

A Polyaniline Nanowire Network with Catalytic Nanoparticles for Chemical Sensing

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One-dimensional conducting polymer nanowires have become the material of interest especially in sensor applications due to their unique electronic properties and their potential to be fabricated into high density and high throughput nanoscale devices [1]. Polyaniline nanowires are particularly interesting due to the ease of synthesis, environmental stability, and tunable conductivity caused by pH change in acidic media.

Although the conductivity of polyaniline is pH-responsive, one of the major issues with polyaniline-based chemiresistive sensor is its lack of selectivity toward the chemical species of interest. One way to tackle this problem is to create a chemical reaction with the target analyte near the polyaniline nanowires which will generate either protons or hydroxyl ions as a by-product. The production of such ions will locally change the pH level in the vicinity of polyaniline nanowires whose conductivity will be altered as a consequence.

In this work, we propose the use of catalytic nanoparticles on the surfaces of polyaniline nanowires to cause catalytic reactions with target molecules of interest. If protons are generated as a result, the resistance of polyaniline nanowires will drop due to the lowering of the local pH. On the contrary, if hydroxyl ions or water are generated by catalysis, the resistance will rise due to the increased local pH level.

To demonstrate and to prove the proposed concept, we have chosen iron oxide (Fe_3O_4) nanoparticles as catalysts for the selective detection of hydrogen peroxide as illustrated in Figure 1. Fe_3O_4 nanoparticles are known to catalytically oxidize hydrogen peroxide to generate hydroxyl ions and radicals as by-products [2], which would reduce the conductivity of the polyaniline nanowires.

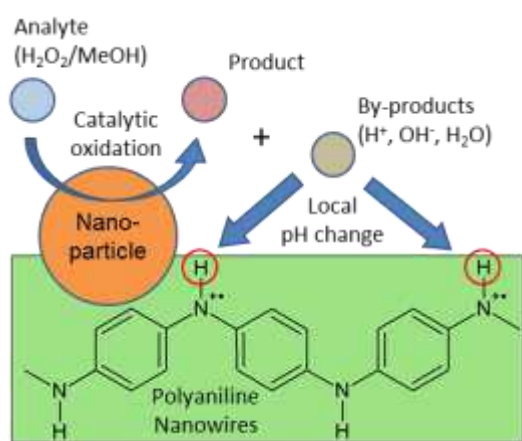


Figure 1: Schematic diagram illustrating the mechanism of catalyst-assisted selective detection of target molecules using polyaniline.

The polyaniline nanowire network bringing two electrodes were prepared by electrochemical synthesis as

reported our previous work on a pH sensor [3]. Figure 2 shows the result of H_2O_2 detection with polyaniline with Fe_3O_4 nanoparticles and its comparison with pure polyaniline without nanoparticles. Clearly, the Fe_3O_4 deposited sensor shows a greater current drop than pure polyaniline sensor, which might be caused by OH^- ions from catalytic reactions.

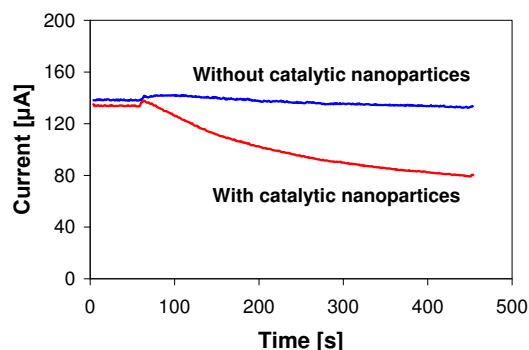


Figure 2: Comparison of polyaniline-based sensor response to 3% H_2O_2 with and without the presence of Fe_3O_4 catalysts. At $t = 60$ s, a fixed volume of 3% H_2O_2 solution was added to pH 5 buffer.

We have demonstrated the feasibility of enabling selectivity to a polyaniline-based chemical sensor by functionalizing the polymer nanowires with nanoparticles that possess catalytic activity with certain chemical species. Multianalyte detection could be possible with a sensor array with each sensor having a specific catalyst. The concept can further be expanded for a generic sensor array by introducing protonating or deprotonating catalyst responding to specific target molecules of interest.

References

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