DOI: http://doi.org/10.21698/simi.2026.ab19

OXYFLUORINATED CARBON NANO-ONIONS AND FLUORINATED REDUCED GRAPHENE OXIDE: PREPARATION ROUTE AND SENSING CONCEPT FOR ROOM-TEMPERATURE ACETONE DETECTION

Bogdan Catalin Serban[1], Marius Bumbac[2,*], Cristina-Mihaela Nicolescu[2], Maria Ruxandra Salagean[3], Octavian Buiu[1]

[1]National Institute for Research and Development in Microtechnologies IMT Bucharest, 126A, Erou Iancu Nicolae Street, RO-077190, Voluntari - Bucharest, bogdan.serban@imt.ro, Romania
[2]Valahia University of Targoviste, Aleea Sinaia Street, 13, 130004 Targoviste, Dambovita, marius.bumbac@valahia.ro, Romania
[3]National College "Saint Sava", General H. M. Berthelot street 23, Sector 1, 010168, Bucharest, Romania

**corresponding author: marius.bumbac@valahia.ro*

Keywords: *acetone, carbon nano-onions, chemiresistor design, plasma functionalization, reduced graphene oxide*

Introduction

Acetone is a common industrial solvent; the EU 8-h exposure limit of 500 ppm [4] defines the window a workplace monitor must resolve. Room-temperature resistive detection with graphene has been demonstrated [1], but unmodified reduced graphene oxide (rGO) responds weakly, by about 1 % at 1000–2000 ppm [5], whereas a carbon nano-onion (CNO) composite has reached a detection limit of 1.2 ppm [6].

This short communication reports a *preliminary material-preparation and sensing concept*, not a validated sensor. It combines plasma-oxyfluorinated multilayer CNOs [2] (ox-CNO-F) with fluorinated rGO (rGO-F), and defines quantitative acceptance criteria, a validation protocol and control layers.

Materials and methods

CNOs are obtained by annealing nanodiamond at 1650 °C in helium, then treated in F_2/N_2 plasma (1:6 v/v, 1.5 bar, room temperature, 2 min injection, 1–5 min exposure) and in Ar/O_2 plasma (3:1, 3 torr, 3 min injection, 10 min exposure). rGO is fluorinated separately in F_2/N_2 (1:5, 1 bar, 5 min injection, 1–5 min exposure). ox-CNO-F (2 mg) is dispersed in 5 mL dimethyl sulfoxide (90 min stirring), rGO-F (2 mg) is added and the mixture is ultrasonicated for 6 h (0.8 mg/mL total solids, 1:1 w/w).

The dispersion is drop cast onto Si/SiO_2 substrates with linear or interdigitated electrodes and treated at 90 °C for 2 h under vacuum. Resistance is obtained from the voltage recorded at constant current. *Planned validation:* acetone vapour is diluted with mass-flow controllers to 25–1000 ppm in synthetic air at 25 °C and 30, 50 and 70 % RH. Response is $S = (R_g - R_a)/R_a$, response/recovery times are t_{90} values, and $LOD = 3\sigma_{noise}/b$, with b the low-concentration calibration slope. Each level is run in three exposure/recovery cycles on at least three devices; ethanol, 2-propanol, toluene and water are interferents. Controls: ox-CNO-F alone, rGO-F alone, non-fluorinated ox-CNO/rGO and pristine CNO/rGO (1:1), compared at matched baseline resistance and deposited mass.

Results and conclusions

Performance targets. At 25 °C, 1 ppm acetone equals 2.38 mg/m³; the EU limit (1210 mg/m³ at 20 °C) equals 500 ppm. Table 1 lists the resulting acceptance criteria.

Table 1 - Acceptance criteria derived for the ox-CNO-F/rGO-F concept

Criterion	Target	Basis
Measuring range	25–1000 ppm	0.05–2 × EU limit [4]
LOD (3σ/b)	≤ 25 ppm	CNO composite: 1.2 ppm [6]
Response at 1000 ppm	> 1 %	pristine rGO ≈ 1 % [5]
t_{90} response/recovery	≤ 2 min	≪ 15-min short-term average
RH effect (30–70 %)	ΔS ≤ 20 %	design target

Expected transduction. Acetone hydrogen-bonded to carboxyl and hydroxyl groups on ox-CNO-F donates electron density, lowering the hole concentration of the p-type network and raising resistance; rGO-F sheets keep percolating paths between nano-onions. Moderate fluorination increases surface polarity, but extensive C–F formation opens a band gap and interrupts conduction [3]; fluorination time (1–5 min) is therefore the main variable, to be correlated with XPS F/O content and Raman I_D/I_G. The contribution is a reproducible, polymer-free ox-CNO-F/rGO-F preparation route with a falsifiable test plan; it will be regarded as validated only when the Table 1 criteria are met and the hybrid outperforms all four controls.

References

[1] Yang, C.-M.; et al. Enhanced acetone sensing properties of monolayer graphene at room temperature by electrode spacing effect and UV illumination. *Sensors and Actuators B*: Chemical 253 (2017), 77–84. https://doi.org/10.1016/j.snb.2017.06.116.

[2] Ugarte, D. Curling and closure of graphitic networks under electron-beam irradiation. *Nature* 359 (1992), 707–709. https://doi.org/10.1038/359707a0.

[3] Cheng, S.-H.; et al. Reversible fluorination of graphene: Evidence of a two-dimensional wide bandgap semiconductor. *Physical Review B* 81 (2010), 205435. https://doi.org/10.1103/PhysRevB.81.205435.

[4] Commission Directive 2000/39/EC establishing a first list of indicative occupational exposure limit values. *Official Journal of the European Communities* L 142 (2000), 47–50.

[5] Kumar, R.; et al. Selective determination of ammonia, ethanol and acetone by reduced graphene oxide based gas sensors at room temperature. *Sensing and Bio-Sensing Research* (2020), 100336. https://doi.org/10.1016/j.sbsr.2020.100336.

[6] Mongwe, T. H.; et al. The use of ex-situ nitrogen-doped olive oil-derived carbon nano-onions for application in chemi-resistive gas sensors to detect acetone at room temperature. *South African Journal of Chemistry* 76 (2022), 38–48. https://doi.org/10.17159/0379-4350/2022/v76a07.