

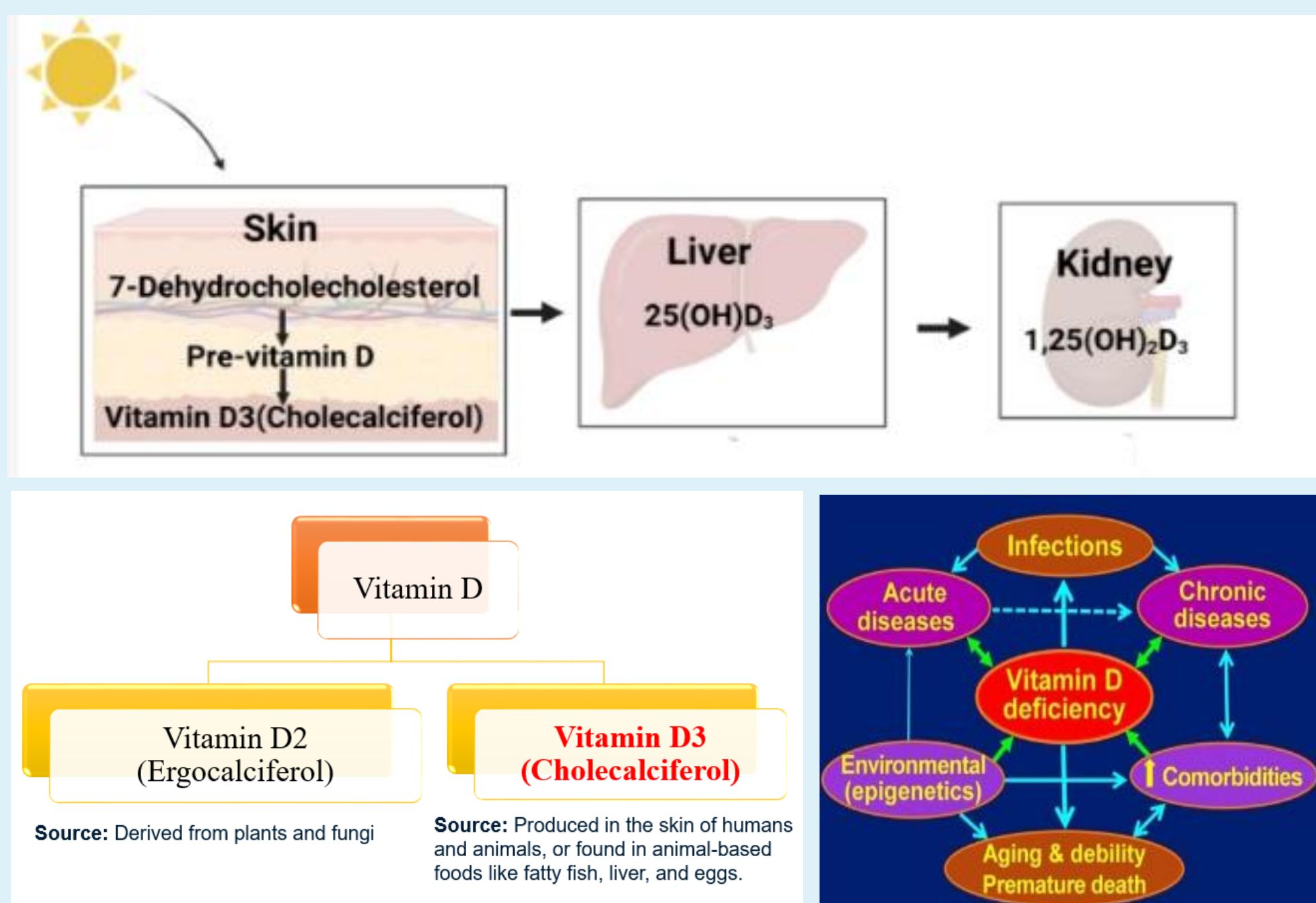
Development of a P3HT-Assisted Palladium Nanoparticle-Modified ITO Electrode for High-Performance Electrochemical Detection of Cholecalciferol

