Label-free graphene-based impedimetric biosensor for real-time tracing of the cytokine storm in blood serum; suitable for screening COVID-19 patients

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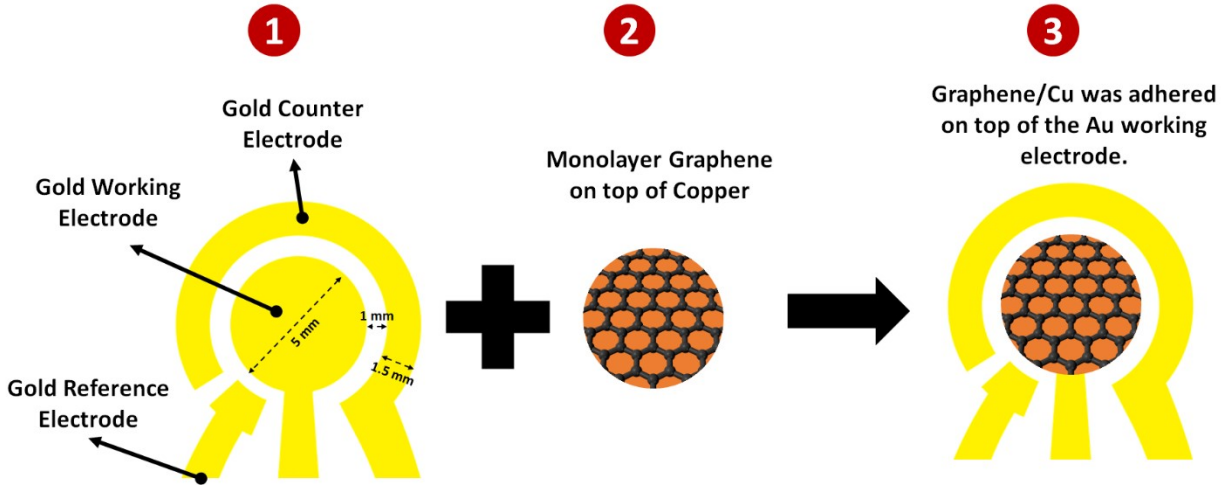

Figure S1 The biosensor is an integrated three-electrode system containing a circular working electrode with diameter of 5 mm and a counter and reference electrode. The distance between the working and reference and counter electrode is 1 mm. The graphene/Cu wafer was cut using laser machine with the diameter of 5 mm (equal size to working electrode diameter) and placed and adhered on top of the working electrode.

