

## SUPPLEMENTARY MATERIAL

# Application of a Sonogel-Carbon electrode modified with gold nanoparticles synthesized through green technique and pine leaf extract for the simultaneous determination of neurotransmitters

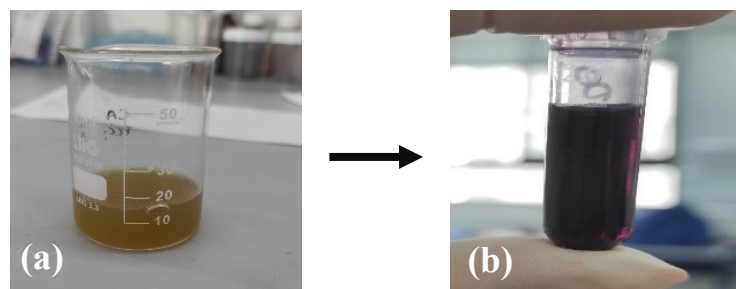
Asma Blel<sup>a,b</sup>, Juan José García-Guzmán<sup>c</sup>, Laura Cubillana-Aguilera<sup>c</sup>,  
José María Palacios-Santander<sup>c,\*</sup>, Chérif Dridi<sup>a,\*</sup>

<sup>a</sup>NANOMISENE Laboratory, LR16CRMN01, Centre for Research on Microelectronics and Nanotechnology (CRMN) of Technopole of Sousse, B. P334, 4054 Sahloul Sousse, Tunisia.

<sup>b</sup>University of Sousse, High School of Sciences and Technology of Hammam, Sousse, Tunisia.

<sup>c</sup>Institute of Research on Electron Microscopy and Materials (IMEYMAT), Department of Analytical Chemistry, Faculty of Sciences, Campus de Excelencia Internacional del Mar (CEIMAR), University of Cadiz, Campus Universitario de Puerto Real, Polígono del Río San Pedro S/N, 11510 Puerto Real, Cadiz, Spain.

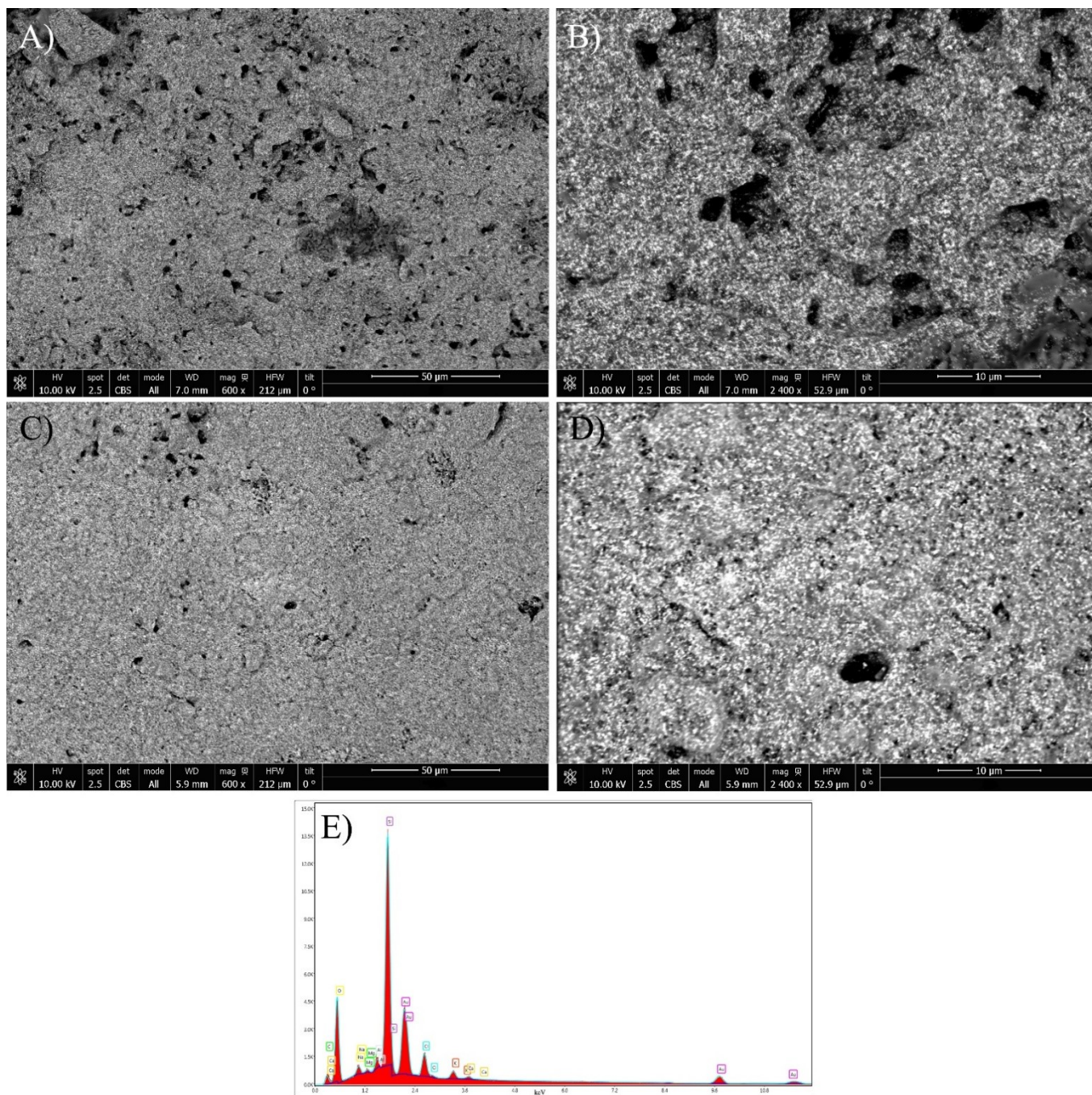
E-mail address: josem.palacios@uca.es (JM Palacios-Santander), [Cherif.Dridi@crmn.rnrt.tn](mailto:Cherif.Dridi@crmn.rnrt.tn) (C. Dridi)



