Detecting Lyme disease using antibody-functionalized single-walled carbon nanotube transistors

Abstract:

We developed a novel detection method for osteopontin (OPN), a new biomarker for prostate cancer, by attaching a genetically engineered single-chain variable fragment (scFv) protein with high binding a!nity for OPN to a carbon nanotube "eld-e#ect transistor (NT-FET). Chemical functionalization using diazonium salts is used to covalently attach scFv to NT-FETs, as con"rmed by atomic force microscopy, while preserving the activity of the biological binding site for OPN. Electron transport measurements indicate that functionalized NT-FET may be used to detect the binding of OPN to the complementary scFv protein. A concentration-dependent increase in the source!drain current is observed in the regime of clinical signi"cance, with a detection limit of approximately 30 fM. The scFv-NT hybrid devices exhibit selectivity for OPN over other control proteins. These devices respond to the presence of OPN in a background of concentrated bovine serum albumin, without loss of signal. On the basis of these observations, the detection mechanism is attributed to changes in scattering at scFv protein-occupied defect sites on the carbon nanotube sidewall. The functionalization procedure described here is expected to be generalizable to any antibody containing an accessible amine group and to result in biosensors appropriate for detection of corresponding complementary proteins at fM concentrations.