

Polypeptide-Based Nanoscale Materials

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Akademisk avhandling

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Abstract

Self-assembly has emerged as a promising technique for fabrication of novel hybrid materials and nanostructures. The work presented in this thesis has been focused on developing nanoscale materials based on synthetic de novo designed polypeptides. The polypeptides have been utilized for the assembly of gold nanoparticles, fibrous nanostructures, and for sensing applications.

The 42-residue polypeptides are designed to fold into helix-loop-helix motifs and dimerize to form four-helix bundles. Folding is primarily driven by the formation of a hydrophobic core made up by the hydrophobic faces of the amphiphilic helices. The peptides have either a negative or positive net charge at neutral pH, depending on the relative abundance of Glu and Lys. Charge repulsion thus prevents homodimerization at pH 7 while promoting heterodimerization through the formation of stabilising salt bridges. A Cys incorporated in position 22, located in the loop region, allowed for directed, thiol-dependent, immobilization on planar gold surfaces and gold nanoparticles. The negatively charged (Glu-rich) peptide formed homodimers and folded in solution at pH < 6 or in the presence of certain metal ions, such as Zn²⁺. The folding properties of this peptide were retained when immobilized directly on gold, which enabled reversible assembly of gold nanoparticles resulting in aggregates with well-defined interparticle separations. Particle aggregation was found to induce folding of the immobilized peptides but folding could also be utilized to induce aggregation of the particles by exploiting the highly specific interactions involved in both homodimerization and hetero-association. The possibility to control the assembly of polypeptide-functionalized gold nanoparticles was utilized in a colorimetric protein assay. Analyte binding to immobilized ligands prevented the formation of dense particle aggregates when subjecting the particles to conditions normally causing extensive aggregation. Analyte binding could hence easily be distinguished by the naked eye. Moreover, the peptides were utilized to assemble gold nanoparticles on planar gold and silica substrates.

Fibrous nanostructures were realized by linking monomers through a disulphide-bridge. The disulphide-linked peptides were found to spontaneously assemble into long and extremely thin peptide fibres as a result of a propagating association mediated by folding into four-helix bundles.

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