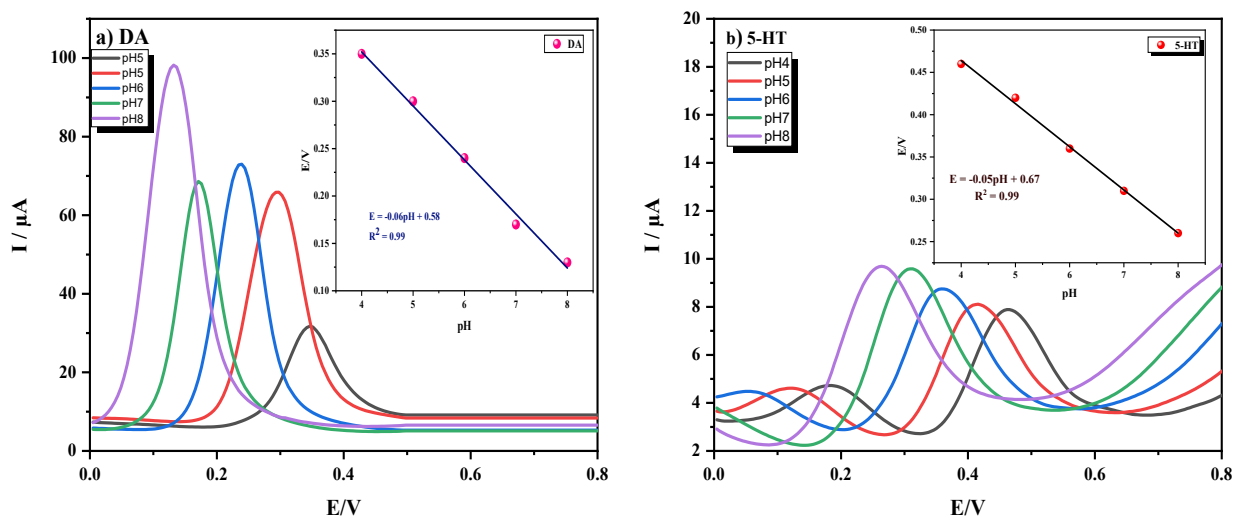
**Pine leaf extract**

**Biosynthesized AuSNPs**

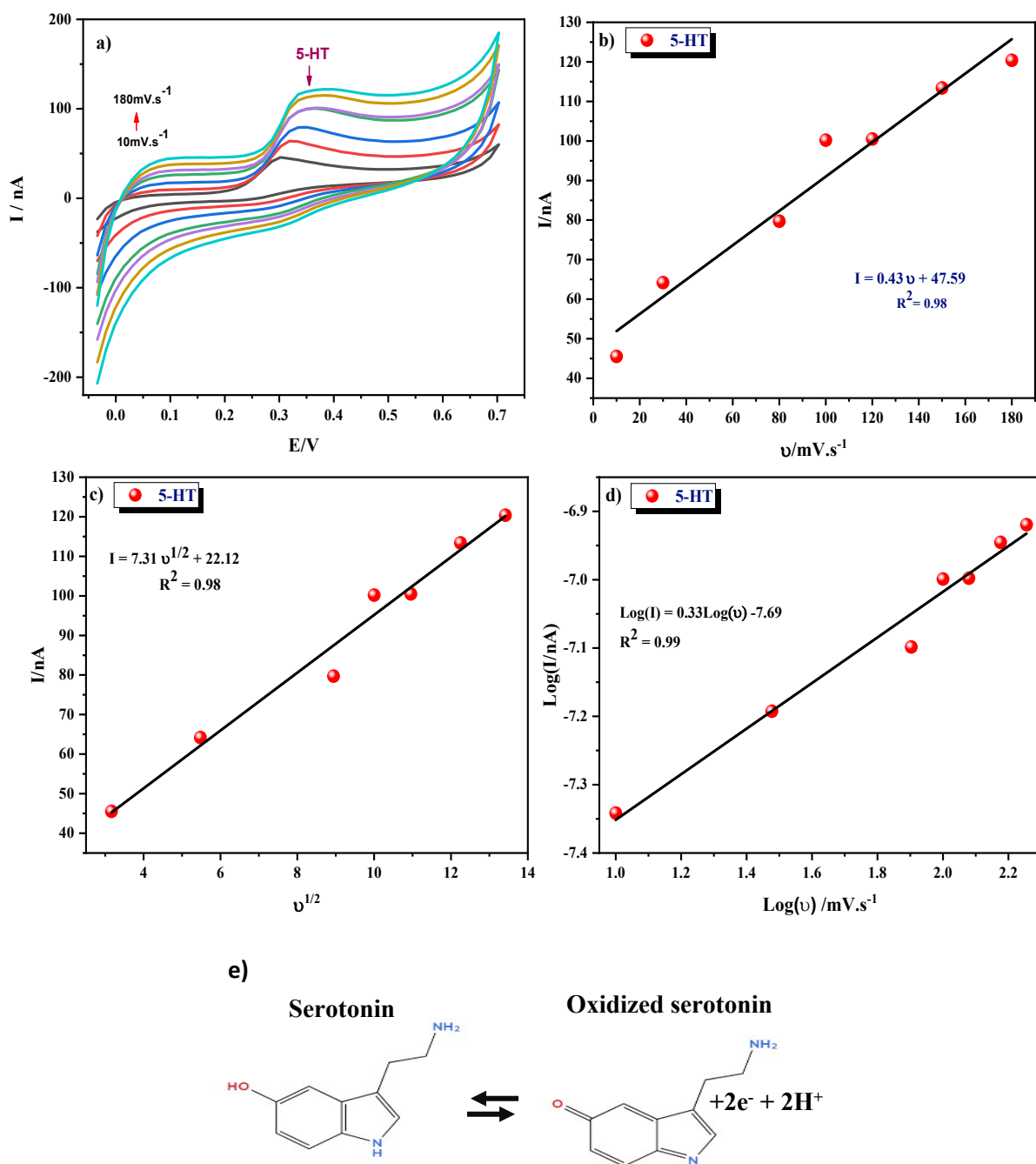
**Figure S1.** Picture of (a) solution containing pine leaf extract and (b) colloidal solution containing the biosynthesized AuSNPs using high energy ultrasound.



