	Engineering	4424	31%	69%
	Chemistry	*336*	*68%*	*32%*
	Chem Eng	*739*	*58%*	*42%*
Grad	**Total**	**1104**	**43%**	**57%**
	Sciences	307	48%	52%
	Engineering	435	30%	70%
	Chemistry	*80*	*51%*	*49%*
	Chem Eng	*56*	*38%*	*62%*

9 Profs.

13 Profs.

	Total	Female	Male
Total	18966	35%	65%
UG	12092	35%	65%
Grad	1104	36%	64%

2 Profs.

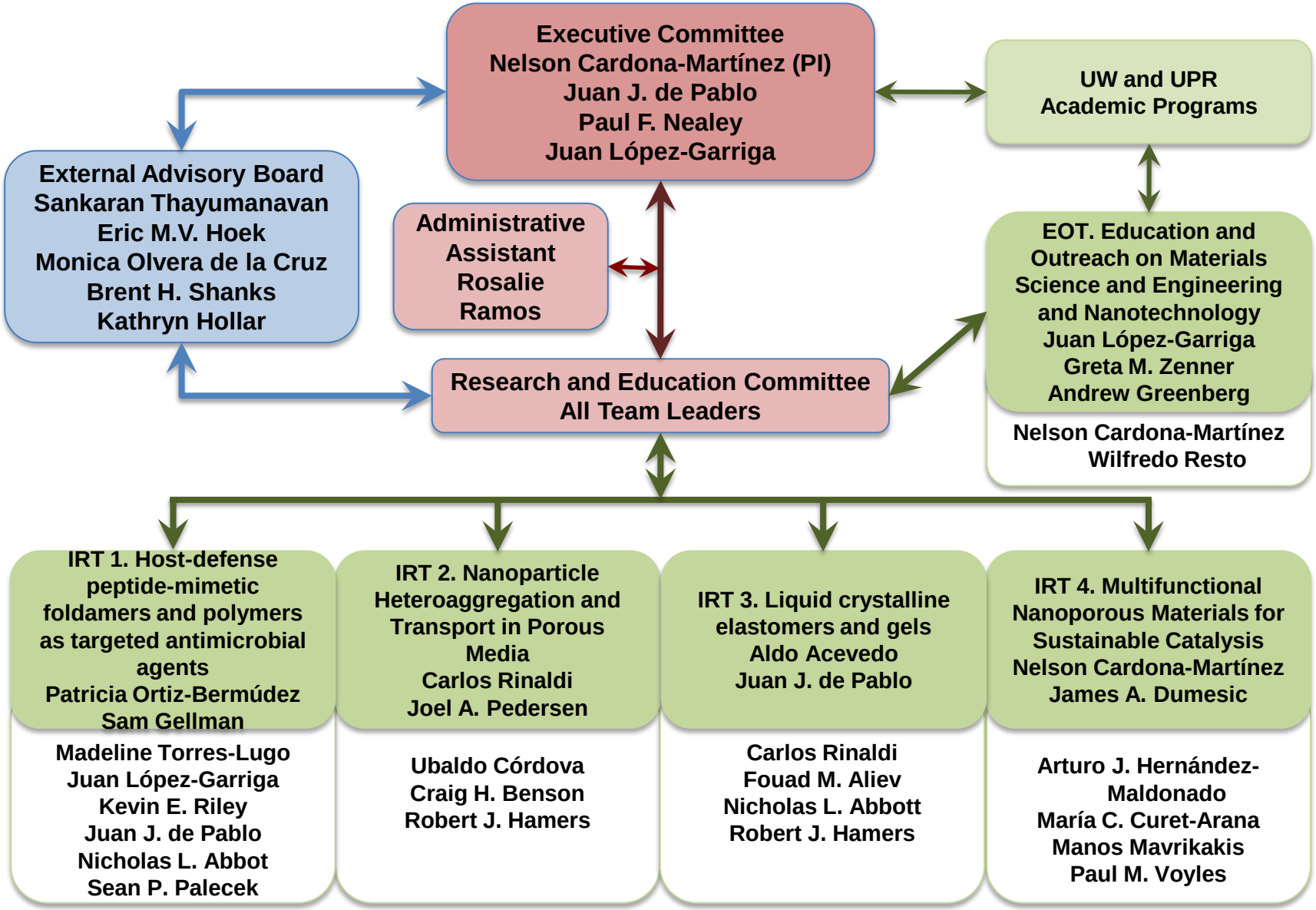
	Total
Total	3830
Chem	244
ChemE	15

1 Prof.

Wi(PR)$_2$EM Mission and Vision

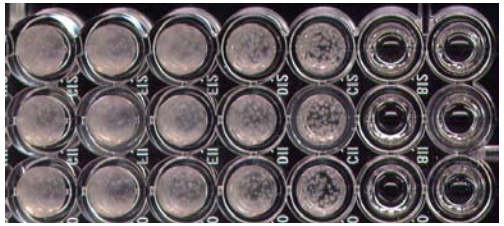
- Strengthen and broaden past collaborations between UW and UPR
  - Leveraging and augmenting reach of alliances.
  - Develop formal long-lasting relationship in nanostructured materials research and education.
- Promote the formation of a strong strategic partnership
