Chemical Engineering Doctoral Defense

A Novel Handheld Real-time Carbon Dioxide Analyzer for Health and Environmental Applications

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abstract

The accurate and fast determination of carbon dioxide (CO_2) levels is critical for many health and environmental applications. For example, the analysis of CO_2 levels in exhaled breath allows for the evaluation of systemic metabolism, perfusion, and ventilation, and provides the doctors and patients with a non-invasive and simple method to predict the presence and severity of asthma, and Chronic Obstructive Pulmonary Disease (COPD). Similarly, the monitoring of CO_2 levels in the atmosphere allows for assessment of indoor air quality (IAQ) as the indoor CO_2 levels have been proved to be associated with increased prevalence of certain mucous membrane and respiratory sick building syndrome (SBS) symptoms.

A pocket-sized CO_2 analyzer has been developed for real-time analysis of breath CO_2 and environmental CO_2. This CO_2 analyzer is designed to comprise two key components including a fluidic system for efficient gas sample delivery and a colorimetric detection unit integrated into the fluidic system. The delivery of gas sample is monitored via an integrated differential pressure transducer. The CO_2 levels in the gas samples are determined by a disposable colorimetric sensor chip. The sensor chip has been optimized to provide fast and reversible response to CO_2 over a wide concentration range, covering the needs of both environmental and health applications. The sensor is immune to the presence of various interfering gases in ambient or expired air. The performance of the sensor in real-time breath-by-breath analysis has also been validated by a commercial CO_2 detector. Furthermore, a 3D model was created to simulate fluid dynamics of breath and chemical reactions for CO_2 assessment to achieve overall understanding of the breath CO_2 detection process and further optimization of the sensor device.

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