Design and Synthesis of MoS₂ Nanostructures and its Potential in Sensing Applications

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Molybdenum disulphide (MoS₂)

IT MoS₂   3R MoS₂   2H MoS₂

Top View
Side View S / Mo / S
3D View

INTRODUCTION

Graphene Oxide (Gr)

GRAPHITE — Oxidation exfoliation → GRAPHENE OXIDE

Mechanical cleavage → GRAPHENE

Chemical vapor depositon
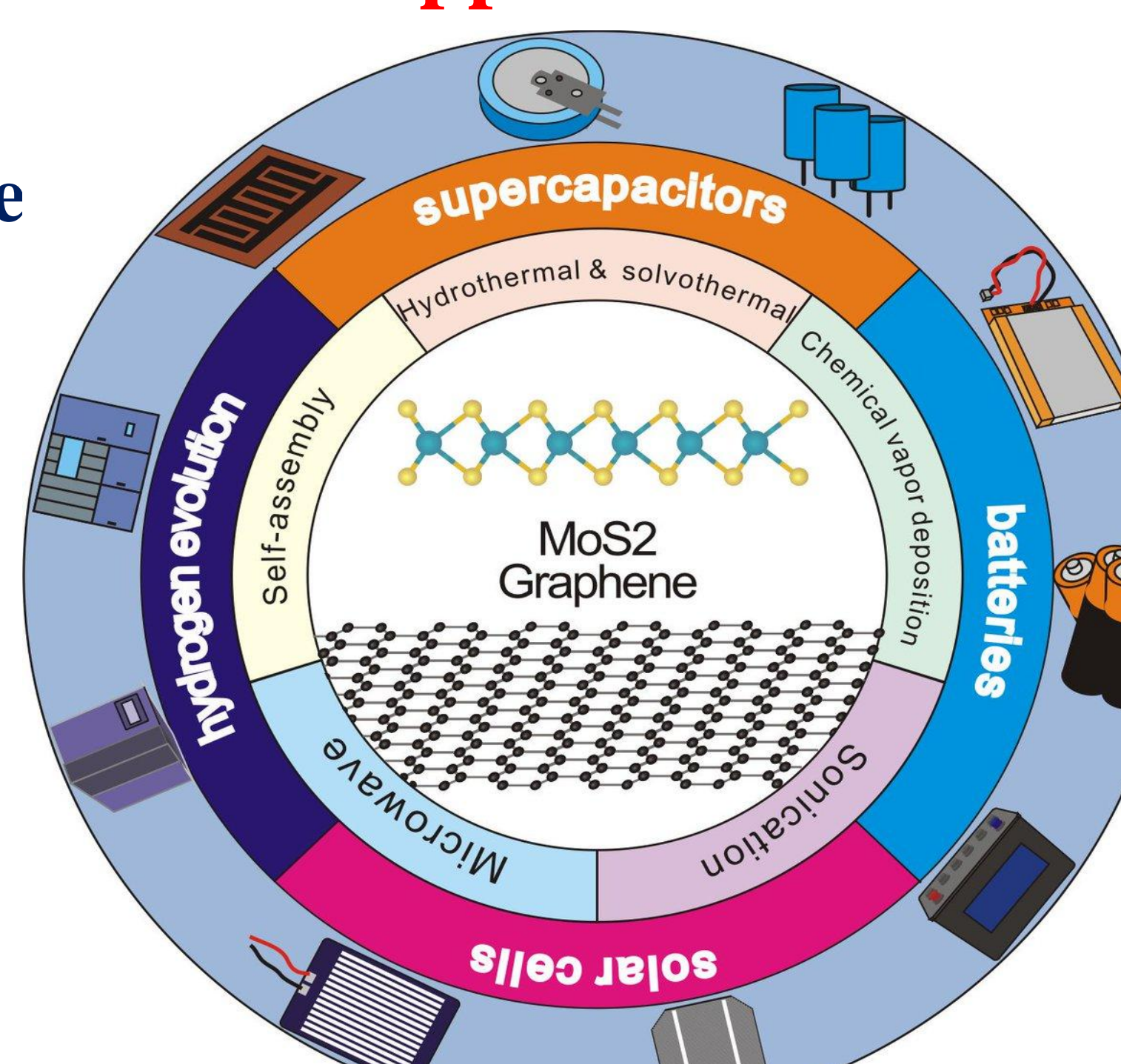
Reduction
chemical
thermal
electrochemical

