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Non-invasive sensors for respiratory health monitoring

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The volume of carbon dioxide (CO2) exhaled by a human along with the presence of various volatile substances can provide valuable physiological data on respiratory health conditions. Exhaled breath mostly consists of carbon dioxide, nitrogen, oxygen and several volatile organic compounds (VOCs). During respiration, carbon dioxide is transported from the tissues in the form of carbonic acid, which is reconverted into carbon dioxide in the lungs before it is exhaled. This task is performed by the enzyme, carbonic anhydrase, which is also important for the regulation of pH and fluid balance in different parts of the body. When the lungs are unable to remove sufficient CO2 from blood, it leads to an increased blood acidic level due to the accumulation of carbonic acid (respiratory acidosis). Whereas, excess concentration of VOCs can occur due to external sources, such as diet or from within the body through different biochemical processes, and their accumulation can lead to lung cancer. Therefore, their detection and evaluation have become essential. Conventional methods are time-consuming hence they can be monitored with simple and efficient enzymatic biosensors. Enzyme-based bio-sensing systems in comparison to traditional analytical methods have all such potential attributes. Enzyme-based biosensors have been developed by combining the innate specificity of enzymes with an electronic system that can detect the concentration of the substance to be analysed. Therefore, the parameters of high specificity and sensitivity make enzymes an ideal component of biosensors. An enzyme-based biosensor can be constructed using immobilised carbonic anhydrase (extracted from spinach leaves) as a recognition component and a pH electrode. An electrical potential is developed in response to the concentration of dissolved CO2. Carbonic anhydrase can undergo selective enzymatic reaction with CO2 and remain insensitive to other components of expired air. A chemical sensor can be coupled with this to monitor VOCs too. A nanomaterial-based sensor can also be employed to detect CO2 and various types of VOCs continuously and at low concentrations. The exhaled breath can then be compared to standard ones to establish a clinical diagnosis of the patient. Hence, breath sampling using these novel biosensors provides an innovative and non-invasive approach for the early detection and screening of various respiratory diseases.

Keywords: Carbonic anhydrase, Volatile organic compounds, Biosensor, Respiratory acidosis, Carbon dioxide

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