INTRODUCTION

Biomimetic science is an emerging research area that is seeing growing academic and commercial interests. With new advances and convergence in nanotechnology and molecular biology, biomimetics is now entering a new era whereby materials can be engineered at the ‘molecular’ level with high precision and inherent biological functions.

The Bioinspired Materials Lab (BML) in IMRE is a cross-disciplinary research laboratory which aims to develop new biologically-inspired materials and platform technologies that minimize energy consumption, reduce ecological footprint, and to improve sustainable living for all. In particular, the lab focuses on deciphering the synthetic design principles of biological building blocks by emulating the intrinsic functions of living systems in directing 1) nanomaterial synthesis, 2) biomolecular recognition and 3) self-assembly processes to engineer next generation multifunctional materials and smart devices for a vast spectrum of technological applications.

FOCUS

Biogenic Photoluminescent Nanoclusters & Applications

Biogenic luminescent metal nanoclusters (NCs) templated by rationally designed biomolecules represent a new class of fluorescent nanomaterials that have both biocompatibility and excellent photostability for biomedical applications. We have established the first systematic investigation on the molecular design principles of nucleic acids to control the formation of metal NCs with tunable emission color, and to synthetically endow the NCs with new catalytic properties and anti-microbial functions. We also use this bioinspired approach to ‘turn’ the protein into bioactive fluorescent sensors without genetically encoding the biomolecules.

Major applications

Biosensing and clinical diagnostics, cellular imaging and targeted delivery, antimicrobial and toxin inhibition, ROS detection, wound healing, drug screening, etc.

Building biomolecular ‘toolbox’ towards customisable bioinspired materials design and synthesis- focuses on establishing the fundamental design rules of biomolecular templates for the synthesis of intricate nanostructures with unique biological and tunable physiochemical properties, which results in low energy use and environmental impact.

Developing versatile biosensors through bioregconition and functionalisation by coupling highly specific molecular recognition elements onto synthetic sensing probes to convert ‘invisible’ biological responses into easily measurable/observable outputs for point-of-care diagnostics, high-throughput drug screening and environmental monitoring.

Design of smart self-assembling hybrid materials that can organize into functionally complex architectures and direct the programmable assembly of hetero-nanostructures to build smart materials and devices with improved performance for medicine (e.g., bioactive drug carrier), energy (peptide-assembled solar cell), and electronic (e.g., DNA logic gate).

“Learning from NATURE, Creating New BIOINSPIRED MATERIALS for MANKIND”
Biofunctionalized sensing probes & controlled-assembly

Biofunctionalised metal nanoparticles (mNPs) are powerful sensing probes due to their unique interparticle distance-dependent optical properties that arise from localised surface plasmons resonance. Our efforts in this area are focused on developing bi-directed assembly strategies for biomolecular detection based on the 1) plasmonic coupling (color change), 2) fluorescent quenching and 3) light scattering properties of mNPs in homogenous solution. Through versatile bioassays design, these metal-nanoprobe can be readily adapted in a point-of-care and on-site detection format, which could culminate into tangible products useful for basic sciences, medical diagnostics, drug screening and industrial processes.

Achievement

- **Label-free, simple-to-use, and rapid nanosensors** to detect a wide range of analytes and for studying important biomolecular interactions, such as gene transcription, DNA mutation and enzymatic reaction (5 patents filed & 1 licensed - ColoQuik™ testing kits).

Selected Research Publications

- Tan, YN; Su, X.; Zhu, Y; Lee, JY. “Sensing of Transcription Factor through Controlled-Assembly of Metal Nanoparticles Modified with Segmented DNA Elements.” ACS Nano, 2010, 4, 5101–5110
- Tan, YN; Su, X; Liu, ET; Thomsen, JS. “Gold-Nanoparticle-Based Assay for Instantaneous Detection of Nuclear Hormone Receptor–Response Elements Interactions.” Anal. Chem., 2010, 82, 2759-2765

Selected Patents

- Tan, YN; New, SY; Su, X. “Protein-based Fluorescent Metal Nanoclusters for Drug Screening.” Singapore Patent No. 201306645-1
- Tan, YN; Lim, YC; Wang, C; Zhang LH. “Method of Forming Controlled-Release Silver Nanocluster with Photoluminescent, Antimicrobial and Toxin Inhibition Properties.” Singapore Patent No. 201307789-6

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