A bio-inspired fractal designed breath sensors fabricated by graphene inks using extrusion 3D printing

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Abstract

Despite a developing number of diagnostic devices in recent years, there are still significant demand for low-cost, fast and simple devices for personalized diagnostic for detection of most concerning human diseases such as cancer, respiratory syndromes, diabetes, obesity, astma etc. Breath analysis could play a significant role in this by providing non-invasive and on-demand human health data collected from abnormal biomarkers patterns from breath samples .[1] As a result, breath sensors can revolutionize medical diagnostics by monitoring and on-demand detection of health parameters in a personalized manner for many diseases. The aim of this work is to demonstrate the performance of extrusion 3D printed chemo-resistive patterned electrode inspired by the 'fern leaf' design with higher surface area to volume (SA/V) ratio for enhanced VOC detection where specially designed graphene ink is used. The concept is illustrated in Figure. 1. First, we have developed a graphene ink formulation that can be printed at room temperature via extrusion-based 3D printer. We adopt the 'Hilbert' design from natural fern leaf and printed the synthesized graphene ink on PET in continuous mode consisting of multiple lines with an average layer thickness of 12 μm overlayed onto printed silver connections, which enhanced the SA/V ratio of printed patterns ten times rather than normal planar/non-fractal design. Herein we demonstrate the bio-inspired 3D extrusion printed graphene ink based chemo-resistive sensors for detecting VOC biomarkers such as acetone, ethanol and methanol to analyse human breath. The as-fabricated sensor exhibits enhanced performance with a high level of tunable selectivity, fast response-recovery time (6/36 sec), as well as wide detection range (5-100 ppm) for ethanol during room temperature operation. This concept has the potential to make a beneficial contribution towards the development of low-cost, high-performing VOC sensors to monitor human health through metabolic breath testing. It could also be implemented in non-invasive biomedical diagnostics for personalised telehealth monitoring.

REFERENCES

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FIGURES

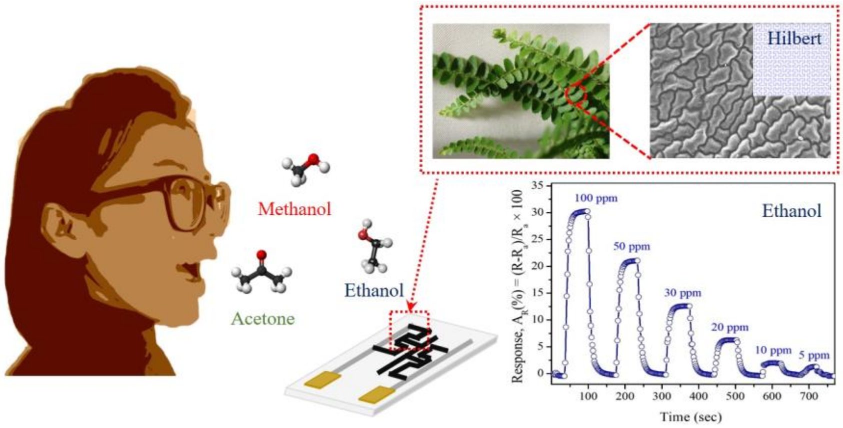

Figure 1: Overview of bio-inspired fractal designed graphene ink based extrusion 3D printed breath sensor.