Electronic Supplementary Material (ESI) for Journal of Materials Chemistry B.

Supplementary Information

Synthesis and Characterization of Porous Carbon-MoS_2 Nanohybrid Materials: Electrocatalytic Performance Towards Selected Biomolecules

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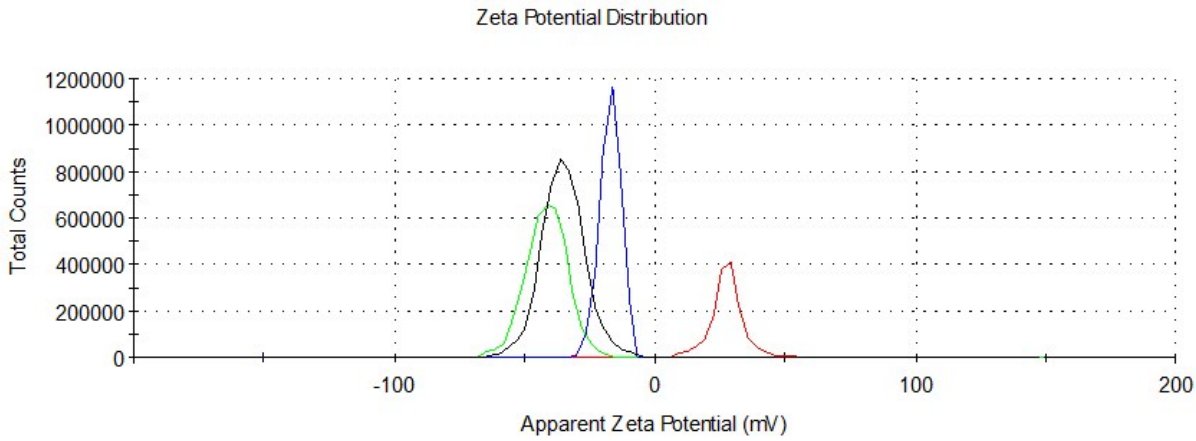

Fig. S1 The Zeta potential measurements. Results for: MoS_2 (black), MoS_2/CNP+ (red), MoS_2/CNP- (green) and MoS_2/CNP+/CNP- (blue).

