Density Functional Theory-Based Study of the Stacking Interaction between Lumiflavin and Delocalized π-Electronic Systems

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Flavins are tricyclic heteronuclear organic ring systems. They are the primary electron-proton mediatory group in many oxidoreductases including quinone reductases. The versatility of chemical reactions in flavoenzymes originates, in part, due to the tuning of flavin's redox energetics by enzyme matrix through several non-covalent interactions.[1-3] They include H-bonding, electrostatics, and π-π stacking interaction types. In this study, aromatic π-π stacking interactions between flavin and a number of π-electron rich molecules have been investigated by density functional theory using several new-generation density functionals. These improved functionals are built with various amounts of Hartree-Fock exchanges to improve non-local effects beyond short-range interactions. The models were evaluated by comparing the geometry and energetics with experimental results. The functional producing best energetics for flavin system was then used to study the kinetics of a hydride transfer reaction of flavin with N-methyl nicotinamide in water using implicit solvation. Finally, a comparison of performance was made between the DFT and computationally less expensive self-consistent density functional tight-binding (SCC-DFTB) theory, where the hydride transfer kinetics was studied using explicit solvent. The opportunities and difficulties with these two theoretical frameworks to model larger systems like flavoenzymes will be presented.

References

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