Electronic polarization induced by high solvent pressure

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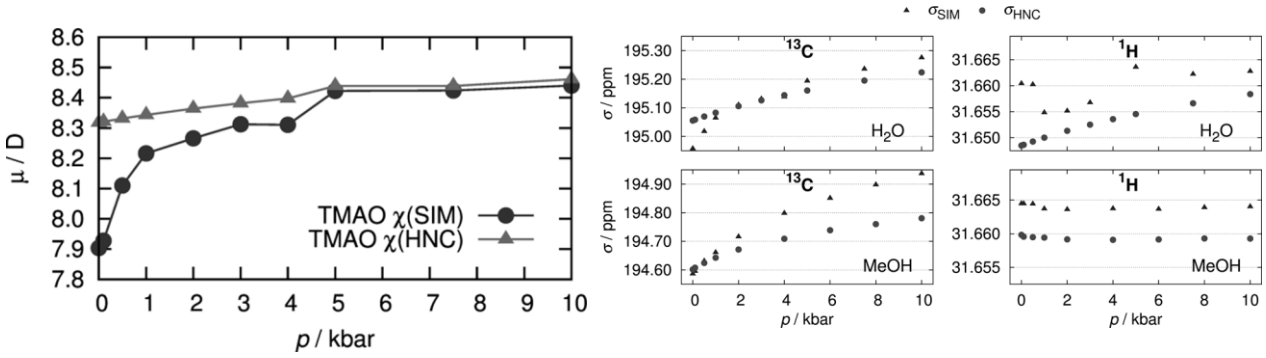
Biochemical processes of a vast number of lifeforms accommodated to extreme conditions such as deep oceanic water depend on the subtle interplay of solvent components. For instance, trimethylamine-*N*-oxide (TMAO) is known to stabilize proteins under high hydrostatic pressure conditions [1] which is barely understood. Applying high hydrostatic pressure has substantial impact on free energy surfaces underlying biological function. This poses a challenge to computational modelling approaches since the applicability of conventional empirical molecular force fields is questionable.

As a step toward clarifying the situation, we need to account for high pressure in quantum-chemical (QC) calculations. A suitable methodology is provided by the "embedded cluster reference interaction site model" (EC-RISM) [2,3] that combines statistical-mechanical 3D RISM integral equation theory and QC calculations. In this context the impact of pressure is introduced by using solvent susceptibility functions containing all pressure dependent properties.

Here we illustrate the methodology for several examples in a pressure range of 1 bar up to 10kbar to demonstrate the relevance of electronic polarization under extreme pressure conditions. In particular, it is shown that the TMAO dipole moment increases strongly with high pressure, which turns out to be decisive for constructing force field parameters suitable for high pressure simulations [4] as well as for interpreting pressure-dependent vibrational spectra. Furthermore, evidence is found that high-pressure NMR (nuclear magnetic resonance) experiments on proteins measure an intrinsic, polarization-related chemical shift baseline which has to be accounted for if conformational transitions are correlated with chemical shift variations [5].



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