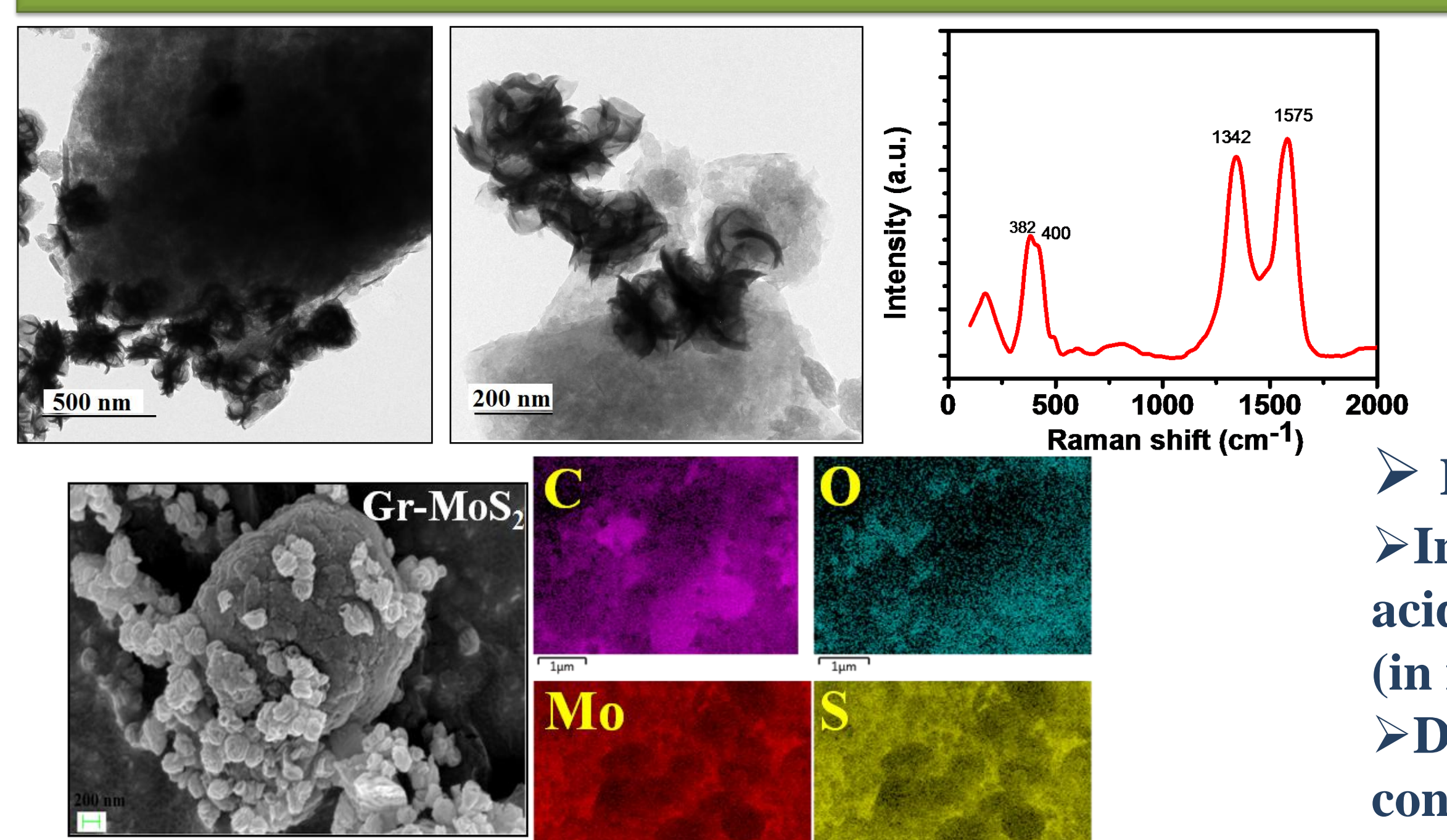REDUCED GRAPHENE OXIDE
CRGO TRGO ERGO

Merits of Gr-MoS₂

➢ Superior electrical conductivity
➢ High surface-to-volume ratio
➢ Ultra-thin thickness
➢ Efficient thermal conductivity
➢ Inert basal surface
➢ Catalytic Property
➢ Optical Property
➢ Band gap
➢ Structural flexibility

Applications

supercapacitors
Hydrothermal & solvothermal
Chemical vapor deposition
batteries
Self-assembly
MoS2 Graphene
Sonication
solar cells
Microwave
hydrogen evolution
Lithium

MORPHOLOGICAL AND STRUCTURAL FEATURES

Raman shift (cm⁻¹): 382 400 1342 1575

Gr-MoS₂ : C, O, Mo, S

DOPAMINE

Motivation, Habits, Exploring, Learning, Feeling Rewarded

Transmitting neuron — Dopamine — Receptor cell
Healthy patient / Parkinson's patient