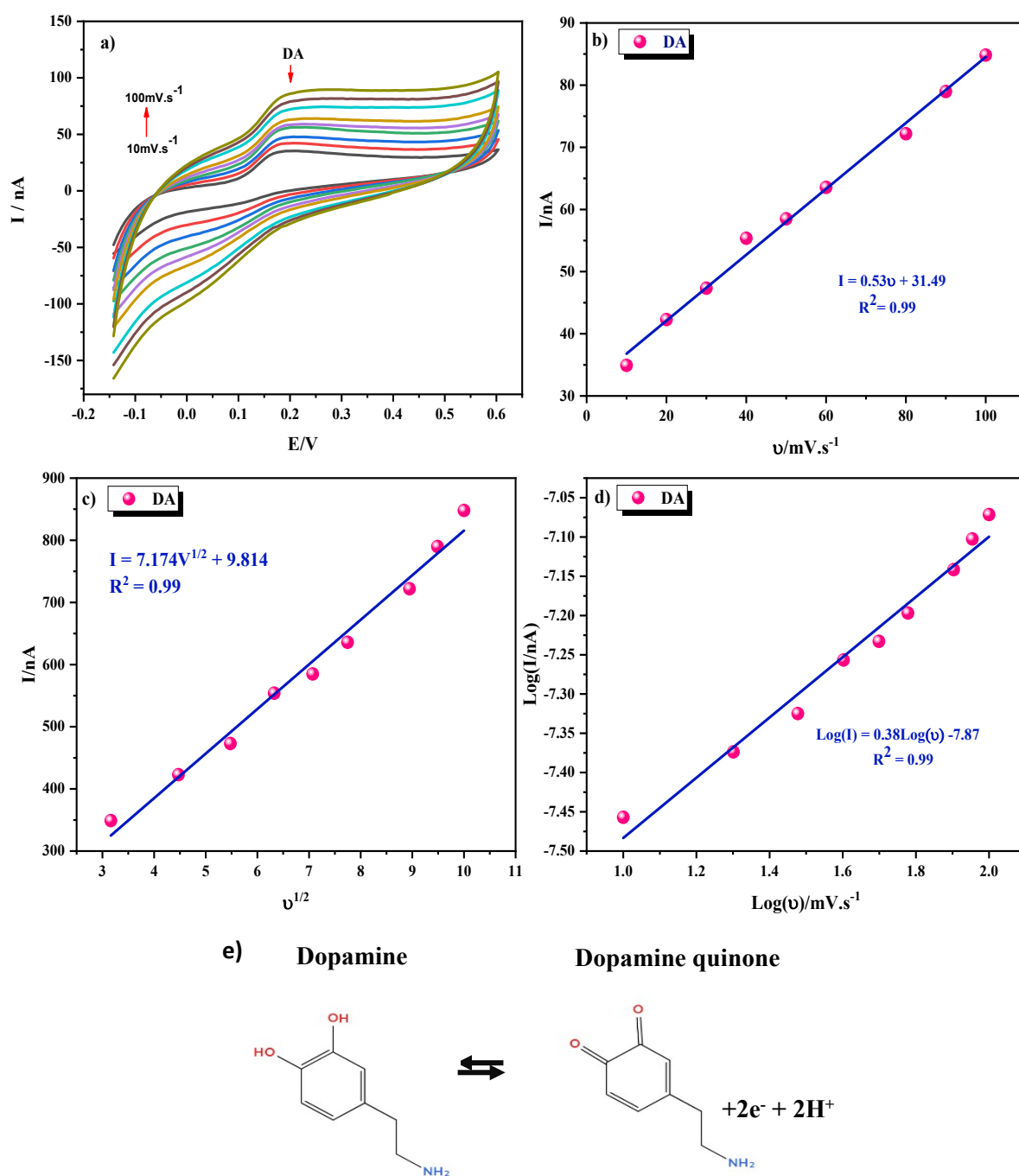
**Figure S2.** SEM micrographs of AuSNPs/SNGCEs at different magnifications of **(a)** and **(b)** non-used electrode, and **(c)** and **(d)** used electrode, respectively, at 600× and 2400× magnifications; **(e)** EDS spectrum of the AuSNPs active layer deposited onto the SNGCEs surface and table with the corresponding semi-quantitative analysis. The detector employed for SEM measurements was a back-scattered electron detector and the emission gun was at 10 kV.



