

Probing Low-Barrier Hydrogen Bonds in Biologically-Relevant Systems with Low-Frequency Vibrational Spectroscopy and Quantum Mechanical Simulations

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Without question, hydrogen-bonding interactions play a pivotal role in the functioning of biological processes, such as enzymatic catalysis and protein folding. Hydrogen bonds have a diverse range of strengths and geometries, with biological reactions relying on the specific interaction in order to proceed as intended. Over the last several decades, the role that low-barrier hydrogen bonds play has been debated, with conflicting reports over their importance having been recorded. In this work, low-barrier hydrogen bonds are investigated in biologically-relevant small-molecule model materials representative of larger (and more complex) systems using a combination of low-frequency vibrational spectroscopy and *ab initio* simulations. Low-frequency radiation has the advantage of probing large-amplitude motions of entire molecules within a material, thus probing the intermolecular and intramolecular potential energy surfaces simultaneously. By understanding the weak interactions within these materials, the role that the low-barrier hydrogen bonds play on the bulk interactions can be obtained, and the results indicate that these phenomena are intimately connected. Furthermore, the coupling of first-principles simulations to the experimental low-frequency spectroscopic results provides a framework for validating the theoretical model, lending valuable confidence to the calculated data. Overall, this study provides a means of capturing and quantifying the role played by low-barrier hydrogen bonds, and lends itself to deeper investigation into more complex materials.