  - Fostering and expanding current and emergent research projects in collaboration with UW's MRSEC on Nanostructured Interfaces and NSEC on Templated Synthesis and Assembly at the Nanoscale.
  - Combining research and education expertise found in the participating institutions into truly synergistic groups.

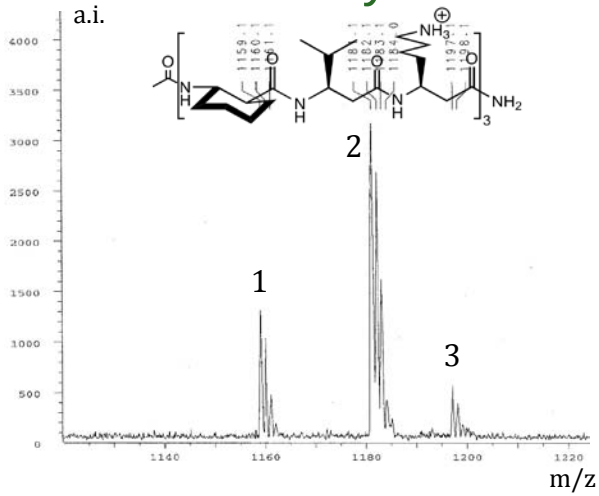
Wi(PR)$_2$EM Organizational Chart

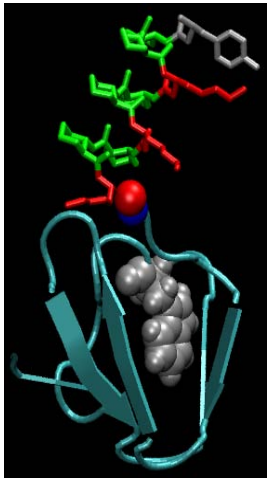


IRT 1. Host-defense Peptide-mimetic Foldamers and Polymers as Antimicrobial agents

- Hypothesis
  - Combination of expertise in synthesis and structural analysis of antimicrobial β-peptides with expertise in microbial physiology and molecular biology will:
    - Elucidate their molecular mechanism of action
    - Enhance their antimicrobial properties
    - Develop novel antimicrobial nylon-3 backbone polymers

