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Materials Science of Molecular and Ionic Condensed Matters

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Electronic charges and molecular forces frequently play important roles in the structure formation of high-temperature plasmas and ionic soft condensed matters, including nano-sized materials and cellular processes in biology. A counter-intuitive phenomenon that the like-sign charges attract and aggregate can occur primarily in liquid at room temperature; this is due to strong electrostatic interactions via multivalent counterions (the ions with opposite charges with respect to the central ion).

Here, I present two such cases, the etching process of material surface (graphite) through hydrogen adsorption, and the charge inversion (over-screening) phenomena which can be applied to gene delivery of negatively charged DNA to cells. In the former study, the ***ab initio*** (quantum mechanics based) molecular dynamics simulation is used, which shows that graphite adsorbs hydrogen atoms through intermolecular forces. This hydrogen adsorption deteriorates carbon-carbon bonds, forms carbon-hydrogen bonds and makes hydrocarbon molecules. In the latter case, macroions attract a large number of oppositely charged counterions so that the formed aggregates are stable and reversely charged with respect to the bare macroions. It should be noted that, for this process, charge neutralizing light *free electrons* are not present, and the electrostatic interactions between ions prevail over diffusive thermal motions because of the Angstrom to nanometer (atomic) scale sizes.

*Many related references are in URL: http://dphysique.nifs.ac.jp/