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Unprecedented Molecular Architectures by the Controlled Self-Assembly of a β-Peptide Foldamer

Sunbum Kwon[1], Aram Jeon[1], Sung Hyun Yoo[1], Im Sik Chung[2] and Hee-Seung Lee[1*]

[1]Molecular-Level Interface Research Center, Department of Chemistry, KAIST, Daejeon 305-701, Korea
[2]BioNanotechnology Research Center, KRIBB, Daejeon 305-333, Korea
[*] hee-seung_lee@kaist.ac.kr

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Nature utilizes the self-assembly of monomeric units by multiple noncovalent interactions for the construction of complex functional systems. In recent decades, a variety of peptide-based scaffolds, which range from simple aromatic dipeptides to small protein fragments, have been studied in order to understand the underlying mechanism and mimic this process to create artificial nano- and microstructures. However, in contrast to the morphologies found in inorganic nanostructures, the morphologies of the peptide-based self-assembled nano- and microstructures are limited to round shapes such as spheres, tubes, and rods. The ability to construct biocompatible peptide-based molecular architectures with anisotropic shapes should expand the possibilities for the design of molecular machines for diverse applications in biological and materials science. Such a construction should be possible if a molecular design principle for monomeric units held together by comparable intermolecular interactions in three orthogonal directions was available,; however, currently this is not the case.

Recently, we reported the first example of highly homogeneous, well-defined, and finite molecular architectures by the self-assembly of β-peptide. β-Peptides (oligomers of β-amino acids) are excellent artificial peptide frameworks that resemble protein-like secondary structures such as helices, strands and turns. Owing to their rigid and unique conformational features, the self-assembly of β-peptides provided unique morphologies that have not been observed with any other molecular building blocks. We believe that our results will provide a new route for the creation of diverse (chiral) functional molecular complexes as well as give an insight into the underlying mechanism of self-association of natural counterparts.