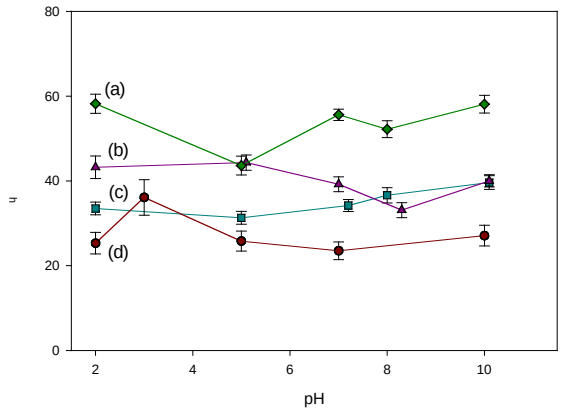




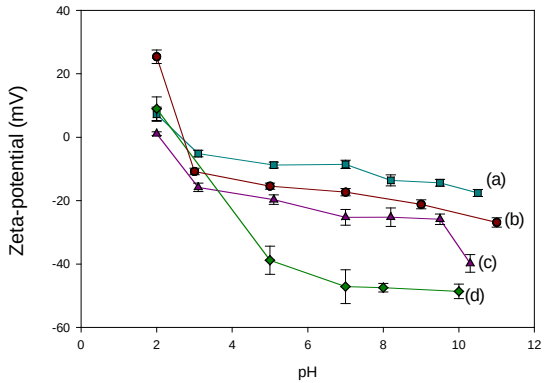


IRT 2. Nanoparticle Heteroaggregation and Transport in Porous Media

- Hypothesis - Understanding nanoparticle heteroaggregation and transport in porous media is crucial in predicting fate and transport of nanoparticle pollutants in the environment.
  - Heteroaggregation – aggregation of engineered nanoparticles with natural colloids
  - Transport in porous media – effect of fixed and mobile phase physicochemical properties on transport of engineered nanoparticles
- In both cases it is expected that interactions will be governed by the size and surface chemistry of the nanoparticles



Hydrodynamic size vs. pH of magnetite nanoparticles coated with a) CMDx 38, b) CMDx 23, c) CMDx 5, and d) commercial CMDx



Charge vs. pH of magnetite nanoparticles coated with a) CMDx 5, b) commercial CMDx, c) CMDx 23, and d) CMDx 38.

IRT 3. Liquid Crystalline Elastomers and Gels

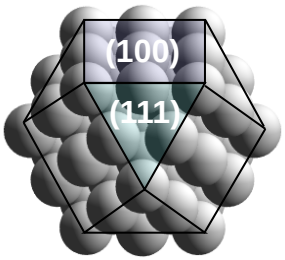
- Design solid-like liquid crystalline elastomers and gels with tunable optical and mechanical properties for chemical and biological sensing and cell-culture applications.

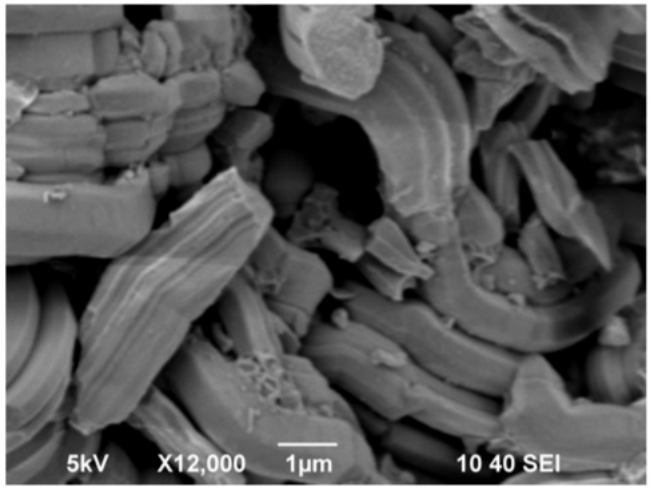
Hypothesis

- Concerted theoretical and experimental effort will lead to rational design of CLC gels and LCE nanocomposites, thereby allowing us to identify the origins of experimentally observed behaviors and to design or dial-in specific thermodynamic, mechanical, and optical responses that rely on advanced molecular models of the considered materials.
  - Chemically crosslinked liquid crystalline elastomers modified with magnetic nano and micro-particles
  - Liquid crystal gels modified with magnetic nano and micro-particles

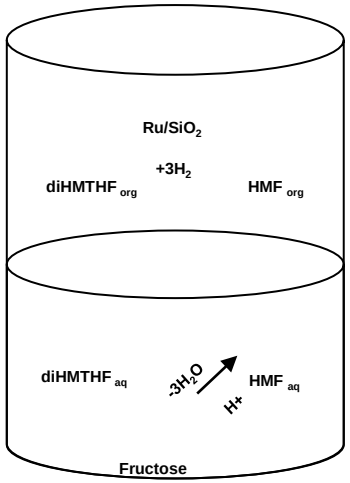
IRT 4. Multifunctional Nanoporous Materials for Sustainable Catalysis

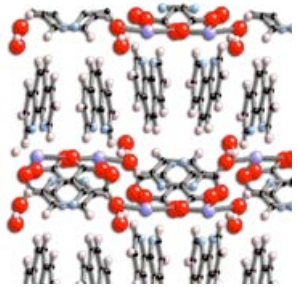
- Hypothesis
  - Combination of surface functionality and pore structure will enable design of novel materials for
    - sustainable conversion of biomass resources into renewable fuels and chemicals
    - for removal of bulk CO_2.





