Supporting Information

Electronic nose based on carbon nanocomposite sensors for clove essential oil detection

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Abstract: this supporting information shows the part of a Wheatstone bridge of each sensor used in e-nose (page S-4) and the calibration curves obtained by the e-nose for CEO, EUG, and EUG.ACET using the different sensing units (S1 to S6) (page S-13).

The e-nose system used in this work is schematically represented in Figure S1 as follow: (1) flow system (Inalar Compact Ns pump, Brazil), (2) sphere valves (Swagelok, Model SS-83KS4, United States), (3) sampling chamber (200 mL glass bottle), (4) heating and stirring plate (Fisatom 752A, Brazil), (5) temperature and humidity sensor (Sensirion Kit EK-H5, SHT2x resolution, Switzerland), (6) 2.4 L glass chamber with sensing units, (7) heating blanket (Fisatom, Brazil), (8) circuit board, (9) data acquisition system (Novus, United States), and (10) computer (LG Electronics, Brazil).

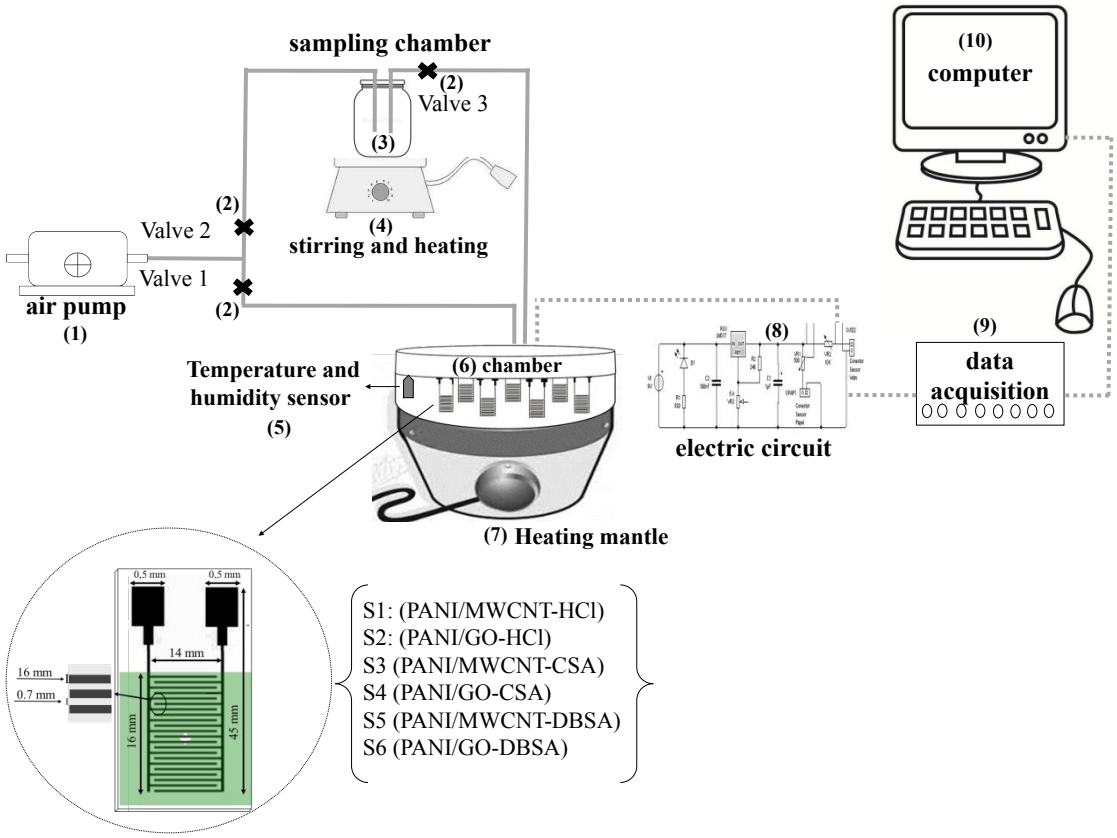

Figure S1. Detailed schematic representation of the e-nose system.

