Supporting information

Electrochemical determination of captopril using disposable graphite electrode modified with a molecularly imprinted film, accompanied by a ratiometric read-out

Ahmed Z. Alanazi[a], Khalid Alhazzani[a], Hossieny Ibrahim[b, c], Al-Montaser Bellah H. Ali[d], Mahmoud Darweesh[e,f], Mohamed M El-Wekil[*d]

[a] Department of Pharmacology and Toxicology, College of Pharmacy, King Saud University, Riyadh, Saudi Arabia

[b] Department of Chemistry, Faculty of Science, Assiut University, Assiut 71516, Egypt

[c] School of Biotechnology, Badr University in Assiut, Assiut 2014101, Egypt

[d] Department of Pharmaceutical Analytical Chemistry, Faculty of Pharmacy, Assiut University, Assiut, Egypt

[e] Department of Medical Biochemistry and Microbiology, Uppsala University, Uppsala, Sweden

[f] Department of Microbiology and Immunology, Faculty of Pharmacy, Al-Azhar University, Assiut Branch, Egypt

*mohamed.elwakeel@pharm.aun.edu.eg, mohamed.mohamoud@ymail.com (corresponding author)

Instrumentation

Cyclic voltammetric (CV) and differential pulse voltammetric (DPV) analyses were conducted using a Versa STAT 3, Model RE-1, manufactured by Princeton Applied Research, a division of AMETEK, USA. The voltammetric cell consisted of three electrodes: a PGE or modified PGE working electrode, a platinum electrode (auxiliary), and an Ag/AgCl (3 M KCl) reference electrode. Scanning Electron Microscopy (SEM) was performed using a JEOL JSM-5400 LV instrument (Oxford, USA). Elemental analysis was carried out using an OXFORD INA Energy Dispersive X-ray Spectrometer (EDX). FTIR spectra were recorded using a Nicolet 6700 FTIR Advanced Gold Spectrometer, with support from OMNIC 8 software, manufactured by Thermo Electron Scientific Instruments Corp., located in Madison, WI, USA. Powder X-ray diffraction (XRD) was conducted using a PW1729 Philips diffractometer interfaced with a computer control unit model PW1710, utilizing a copper source. Dynamic light scattering (DLS) was recorded with the ZEN 3600 Nano ZS model from Malvern in the UK.

Preparation of real samples

Twenty tablets were accurately weighed and ground. Subsequently, an amount equivalent to the content of one tablet was transferred into a 100 mL calibrated flask containing 20 mL of double-distilled water (DDW), followed by sonication for 25 minutes. The flask was then filled to the volume with DDW before centrifugation at 3000 rpm for 20 minutes. The resulting suspension was filtered, and a specific aliquot was transferred to a voltammetric cell containing B.R. buffer (pH 3.5). Analysis was conducted both before and after the addition of various amounts of captopril.

For human serum analysis, 1.5 mL of blood samples were collected from healthy, non-smoking volunteers' forearm veins into heparinized polyethylene tubes. The tubes were then centrifuged at

4000 rpm for 20 minutes, and the supernatant (plasma) was refrigerated at −80°C until analysis. Subsequently, 0.5 mL of plasma was mixed with 0.5 mL acetonitrile and subjected to centrifugation for approximately 15 minutes to remove potential interference. Human serum was measured using the proposed method before and after spiking with different concentrations of captopril.

Regarding human urine analysis, 1.5 mL of urine was collected and diluted to 5 mL with DDW. The sample was then centrifuged at 4000 rpm for 20 minutes. Human urine was subsequently measured using the proposed method before and after spiking with different concentrations of captopril. The study adhered to the regulations established by the Egyptian authorities and received authorization from the Institutional Human Ethics Committee at Assiut University, Egypt.

