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Silicon Nanowires Fluorescence Sensor for Cu(II) Ion

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Extended Abstract

With high surface to volume ratio, high stability, easy modification and biocompatibility, silicon nanowires (SiNWs) have been widely capitalized to develop various sensors for the chemical and biological detection (Shao et al., 2010). Most of these sensors are based on electrical and electrochemical methods (Cui et al., 2001). A sensor based on the optical signal detection may provide some advantages, such as immune to electromagnetic noise and ease of data acquisition and transfer through an optical fibre, avoiding double electrode in electrochemical detection. Among optical signal detections, fluorescence detection is of high sensitivity, high-speed spatial analysis of the cells and the less cell-damaging means of the visualizing analytes in the living cells (Giepmans et al., 2006). Cu(II) is a very important element for hemopoiesis, metabolism, and immune system and its detection is essential and popular. Although a variety of fluorescent agents for Cu(II) have been reported, most of them were based organic molecules in solution, which were usually suffered from water-fast, complicated synthesis and unavoidable hydrolysis by intracellular esterase when used as cellular imaging agent. By grafting these organic molecules onto the surface of the SiNWs, these organic molecules could easily enter into a cell without hydrolysis by intracellular esterase and especially could be oriented to the special part of the cell by inserting the one-dimension nanomaterials into the cell(Yun et al., 2010). In this study, the fluorescence sensing molecules were immobilized onto the surface of the SiNWs to form SiNWs-based fluorescence sensors for Cu(II).

Firstly, the SiNWs were covalently modified by fluorescence ligand, N-(quinoline-8-yl)-2-(3-triethoxysilyl-propylamino)-acetamide (QlOEt) and finally formed a "turn-off" fluorescence sensor to realize a highly sensitive and selective detection for Cu(II). The QlOEt-modified SiNWs sensor has sensitivity for Cu(II) down to 10-8M, which is more sensitive than QlOEt alone. Metal ions interferences have no observable effect on the sensitivity and selectivity of QlOEt-modified SiNWs sensor. The SiNWs-based fluorescence sensor is reversible by addition of acid to replace Cu(II).

However, in some special case, the sensor based on fluorescence quenching is inconvenient to detect trace metal ions due to the interference from other quenchers. Therefore, we further prepared a "turn-on" fluorescence sensor for Cu(II) by covalently immobilizing the rhodamine 6G (R6G) derivatives onto the surface of the SiNWs. The R6G-modified SiNWs released the R6G molecular from the SiNWs in the presence of Cu(II), which causes a significant enhancement of the fluorescence over other metal ions such as Li+, Na+, K+, Mg2+, Pd2+, Hg2+, Mn2+, Zn2+, Co2+, Ni2+, Ag+ etc. The presence of 10 equivalents of other metal ions has no significant influence on the response of the R6G modified SiNWs to Cu(II). The present Cu(II) sensor exhibits a linear response in the range of 0.0-7.0□M Cu(II).

Taking into account of the biocompatibility of SiNWs, the SiNWs modified with the R6G derivatives could be inserted into a single cell and exhibit a fluorescence response by releasing a fluorophore at specific location where Cu(II) exists. The current sensor structures may be extendable to other chemo- and biosensors, and even to nanosensors for direct detection of specific materials in intracellular environment.

References

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