

Electric Conductivity Based DNA Sensor for Sequence-specific DNA Recognition

J.J. Toppari*, S. Tuukkanen, V. Hytönen, A. Kuzyk, J. Virtanen, M.S. Kulomaa, P. Törmä

NanoScience Center, University of Jyväskylä, P.O. Box 35 (YFL), FIN-40014 University of Jyväskylä, Finland

During the past few years electrical properties of double helical DNA have been studied widely. However, the experimental results obtained by several different methods seem controversial. The charge transport along the double helical DNA has been found to be very sensitive to quality of the π -stacking of base pairs. So a single base pair mismatch decreases electrical conductivity critically. This property of DNA could be used in sequence-specific recognition of DNA.

We are developing a nanoscale thin film based DNA sensor, where the vertical edges of the metal-insulator-metal multilayer structure are used as an active region. Sequence-specific recognition of DNA is done by monitoring the completeness of a forming double helix structure between the separated gold electrodes during the assay. This again can be done by measuring the electrical conductivity between the electrodes. The sensor can also be used for studying the conductivity of DNA giving essential information related to its potential use as a component of future electronics.

Since DNA-based pharmacological methods are becoming more popular, this kind of DNA sensor has obvious applications in biological and medical analysis. The method has two major advantages compared to present DNA analysis methods: The copying of DNA with PCR is not needed because the forming of the double helix structure could be observed with only few target DNA strands. Secondly, the detection of a single mismatch, which is very difficult by using present methods, would be relatively easy because the electrical conductivity has a high π -stack sensitivity.

As preliminary experiments we have guided the synthetic thiol-modified oligonucleotides with DC electric field and attached them to the gold surface via thiol-groups. Observation of successful guiding and attaching was done using scanning electron microscopy and complementary oligonucleotides which were linked to the surfaces of gold nanoparticles. Since DNA in an aquatic solution is highly polarisable, also dielectrophoresis (DEP) can be used in trapping and orientating. We have also tried this method with AC electric field to suppress the guiding due to static electrophoresis.

* Corresponding author.

Email address: jussi.toppari@phys.jyu.fi (J.J. Toppari).