Pre-synaptic neuron
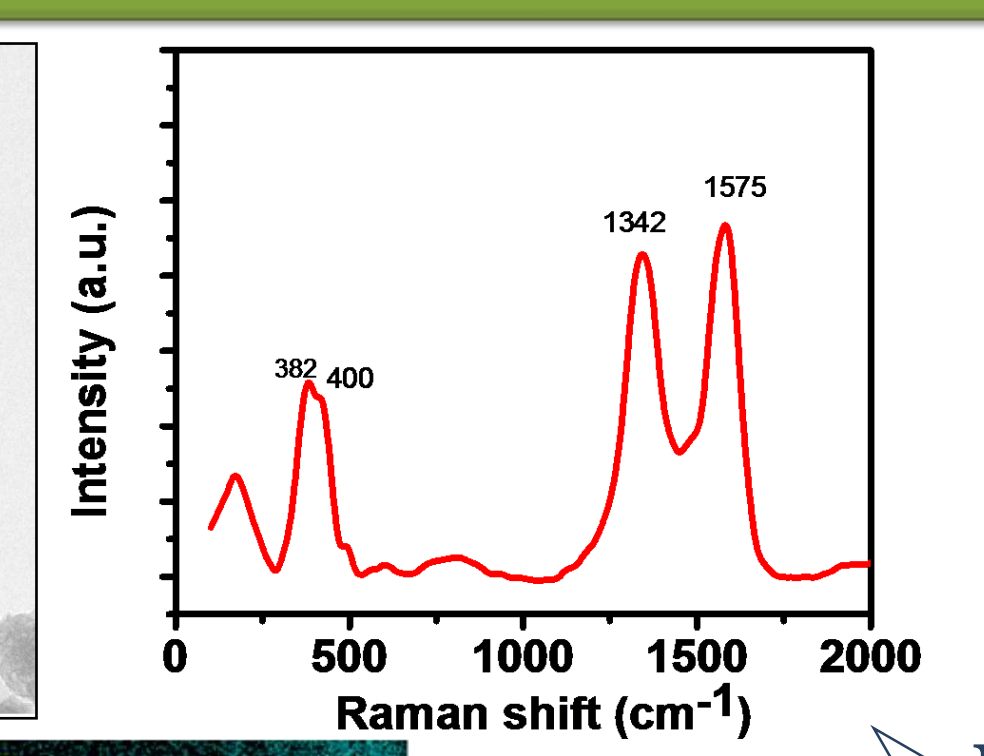Dopamine transporter (DAT)
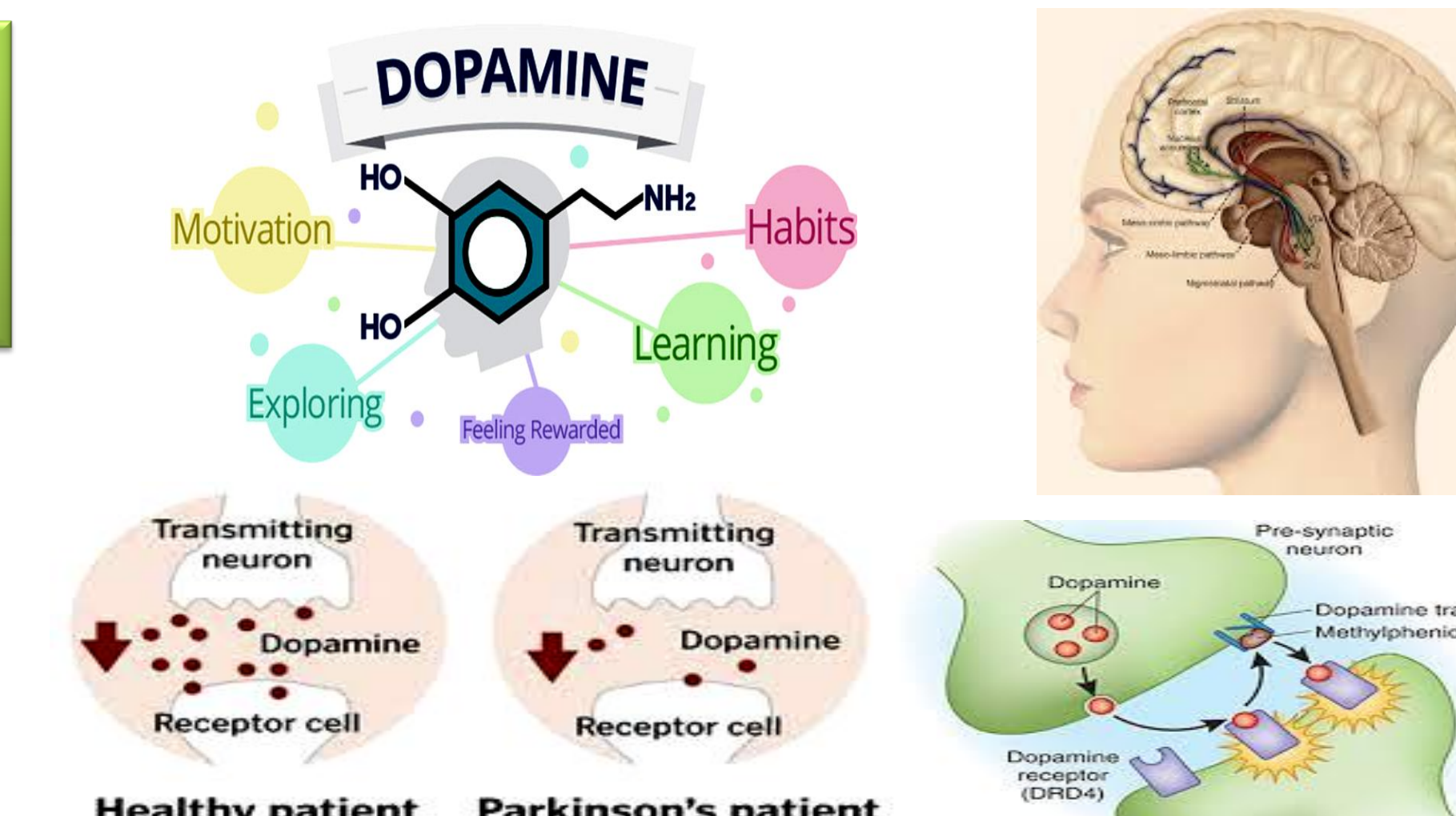Methylphenidate (MPH)
Dopamine receptor (DRD4)

Challenges in electrochemical dopamine sensing

➢ Lower physiological concentration levels (25-50 nM)
➢ Interferences from the structurally similar biomolecules such as Ascorbic acid (AA) and uric acid (UA) which are present in fairly higher concentrations (in mM), in biological tissues.
➢ Due to the structural similarities of DA, UA and AA, most of the conventional electrodes such as Au, Pt, and glassy carbon electrode (GCE) lack selectivity to them due to overlapping voltammetric responses.

RESULTS AND DISCUSSIONS

SELECTIVE ELECTROCHEMICAL SENSING OF DOPAMINE(DA)

