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Dynamic Nucleic Acid Nanostructures and Systems: From Fundamental Concepts to Applications

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12.00 p.m.

CIC biomaGUNE - Seminar Room

The base sequence of nucleic acids (NAs) encodes substantial structural and functional information into the biopolymer. Structural information includes stimuli-responsive reversible reconfiguration of NAs nanostructures, such as G-quadruplexes, i-motif or triplex assemblies, and functional properties, such as sequence-specific recognition and binding of low-molecular-weight or macromolecular ligands (aptamers) and catalytic functions (DNAzymes). These features of NAs provide the basis for the development of the area of DNA nanotechnology. Our laboratory has developed over the years diverse topics, presenting key elements of DNA nanoscience related to DNA sensing and imaging, DNA switches and machines, NAs-based computing circuits and DNA-based structures. The present lecture will discuss recent advances in the development and applications of nanoparticle/microparticle-DNA hybrid materials, and particularly, introduce dynamic NAs-based materials and circuitries and their potential uses. The following topics will be addressed:

(i) The development of homogeneous/heterogeneous catalysts - NA aptamer conjugates as new nanozymes emulating native enzymes. The application of the aptamer-modified nanozymes as chemotherapeutic agents will be presented. Moreover, the use of NAs-modified metal-organic framework nanoparticles (NMOFs) as nanozymes and stimuli-responsive drug carriers will be addressed.

(ii) The assembly of DNA-based hydrogels as stimuli-responsive materials and their application as shape-memory, self-healing controlled drug release and robotic matrices will be described. Moreover, the synthesis of drug-loaded stimuli-responsive DNA-based hydrogel microcapsules will be presented and their use for controlled drug release and immunogenetic therapy will be introduced.

(iii) The concept of DNA-based constitutional dynamic networks (CDNs) and dissipative, transient, DNA circuitries will be introduced. The application of the networks for gene therapy, dynamically controlled biocatalysis, dynamic nanomedicine (blood clotting and gene therapy), and dynamic coltrol over aggregation/de-aggregation of nanoparticles will be addressed. Moreover, the use of dynamic DNA frameworks to assemble transient DNA- microdroplets, revealing catalytic and evolutionary features, will be introduced as the future challenge of DNA nanotechnology (DNA-based protocells).