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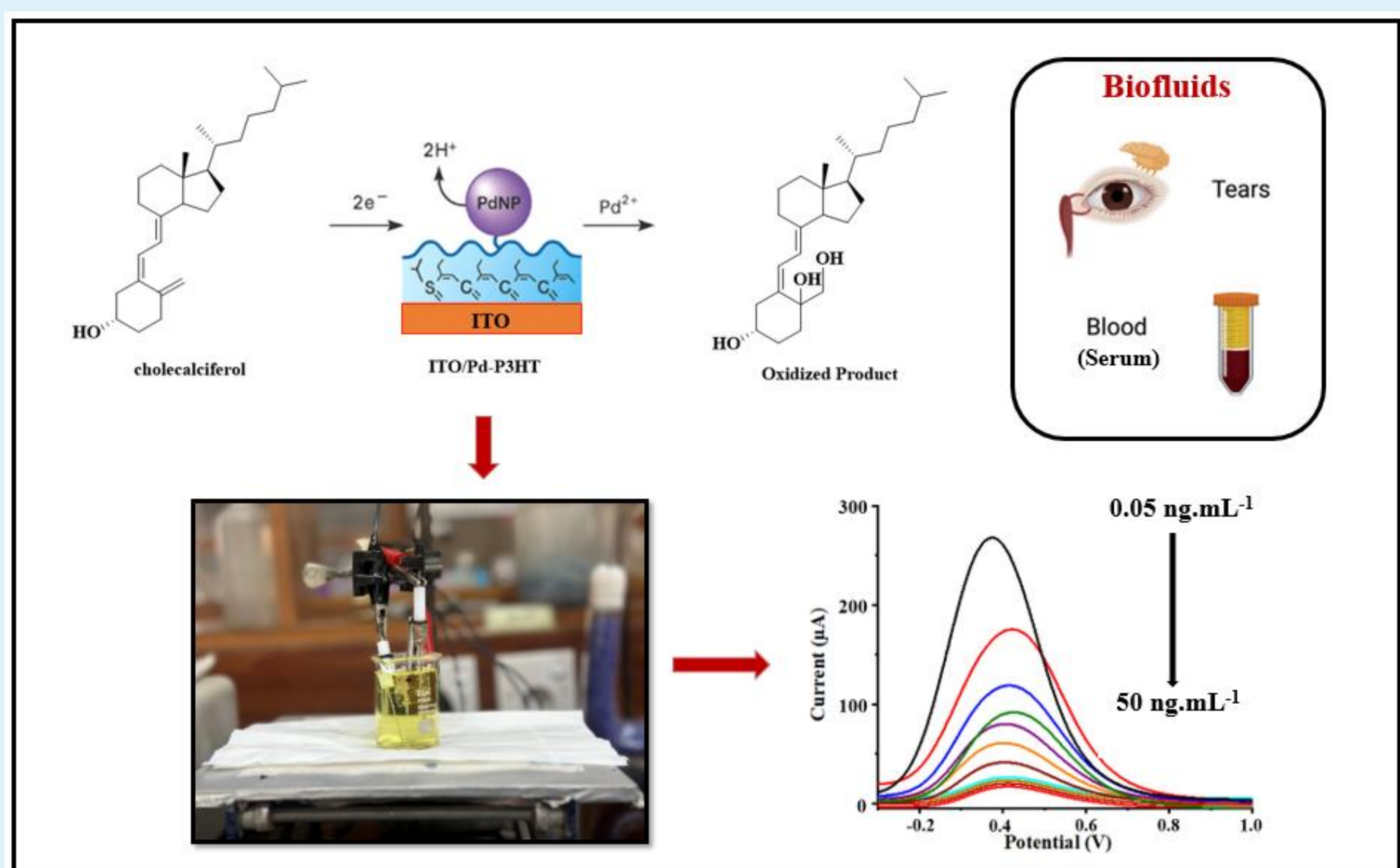
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Introduction

