doi:10.1017/S1431927621000854
Microsc. Microanal. 27 (Suppl 1), 2021

Biomimetic Self-Assembly and Structural Observation of Amino Acid Nanomaterials using Electron Microscopy

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Self-assembly of small molecules via non-covalent interactions such as ionic bonds, hydrogen bonding, van der Waals interactions, and p-p interactions among aromatic units is regarded as one of the major forces contributing to cellular life. This is due to the fact that having a supramolecular structure is vital for peptides, proteins, DNA, lipids, and other important molecules to maintain their structural integrity and to perform biological functions. Electron microscopic techniques have been widely used to reveal the nanoscale structural features of bio-inspired self-assemblies, which have broadened our understanding of their structure-property relationships in complex biological systems. Electron microscopy has also been applied to observe predetermined self-assemblies of biomolecules for a variety of biomedical applications including drug delivery, gene delivery, tissue engineering, and antimicrobials, as well as bio-inspired ceramic nanostructures, electrochemical sensors, and carbon electrodes. However, recent studies related to neurodegenerative diseases, including Alzheimer's, Parkinson's, chronic traumatic encephalopathy, and phenylketonuria (PKU), have shown that these diseases are likely linked to the nonproteinaceous building blocks which can form amyloid-like fibrils, emphasizing the need for further investigation of the self-assembly of metabolites such as amino acids. In our study, we investigated the self-assembly of both aliphatic and aromatic amino acids including phenylalanine, which is directly related to PKU. We also determined the effects of anaerobic conditions on the self-assembled nanostructures by observing the changes in structural and stability properties in different self-assembly conditions. Using scanning electron microscopy, we were able to demonstrate concentration dependent formation of amino acid self-assemblies consisting of nanofibers and nano-plates. Moreover, we explored the potential of nano-porous networks that we obtained from self-assembly of phenylalanine as an effective face mask component against air-borne pathogens.

Acknowledgments

The research work is supported by the Office of the Assistant Secretary of Defense for Health Affairs and Department of Energy. The authors acknowledge the use of the WVU Shared Research Facilities. Opinions, interpretations, conclusions, and recommendations are those of the authors and are not necessarily endorsed by the funding agencies.

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https://doi.org/10.1017/S1431927621000854 Published online by Cambridge University Press