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TiO_2 Nanotube Array Based Selective Vapor Sensors for Breath Analysis

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Abstract : Breath analysis is a quick, noninvasive and inexpensive technique for disease diagnosis can be used on people of all ages without any risk. Only a limited number of volatile organic compounds (VOCs) can be associated with the occurrence of specific diseases. These VOCs can be considered as disease markers or breath markers. Selective detection with specific concentration of breath marker in exhaled human breath is required to detect a particular disease. For example, acetone (C_3H_6O), ethanol (C_2H_5OH), ethane (C_2H_6) etc. are the breath markers and abnormal concentrations of these VOCs in exhaled human breath indicates the diseases like diabetes mellitus, renal failure, breast cancer respectively. Nanomaterial-based vapor sensors are inexpensive, small and potential candidate for the detection of breath markers. In practical measurement, selectivity is the most crucial issue where trace detection of breath marker is needed to identify accurately in the presence of several interfering vapors and gases. Current article concerns a novel technique for selective and lower ppb level detection of breath markers at very low temperature based on TiO_2 nanotube array based vapor sensor devices. Highly ordered and oriented TiO_2 nanotube array was synthesized by electrochemical anodization of high purity tatinium (Ti) foil. 0.5 wt% NH_4F, ethylene glycol and 10 vol% H_2O was used as the electrolyte and anodization was carried out for 90 min with 40 V DC potential. Au/TiO_2 Nanotube/Ti, sandwich type sensor device was fabricated for the selective detection of VOCs in low concentration range. Initially, sensor was characterized where resistive and capacitive change of the sensor was recorded within the valid concentration range for individual breath markers (or organic vapors). Sensor resistance was decreased and sensor capacitance was increased with the increase of vapor concentration. Now, the ratio of resistive slope (mR) and capacitive slope (mC) provided a concentration independent constant term (M) for a particular vapor. For the detection of unknown vapor, ratio of resistive change and capacitive change at any concentration was same to the previously calculated constant term (M). After successful identification of the target vapor, concentration was calculated from the straight line behavior of resistance as a function of concentration. Current technique is suitable for the detection of particular vapor from a mixture of other interfering vapors.

Keywords : breath marker, vapor sensors, selective detection, TiO_2 nanotube array
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