The e-nose system is based on three modules. The first module is responsible for heating and maintaining the chamber temperature and the gas flow. The second consisted of the Wheatstone bridge for the electrical signal acquisition from each sensor. The third module was responsible for the execution, monitor, and record the sensor information.

The sensing units used in the experiments were resistive sensors. So, each sensor was part of a Wheatstone bridge, as showed in Figure S2. The signal collected was obtained in voltage (mV). The system has 6 bridges to perform the experiments using 6 gas sensors simultaneously (S1 to S6). The signal obtained at the center of the bridge (represented by

the “Signal” element) was monitored by the data acquisition system (Novus, Field Logger model, United States). Firstly, the signal was adjusted through a trim point, so all measurements initiate at the same baseline value, regardless of their initial resistance.

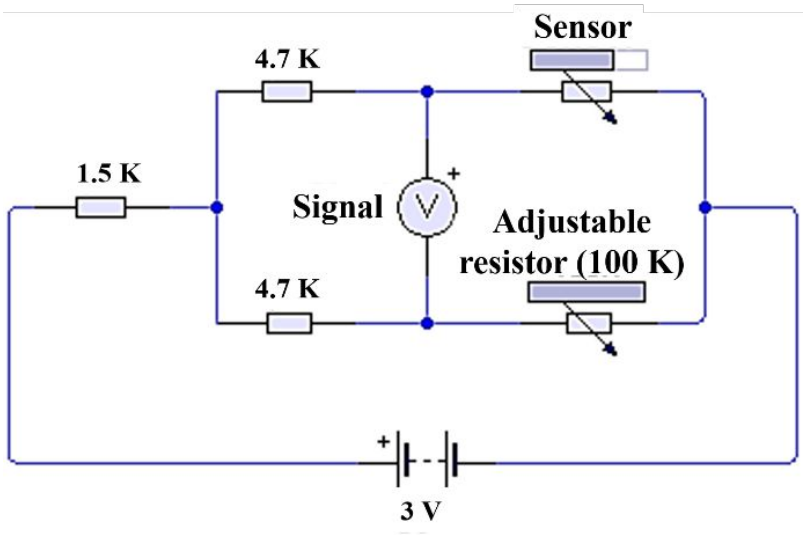

Figure S2. Wheatstone bridge scheme used in the e-nose system.

The sample composition (CEO, EUG, and EUG.ACET) was obtained by GC/MS. The analysis was performed with a polar column (Rtx-Wax Restek, 30 m×0.25 mm, 0.25 mm thickness) and a flame ionization detector (FID), at the following temperatures: 40-180 °C (3 °C min-1), 180-230 °C (20 °C min-1), 230 °C (20 °C min-1), injector temperature at 250 °C, a detector at 275 °C, with a 50:1 split ratio. Nitrogen (99.99% purity, White Martins) was the carrier gas, with a 1.5 mL min-1 flow rate. The samples (0.4 mL) were diluted in dichloromethane (99.99% purity, Merck) in a proportion of 1:10 (v/v). It was injected 1 µL of the diluted sample.