SBA-15S3 As synthesized.





EOT. Education and Outreach in Materials Science and Engineering and Nanotechnology

- Implement interdisciplinary education programs that foster strong, effective, and productive education impacts
- Activities dedicated to:
  - K-12 teachers and students
  - Undergraduates
  - Graduate students & postdoctoral researchers
  - General Public

- Science on Wheels Educational Center

From Macro to Nano
1659 participants

Liquid Crystals, Ferrofluids, Memory Alloys
1950 participants

NanoBio
1352 participants

Surface Area, Catalysis, NanoPorous Materials
1089 participants

Playground
360 participants

Wi(PR)$_2$EM Research, Education, and Outreach Goals

- Develop formal long-lasting relationship in nanostructured materials research and education
- Implement interdisciplinary education programs
- Provide effective mentoring to young faculty at UPR
- Promote and develop industrial interactions.

UW Advanced Materials Industrial Consortium (UW-AMIC)

- Comprises 15 member companies
- Wi(PR)EM faculty and students are included in the consortium membership and activities
  - Annual meeting
  - Students resumes and posters will be posted on the consortium website for all member companies to access
  - We will encourage Industry in Puerto Rico to become consortium members in active collaboration with Wi(PR)EM and UW students and Faculty

IRT 2. Goals

- Develop model nanoparticle colloids for studies of heteroaggregation and transport in porous media.
- Develop particle-scale computational models for nanoparticle heteroaggregation with natural colloids, incorporating the effects of particle shapes, relative sizes, surface charge, surface chemistry, and hydrodynamic interactions.
- Investigate the influence of surface chemistry on nanoparticle heteroaggregation with environmental colloids over a range of solution conditions relevant for freshwater environments.
- Investigate the influence of nanoparticle surface chemistry on transport through porous media representative of soils and sediments.

Calculator based laboratory and sensors (CBLS)

LabQUEST Visible Spectrophotometer

Teachers, Students, Science, and Technology

- Activities are arranged in two mayor areas:
  - Summer workshops
  - Follow-up activities
- Follow-up activities are divided in:
  - visits to schools
  - visits to UPR Mayagüez
  - Saturday academies
- Summer workshops are focused on the training of teachers in the link between chemistry and research through the use of Calculator Base Laboratory (CBL), LAB-QUEST and UV-Vis spectroscopy.

Enhancing and Broadening the Undergraduate Experience

- REU
- Materials Science Certificate
- Grad School Readiness Workshops
  - Workshops to help Puerto Rico students with the verbal sections of the GRE
  - Strengthen their communication skills
- Undergraduate Materials Journal

Building a Collaborative, Inclusive Research Infrastructure

- Research Exchanges
- Mentoring Experience
- Grant Writing Workshops
- Postdoctoral Teaching Exchange
- Young Faculty Mentoring Program