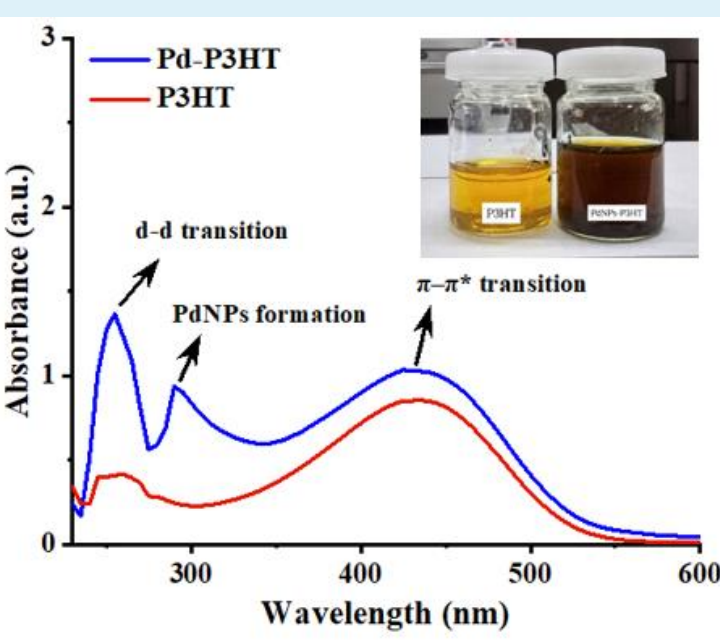


Schematic Representation

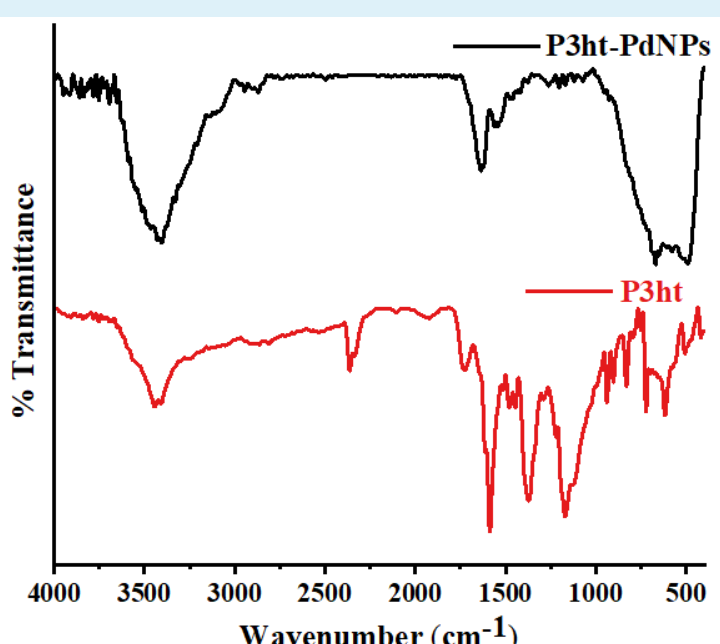


Characterization

