

Metabolite and peptide nanotechnology: implications for materials science and biosensing

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The formation of ordered nanostructures by molecular self-assembly of proteins and peptides represents one of the principal directions in nanotechnology. A systematic reductionist approach allowed us to identify extremely short peptide sequences, as short as dipeptides (e.g., diphenylalanine), which could form well-ordered amyloid-like β -sheet-rich assemblies comparable to supramolecular structures made of much larger proteins. The unique physical properties of these assemblies (mechanical, optical, electronic, piezoelectric) allowed their utilization in various technological applications, including the fabrication of ultrasensitive sensors. The ability to increase the surface area of electrodes in orders of magnitude, as well as its functionality, is especially useful for specific and sensitive detection. The use of exceptional helix inducer motifs allowed the fabrication of single heptad repeats used in various bio-interfaces, including their use as surfactants and DNA-binding agents. Two additional directions of the reductionist approach include the use of peptide nucleic acids and co-assembly techniques. In recent years, we have become interested in metabolite self-assembly. Metabolites are immensely important for the routine function of every cell and take part in numerous physiological processes. We discovered that metabolites (including amino acids, nucleobases, sphingolipids, and vitamins) could form ordered assemblies with supramolecular β -sheet-like organization. Metabolite self-assembly has several advantages, including exceptional biocompatibility, inexpensive production, facile modeling, and biodegradability in vivo. Co-assembly of metabolites resulting in high rigidity can be further used in different biomedical and nanotechnological applications. Metal-coordinated metabolite assemblies were also found as exceptional catalysts serving as nano-mimics. We currently explore the utilization of metabolite assemblies for various sensing applications.