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The ARC Research Hub for Graphene Enabled Industry Transformation

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

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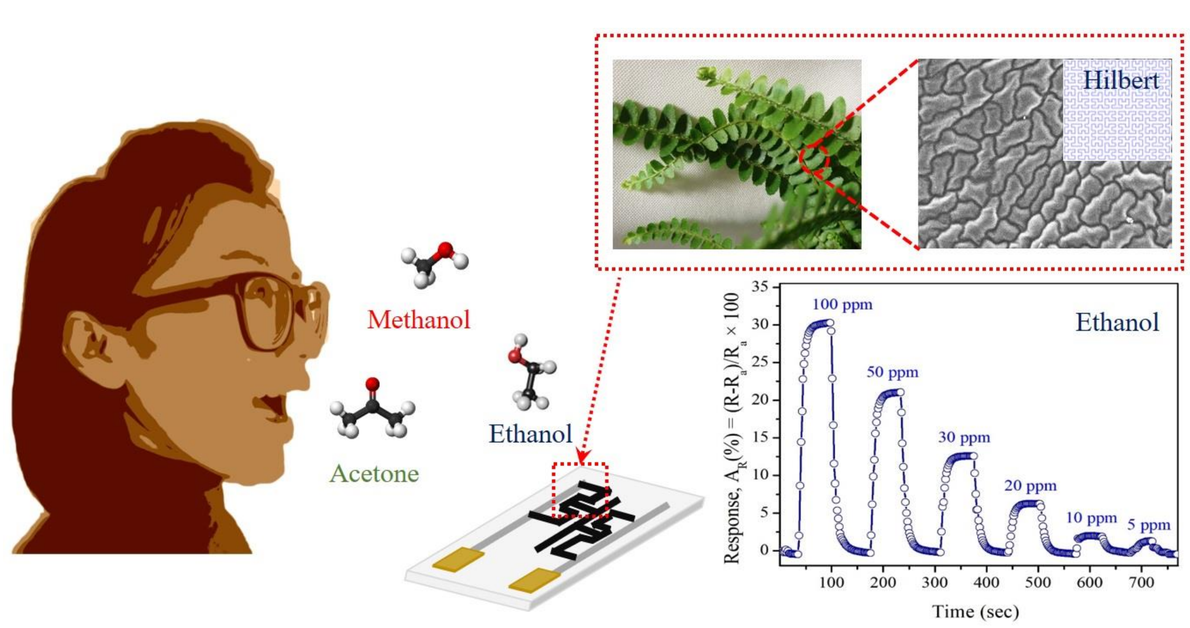
INTRODUCTION

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, asthma 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 .[1,2] 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 goals 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.

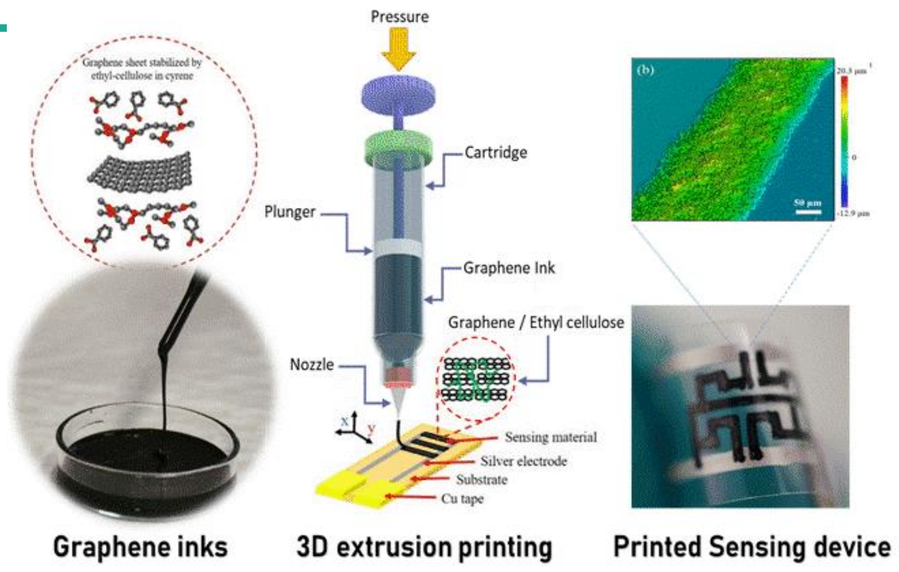


RESEARCH GAPS

- Metal-based inks have limitations and needs the replacement.
- Graphene inks are solution but not developed yet for extrusion process.
- Non-invasive biomedical diagnostics telehealth monitoring devices are required.

