Simple Detection of Binding Events Using an Anchoring Transition of Liquid Crystals on the Immobilized oligoDNAs

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To detect biological events, biosensors require a transducer part where specific biomolecular binding events at a bioreceptor part is converted to measurable quantitative signals. Currently, most of biosensors adopt a fluorescent or radioactive probing technique as a transducer. However, such approaches require expensive and sophisticated analysis procedures with laboratory-based equipment. In this work, we propose a novel method for optically detecting hybridization results in a deoxyribonucleic acid (DNA) chip using an anchoring transition of liquid crystal (LC) alignment. To investigate the effects of structural changes of DNA on the LC alignment, we used a functional substrate on which single-stranded oligonucleotide DNA (ssDNA) was selectively immobilized to a Biotin Chip substrate. In our experiment, we used a 19-mer oligoDNA or p53 tumor suppressor as a bioreceptor and its complementary partner oligoDNA as a target material. Before hybridization, surface nematic LC (NLC) molecules on the immobilized ssDNAs are homeotropically aligned by a steric interaction between the freely penetrated NLC molecules and the ssDNA. After hybridization, the penetration of the NLC molecules is hindered by the double strand DNA (dsDNA) due to their increased packing density. Such an interface condition makes the surface ordering of the NLC molecules very weak, as a result, the NLC in the bulk has a planar inhomogeneous orientation. Although hybridization events of the DNA and the subsequent molecular interaction between the immobilized DNA and the NLC molecules takes place within a layer whose thickness is in the tens of nm, such binding events can be communicated to the NLC bulk beyond a distance of tens of ?Ým though the long-range elastic deformation of the NLC molecules. Thus, the hybridization event is converted to amplified optical signals via birefringent nature of the NLC between crossed polarizers. Our NLC-based DNA chip array showed that the extinction ratio of transmitted light depending on the hybridization results was approximately four, which could be read by the naked eye. Since such anchoring behaviors on the immobilized DNA are very similar to those on the conventional amphiphilic homeotropic surfactant of LCs, it is expected that quantitative analysis of hybridization events can be explored with our simple system.

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