Development of a multianalyte electrochemical sensor for uric acid, H_2O_2, and pH detection for respiratory disease biomonitoring

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Chronic respiratory diseases represent a significant global health burden, both in terms of morbidity and healthcare costs. Among these, chronic obstructive pulmonary disease (COPD) is recognized as one of the leading causes of mortality worldwide, while asthma, though generally associated with lower mortality rates, substantially impacts patients' quality of life and functional capacity. The management of these conditions imposes a considerable strain on national healthcare systems, underscoring the need for innovative diagnostic tools capable of providing rapid, accurate, and non-invasive detection of disease-related biomarkers. The pathophysiology of asthma and COPD is closely linked to persistent inflammation and oxidative stress, which result in the production of specific biomarkers. Among these, elevated levels of hydrogen peroxide (H_2O_2), increased concentrations of uric acid (UA), and pH acidification in exhaled breath condensate have been consistently reported in the literature as indicative of airway inflammation and tissue damage. Numerous studies have emphasized the relevance of these biomarkers in monitoring disease severity and progression, underscoring the importance of reliable detection methods. Despite the development of several electrochemical sensors for the individual or dual detection of these biomarkers, the simultaneous monitoring of multiple indicators has emerged as a more effective approach. This strategy enables comprehensive disease assessment, facilitates timely therapeutic intervention, and enhances the overall management of chronic lung diseases. To address these challenges, we present the design, fabrication, and electrochemical characterization of a multi-analyte sensor specifically engineered for the concurrent detection of H_2O_2, UA, and pH alterations. The device was fabricated using an indium tin oxide-coated polyethylene terephthalate (ITO-PET) substrate and integrates two rGO/AuNPs electrodes for the detection of H_2O_2 and UA, alongside one rGO/AuNPs/PANI electrode dedicated to pH monitoring. The system also comprises an ITO-based counter electrode, and a reference electrode fabricated using silver/silver chloride (Ag/AgCl) paste. Electrochemical characterizations were carried out in both phosphate-buffered saline (PBS) and Minimum Essential Medium (MEM) to evaluate the device performance in different controlled environments. The proposed sensor exhibited high sensitivity, reproducibility, and operational stability in detecting the target biomarkers simultaneously. Its performance demonstrates clear advantages over conventional approaches, particularly in terms of affordability, ease of use, and rapid response time. As such, the developed device represents a promising alternative for the early diagnosis and monitoring of chronic respiratory diseases.

Keywords: *electrochemical sensor, simultaneous, ITO-PET, rGO, COPD, Asthma*