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Control of Peptide Amphiphile Supramolecular Nanostructures by Isosteric Replacements

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Abstract

Supramolecular nanostructures with tunable properties can have applications in medicine, pharmacy, and biotechnology. In this work, we show that the self-assembly behavior of peptide amphiphiles (PAs) can be effectively tuned by replacing the carboxylic acids exposed to the aqueous media with isosteres, functionalities that share key physical or chemical properties with another chemical group. Transmission electron microscopy, atomic force microscopy, and small-angle X-ray scattering studies indicated that the nanostructure's morphologies are responsive to the ionization states of the side chains, which are related to their pK_a values. Circular dichroism studies revealed the effect of the isosteres on the internal arrangement of the nanostructures. The interactions between diverse surfaces and the nanostructures and the effect of salt concentration and temperature were assessed to further understand the properties of these self-assembled systems. These results indicate that isosteric replacements allow the pH control of supramolecular morphology by manipulating the pK_a of the charged groups located on the nanostructure's surface. Theoretical studies were performed to understand the morphological transitions that the nanostructures underwent in response to pH changes, suggesting that the transitions result from alterations in the Coulomb forces between PA molecules. This work provides a strategy for designing biomaterials that can maintain or change behaviors based on the pH differences found within cells and tissues.

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