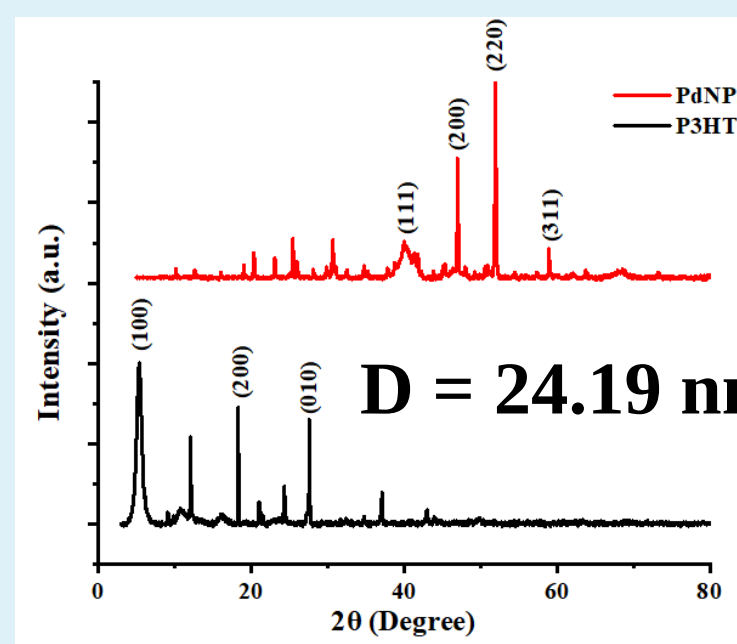
UV-Vis Analysis



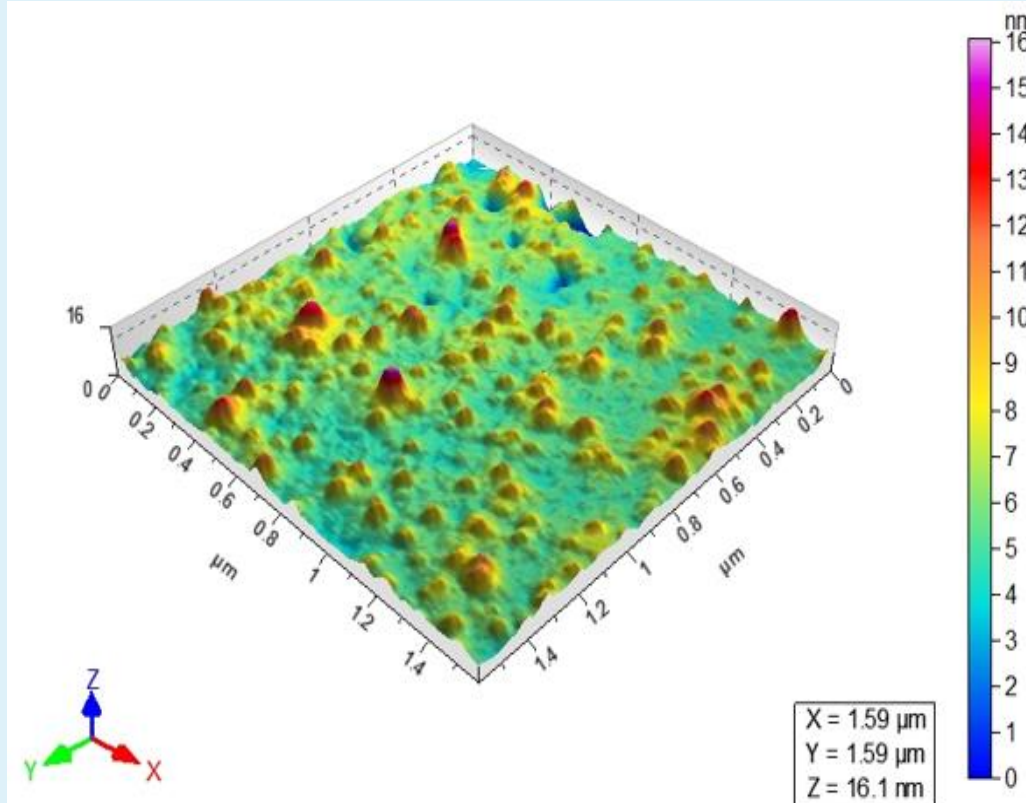
FTIR Analysis



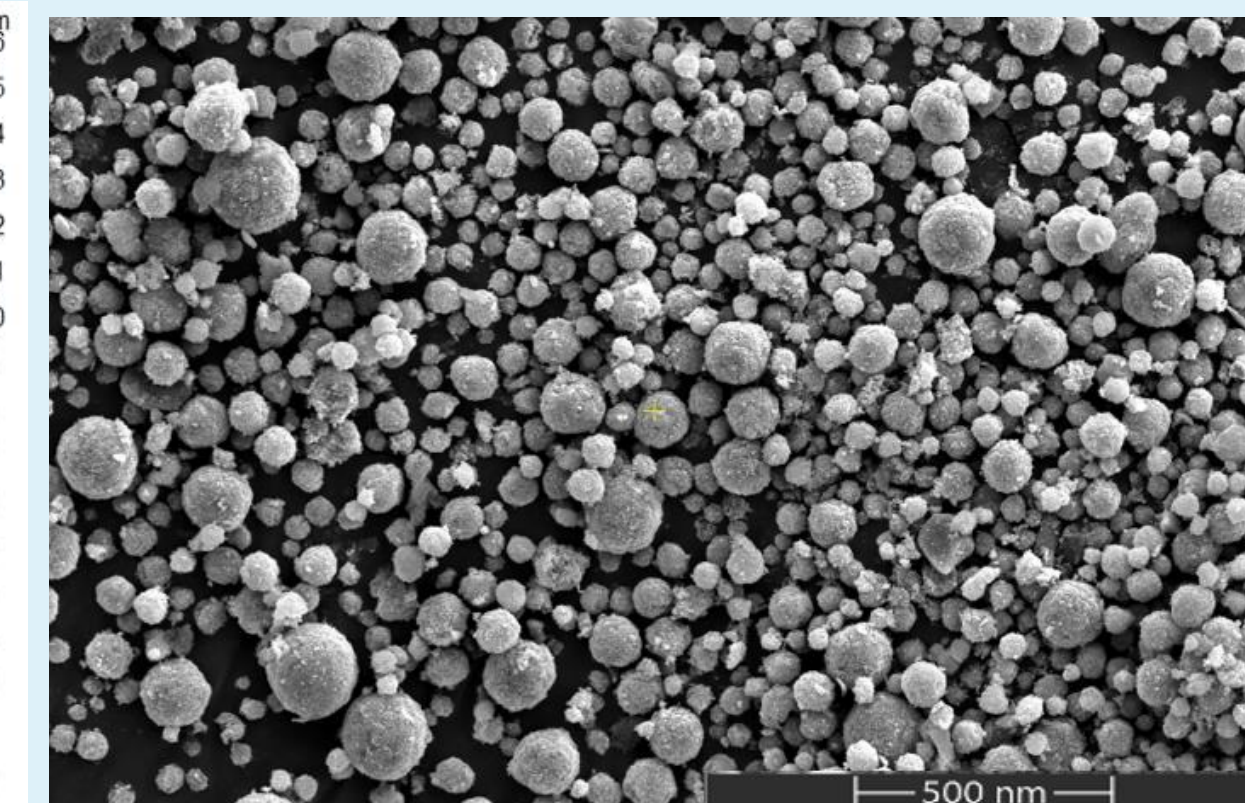