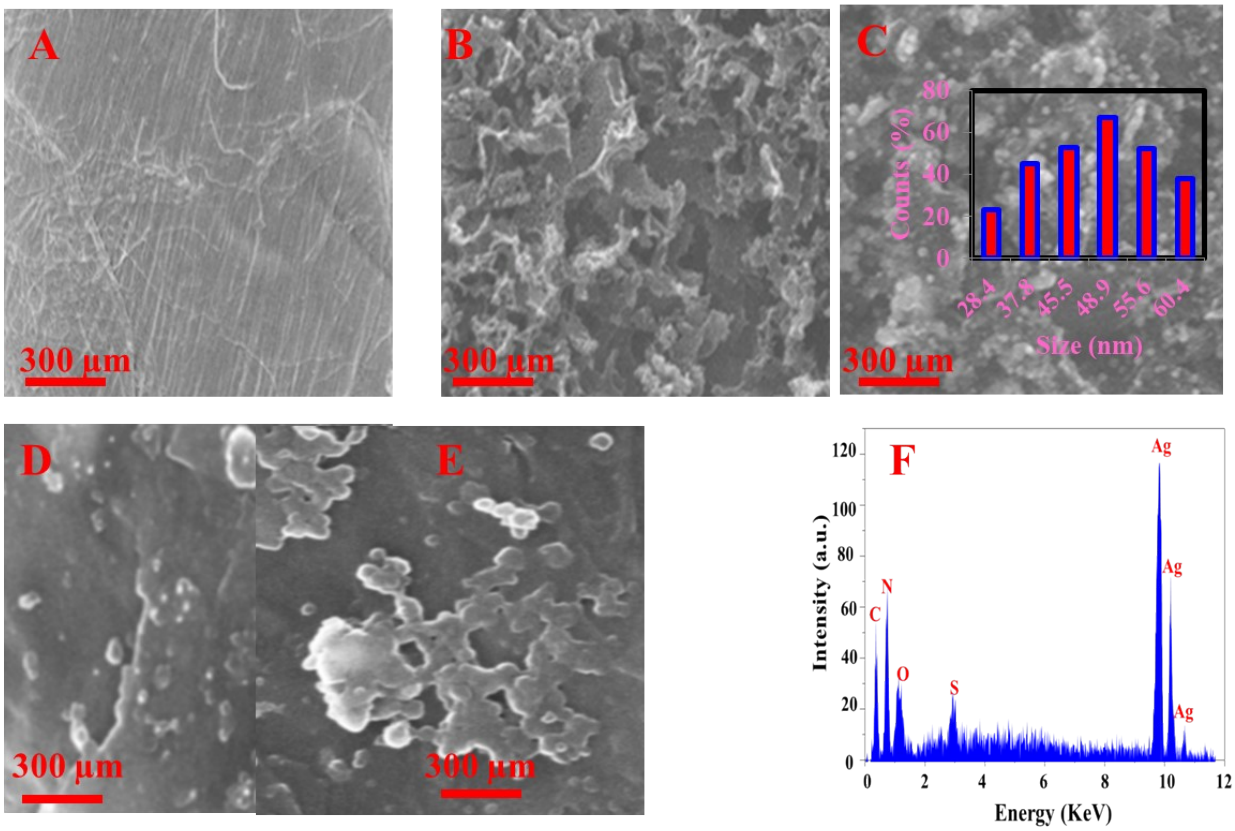


Fig.S1 SEM images of (A) Bare GE, (B) NS-PC/GE, (C) NS-PC@Ag/GE (inset is grain size distribution), Cu-NIP@NS-PC@Ag/GE (D), and Cu-MIP@ NS-PC@Ag/GE (E) while (F) is EDX spectrum of NS-PC@Ag/GE.

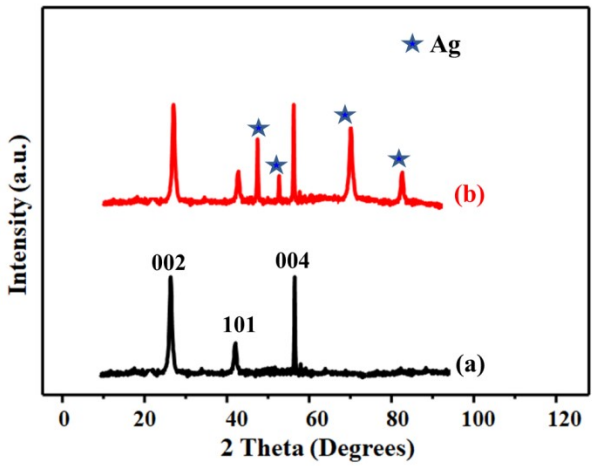


Fig. S2 PXRD pattern of NS-PC/GE (a) and NS-PC@Ag/GE (b).

