New Tight-Binding Quantum Chemistry Methods for the Exploration of Chemical Space

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The GFN-xTB family of semi-empirical tight-binding methods, which are variants of the well-known DFTB approaches, is introduced. The methods follow a global and element-specific parameters only strategy and are consistently parameterized for all elements through radon. Their original purpose and main target for the parameter optimization has been the computation of molecular geometries, vibrational frequencies, and non-covalent interactions. Very recently, the original GFN-xTB has been extended by including multipole electrostatic as well as one-center exchange-correlation terms leading to higher accuracy (at lower empiricism) specifically for non-covalent interactions and conformational energies[1]. A new, much faster (speedup of 3-5) first-order form employing classical electrostatics is briefly described (GFN0-xTB) The most sophisticated GFN2-xTB approach which furthermore employs density dependent D4 dispersion, is effectively used in the framework of meta-dynamics (MTD) to globally explore chemical compound, conformer, and reaction space[2]. The biasing potential given as a sum of Gaussian functions is expressed with the RMSD in Cartesian space as a metric for the collective variables. For typical conformational search problems of organic drug molecules, the new MTD(RMSD) algorithm yields lower energy structures and more complete conformer ensembles at reduced computational effort. Because TB methods (when combined with the Fermi-smearing technique) can also describe difficult electronic situations at least qualitatively correct, chemical reaction space exploration in a virtual nanoreactor also for transition metal containing systems is routinely possible.

References:
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