Reply to Comment on "Electron-Correlated Calculations of Electric Properties of Nucleic Acid Bases"

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In the preceding paper,[1] Hobza, Sponer, and Leszczynski have commented on our recent paper.[2] In response, we would like to offer the following observations:

Hobza, Sponer, and Leszczynski are obviously right in pointing out our failure to clearly indicate that *some* of their calculations were performed with the modified rather than the standard 6-31G* basis set.[3-8] But contrary to what they wrote in their original comment, it was not always "clearly stated in all of (their) papers" as, for instance, in the introduction to ref 5 they wrote that "the calculations were made at the MP2/6-31G* level of theory", referring to their earlier work[3] which appeared to have utilized the modified basis set. Furthermore, they failed to acknowledge in their comment[1] that some of their calculations *were* performed[4,8] with the standard 6-31G* basis set, which we examined and found to be deficient. We did not examine all possible derivatives of the 6-31G basis set because we considered it to be of secondary importance. As Hobza et al. write,[1] "it is well known that the standard 6-31G* basis set underestimates significantly the polarizability...". We did not even perform 6-31G** polarizability calculations for all of the bases as clearly stated in our paper.[2] We noted that the standard 6-31G** basis set underestimated the components of dipole polarizability "by as much as 40%", which should be considered as the rough upper limit on the error with respect to results obtained with Sadlej's basis set. Their modified 6-31G* basis set gives errors of "only" 20%, which, fortunately, is below our limit. Unfortunately, despite the beneficial effect of the diffuse d function, the modified basis set still remains deficient. We want to emphasize that our values of the electric properties of nucleic acid bases, while perhaps the most accurate to date, certainly did not reach the basis set limit and may be in error by another 10% or more at a given level of theory.

Our comment about the underestimation of the stability of the stacked configuration with respect to the H-bonded one applied to the MP2 results as only those were available at the time our publication was submitted. Sponer and Hobza themselves wrote that "For comparison of the H-bonded and stacked pairs we believe that the MP2 level is sufficient to provide reliable relative stabilization energy values. We are at least not aware of any evident failure of the MP2 procedure in this respect."[3] Our "misleading" conclusions were influenced by the MP2 results of Hobza and Sponer as epitomized in the preceding two sentences. To be more precise, our reasoning went as follows: the differences between the values of multipole moments obtained with the standard 6-31G** and Sadlej's basis set are not very significant whereas polarizabilities are quite profoundly affected as our calculations and those of Hobza et al.[1] show. We can therefore expect the dispersion energy to be more significantly affected than the electrostatic energy. The UCHF dispersion energy, which is a part of the MP2 supermolecule energy,[9] is a variational quantity[10] so it is not difficult to predict how it is going to behave when the quality of the basis set is improved. The newest results of Sponer and Hobza[11] obtained at the CCSD(T) level of theory appear to contradict not only one sentence from our publication but quite a few works of their own.[3-8] Furthermore, their newest data do not vindicate the quality of their previous results and their basis set but point to the fortunate (or unfortunate) cancellation of errors. We do not know what basis sets were used in those calculations (the modified 6-31G* certainly is not the best choice), but knowing the present limitations of both hardware and software there is no doubt that the newest results of Sponer and Hobza certainly did not reach the basis set limit, and treating these results as the ultimate truth is inappropriate. It is well known[9,12] how difficult it is to saturate the dispersion energy, and it may take a while longer before we know the "real" relative importance of stacking and H-bonded interactions in nucleic acids.

References and Notes

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