XRD Analysis



AFM Analysis

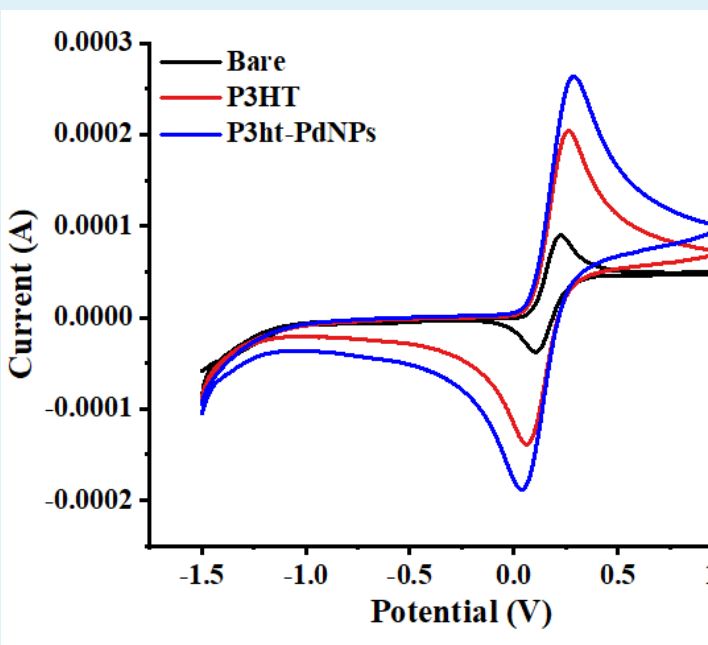


SEM Analysis

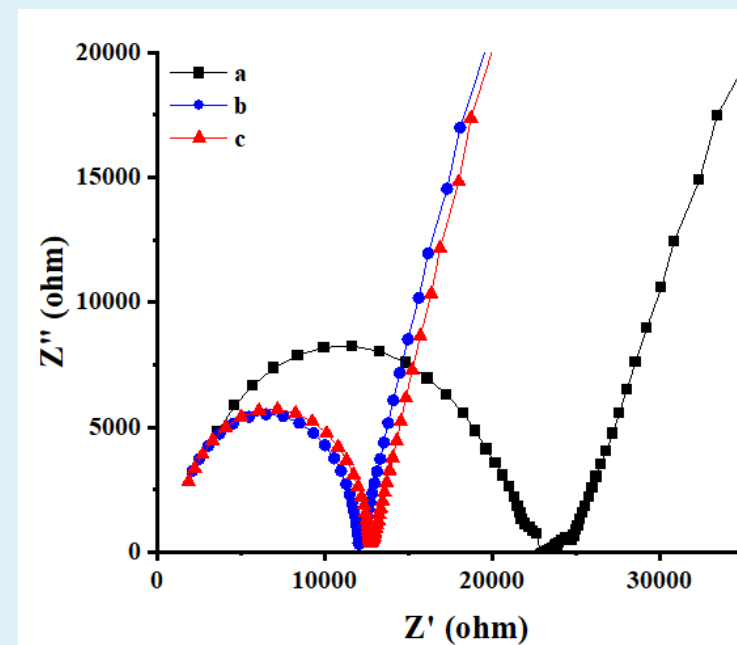