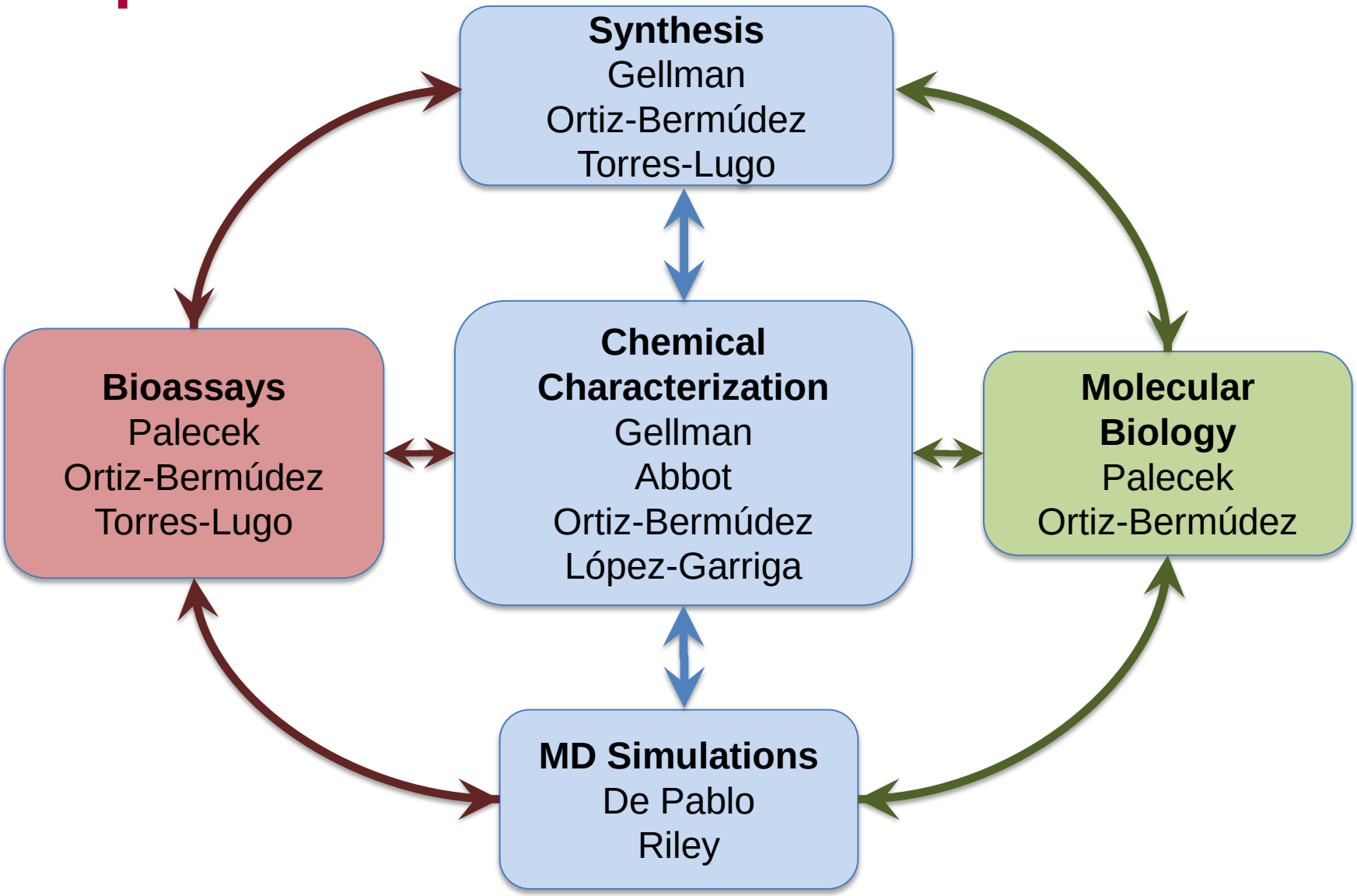
Exciting K-12 Students and Teachers about Materials Science and Engineering and Nanotechnology

- Science on Wheels
  - Nanodays
    - US March 27 – April 4, 2010
    - UPRM April 5 – 11, 2010
  - Module Training
    - One-week long summer workshop
- Teacher-Student Research Experiences

External Advisory Board

- Sankaran Thayumanavan
  - Professor of Chemistry at the University of Massachusetts Amherst
- Eric M.V. Hoek
  - Professor of Civil and Environmental Engineering Department and California NanoSystems Institute, UCLA
- Monica Olvera de la Cruz
  - Professor of Materials Science and Engineering and the director of the Materials Research Science and Engineering Center at Northwestern University
- Brent H. Shanks
  - Professor of Chemical Biological Engineering at Iowa State University and Director of the Engineering Research Center for Biorenewable Chemicals
- Kathryn Hollar
  - Director of Educational Programs for the Nanoscale Science and Engineering Center at Harvard School of Engineering and Applied Sciences