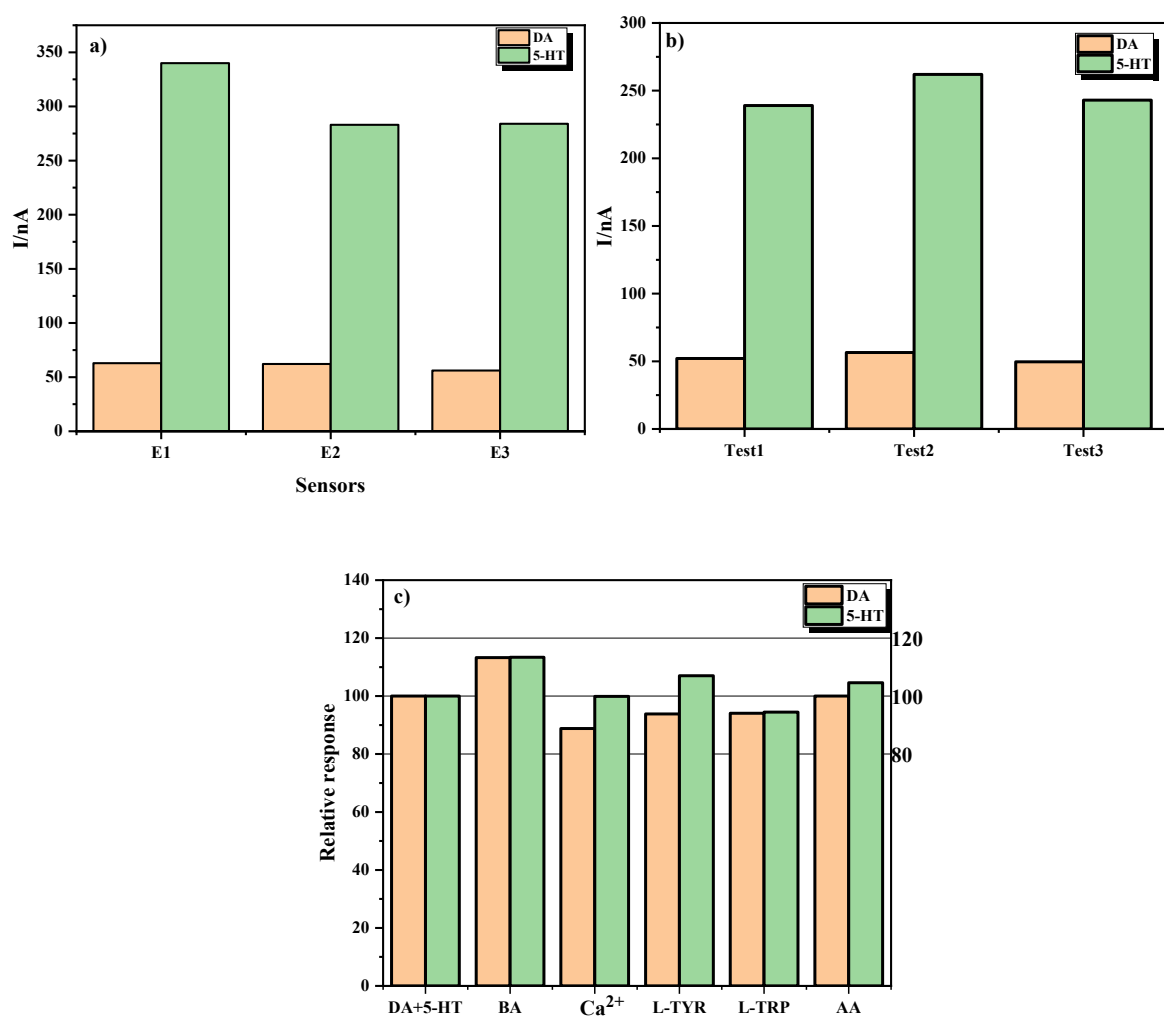
**Figure S3.** Voltammograms and dependence of peak potential ( $E_p$ ) with respect to the pH values (4, 5, 6, 7 and 8; insets) for (a) DA ( $10^{-3}$  M) and (b) 5-HT ( $10^{-4}$  M) determination, respectively, in PBS 0.1 M.