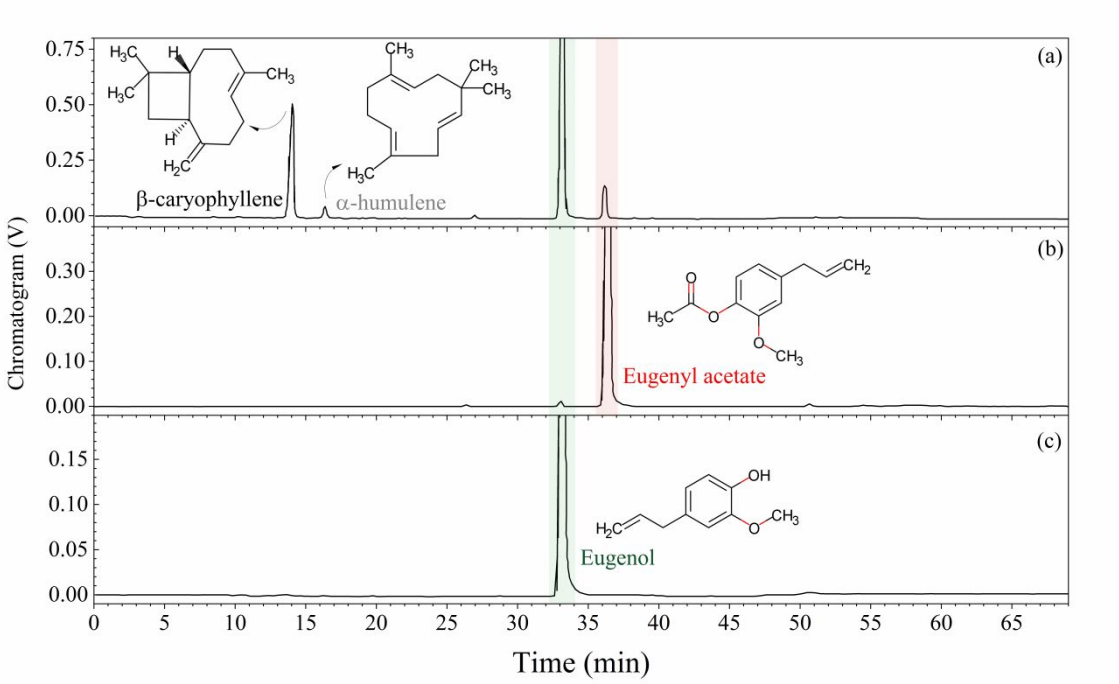

Figure S3. Chromatograms obtained for CEO (a), EUG.ACET (b) and EUG (c) using GC/MS.

