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7. Title

Development of Multiscalar Materials for Biological Applications

12. Investigator Name(s) (Last Name and Initials)

Hayes, D. J.

20. Termination Date 12/31/2015 | 40. Period Covered (mo/da/year): 01/01/2011 TO 12/31/2011

Outputs:

This project provided an understanding of hierarchical size scale phenomena and processes; developed and characterized multiscalar materials; developed muliscalar devices and systems for tissue engineering; and provided an understanding of the economic, environmental, safety and health impacts of multiscalar technology in agricultural, biomedical and biological processing systems. Dissemination of findings included disclosure of several patentable technologies through the Office of Intellectual property, and presentations at national and international conferences, local and regional symposia, and ACE meetings. Three peer-reviewed publications and four conference presentations resulted from this work. Specific outputs include: 1) Development of nanoscale photoactivatable nucleic acid delivery vehicles for control of gene silencing in cells and tissues, providing improved efficacy in gene control; 2) Exploration of selective antimicrobial theranostics based on an iron core and silver shell nanoparticle and surface functionalized with ceragenins to provide strain selectivity; 3) Developement of a biomass mediated method for synthesizing silver nanoparticles (SNP) and incorporating them into biocompatible/bioresorbable PLLA nanocomposite scaffolds to impart antimicrobial properties to chronic indwelling devices; and 4) A new thermal process has been developed for synthesizing the silicate ceramic, akermanite. PCL akermanite has been combined with thermal precipitation process to create tissue engineering scaffolds for the repair of critical sized bone defects.

Outcomes/Impacts:

Outcomes of this project have impacts that will further develop nanotechnology applications, improve existing therapies, enable new modalities of diagnosing and curing disease and provide a better understanding of dangers of nanomaterials. Substantial progress has been made in the development of bioactive nanocomposite polymers for tissue engineering applications. Two projects have examined the use of silver and the silicate based ceramic akermanite as nanoscale additives to impart antimicrobial and osteogenic properties, respectively, to multiscalar polymer composite scaffolds. Optimal inorganic phase content (dry wt/wt%) was determined for the bioactive components to maximize desirable mechanical and biological properties while reducing unwanted side effects such as cytotoxicity. Efforts to explore novel materials and targeting techniques to impart selectivity to antimicrobials and diagnostics have resulted in the development of an iron core, silver shell nanomaterial theranostic (combination therapy and diagnostic) device. Different ceragenins, which mimic antimicrobial peptides in form and function, provide greater selectivity to the nanodelivery vehicle. A ceragenin molecule, CSA-124, has been designed such that when combined with the iron core, silver shell nanodelivery vehicle it improves selectivity for methicillin-resistant staphylococcus aureus, as demonstrated by spatial localization and improved antimicrobial efficacy. The Louisiana crayfish, Procambarus Clarkii, was used as a specimen to measure SNP accumulation in an effort to assess toxicity and bioaccumulation effect in the food chain. Silver nanoparticles were compared with silver nitrate and potassium nitrate to determine the contribution of nanoscale morphology to silver toxicity. Silver, in the nanoparticle form, is five times less acutely toxic (in a 96 hour exposure) than ionic silver sources. A proportionally higher concentration of silver accumulation was found in the gills of silver nitrate treated animals. Greater concentrations of silver were found in the brain tissue and tail muscle of crayfish treated with SNP. Reduced mortality of this may be related to greater exposure times, aloowing silver to accumulate in non-respiratory tissues.

Publications:

Cole, M. R.; Li, M.; El-Zahab, B.; Janes, M. E.; Hayes, D.; Warner, I. M., Design, Synthesis, and Biological Evaluation of β-Lactam Antibiotic-Based Imidazolium- and Pyridinium-Type Ionic Liquids. Chemical Biology & Drug Design 2011, 78 (1), 33-41.

Qureshi, A. T.; Monroe, W. T.; Lopez, M. J.; Janes, M. E.; Dasa, V.; Park, S.; Amirsadeghi, A.; Hayes, D. J., Biocompatible/bioabsorbable silver nanocomposite coatings. J. Appl. Polym. Sci. 2011, 120 (5), 3042-3053.

Participants:

Hayes, D.J., (PI), A. Qureshi, E. Hodges, M. Hoppens, A. Zanetti, C. Smith, J. Landry, J. Hollier, K. Kilchrist, M. Barnum, and J. Duhon, LSU AgCenter.

Target Audiences:

Other researchers in biology, physics, chemistry, engineering and medicine. Research and development personnel in biotechnology, pharmaceutical, food processing, agriculture and other industries.

Project Modifications:

Nothing significant to report during this reporting period.

Approved (Signature)	Title	Date