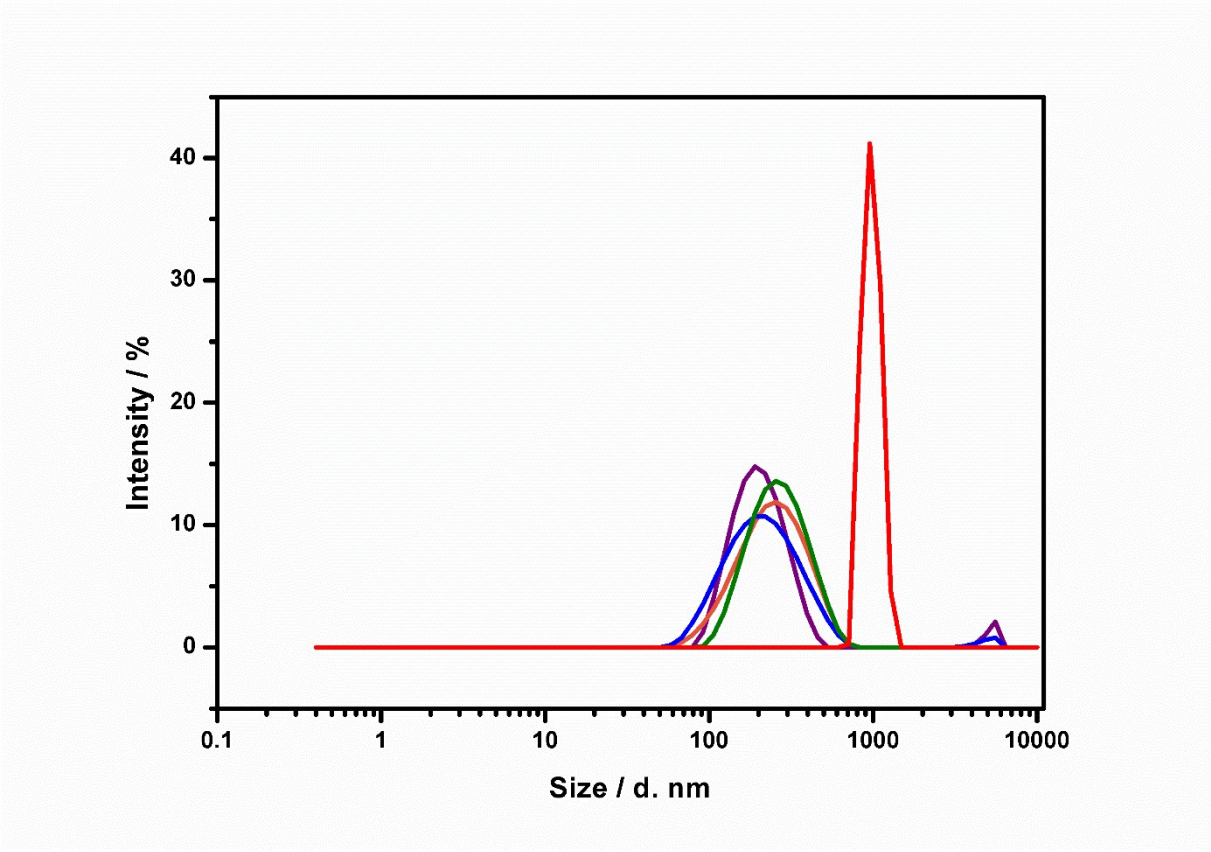

Fig. S2 The DLS measurements. Results for: MoS_2 supernatant (purple), MoS_2 precipitate (orange), MoS_2/CNP+ (green), MoS_2/CNP- (blue) and MoS_2/CNP+/CNP- (red).

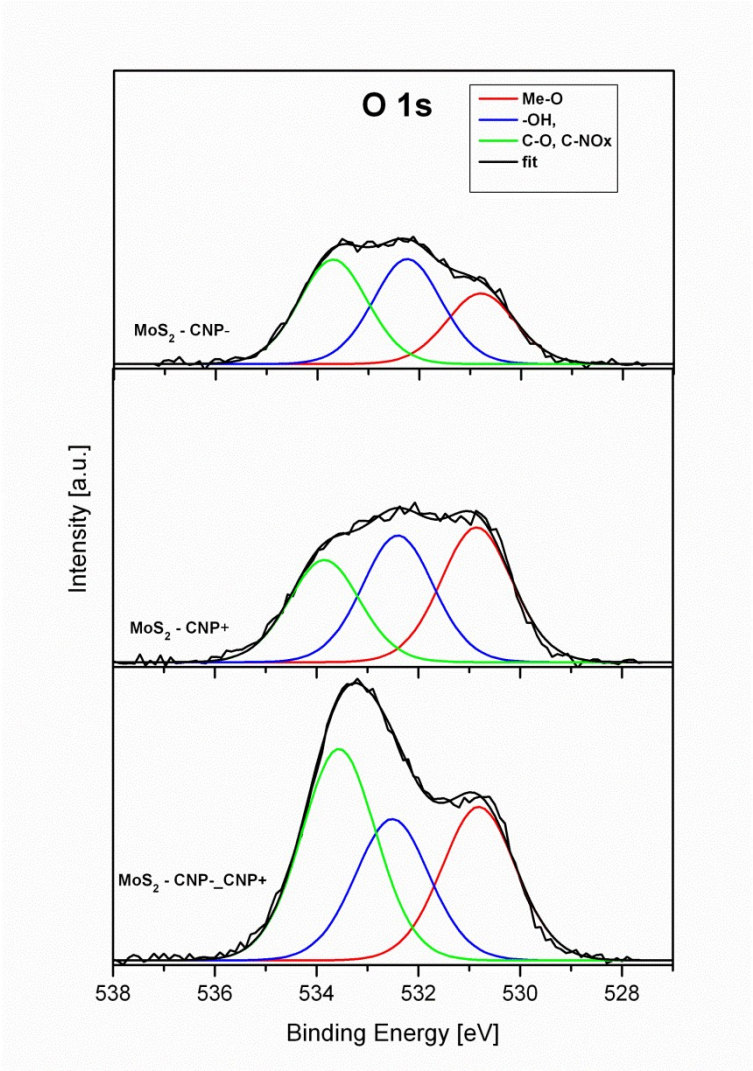

Fig. S3 shows HR-XPS spectra of O 1s recorded for MoS_2/CNP-, MoS_2/CNP+ and MoS_2/CNP+/CNP-) samples. De-convoluted peaks present various chemical states of oxygen species.