❖ An important neurotransmitter in the mammalian central nervous system
❖ Influences the function of brain, metabolic system of human body, cardiovascular, central nervous, renal, and hormonal systems
❖ Deficiency leads to the Parkinson's disease, schizophrenia, drug addiction and HIV infection
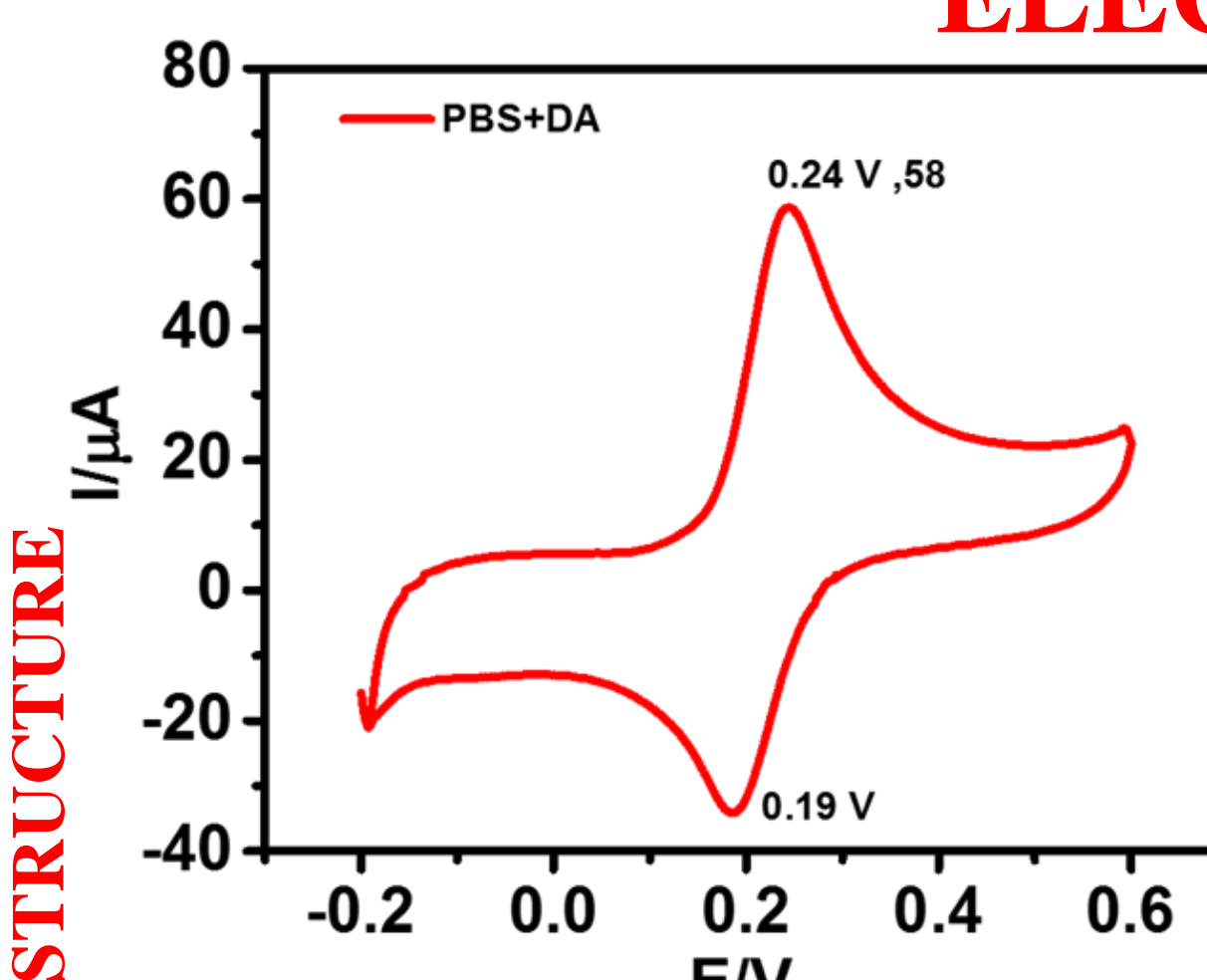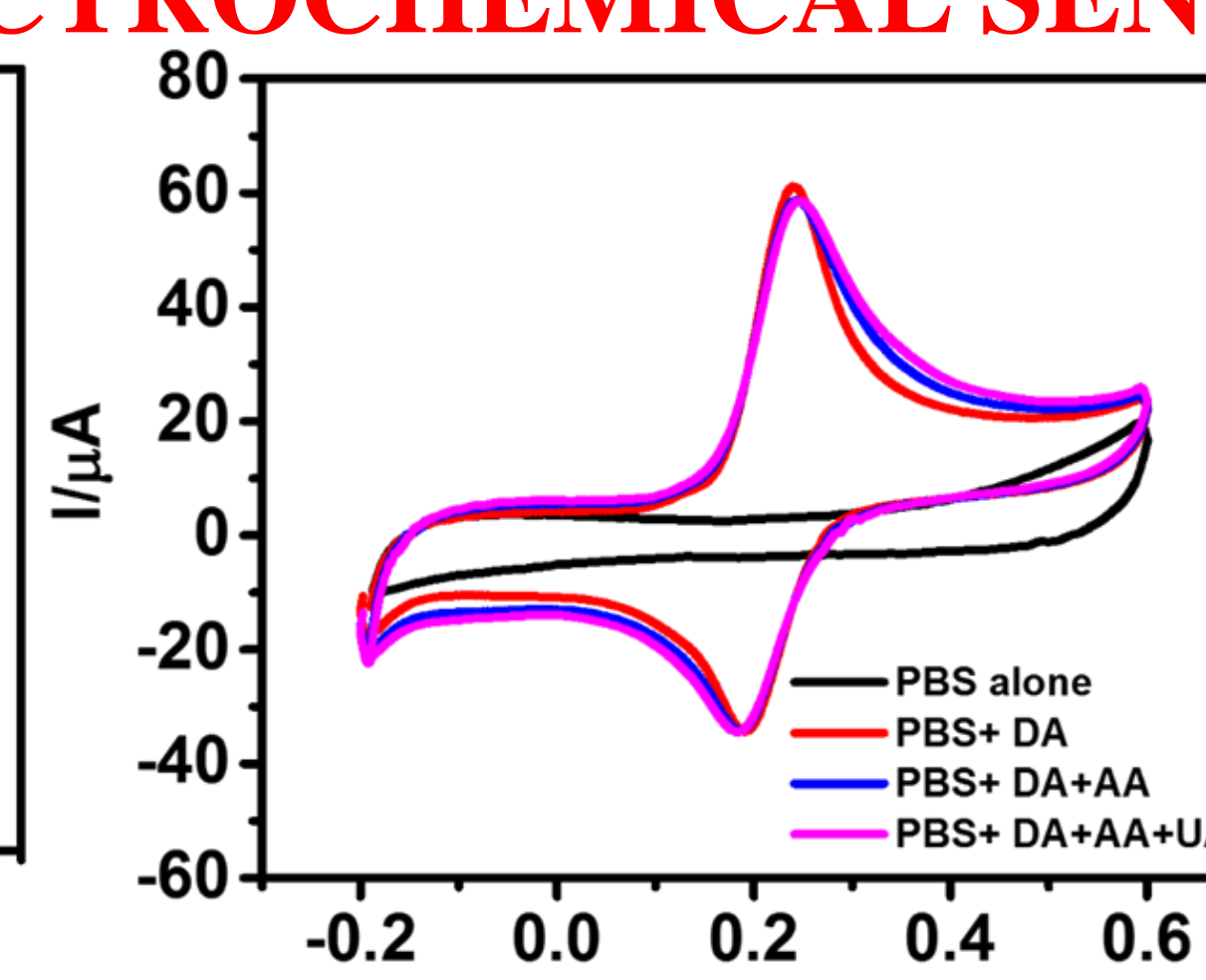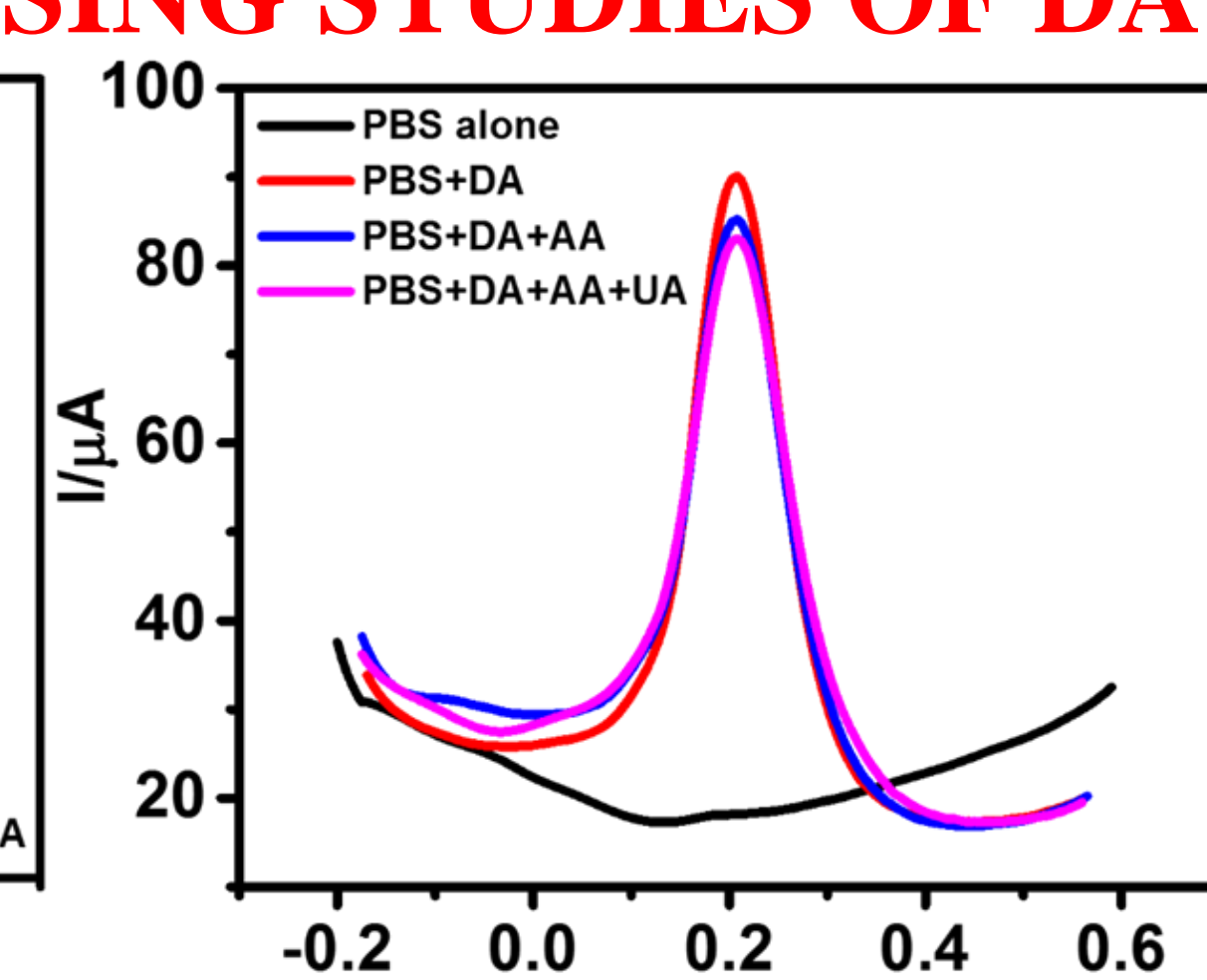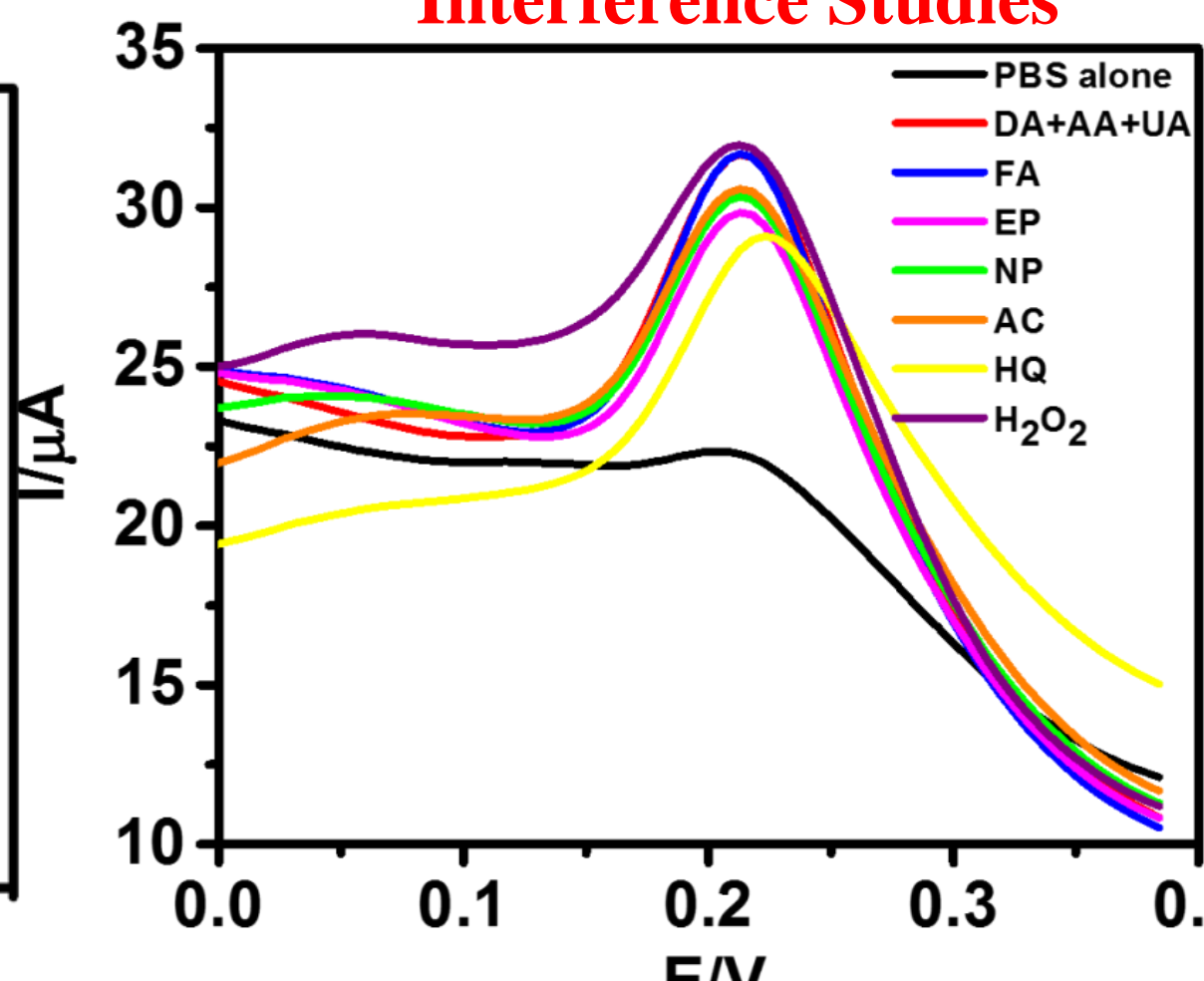
DA — A
AA — B
UA — C