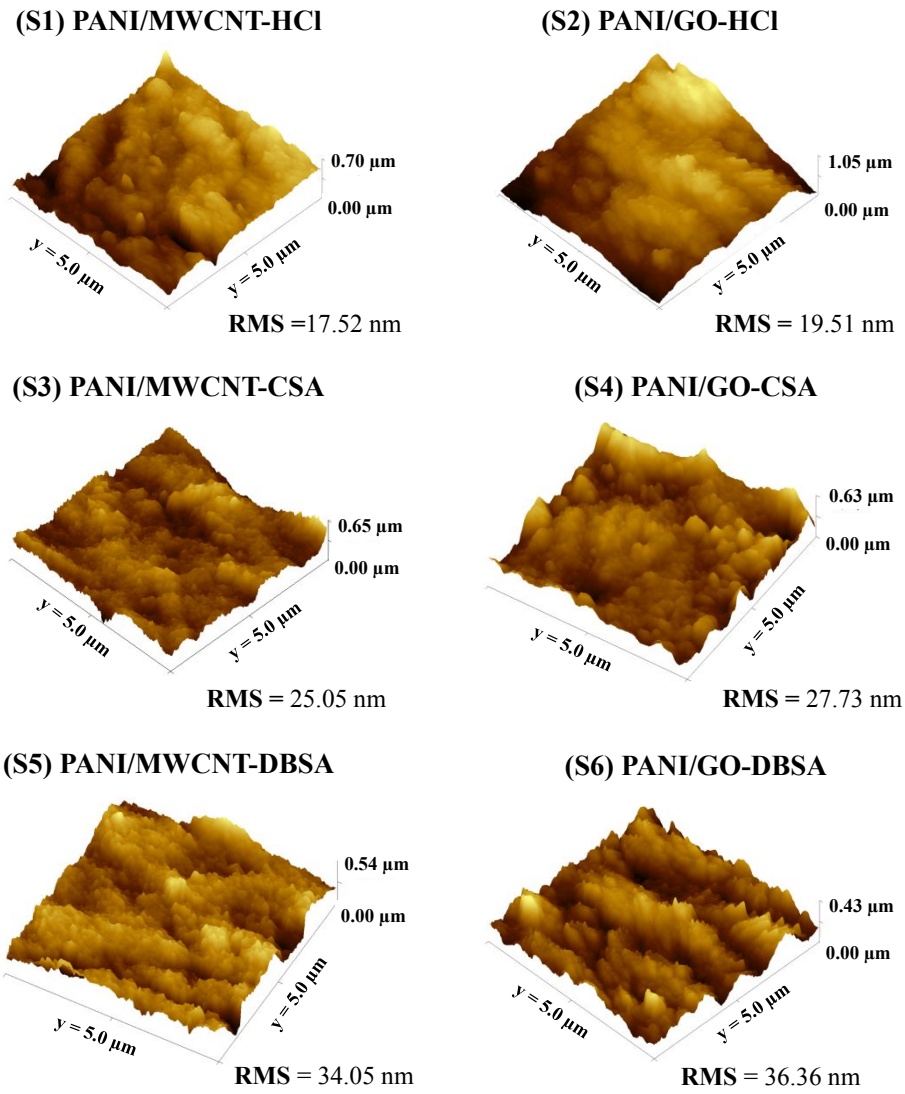

Figure S4. Topographic images and the roughness (RMS) of the sensing units (S1 to S6) with PANI/MWCNT and PANI/GO films doped with HCl, CSA, and DBSA on GIE tracing paper substrate (area 25 µm²).

Table S1. Values of response time and recovery time were evaluated for the concentration of 4.0 ppm of CEO, EUG, and EUG.ACET.

Sensing units	CEO		EUG		EUG.ACET	
	Response time (s)	Recovery time (s)	Response time (s)	Recovery time (s)	Response time (s)	Recovery time (s)
S1	11.09	94.73	13.26	106.29	9.84	101.04
S2	10.33	80.79	12.75	100.97	9.16	98.70
S3	9.73	78.80	10.68	91.09	7.32	87.70
S4	8.46	64.66	9.14	89.69	7.09	86.63
S5	7.24	30.99	7.97	85.26	5.87	74.54
S6	6.91	23.30	7.44	82.12	5.39	60.00