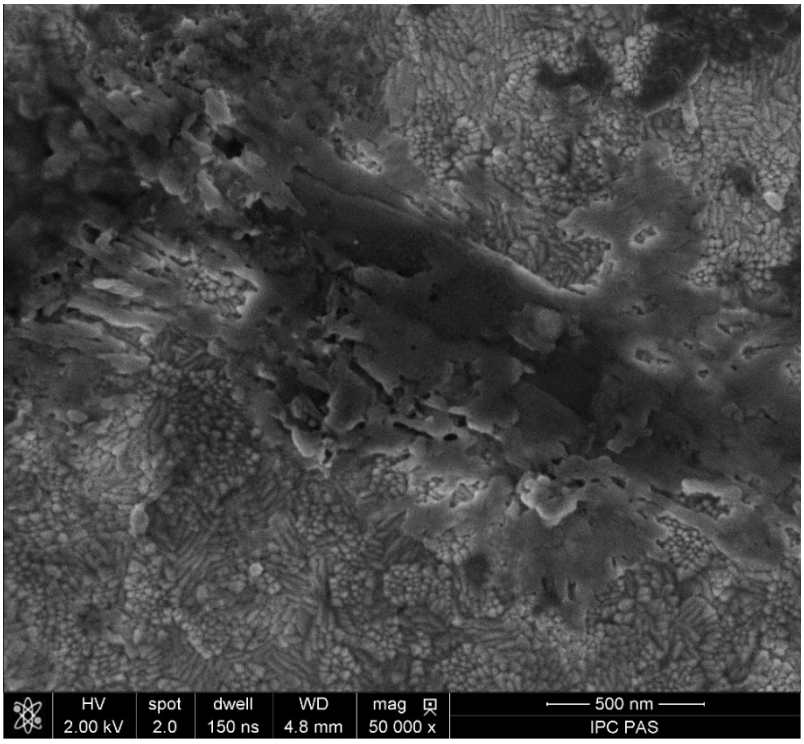

Fig. S4 SEM image of deposit obtained from MoS_2 supernatant on ITO electrode.

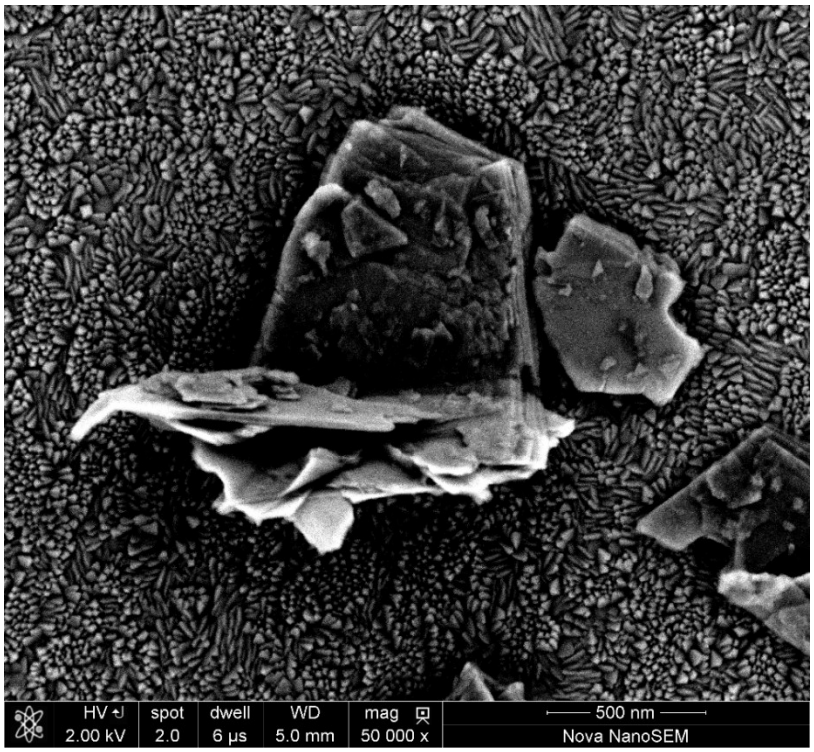

Fig. S5 SEM image of MoS_2 precipitate on ITO surface.