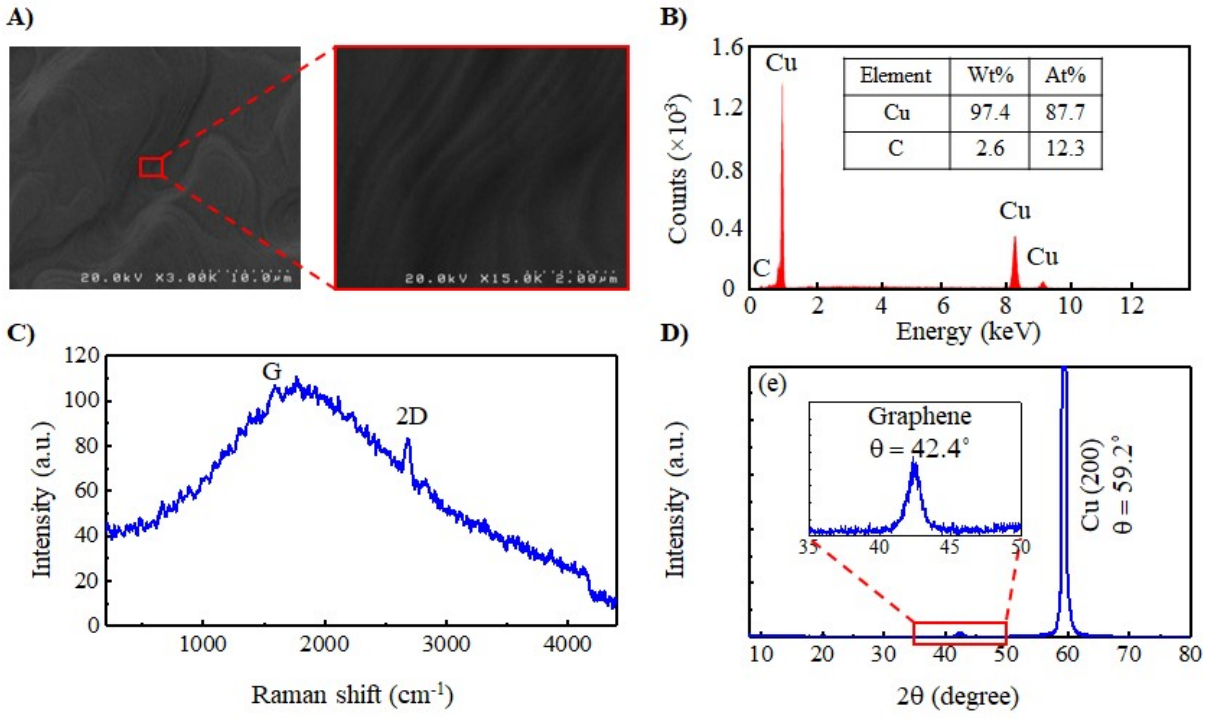

Figure S2 (A) SEM, (B) EDX, (C) Raman and (D) XRD analysis of graphene on top of Cu substrate.

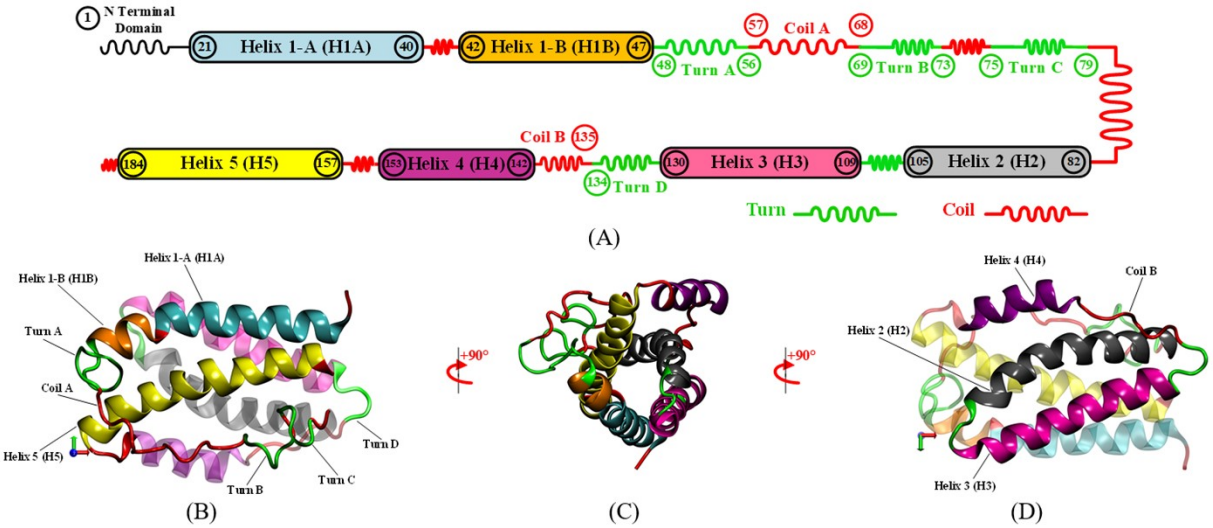

Figure S3 (A) Schematic representation of Interleukin 6 (IL-6). The range of residue numbers is given for each domain at its beginning and end. New cartoon representations of the IL-6 fold representing the four membrane helices (Transparent yellow, Transparent pink, Transparent purple, Transparent gray), and the two malformed helices (Cyan and Orange) as well as the connecting loops including coil and turn domains. ***(B)*** *Left side view;* ***(C)*** *End-on view;(D) Right side view.*