**Figure S4.** (a) CV voltammograms of 5-HT (10  $\mu$ M) in PBS (0.1 M, pH 8) at various scan rates: 10, 30, 80, 100, 120, 150 and 180  $\text{mV}\cdot\text{s}^{-1}$ , obtained with a AuSNPs/SNGCE; (b) plot of oxidation peak current,  $I$  vs  $v$ ; (c) linear relationship between  $I$  and  $v^{1/2}$ ; (d) linear relationship between  $\log I$  and  $\log v$ ; and (e) electrochemical oxidation mechanisms of 5-HT proposed at the working electrode.

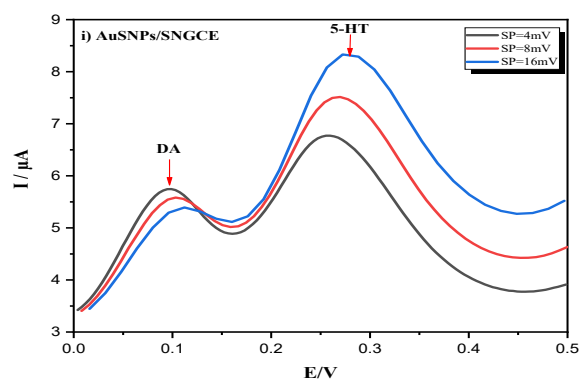
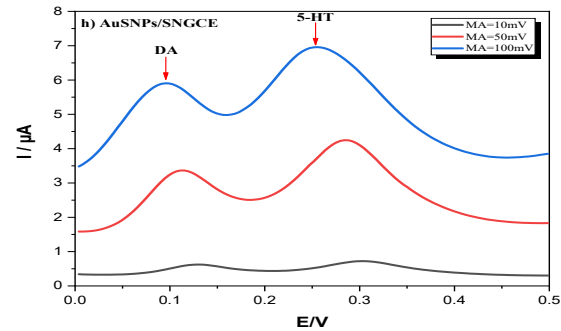
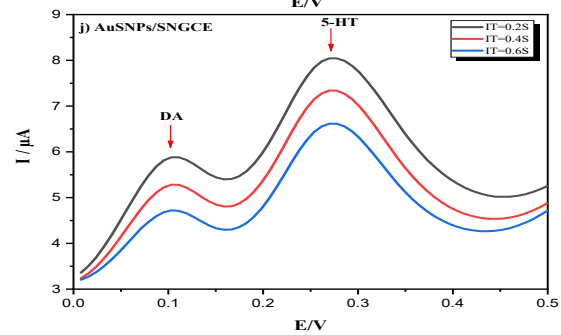
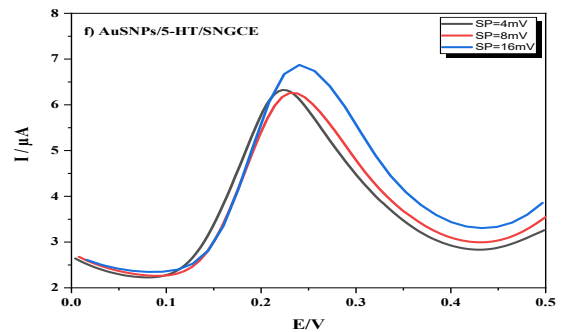
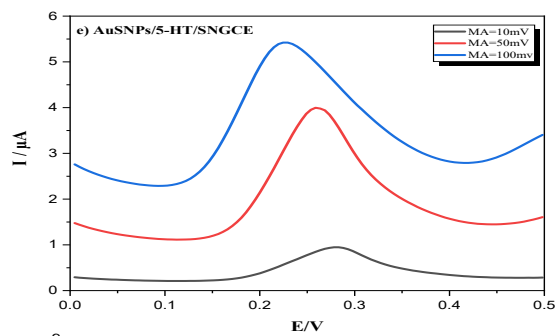
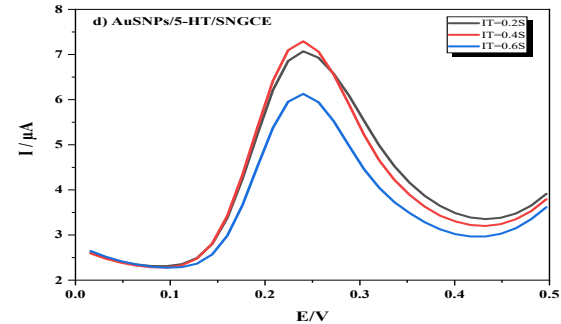
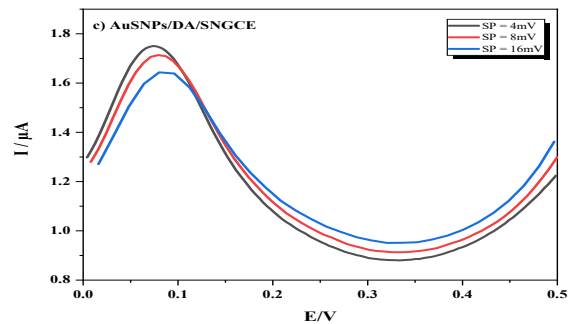
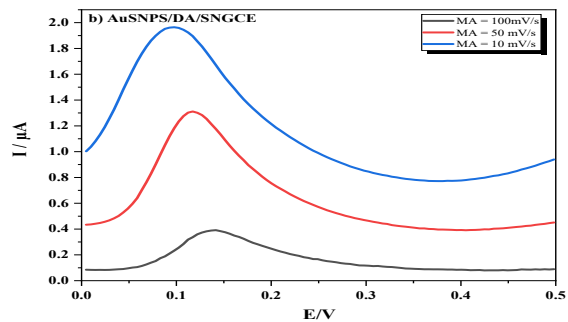
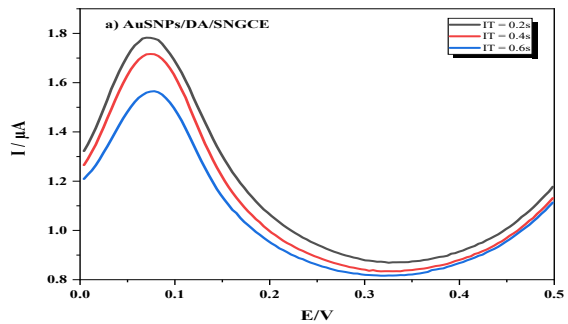