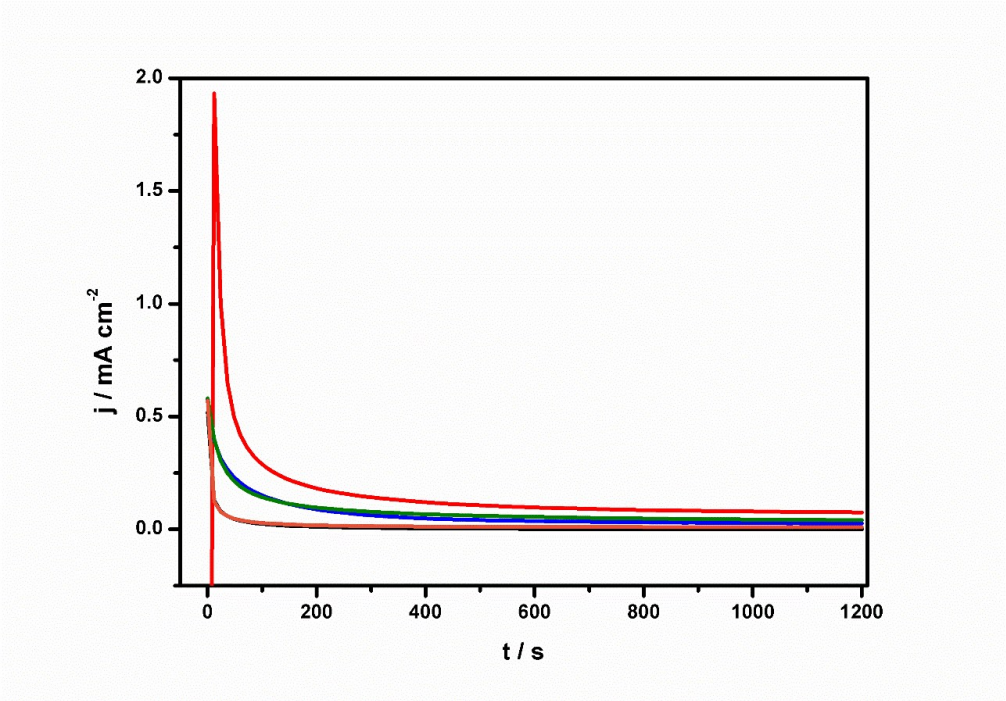

Fig. S6 Chronoamperograms (constant potential +0.6 V *vs.* Ag|AgCl) obtained in 1 mM $K_3[Fe(CN)_6]$ solution in 0.1 M phosphate buffer (pH 7.4) on bare glassy carbon electrode (black) and modified with MoS_2 (orange), MoS_2/CNP- (blue), MoS_2/CNP+ (green), and MoS_2/CNP-/CNP+ (red).

The electrochemically active electrode surface was obtained from the slope of the so-called Cottrell plot (current *vs*. reciprocal of square root of time) obtained from the potential step experiment performed in 1 mM $K_3[Fe(CN)_6]$ in 0.1 M phosphate buffer solution.
Calculation is based on the Cottrell equation [1]:

$$i(t) = n\ F\ A\ D^{1/2}\ C^{1/2}\ \pi^{-1/2}\ t^{-1/2}$$

where n – number of electrons, F – Faraday constant, A – electrode surface, D – diffusion coefficient, C – concentration of the redox probe, t – time.
This equation predicts linear dependence of the current vs. square root of time. Here other parameters are known: n = 1, c = 1 mM and $D = 0.76 \times 10^{-5}$ cm^2 s^{-1}. Therefore, the value of A can be calculated.