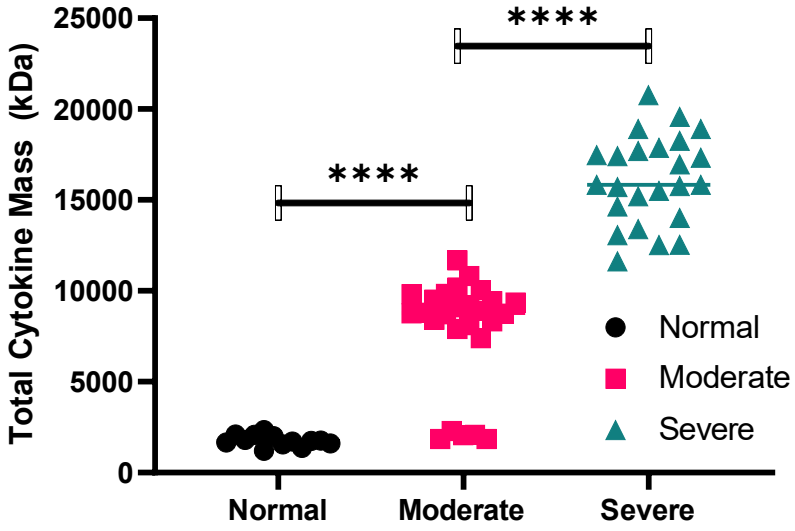

Figure S4 Comparing secreted levels of total cytokine mass in the blood serum of normal donors,and patients with moderate and severe hypercytokinemia. Here, hypercytokinemia alone means sum of the moderate and severe cases. The total cytokine mass was measured by ELISA for all of the 63 samples.

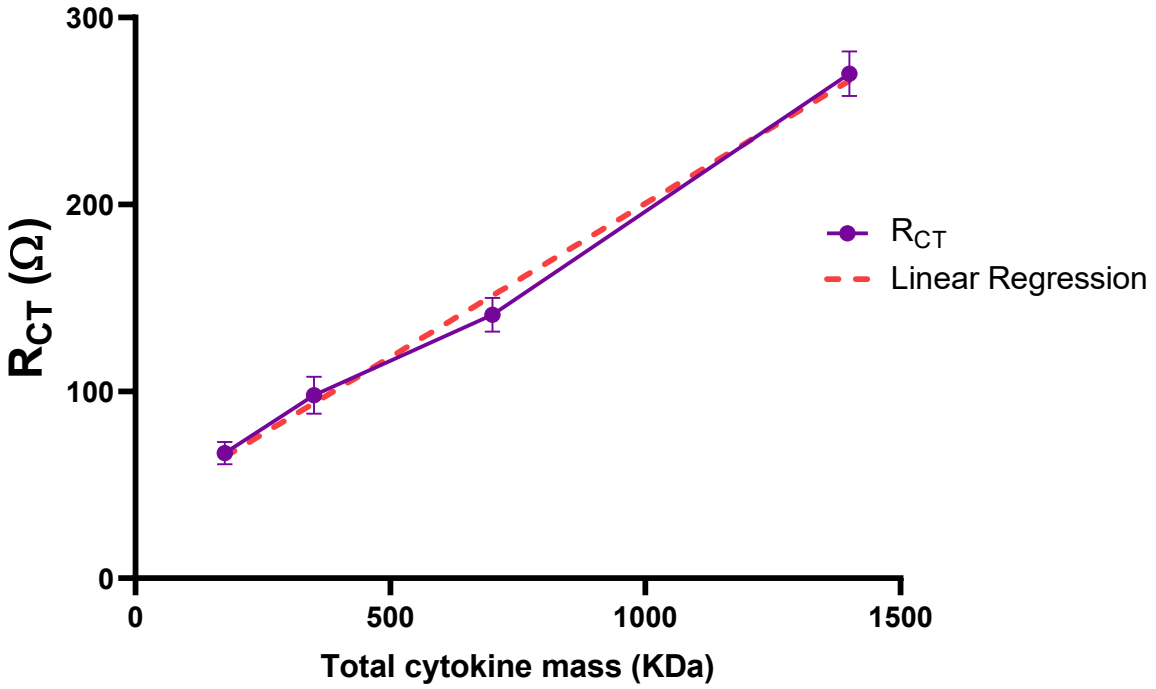

Figure S5 Electrochemical response studies of developed EIS-biosensor for blood serums with a specified amount of total cytokine mass, which is almost a linear function. The detection limit for the device is calculated as 175 kDa total cytokine mass.