**Figure S5.** (a) CV voltammograms of DA (10  $\mu$ M) in PBS (0.1 M, pH 8.) at various scan rates: 10, 20, 30, 40, 50, 60, 80, 90 and 100  $\text{mV s}^{-1}$  obtained with a AuSNPs/SNGCE; (b) plot of oxidation peak current,  $I$  vs  $v$ ; (c) linear relationship between  $I$  and  $v^{1/2}$ ; (d) linear relationship between  $\log I$  and  $\log v$ ; and (e) electrochemical oxidation mechanisms of DA proposed at the working electrode.



**Figure S6.** (a) Reproducibility (n = 3 different sensors), (b) repeatability (n = 3 times the same sensor) and (c) selectivity studies (interfering substances at 100-fold higher concentration than DA and 5-HT: boric acid (BA), L-tryptophane (L-trp), L-tyrosine (L-tyr), calcium ions ( $\text{Ca}^{2+}$ ) and ascorbic acid (AA)), respectively, for the simultaneous determination of 5  $\mu$ M DA and 5-HT.

Electrode used: AuSNPs/SNGCE in PBS solution (0.1 M, pH 8).



**Figure S7.** Optimization of DPV parameters for DA and 5-HT, individually and simultaneously: (a, d) effect of interval time (IT = 0.2, 0.4, and 0.6 s); (b, e) effect of modulation amplitude (MA = 10, 50, and 100 mV); (c, f) effect of step potential (SP = 4, 8, and 16 mV), corresponding to individual determination of DA and 5-HT, respectively; (i, f and h) represent the study of the effect of IT, MA and SP in the simultaneous determination of DA and 5-HT, respectively.