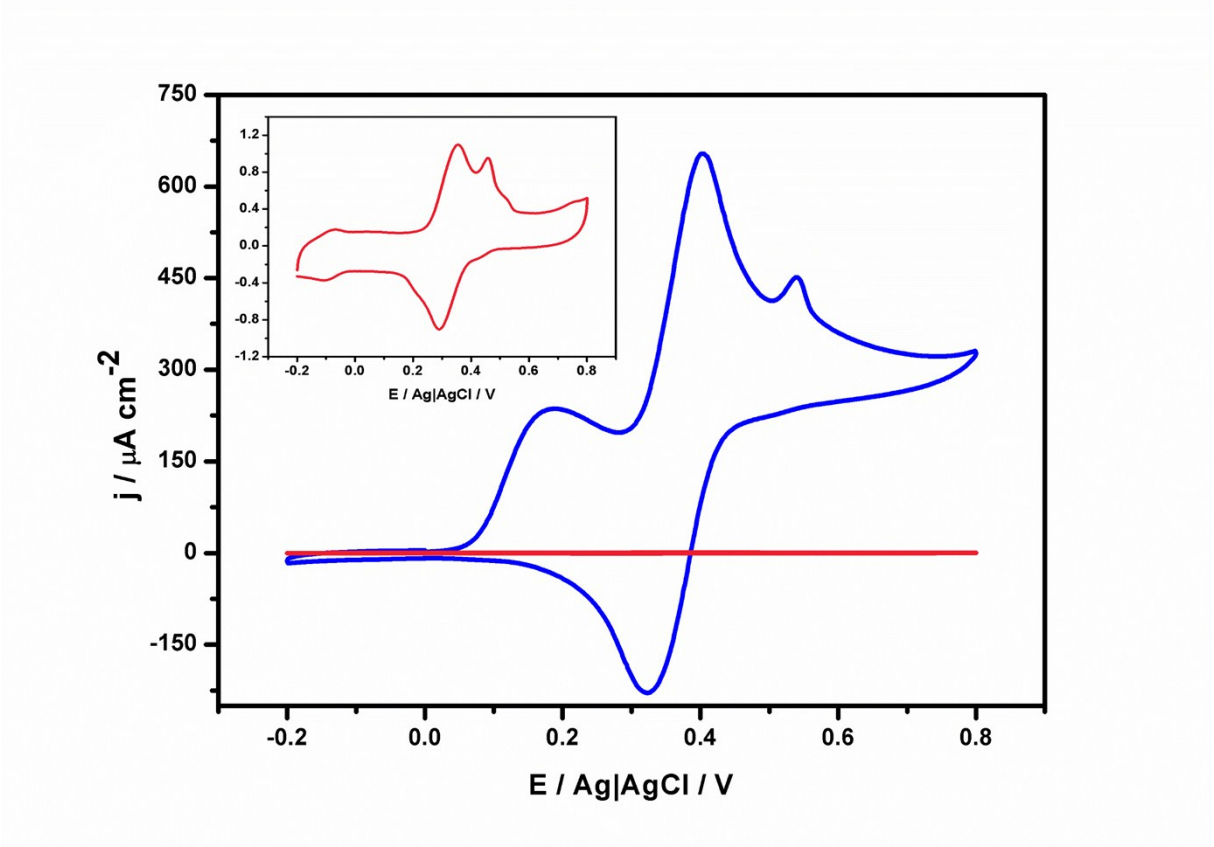

Fig. S7 Cyclic voltammogram (scan rate 0.1 Vs^{-1}) obtained in 2 mM dopamine (DA) 1 mM ascorbic acid (AA) and 1 mM uric acid (UA) in the in 0.1 M phosphate buffer solution (pH 4.8). The experiments were performed with electrode modified with MoS_2/CNP-(blue) and only with CNP- (pink).