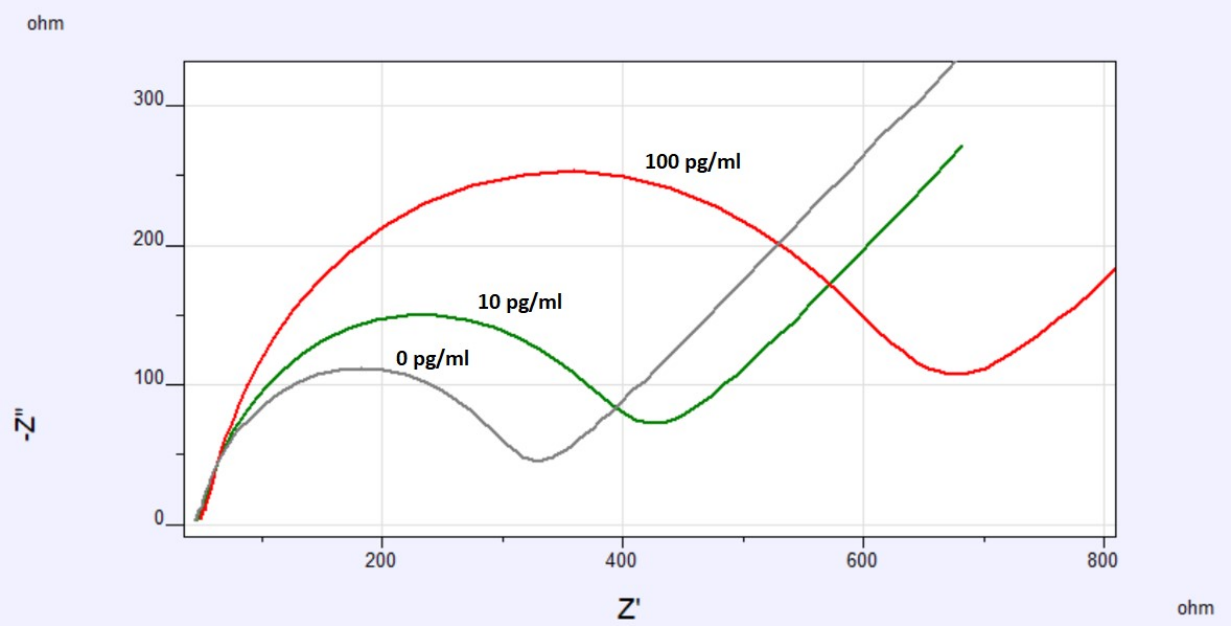

Figure S6 The EIS analysis was done and the Nyquist diagram was plotted for different concentrations of the IL-6 in a human serum.

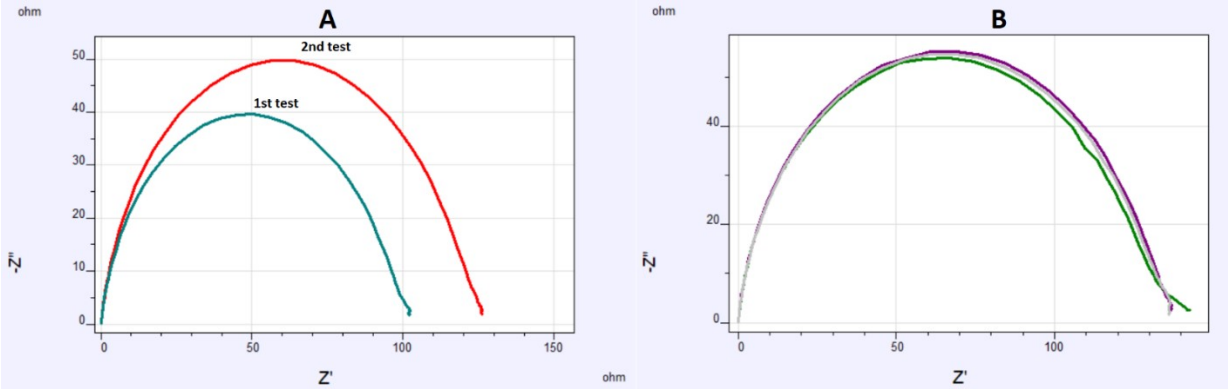

Figure S7 (A) R_{CT} analysis from the blood serum of a healthy donor for two consecutive experiments and after each time of exposing to graphene/cu electrode. (B) the EIS results of a blood serum tested on three different sensors with a new graphene electrode.