Paving the way to Point of Care (POC) devices for SARS-CoV-2 detection

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Experimental section.

Scheme 1SI. Design of the potentiostat at hardware and software levels.

Figure 1SI. Block Diagram of LMP91000 signal conditioner.
Figure 2SI. ADS1115 ADC (A) and MCP4728 DAC (B) Block Diagrams.

Figure 3SI. Sigma-Delta Converter for 1bit Block Diagram.

Figure 4SI. OPA388 Operational Amplifier Block Diagram.
Figure 5 SI. Block Diagram of the developed potentiostat including all the hardware modules.

Figure 6 SI. Software modules.
Results and discussion

Synthesis and characterization of gold nanotriangles (AuNTs).

A seed-mediated growth method was followed for the synthesis of AuNTs [1]. Briefly, Na$_2$S$_2$O$_3$ solution (firstly, 30 mL and secondly 12.5 mL of 0.5 mM solution) was added to 25 ml of 2 mM HAuCl$_4$ under stirring vigorous. After few minutes, when the solution turned deep red, a mixture of spherical and triangular gold nanoparticles is obtained. Finally, AuNTs (dark green solution) were isolate from the spherical seeds using a surfactant-assisted depletion methodology in the presence of cetyltrimethylammonium bromide (CTAB).

The synthesized AuNTs were characterized by different techniques as UV-visible-NIR spectroscopy, Transmission electron microscopy (TEM), Atomic Force Microscopy (AFM) and Scanning Electron Microscopy (SEM) to elucidate their morphology, size and properties. The spectra UV-visible-NIR spectroscopy (Figure 7A SI) shows the appearance of the characteristic band at 1015 nm associated with the formation of triangular nanoparticles and evidence the success of synthesis and AuNTs separation. The dimensions and morphology of the AuNTs were determined by TEM (see Figure 7B SI). AuNTs have a triangular morphology with an average size of 156 nm ± 0.5 nm (lateral length). AFM images of AuNTs on Highly Oriented Pyrolytic Graphite (HOPG) confirms their triangular morphology (Figure 7D SI). The morphologic AuNTs characteristics found by SEM (Figure 7C SI) are in good agreement with those observed by TEM and AFM. Based on the results obtained, we can confirm the successful synthesis and isolation of the AuNTs.
**Figure 7SI.** A) UV-visible-NIR spectra of AuNTs. TEM (B) and SEM (C) images of the AuNTs on HOPG substrates. Insets: magnified images. C) 2D AFM image of a group of AuNTs. Inset: AFM image of a single AuNT.

**Table 1 SI.** Comparison between the most suitable development boards.

|                  | Arduino YUN | BeagleBone Black | Raspberry Pi 3B+ |
|------------------|-------------|-------------------|------------------|
| Analog / Digital GPIOs | 12 / 20     | 7 / 19            | - / 17           |
| CPU (Cores / Clock)  | 1 / 400MHz  | 1 / 1Ghz          | 4 / 1.4GHz       |
| RAM               | 64MB        | 512MB             | 1GB              |
| ROM               | 16MB        | 4GB + µSD         | µSD              |
| ETH / WiFi / Bluetooth | 100Mbps / Y / N | 100Mbps / N / N | 300Mbps / Y / Y  |
| Other Protocols    | PC, Serial  | PC, Serial, SPI   | PC, Serial, SPI  |
| Operating System   | Custom      | Linux             | Linux            |
| Size (L x W)       | 73 x 53 mm  | 86 x 53 mm        | 85 x 56 mm       |
| Cost              | 53$         | 59$               | 37$              |
Table 2 SI. Cost of the Controller Board module at the date of April 2022.

| Item                                      | Cost  |
|-------------------------------------------|-------|
| Raspberry Pi 3B+ development board        | $37   |
| Samsung EVO 64GB MicroSDXC Class 10 µSD card | $16   |
| 5V 2.5A µUSB power adapter                | $16   |
| 1m CAT 5e RJ45 Ethernet cable             | $1.8  |
| **Total**                                 | **$70.8** |

Table 3SI. Total cost of the data acquisition board module at the date of April 2022.

| Item                                      | Cost  |
|-------------------------------------------|-------|
| Texas Instruments LMP91000 potentiostat   | $5.4  |
| Texas Instruments ADS1115 analog-to-digital converter | $6.4 |
| Microchip MCP4728 digital-to-analog converter | $2.1 |
| Texas Instruments OPA388 operational amplifier (x2) | $6.4 |
| Several filtering and decoupling capacitors | $1.07 |
| **Total**                                 | **$21.37** |
Figure 8 SI. CSPE covered by AuNTs.

Figure 9 SI. Calibration plot of the biosensor response vs SARS-CoV-2 concentration (from 1 fM to 500 fM).
Figure 10SI. Bar diagrams of the biosensor response (represented as signal increase in %) after hybridization with 500 fM of complementary CoV-2, a mixture of 500 fM of CoV-2 and 50.0fM of Influenza A sequences and a mixture of 50.0 fM of CoV-2 and 500fM of CoV-1 sequences. Data are presented as mean ± SD (n = 3 different electrochemical biosensing platforms).
Figure 11SI. Bar diagrams of the biosensor signal increase after the hybridization with Samples of SARS-CoV-2 infected patient (25 Cts) and non-infected patient used as control (Control). Data are presented as mean ± SD (n=3 different biosensors).

References

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