ELECTROCHEMICAL SENSING STUDIES OF DA

MERITS of PGr-MoS₂STRUCTURE

PGr alone
MoS₂ alone
PGr-MoS₂ mixture

Interference Studies

PBS alone, DA+AA+UA, FA, EP, NP, AC, HQ, H₂O₂

Analyte ions: DA, Hg²⁺, Pb²⁺, Cd²⁺, Cu²⁺, Zn²⁺, Co³⁺, Cu²⁺, Sn²⁺, Ni²⁺, Cr⁶⁺, Li⁺
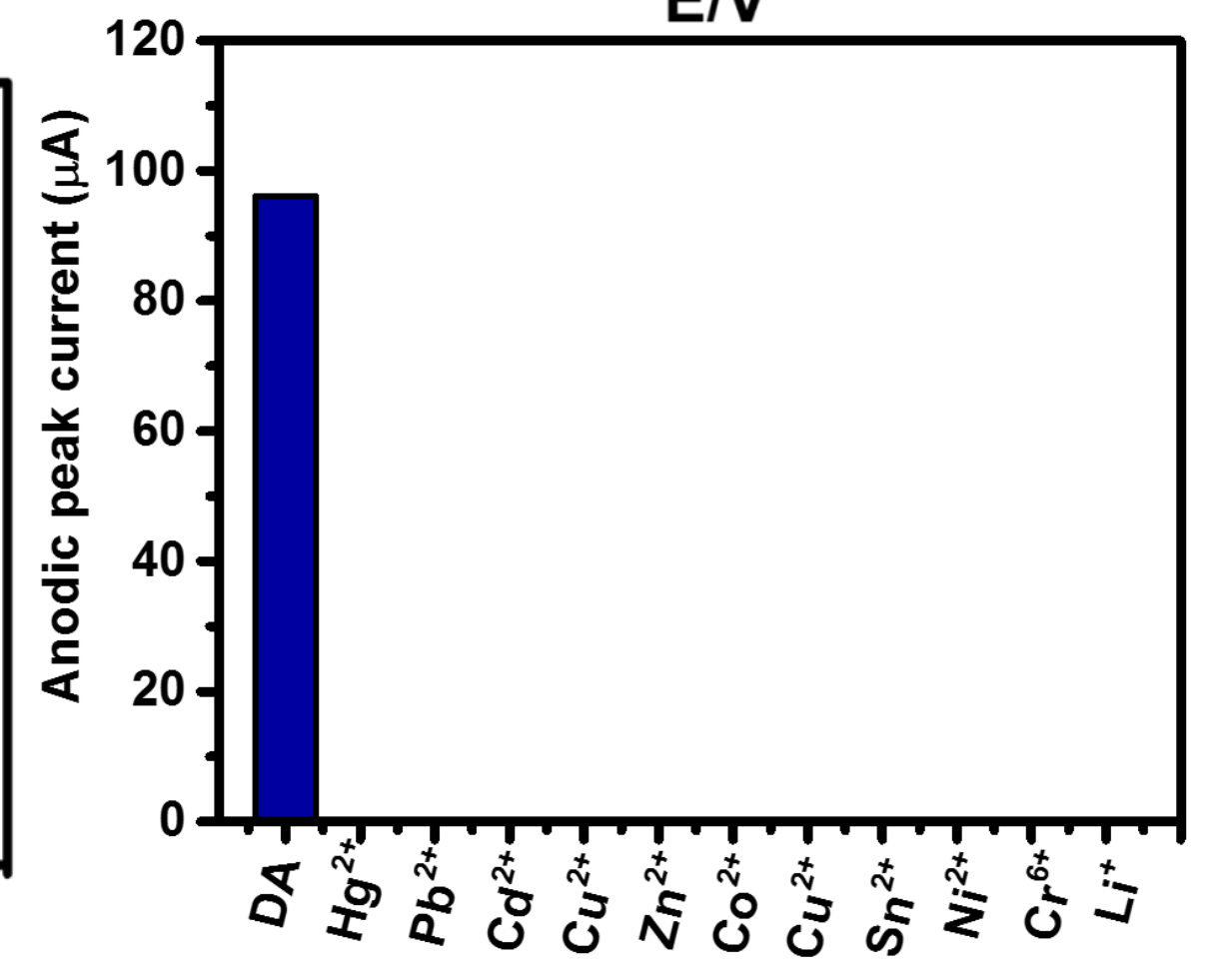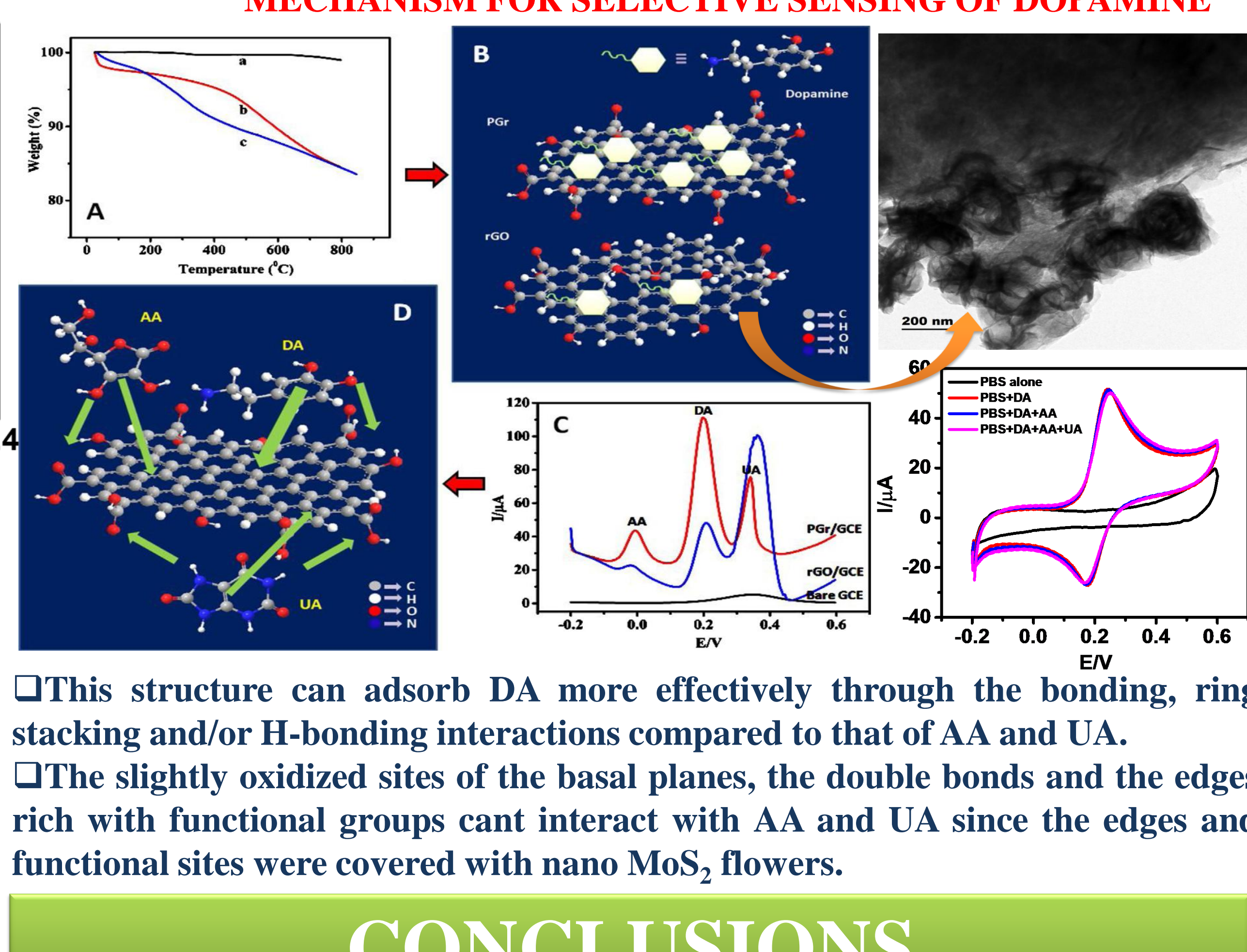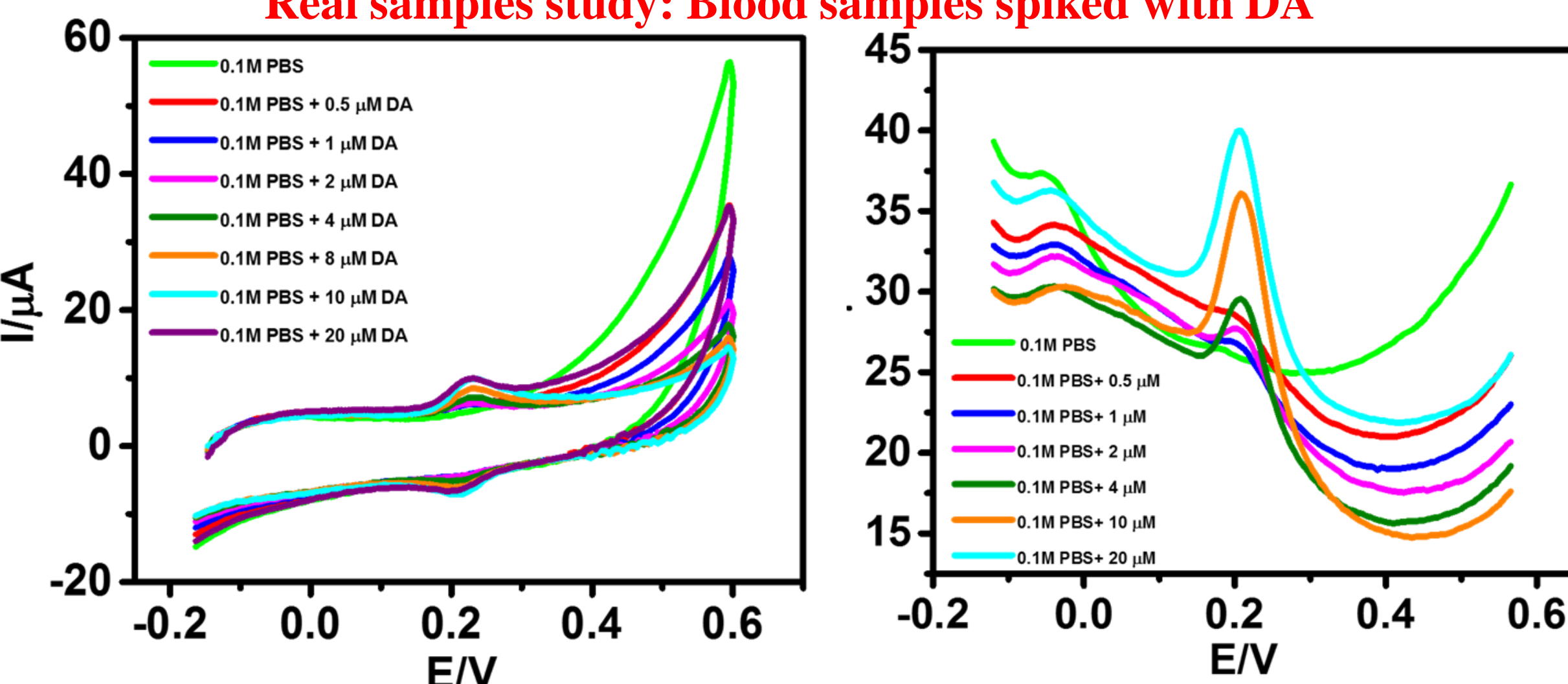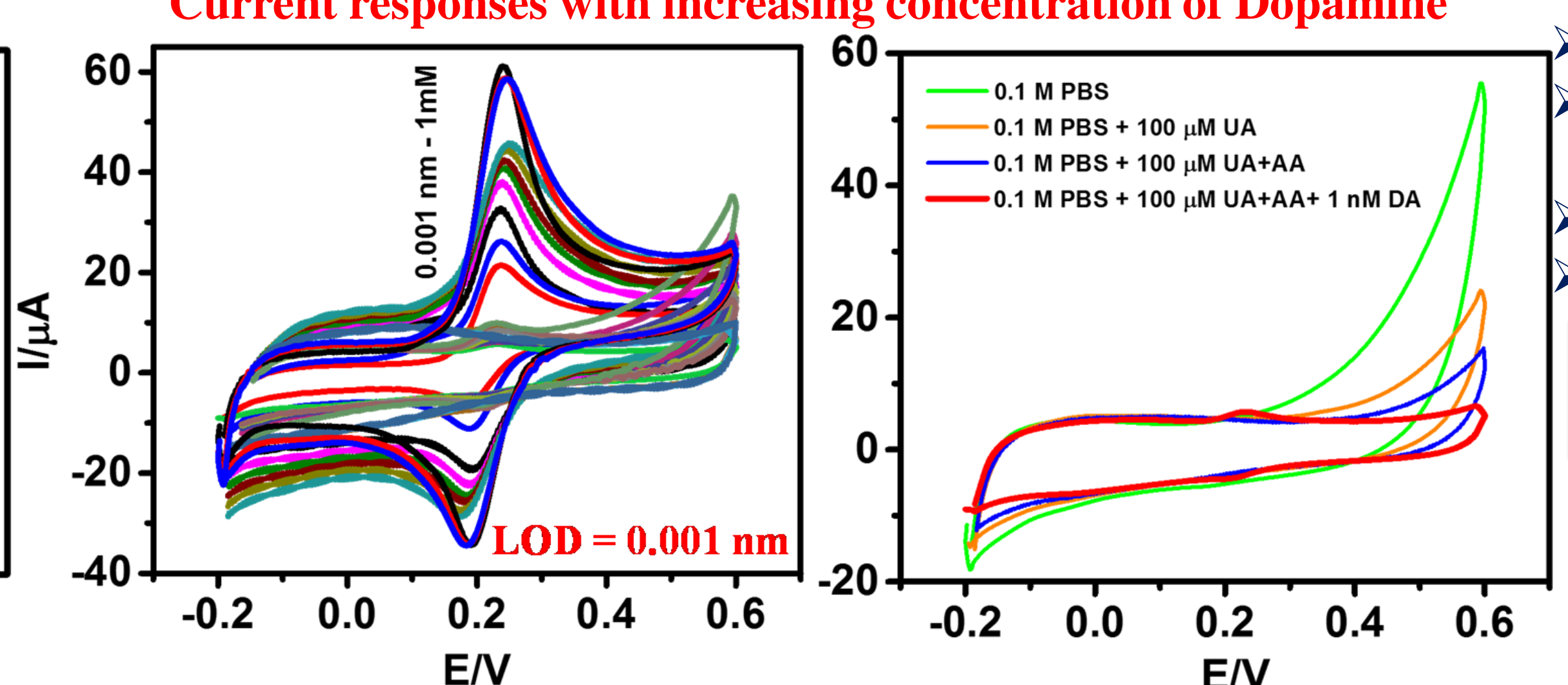
MECHANISM FOR SELECTIVE SENSING OF DOPAMINE

