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**Nanomaterials for biomedical and environmental applications**

**Presentation 1.** ***Medical Nanomaterials for Development of Targeted and Controlled Drug Delivery for Cancer Therapeutics***

Medical Nanotechnology or Nanomedicine is the application of nanotechnology in medicine as it applies to cure diseases and repair of damaged tissues such as bone, muscles and nerves. Some of the key goals of nanomedicine include the development of cures for traditionally incurable diseases such as cancer through the use of nanotechnology and to provide more effective cures with fewer side effects by means of targeted drug delivery systems.

Cancer nanomedicine has become or developed as an interdisciplinary area merging science, engineering and medicine with the sole purpose of providing new tools to fight cancer. The promise of nanomedicine in cancer research is the development of nanomaterials for prevention, early detection, imaging diagnostics and multifunctional therapeutics.

At present, in terms of diagnosis the only factor that really correlates to the patient survival is early cancer detection. Cancer therapies are currently limited to surgery, radiation, and chemotherapy, such approach kills healthy and sick cells indiscriminately. All three methods risk damage to normal tissues or incomplete eradication of the cancer. Similarly, the present imaging techniques is limited by cancer resurgence that after surgery occurs due to failure to recognize and remove all cancerous colonies.

Nanomedicine provides the means to aim therapies directly and selectively at cancerous cells by using nanocarriers, passive targeting, active targeting and destruction from within. Nanomedicine for cancer treatment for instance, foresees that in an effective cancer treatment, a device with target drug delivery nanoparticles coated with targeting agents and loaded with anticancer drugs can circulate through the blood vessels until they reach the target cancerous cells and upon attachment, they can release the drug load directly into the targeted malignant cells.

Currently, most cancer research with nanomedicne is in diagnostic tools, although there are many other application of nanomaterials in medicine to improve and implement targeted and controlled drug delivery. This presentation will describe the development of encapsulation in polymeric nanoparticles and the targeted controlled delivery of drugs in effective and minimally invasive cancer treatment.

***Presentation 2. Synthesis of lipid nanoparticle affinity chelating liposomes for protein immobilization and separations and effect of PEG on aggregation and binding interactions.***

In this work we studied and characterized the properties of self-assembled ligand-modified liposomes (large unilamellar vesicles) upon binding to metal ions and proteins in solution. The lipids, dimyristoyl phosphatidylethanolamine (DMPE) and dimyristoyl phosphatidylcholine (DMPC) and cholesterol (CHOL) were used in the liposome preparations. The approach used here was an extrusion method were the mixture of lipids and cholesterol are first hydrated and after a process of freeze and thaw the suspension is filtered by extrusion several times using 600, 200 and finally 100 nm membranes. Thus, the size of the prepared nanoparticle liposomes is on average close to 100 nm and verified by light scattering. To prepare the chelating functionalized nanoparticle liposomes, their surface was modified by coupling the tridentate chelating agent, iminodiacetic acid (IDA), and a flexible polymer, polyethylene glycol (PEG), by different methods. In one of these methods, the amino groups of DMPE was reacted with bromoacetic acid to form the chelating-IDA system. Similarly, to incorporate PEG on the liposomes, the amino groups of DMPE were reacted with the activated tresylated-PEG. The modified so-called chelating liposomes (liposome-IDA) were able to bind metal ions from solutions, specifically copper (Cu(II)). The liposome-IDA-Cu(II) complex was used to bind histidine-containing proteins such as myoglobin, lysozyme, and the mixture of these. PEG modified liposomes (PEGylated liposomes) were used to increase the stability of liposomes and to prevent aggregation that was experienced when chelating liposomes bound proteins or even metal ions.

**Presentation 3*. Self-assembled Reversible and Directional Bio-molecular Nanostructured Templates for Development of Bio-nano-interconnects***

This work concerns with our research in biorecognition for development of Reversible Bio-Nanointerconnects. Microtubules (MTs) are self-assembled subcellular proteinaceous filaments with nanoscale diameters and micrometer scale lengths. MTs are biopolymers assembled from two, related protein monomers; and tubulin. The aspect ratio of MT, the reversibility of their assembly and ability to be metallized make them excellent candidates to serve as templates for the fabrication of nanowires. Our work focuses on developing technology for bottom-up approaches to nano-electronics manufacturing inspired by biological processes. We will present as a first step for the fabrication of nanoscale interconnects in microelectronic devices the molecular assembly for the functionalization with self-assembled monolayers (SAMs) of a gold surface with a gamma-tubulin as a biospecific linker for MTs.  Our in situ approach to manufacturing a MT interconnection on a silicon wafer using biomolecular templates consists of (a) a starting electrode functionalized with a derivatized MT nucleating complex (cap) via specific affinity recognition ligands, (b) controlled growth of MTs from the starting electrodes toward a target electrode, (c) binding of the MT plus end to capping agent bound to the target electrode via specific ligands, and (d) disassembly of uncapped MTs and subsequent metallization of interconnecting protein template.

**Presentation 4**. ***Development of engineered reversible and regenerable, high capacity adsorbents for sustainable removal of arsenic from contaminated waters***

The main objective of this work is the development and implementation of high capacity reversible and regenerable arsenic adsorbents as an effective sustainable, cost effective and practical process for removal of arsenic in a highly concentrated form from contaminated waters. The significance in this approach is that there is no need for disposal of the adsorbent media, the resulting adsorbents developed and used in this work, once the arsenic is effectively removed and eluted, they can be easily regenerated and re-used a great number of times without losing their capacity and effectiveness. The process allows a very efficient recovery of arsenic and adsorbent media leaving absolutely no waste to dispose of.

The proposed technology is based on the preparation of reversible, high capacity and efficient adsorbents to remove arsenic from contaminated waters using new chelating polymers, carboxylated-and picolylated polyethyleimine (PEI)-grafted-polymeric matrices as the basis to incorporate high capacity chelating ligands for specific metal ions and arsenic. The resulting structures can be characterized as regenerable synthetic ferric oxide adsorbents with high and selective capacity for arsenic. These adsorbents of very high metal content make capacity and selectivity for arsenic adsorption and desorption extremely effective down to ppb levels (below 10ppb). In the present approach we use the concept that metal ions have affinity for many inorganic and organic substances, including arsenic, and that such affinity is usually preserved but often modulated by immobilization to a solid support. These immobilized metal ions will function as adsorption sites for arsenate and arsenite. This is truly a program interdisciplinary in nature; it will help advance knowledge and understanding in several research fields since it involves chemical synthesis, chemical analysis, experimental and theoretical analysis, environmental remediation and engineering design.