Computational Study of Styryl-based Dyes for the Development of Novel Biomarkers of RNA

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Abstract

The localization of RNA molecules in living cells is important because it is directly related to the localization of the respective translated proteins. This motivated research on developing molecules and techniques to selectively visualize RNA in specific parts of the cell. One widely used method is the fluorescence *in situ* hybridization (FISH). FISH employs fluorophore-linked RNA probes, which bind to the RNA targets in the cell[1]. Fluorescence imaging can then provide a picture of the regions of the cells where the target RNA is localized by measuring the fluorescent emission of the fluorophore. The ideal chromophores for *in vivo* experiment should exhibit absorption at wavelengths compatible with the cell transparency, high quantum yield, bright emission, and should be resistant to photobleaching. We performed electronic structure calculations to study the spectral properties of a group of styril-based molecules that can be potentially used as RNA biomarkers. We computed electronic transitions and analysed the state and transition properties of the lowest bright excited state. The analysys of the one-particle transition density matrix (1TDM) and natural transition orbitals (NTOs) allowed the characterization of the electronic transitions. From the absorption and emission spectra we estimated the intrinsic fluorescence lifetimes and Stokes shifts. All excited-state calculations were performed at the DFT/ωB97X-D/aug-cc-pVTZ level of theory for isolated chromophores and in solvent environments. The effect of the environment was described by an implicit solvent method using the polarizable continuum model (PCM) for water, DMSO, and DNA[2]. Our results show that all chromophores exhibit bright low-lying electronic tranistions in the visible range. Based on the analysis of the 1TDM and NTOs, we can assign the character of these transitions to be either charge-transfer or local excitation. The chromophores with charge-transfer states have the largest Stokes shifts and the longest intrinsic fluorescence lifetimes. Starting from these results we can further functionalize the current set of chromophores to make them suitable for experiment *in vivo*.

References

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