Amgen Seminar Series in Chemical Engineering

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Magnetic Nanoparticles and Nanocomposites: Development for Medical and Environmental Applications

By

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We apply chemical engineering fundamentals to the rational design, synthesis, and application of novel nanoparticle systems and macromolecular materials. In particular, we are interested in designing and applying advanced materials based on magnetic nanoparticles (MNPs) and nanocomposites. Magnetic nanocomposites are a relatively new class of advanced materials, which have attracted interest as intelligent materials for biomaterial and other applications. In our lab, we are primarily interested in MNPs due to their ability to respond to an alternating magnetic field (AMF) resulting in local energy delivery and potentially localized heating. We have incorporated MNPs into nanocomposites that exhibit new and unique properties such as remote actuation, and the resultant properties of the nanocomposite can be easily tailored by manipulating the composition of the polymer and the nanoparticulate material.

Here, some of our recent activities in the development and application of MNPs and their nanocomposites will be presented. In particular, the application of functionalized MNPs for cancer therapy and environmental remediation will be highlighted. For potential cancer therapy applications, we have been particularly interested in determining the role of reactive oxygen species (ROS) catalytically generated from the surface of iron oxide MNPs, and using a methylene blue degradation assay, we demonstrated that magnetically mediated energy delivery (MagMED) is capable of enhancing the Fenton-like generation of ROS. Here, further studies of the surface reactivity of MNPs and the enhancement of this reactivity with AMF exposure will be presented, as well as the effects of small molecule and macromolecular coatings. These demonstrations illustrate the potential of AMF-induced ROS in cancer therapy. For environmental applications, AMF exposure and the associated energy delivery can be used to carry out various functions. For example, we will present data showing the AMF exposure being used to change the binding properties of an MNP coating.

J. Zach Hilt is the Gill Eminent Professor of Chemical Engineering in the Department of Chemical and Materials Engineering at the University of Kentucky. Prof. Hilt received his bachelor degrees in Chemistry and Physics from Miami University (Ohio). He completed his Masters degree in Chemical Engineering from Purdue University and his Doctor of Philosophy in Chemical Engineering from the University of Texas at Austin. Prof. Hilt's research laboratory focuses on the rational design, synthesis, and application of nanoparticle systems and macromolecular materials. Prof. Hilt has authored numerous referred publications, including a highly cited review "Hydrogels in Biology and Medicine: From Molecular Principles to Bionanotechnology" published in Advanced Materials. He is co-editor of "Nanotechnology in Therapeutics: Current Technology and Applications" which is published by Horizon Scientific Press and is one of the first books dedicated to the topic of nanotechnology in drug delivery. Prof. Hilt is the Leader of the UK Superfund Center Training Core. He is also co-Director of the UK NSF REU Program on Bioactive Interfaces and Devices. He is a fellow of the American Institute for Medical and Biological Engineering (AIMBE), and he is a member of the American Institute for Chemical Engineers (AIChE), Materials Research Society, Society for Biomaterials, American Chemical Society, and the Biomedical Engineering Society. He has taken an active role in these professional societies, including recently serving as the chair of the AIChE Nanoscale Science and Engineering Forum.

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