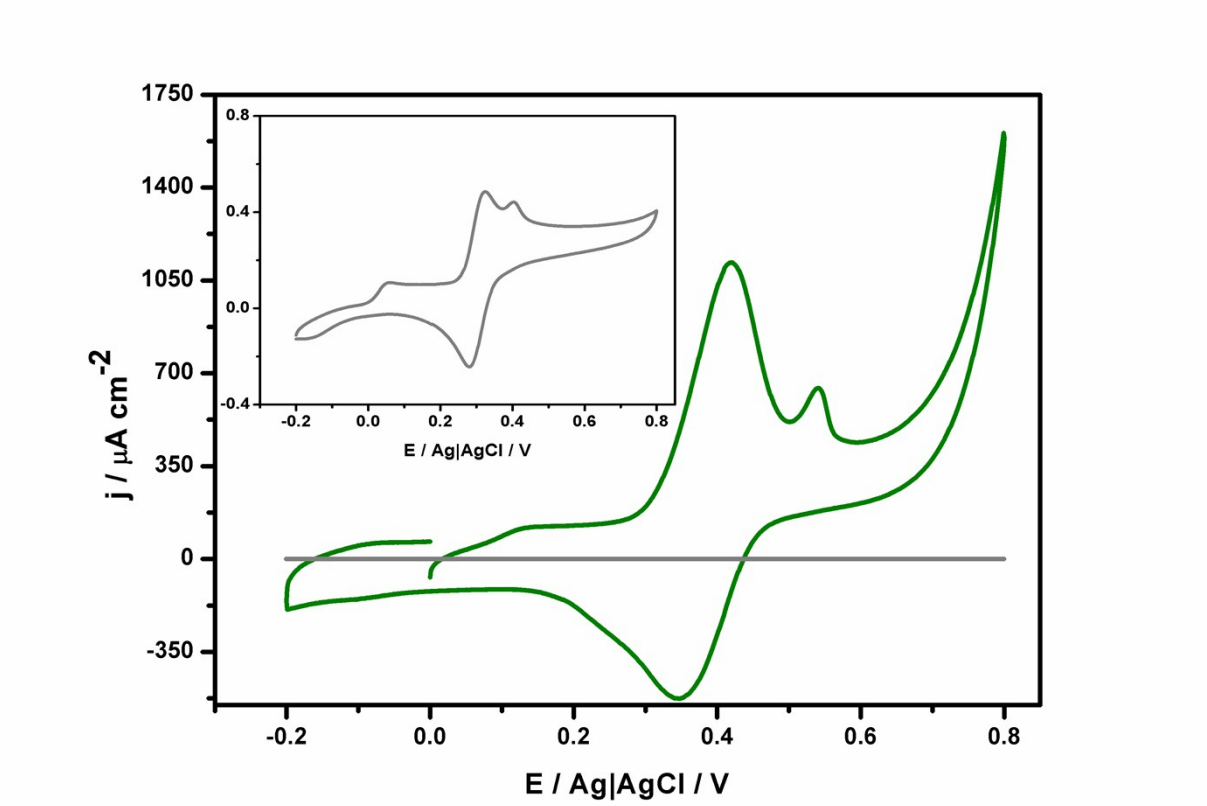

Fig. S8 Cyclic voltammogram (scan rate 0.1 Vs^{-1}) obtained in 2 mM dopamine (DA) 1 mM ascorbic acid (AA) and 1 mM uric acid (UA) in the in 0.1 M phosphate buffer solution (pH 4.8). The experiments were performed with electrode modified with MoS_2/CNP+ (green) and only with CNP+ (grey).

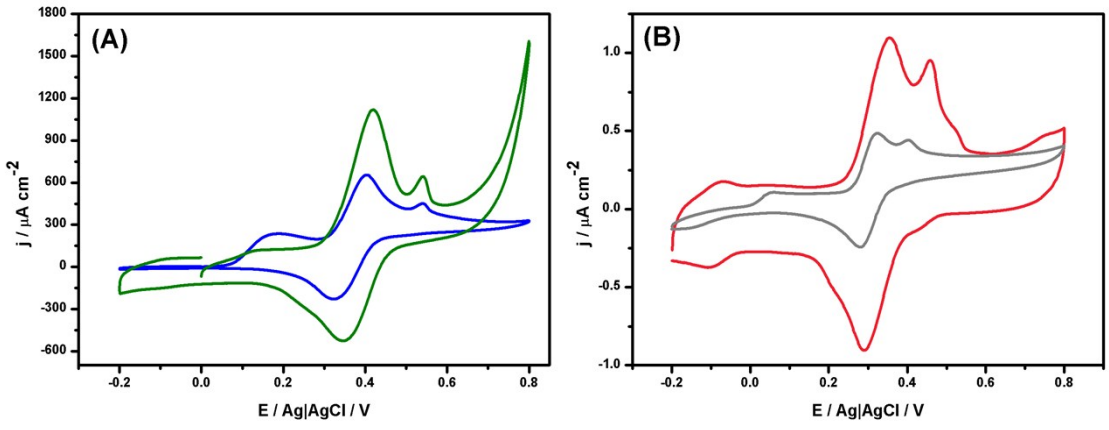

Fig. S9 Comparison of glassy carbon electrode modified with MoS_2/nanoparticles (A) where green is for MoS_2/CNP+ and blue is for MoS_2/CNP-, and electrodes modified with carbon nanoparticles (B), where grey colour is for CNP+, and pink is for CNP-.