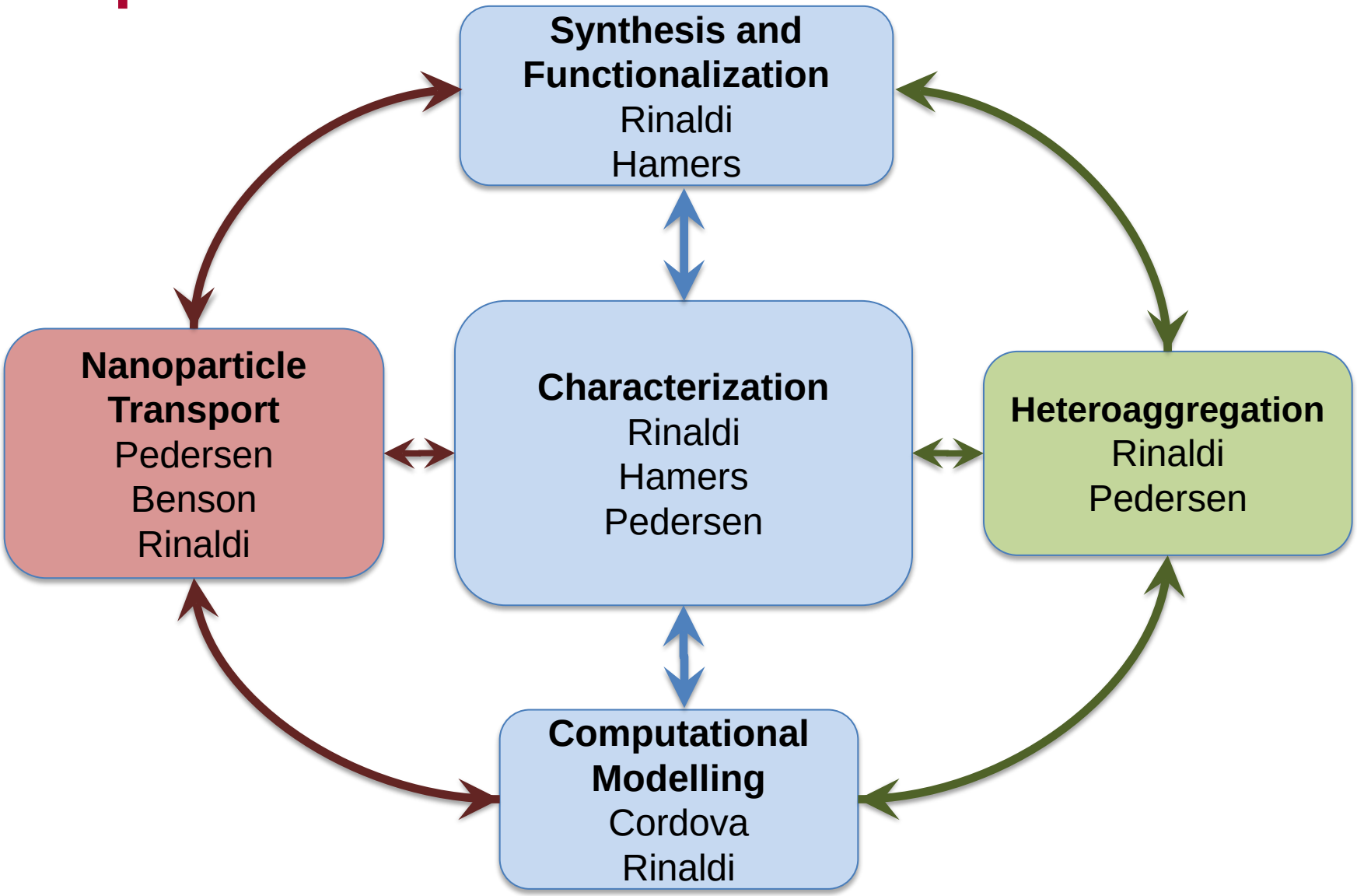
IRT 1. Expertise and Responsibilities



IRT 1. Goals

- Establish relationship between oligomer and polymer structure and their biological activities to enhance toxicity against bacteria and fungi relative to human cells.
- Explore targeting strategies based on unique molecular information present on microbial cell surfaces
- Elucidate the mechanism of action of beta-peptides using molecular approach
- Develop nylon-3 derivatives with a high propensity for self-assembly to form intrinsically antimicrobial materials

