Engineering DNA conductivity: can we? by what mechanisms? and to what end?

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Through a very recent set of experiments, we show that it is possible to molecularly engineer DNA conductivity [1]. Much like the way to dope semiconductors, foreign ("impurity") ions are added into the DNA molecule to alter its conductivity. Unlike the semiconductor doping process, the added ion is self-guided to the target site – the imino proton between the double strands of each base pair. Once there, the ion inserts itself into that site. The engineered DNA exhibits a many-fold increase in conductivity, to the extent of becoming metallic upon complete substitution.

By what mechanisms does DNA conduct? And, therefore, how might we find other new degrees of freedom in engineering DNA? These are among the questions motivating our on-going investigations on this new front. We perform a comparative analysis of plausible conduction mechanisms responsible for the charge transport in different types of DNA macromolecules. Transition from the wide- to narrow-bandgap semiconductor-like behavior observed for short DNA oligomers and native λ-DNA macromolecules is shown to likely arise from the internal disorder characteristics of λ-DNA with virtually random nucleotide sequences. Substitution of imino protons with metal divalent cations in the process of M-DNA synthesis is thought to result both in the DNA structure stabilization and in the transformation of electronic bands which leads to the M-DNA metallic-like conductivity. Changes in conduction mechanism of M-DNA under reversible conversion into B (λ)-DNA form are discussed and possible applications for DNA-based nanoelectronics are briefly outlined.

[1] A. Rakitin, P. Aich, C. Papadopoulos, Yu. Kobzar, A. S. Vedeneev, J. S. Lee, and J. M. Xu, "Metallic conduction through engineered DNA: DNA nanoelectronic building blocks", *Phys. Rev. Lett.* **86**, 3670 (2001).