Abstract

Living organisms are among the finest architectures made by the Master Craftsman 'Nature', through the utilization of self-assembling strategy. The present thesis unveils the effort of small bioactive molecules to form self-aggregated architecture under the influence of the non-covalent interactions. Using high-end spectroscopic and microscopic tools we have gained prominent understanding about the morphological information together with the microenvironment of the self-aggregated species. The inherent ability of the small molecules to form this higher-order architecture is not necessarily a blessing; sometimes it creates a nuisance. We decipher that small polyphenolic molecules like gallic acid (GA) and methyl gallate (MG), have the ability to form supramolecular architecture. Exploiting fluorescence lifetime imaging microscopy (FLIM), we have gain the microenvironment information in the form of lifetime of the fluorophore. We found that because of their well-formed packing the anticancer activity of the polyphenolic molecules has been greatly reduced. Interestingly, when these two polyphenolic molecules are present at equivalent molar ratios the cross-assembly displays significant deviation both in terms of morphology and local environment. Moreover, their imperfect packing crumbles under the physiological conditions, resulting a greater activity being found over the solo-polyphenols. Further, we chose the MG, as a low-molecular-weight (LMW) hydrogelator, to construct hydrogels without involvement of any cross-linking agents. Along with molecular dynamic (MD) simulation, sophisticated spectroscopic and microscopic studies provide the underlying molecular mechanism behind the assembly. We introduced ultrasound to facilitate the hydrogelation. This LMW hydrogel exhibits strong antibacterial activity, with good biocompatibility and hemocompatibility, making it suitable for therapeutic applications. Next, we modulate the hydrogelation process of another single-amino acid derivative compound, Fmoc-Methionine, by employing the solvent engineering strategy. This provides the generation of various hydrogels with different optical and mechanical properties, which could be utilized to develop a matrix for 3D cell culture assay. Moreover, this solvent engineering process doesn't hamper the inherent properties of the small molecule itself. Therefore, the current studies in this thesis, provides significant insights to develop several materials that could be applicable in various therapeutic scenarios.

Keywords: Self-assembly, Polyphenols, Hydrogels, Cell Culture, Bacteria Culture, Cancer