IRT 2. Expertise and Responsibilities



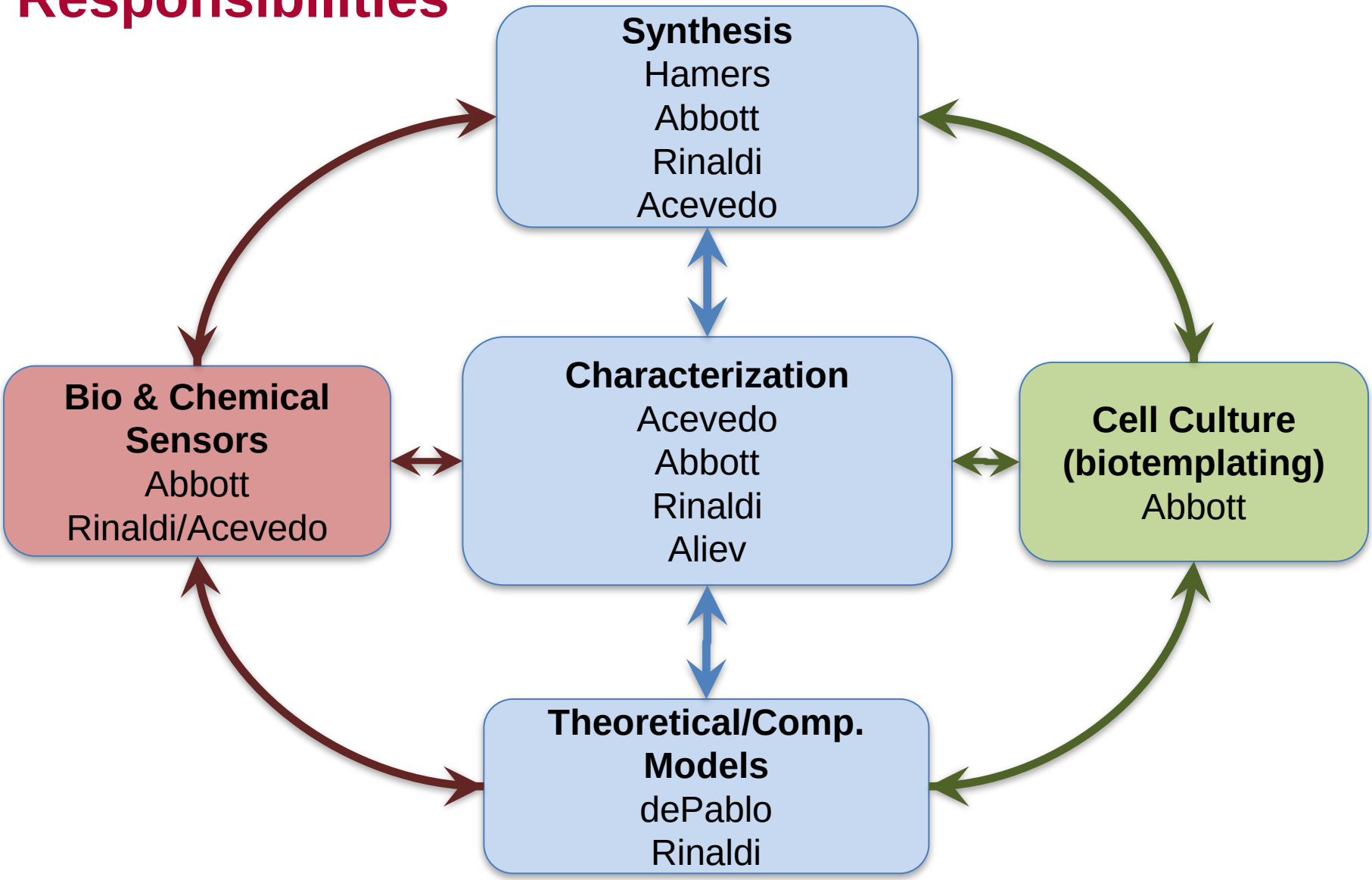
IRT 2. Expertise and Responsibilities

- Nanoparticles will be synthesized and functionalized by Rinaldi, Hamers and Fernandez.
- Heteroaggregation will be studied by Rinaldi and Pedersen through a combination of dynamic and static light scattering, particle electrophoresis, small angle x-ray scattering, cryo-TEM, and atomic force microscopy.
- Computational models of heteroaggregation will be developed by Cordova and Rinaldi, taking into account relative size differences between particles, magnetic dipole-dipole, electrostatic, van der Waals, and specific interactions, and hydrodynamic lubrication forces between approaching particles.
- Pedersen, Benson, and Rinaldi will conduct column experiments to examine nanoparticle transport through porous media under controlled flow-through conditions.

IRT 2. Current Status

- One graduate student has been recruited – Ms. Loyda García, MS Civil and Environmental Engineering, Puerto Rican
- Initial work will focus on studying nanoparticle colloidal stability under conditions representative of waste water treatment plants
  - Nanoparticles engineered for biomedical applications are likely to enter the environment through waste waters.
  - Hence an initial step in removing these pollutants would be waste water treatment plants.
  - Because nanoparticles for biomedical applications are engineered to be colloidally stable under conditions of high ionic strength and in the presence of biopolymers, it is possible that traditional steps in treating waste water are inadequate in removing these potential pollutants.

IRT 3. Expertise and Responsibilities

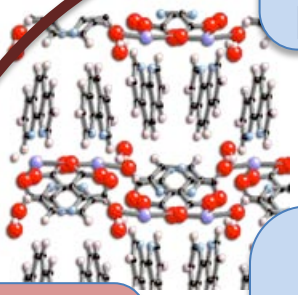


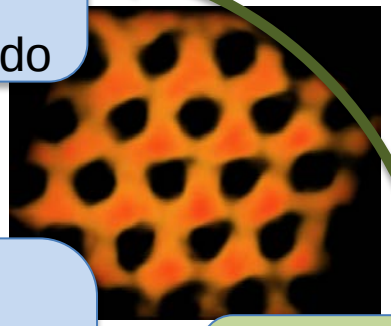