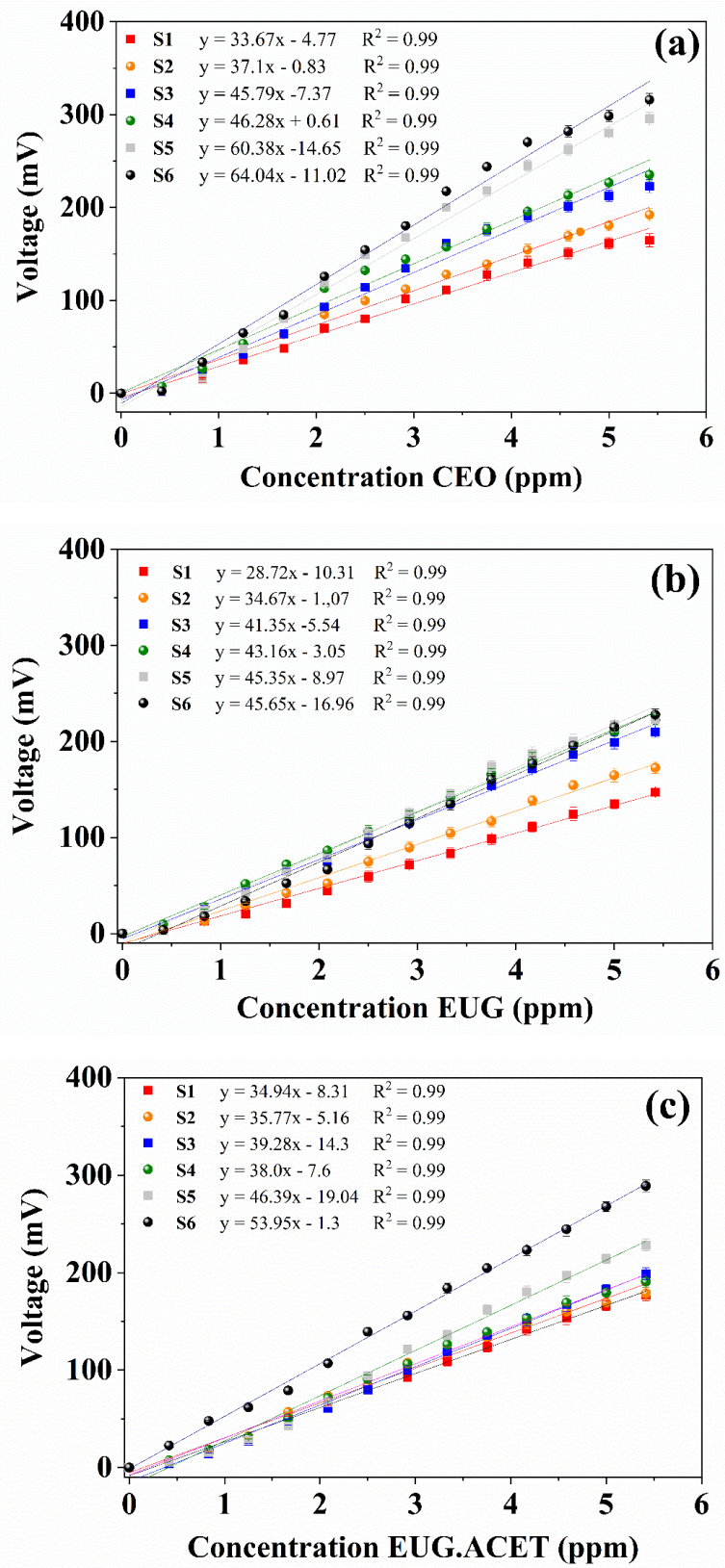

Figure S5. Calibration curve for CEO **(a)**, EUG **(b)**, and ACET.EUG **(c)** obtained by the sensing units of the e-nose array (S1, S2, S3, S4, S5, and S6). The error bars indicate the calculated standard deviation.

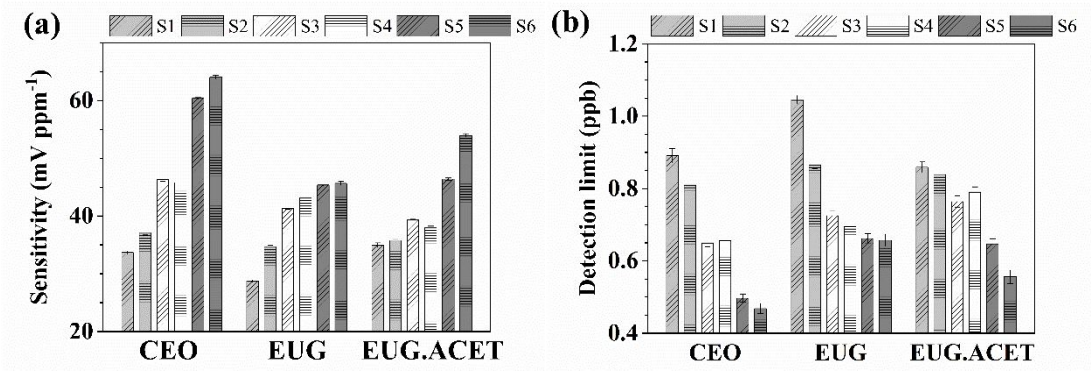

Figure S6. Bar plot of sensitivity (a) and detection limit (b) values calculated for the e-nose sensing units (S1, S2, S3, S4, S5, and S6) in the detection of CEO, EUG, and EUG.ACET. The error bars indicate the standard deviation of triplicate experiments.

