

All materials were characterized by ^1H NMR, FTIR, and Mass Spectrometry. Elemental analyses were consistent with the proposed structures. Self assembled monolayers of ferrocenyl ferraazetine disulfide were obtained by dipping Au electrodes into 1 mM ferrocenyl ferraazetine disulfide/hexane solutions. Subsequent exposure of the ferrocenyl ferraazetine disulfide treated electrodes to 1 mM hexane solutions of reference molecule, ferrocenyl dithiol, resulted in adsorption of the reference molecule onto the electrode surface. A 1:1 sensor:reference molecule surface coverage was achieved for a three minute exposure time, as shown in FIG. 6, demonstrating the CO dependent cyclic voltammetry of an Au macroelectrode (0.02 cm^2) modified as described. Upon exposure to CO, the reference wave (the wave at more negative potential) which is insensitive to CO remains constant in potential, whereas the indicator wave shifts 120 mV positive.

Preliminary studies indicate that a comparable effect may be observed with a microelectrode device operated as a two terminal device using a solid electrolyte such as poly[bis(2-(2'-methoxyethoxy)ethoxy) phosphazene] (MEEP)/ LiCF_3SO . The latter demonstrates a two terminal solid state gas sensor for CO.

Au electrodes derivatized with thiol reagents are quite robust, but obviously long term durability is an issue in many sensor applications. Sensor electrodes described in examples 1 to 3 have been used intermittently over a period of several weeks with reproducible response to variation in pH. The two-terminal, voltammetric microsensor is self-assessing, in that failure of the device-active materials is revealed by an inability to detect current peaks.

Modifications and variations of the sensor devices and methods of preparation and use thereof will be obvious to those skilled in the art from the foregoing description. Such modifications and variations are intended to come within the scope of the appended claims.

We claim:

1. An two-terminal voltammetric electrochemical sensor comprising:

a working, electrode comprising surface confined chemically sensitive redox material and chemically insensitive redox material in a thickness functionally equivalent to that of a monolayer, wherein the two materials act as terminals and

a counterelectrode having a surface area at least 10^2 larger than the surface area of the working electrode.

2. The sensor of claim 1 further comprising means for measuring a difference in redox potential between the chemically sensitive redox material and the chemically insensitive redox material.

3. The sensor of claim 2 wherein the measuring means applies a linear sweep of applied voltage to the sensor

and detects the difference in separations between changes in potential of the two redox materials.

4. The sensor of claim 1 wherein the conductivity of the chemically sensitive redox material changes in response to changes in pH and the conductivity of the chemically insensitive redox material does not measurably change in response to changes in pH.

5. The sensor of claim 1 comprising more than one different chemically sensitive redox materials.

6. The sensor of claim 1 wherein the electrode is formed on an inert, electrically conductive material selected from the group consisting of platinum, gold, silver, palladium, carbon, tin doped indium oxide, tin oxide and combinations thereof.

7. The sensor of claim 1 wherein the electrode is formed of an inert, electrically conductive material on a chemically inert, electrically insulating material.

8. The sensor of claim 1 wherein the redox materials are electroactive molecules with functional groups that bind or coordinate to the electrode surface.

9. The sensor of claim 1 wherein the redox materials bind or coordinate to another material confined to the electrode surface.

10. A method for making a two-terminal voltammetric sensor comprising

forming a working electrode having a chemically sensitive redox material and a chemically insensitive redox material confined on the surface of an electrically conductive substrate in a thickness functionally equivalent to that of a monolayer, wherein the two materials act as terminals, and a counter electrode having a surface area at least 10^2 larger than the surface area of the working electrode.

11. The method of claim 10 further comprising placing the electrode in an environment where a change in chemical concentration is to be detected, applying means for measuring a difference in redox potential between the chemically sensitive redox material and the chemically insensitive redox material to the electrode, and measuring a difference in redox potential as a function of the change in chemical concentration at the electrode.

12. The method of claim 11 further wherein a linear sweep of voltage is applied to the sensor and the difference in separations between changes in potential of the two redox materials is measured.

13. The method of claim 10 wherein the conductivity of the chemically sensitive redox material changes in response to changes in pH and the conductivity of the chemically insensitive redox material does not measurably change in response to changes in pH, further comprising detecting changes in pH.

14. The method of claim 10 wherein the microelectrode comprises more than one different chemically sensitive redox materials, further comprising measuring changes in chemical concentration of more than one species.

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