IRT 3. Specific Goals

- Develop molecular models of colloidal liquid-crystalline gels capable of describing structure and properties at equilibrium and beyond equilibrium.
- Develop molecular models of liquid crystalline elastomers that incorporate the kinetics of formation and that describe structure and properties both at equilibrium and beyond equilibrium.
- Synthesize soft colloidal liquid-crystalline gels with mechanical properties in the kPa regime and characterize their structure and mechanical response
- Synthesize soft liquid crystalline elastomers with mechanical properties in the kPa regime and characterize their structure and mechanical response
- Demonstrate the use of the models and materials for sensing of toxic chemicals, for sensing of viruses, and for actively controlled culture of cells.

IRT 4. Expertise and Responsibilities

Synthesis
Dumesic
Cardona-Martínez
Hernández-Maldonado

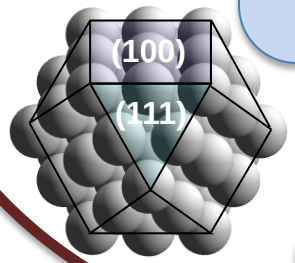


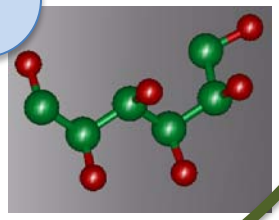


Separations
Hernández-Maldonado

Characterization
Dumesic
Cardona-Martínez
Hernández-Maldonado
Voyles

Catalysis
Dumesic
Cardona-Martínez





Theory and Computation
Mavrikakis
Curet-Arana

IRT 4. Goals

- Develop and characterize hierarchical catalytic materials with metallic and hydrophobic functionalities.
- Develop and characterize hierarchical catalytic materials with metallic and acidic functionalities.
- Develop and characterize porous polymeric materials with pillared layered structures.
- Systematically screen for potential novel bimetallic alloy nanoparticles that would be able to outperform conventional noble metal catalytic nanoparticles.
- Test the catalytic and adsorption properties of the nanostructured materials developed.