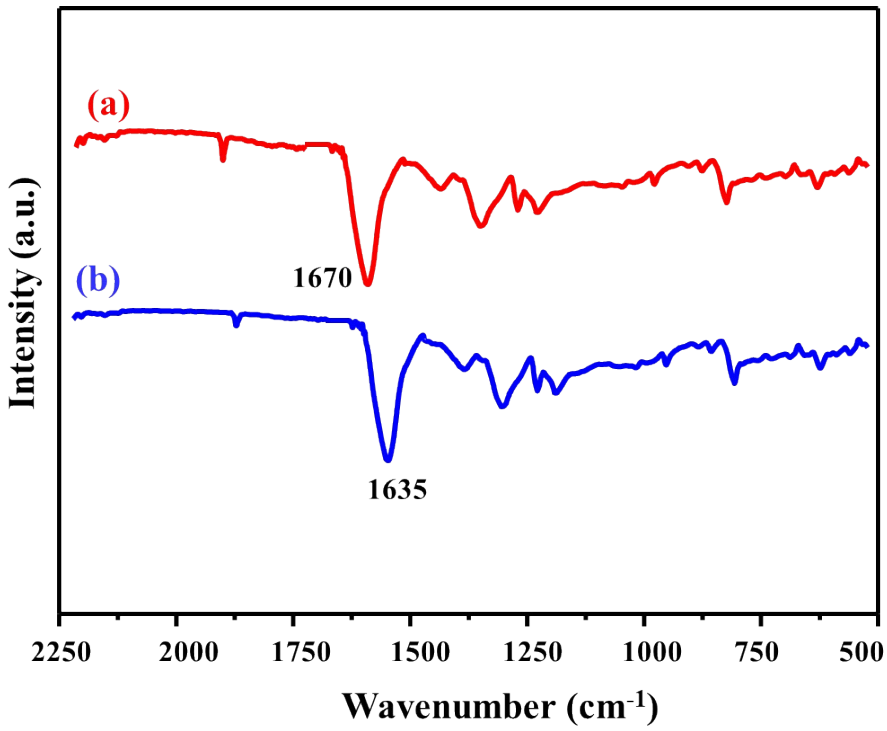


Fig.S3 FTIR spectra of PY-COOH (a) and PY-COOH@Cu coordinated complex (b).

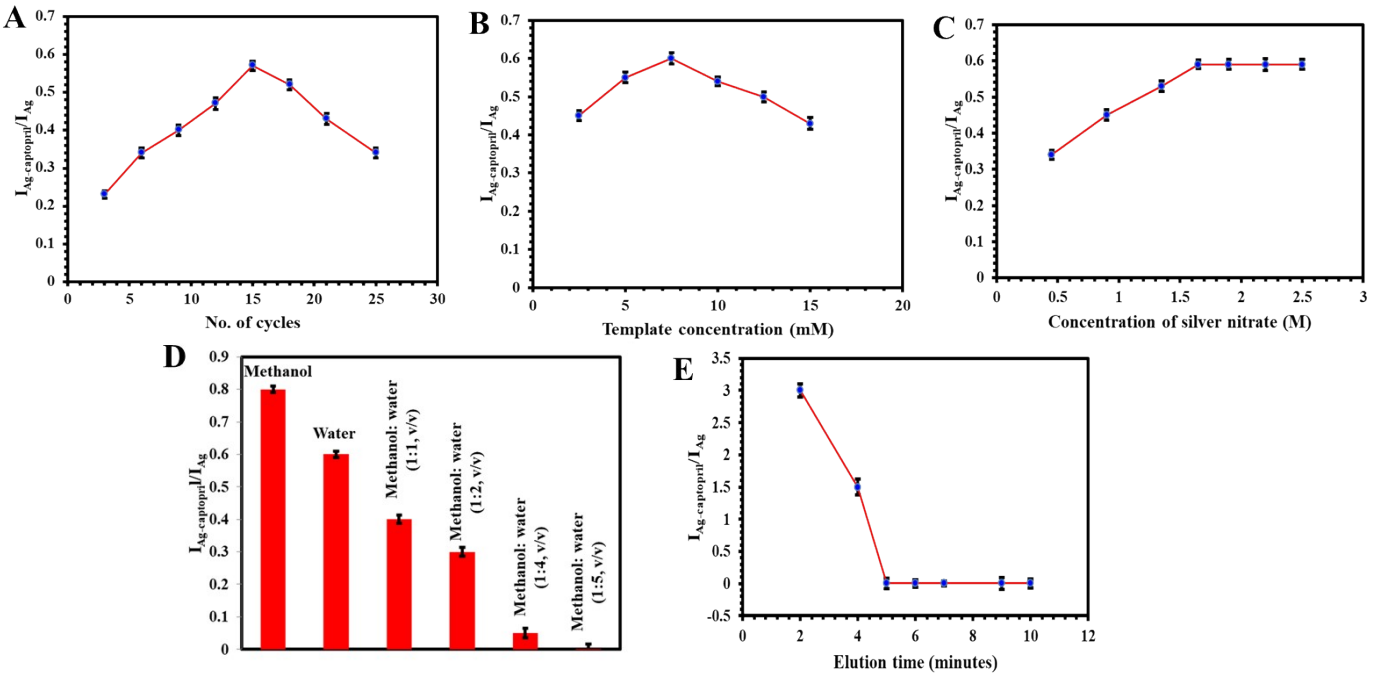


Fig.S4 The effect of electro-polymerization cycles (A), template concentration (B), concentration of $AgNO_3$ (C), elution solvent/proportion, and elution time (D) on the response of 90 nM captopril at Cu- MIP@ NS-PC@Ag/GE.