AIMS

- **To develop fractal designed breath sensor by graphene ink using 3D extrusion printing and demonstrate its sensing performances.**



METHODOLOGY

- **Inks are formulated using exfoliated graphene (pG), cyrene and ethyl-cellulose (EC).**
- **Fractal designed micro-pattern was direct 3D-extrusion printed on PET substrate.**
- **Fabricated structure were characterized by SEM, Profilometer, Raman, FTIR, XRD.**
- **Breath sensor was fabricated and tested on EtOH, MeOH, and acetone at room temperature.**

RESULTS AND DISCUSSIONS

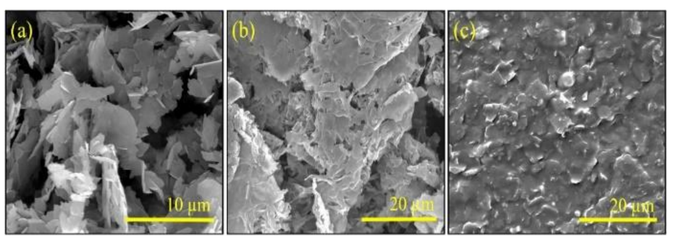


Fig. 1: *FESEM images of (a) pristine graphene (pG), (b) pristine graphene/ethyl-cellulose (pG/EC) black powder, and (c) cyrene based graphene ink.*

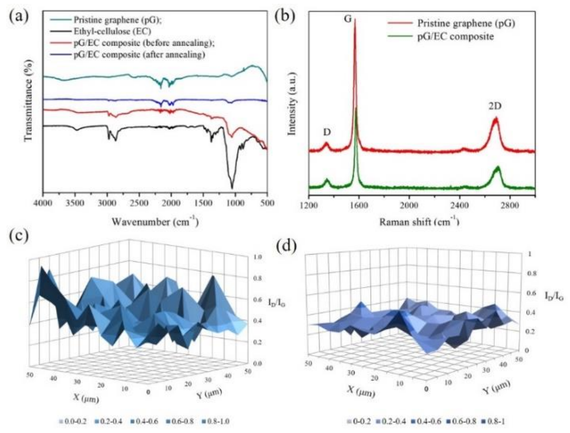


Fig. 2*: (a) FTIR, (b) Raman, and (c,d) 3D Raman map for pG and pG/EC.*

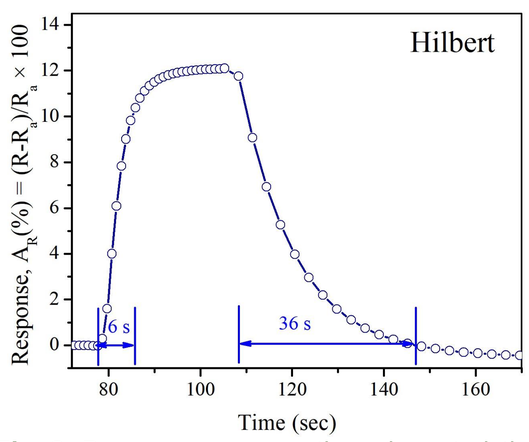


Fig. 3*: Response-recovery time characteristics for fractal designed breath sensor to ethanol.*

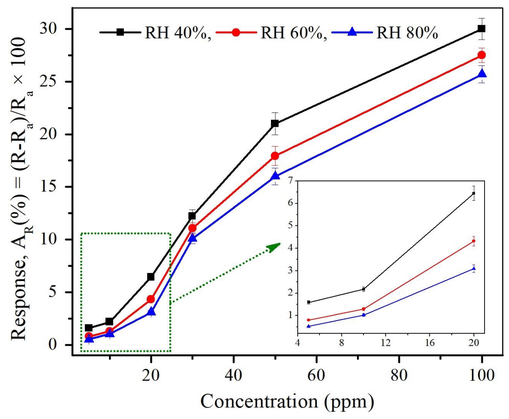


Fig. 4*: Relative humidity effect to saturated ethanol at RT.*

CONCLUSIONS AND PERSPECTIVES

- **Extrusion printing of micro patterns followed the design of natural fern leaf "Hilbert" on PET substrates with excellent reproducibility is demonstrated**
- **Hilbert designed fabricated sensor have enhanced SA/V ratio (10 times) than planar/non-fractal design.**
- **The sensor exhibits enhanced performance with a high level of tuneable selectivity, fast response-recovery time (6/36 sec), as well as wide detection range (5-100 ppm) for ethanol at room temperature.**
- **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.**

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