CARBON NANOTUBE BASED ION SELECTIVE FIELD EFFECT TRANSISTORS

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In this communication we report a novel type of ion selective field effect transistors (ISFETs).They incorporate a network of carbon nanotubes as transduction layer, and do not need an external reference electrode.

ISFETs were first reported in 1970.[1] They are potentiometric sensors, of the family of chemically modified field effect transistors (CHEMFETs), and have several similarities to the well known ion selective electrodes (ISEs). ISFETs are based on an ion selective membrane that replaces the gate electrode in metal oxide field effect transistors (MOSFET). The membrane is able to selectively detect ions in solution. Nowadays, the future of ISFETs is compromised by the difficulty of miniaturizing the necessary external reference electrode. Another technical problem is the instability associated to the interface between the membrane and the transducer electronics due to the conversion of the ionic current to an electronic one.

Dekker et al[2] successfully integrated a carbon nanotube (CNT) as the semiconductor element into a field effect transistor in 1998. As CNTs are very sensitive to minimal variations in their chemical environment their usefulness in sensing devices is enormous. One of their drawbacks, however, is that they have to be effectively isolated from interferences to be selective enough and even specific to the target analyte. In the last years, sensors based on carbon nanotube field effect transistors (CNTFETs) have appeared.[3-5] All of these sensors link the sensory layer to the CNT transducer by means of either weak forces or covalent bonds. In this way, different kinds of analytes can be detected, but they are all medium-large. The selectivity is achieved by covering CNTs, covalently or noncovalently, with molecules that have a specific molecular recognition receptor and introducing blocking reagents to prevent non specific binding.

In the present communication we report the development of a CNT based ISFET selective to potassium. We cover the carbon nanotubes with a membrane containing valinomycin in a matrix of polyvinylchloride (PVC). This membrane has already been demonstrated to be effective in the ISFET technology.[6] With this device we are able to selectively detect concentrations of 10^{-7}M of potassium in the presence of interferences that do not influence on the instrumental response.

The advantages of this CNTFET device are clear. On the one hand, we take advantage of the nanotubes so that the reference electrode does not have to be used, and the sensitivity of the system is good. This is an effective way of miniaturizing the ISFET technology. On the other hand, the ion selective membrane covering the CNTs operates as an isolation layer, which effectively shields the CNTs from the presence of the small charged ions or polar molecules in solution.

References:

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