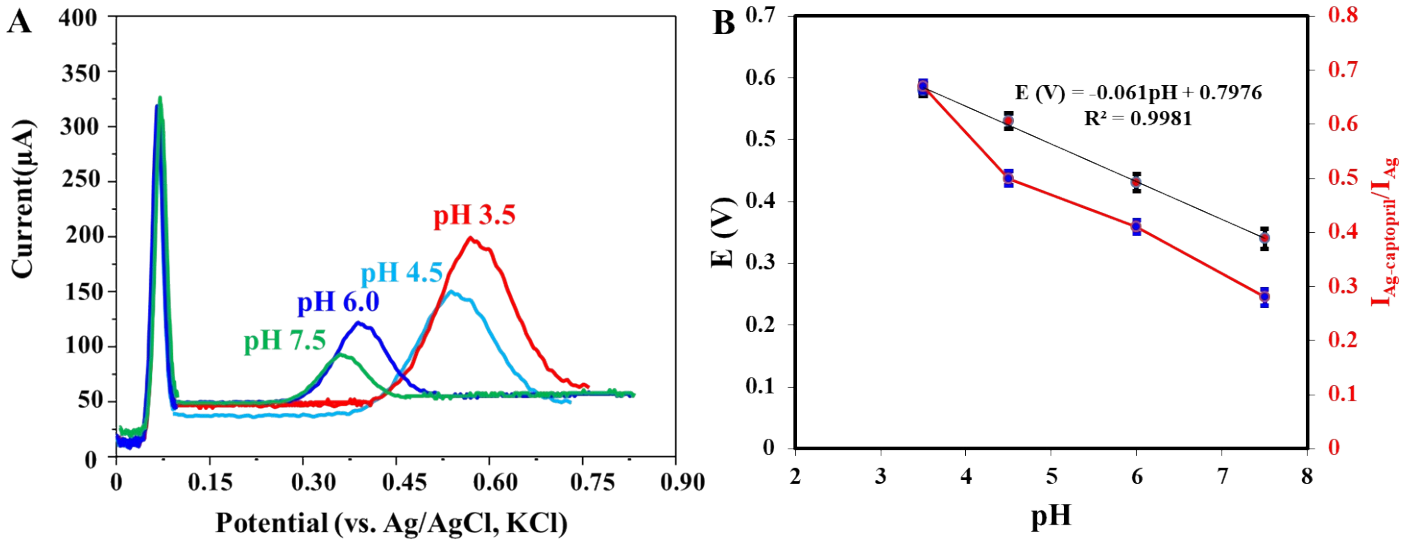
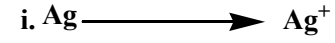


Fig.S5 (A) DPV of 90 μM captopril determined by Cu- MIP@ NS-PC@Ag/GE in R.B. buffer with different pH values. (B) The effect of pH value on Epa and $I_{Ag\text{-}captopril}/I_{Ag}$.



VIII

Scheme S1 The proposed coordination interaction between captopril and Ag^{+} and oxidation of the resultant complex.

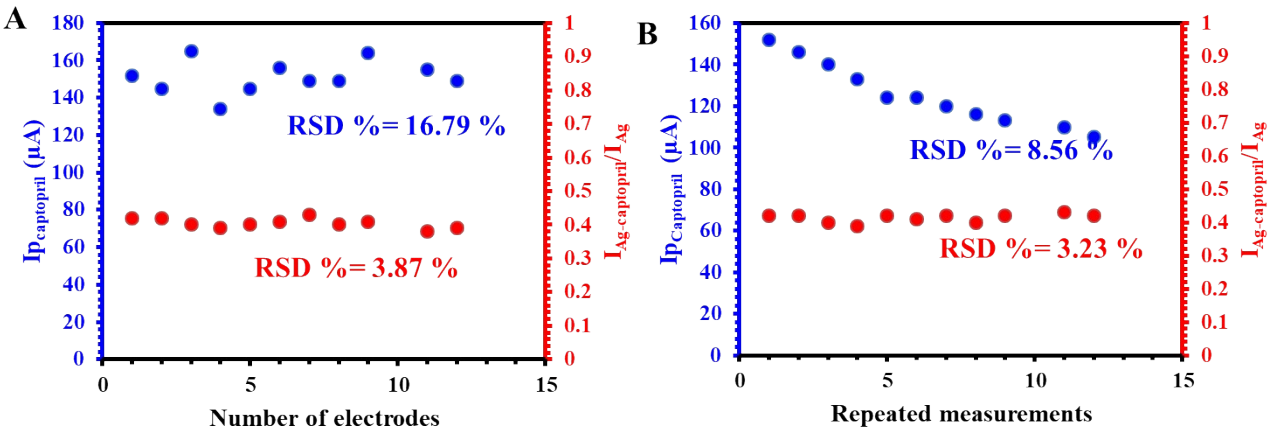


Fig.S6 (A) Ratiometric and non-ratiometric responses of twelve platforms under the same conditions; (B) Repeatability of ratiometric and non-ratiometric responses.