

ABSTRACT

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Thesis Title: "Peptide-tethered Naphthalene Diimide and Peptide Amphiphile-Based Functional Soft Materials and Metal Nanocluster-Based Nanohybrids"

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This thesis in general discusses several functional nanomaterials and nanohybrids. More specifically it contains soft materials designed from peptide amphiphiles as well as peptide-conjugated naphthalene diimide and their potential applications in eukaryotic cell culture, designing antimicrobial agents and semiconducting materials. The final part of the thesis describes enhancement of optoelectronic property in a new fluorescent copper nanocluster and titanium dioxide nanoparticle-based nanohybrid system. Peptide amphiphiles containing Histidine in one end, have potential for aggregate in various ways. A histidine-based amphiphile forms clear hydrogel in the pH range of 5.5 to 8.5. The morphology, mechanical strength and thermal stability of this hydrogel is tuned to make this hydrogel capable of acting as a matrix to grow NIH-3T3 fibroblasts and RAW264.7 murine macrophages. This tuning is made possible by making a two-component hydrogel with the peptide amphiphile and succinic acid. The probable model of self-aggregation is proposed using data from powder XRD and FT-IR signatures. Another histidine-based peptide amphiphile is found to form strong metallo-gel in presence of silver nitrate salt. By varying the photo-reduction conditions, it is possible to synthesize both few-atom silver nanoclusters and silver nanoparticles from the same metallo-gel. Enhancement of gel-strength in nanomaterial-included hydrogels can be traced to the fact that all the nanomaterials grow along the hydrogel fibers, thus, facilitating cross-linking between the nano-fibers. These hydrogels are potential antimicrobial agents. Reactive oxygen species (ROS) produced by the nanomaterials, are identified as the main reason of bacteria death. The next study deals with a naphthalene diimide molecule having peptide amphiphiles attached to its imide position and hydrocarbon chain attached to its core. The aggregation study reveals that this molecule shows H and J-type aggregation when non-polar solvents are gradually added to the monomer solvent chloroform. The solvent induced aggregation initially affects H aggregation but finally J aggregation is seen over 9:1 hydrocarbon solvent to chloroform solvent ratio. The morphology changes from nanorods (H aggregate) to nanofibers (J aggregate) in the self-assembly. This molecule is further studied to investigate its semiconducting nature. The current output of this material is tuned by adding various benzene-based π -systems. It is found that more electron rich π -systems makes hybrid systems that show enhancement of current. In the last study, a nanohybrid is formulated using copper nanocluster and TiO₂ nanoparticles and it is characterized by spectroscopic analysis. Positively charged nanoclusters sit inside the Lewis-acidic pore of TiO₂. The photocurrent and dark current of TiO₂ nanoparticles are improved significantly by the nanocluster. Systematic variation of their weight ratio vividly demonstrated that 10% w/w TiO₂-Cu NC hybrid was the most effective current generator. The mechanism of the enhancement is discussed from valence-band XPS and diffused reflectance spectroscopic studies.

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