Table 1. A comparison between this work and recently reported literature on carbon nanomaterials modified electrodes for simultaneously determination of dopamine in the presence of ascorbic acid and uric acid. (GC – glassy carbon, OMC – ordered mesoporous carbon, CNO – carbon nanoonion, PDDA - poly(diallyldimethylammonium chloride), CNP carbon nanoparticles, NG - nitrogen doped graphene, MWCNT – multiwalled carbon nanotubes, CCE–carbon ceramic electrodes, MCNF/PG - Mesoporous carbon nanofiber-modified pyrolytic graphite electrode, GC/Fe_3O_4@CNT-N Amino-group Functionalized Mesoporous Fe3O4@Graphene Sheets, GS_PTCA - graphene sheets 3,4,9,10-perylenetetracarboxylic acid tube hybrid, Au/Gr-Au gold electrode modified with graphene/gold or gold-silver, GONR - graphene oxide nanoribbons, GC – graphene sheets, MoS_2 – molybdenum disulphite nanopetals), Trp-tryptophan.

Electrode material	**Interferences**	**Calibration range (µM)**	**Detection limit (µM)**	**Technique**	**Ref.**
GC/OMC/Nafion	AA, UA	1-90	0.5	DPV	[3]
GC/CNO/PDDA	AA, UA	50-4000	10	DPV	[4]
ITO/CNPs	AA, UA	0.4–350	0.4	DPV	[5]
NG	AA, UA	0.5-170	0.25	DPV	[6]
MWCNT/CCE	AA, UA	0.5-100	0.31	DPV	[7]
MCNF/PG	AA, UA	0.05-30	0.02	DPV	[8]
GC/Fe3O4@CNT-N	AA, UA	0.005-0.065	0.05	SWV	[9]
GS–PTCA	AA, UA,Trp	0-374.4	0.13	DPV	[10]
Au/Gr-AuAg	AA,UA	0.3-300	0.205	SWV	[11]
Au/Gr-Au	AA,UA	10-100	30.3	SWV	[11]
CPE/Au-NP	AA,UA	0.08-200	0.03	DPV	[12]
GC/GONR	AA,UA	0.15–12.15	0.08	DPV	[13]
SG	AA,UA	0-90	0.02	DPV	[14]
GC/MoS2/CNP	AA, UA	0-1	0.02	DPV	this work

References:

[1] F.G. Cottrell, Z. Phys. Chem. 42 (1903), p. 385.

[2] A.J. Bard, L. Faulkner, "Electrochemical Methods. Fundamentals and Applications" 2nd Ed. Wiley, New York. 2001. p. 163. ISBN 0-471-04372-9.

[3] D Zheng, J Ye, L Zhou, Y Zhang, C Yu, J. Electroanal. Chem., 2009, 652, 82-87.

[4] J. Breczko, M. E. Plonska-Brzezinska, L. Echegoyen, Electrochim. Acta, 2012, 72, 61–67.

[5] M. Kundys, K. Szot, E. Rozniecka, M. Jönsson-Niedziółka, R. Lawrence, S. D. Bull, F. Marken, M. Opallo, Anal. Methods, 2014, 6, 7532-7539.

[6] Z.-H. Sheng, X.-Q. Zheng, J.-Y. Xu, W.-J. Bao, F.-B. Wang, X.-H. Xia, Biosens. Bioelectron., 2012, 34, 125–131.

[7] B. Habibi, M. H. Pournaghi-Azar, Electrochim. Acta, 2010, 55, 5492–5498.

[8] Y. Yue, G. Hu, M. Zheng, Y. Guo, J. Cao, S. Shao, Carbon, 2012, 50, 107–114.

[9] D. M. Fernandes, M. Costa, C. Pereira, B. Bachiller-Baeza, I. Rodríguez-Ramos, A. Guerrero-Ruiz, C. Freire, J. Coll. Inter. Sci., 2014, 432, 207–213.

[10] W. Zhang, Y. Chai, R. Yuan, S. Chen, J. Han, D. Yuan, Anal. Chim. Acta, 2012, 756, 7–12.

[11] S. Pruneanu, A. R. Biris, F. Pogacean, C. Socaci, M. Coros, M. C. Rosu, F. Watanabe, A. S. Biris, Electrochim. Acta, 2015, 154, 197–204.

[12] A. Afraz, A. A. Rafati, M. Najafi, Mat. Sci. Eng. C, 2014, 44, 58–68.

[13] C.-L. Sun, C.-T. Chang, H.-H. Lee, J. Zhou, J. Wang, T.-K. Sham, W.-F. Pong, ACS Nano, 2011, 5, 7788–7795.

[14] S.-J. Li, J.-Z. He, M.-J. Zhang, R.-X. Zhang, X.-L. Lv, S.-H. Li, H. Pang, Electrochim. Acta, 2013, 102, 58–65.