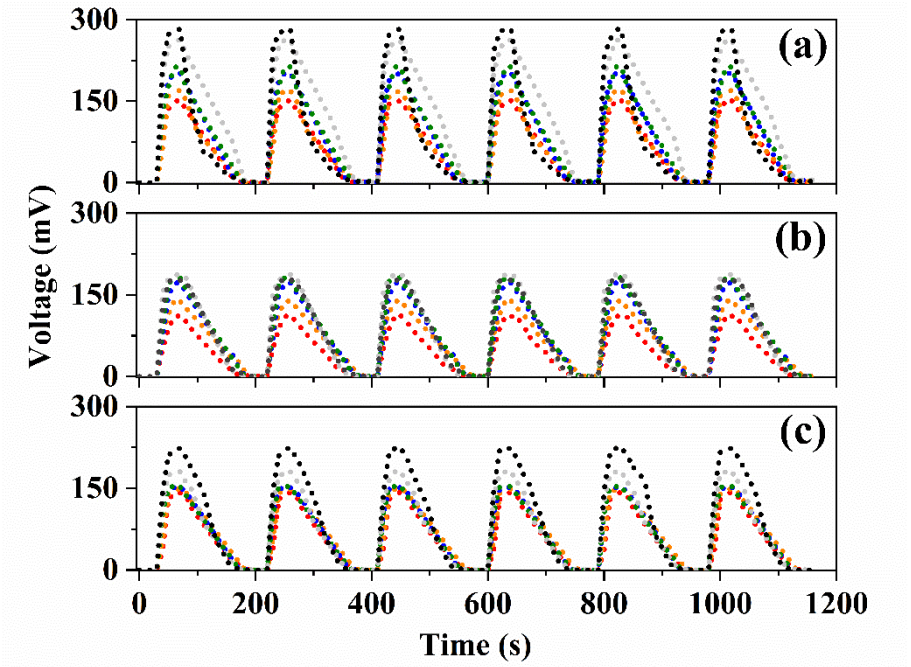

Figure S7. Reversibility of sensing units to (a) CEO, (b) EUG, and (c) EUG.ACET. (••••) S1 (PANI/MWCNT-HCl); (••••)S2 (PANI/GO-HCl); (••••) S3 (PANI/MWCNT-CSA); (••••) S4 (PANI/GO-CSA); (••••) S5 (PANI/MWCNT-DBSA); (••••) S6 (PANI/GO-DBSA).

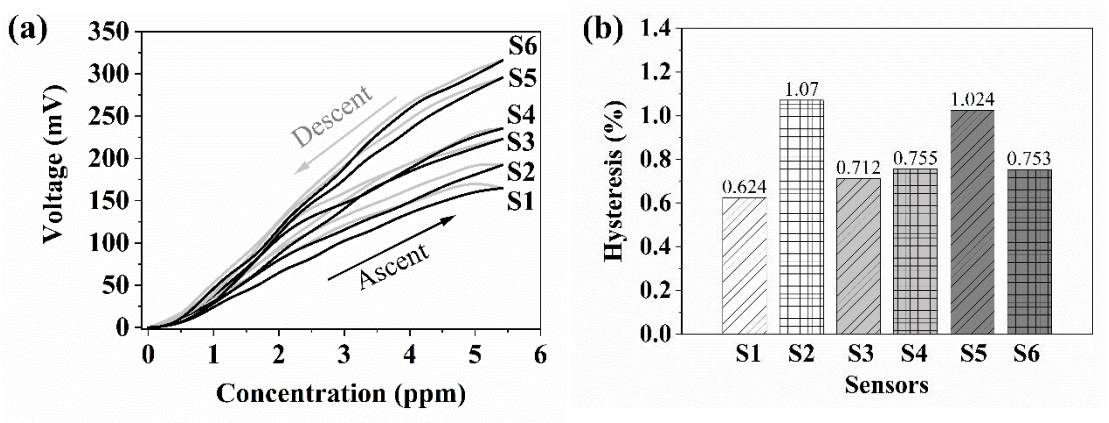

Figure S8. Hysteresis response (a) upward and downward curves and (b) mean values for the sensors. S1 (PANI/MWCNT-HCl); S2 (PANI/GO-HCl); S3 (PANI/MWCNT-CSA); S4 (PANI/GO-CSA); S5 (PANI/MWCNT-DBSA); S6 (PANI/GO-DBSA).