❑ This structure can adsorb DA more effectively through the bonding, ring stacking and/or H-bonding interactions compared to that of AA and UA.
❑ The slightly oxidized sites of the basal planes, the double bonds and the edges rich with functional groups cant interact with AA and UA since the edges and functional sites were covered with nano MoS₂ flowers.

CONCLUSIONS

➢ Gr-MoS₂ nano composites was synthesized using a simple hydrothermal method
➢ Selective electrocatalytic activity towards the oxidation of DA (in the presence and absence of AA and UA)
➢ High stability and excellent reproducibility towards detection of DA.
➢ Lowest LOD values compared to the previous reports for DA as low as 0.001

Real samples study: Blood samples spiked with DA

0.1M PBS
0.1 M PBS + 0.5 µM DA
0.1 M PBS + 1 µM DA
0.1 M PBS + 2 µM DA
0.1 M PBS + 4 µM DA
0.1 M PBS + 8 µM DA
0.1 M PBS + 10 µM DA
0.1 M PBS + 20 µM DA

Current responses with increasing concentration of Dopamine

0.001nM - 1mM
LOD = 0.001 nm

0.1 M PBS
0.1 M PBS + 100 µM UA
0.1 M PBS + 100 µM UA+AA
0.1 M PBS + 100 µM UA+AA+ 1 nM DA

REFERENCES

1. S. Wu, Q. He, C. Tan, Y. Wang, H. Zhang,Graphene-based electrochemical sensors, Small 9 (2013) 1160–1172.

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