Electrochemical Studies

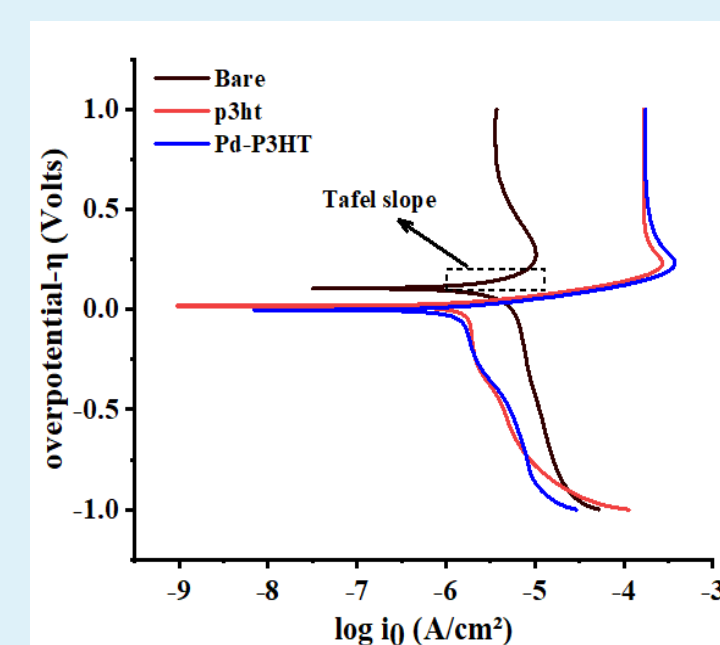
CV Analysis



EIS Analysis

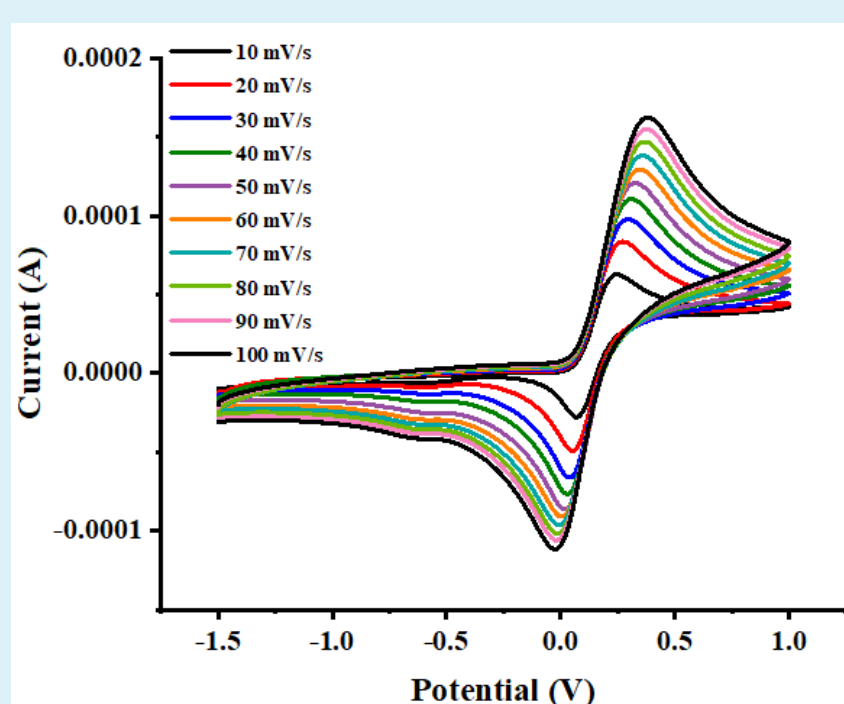


Tafel Plot

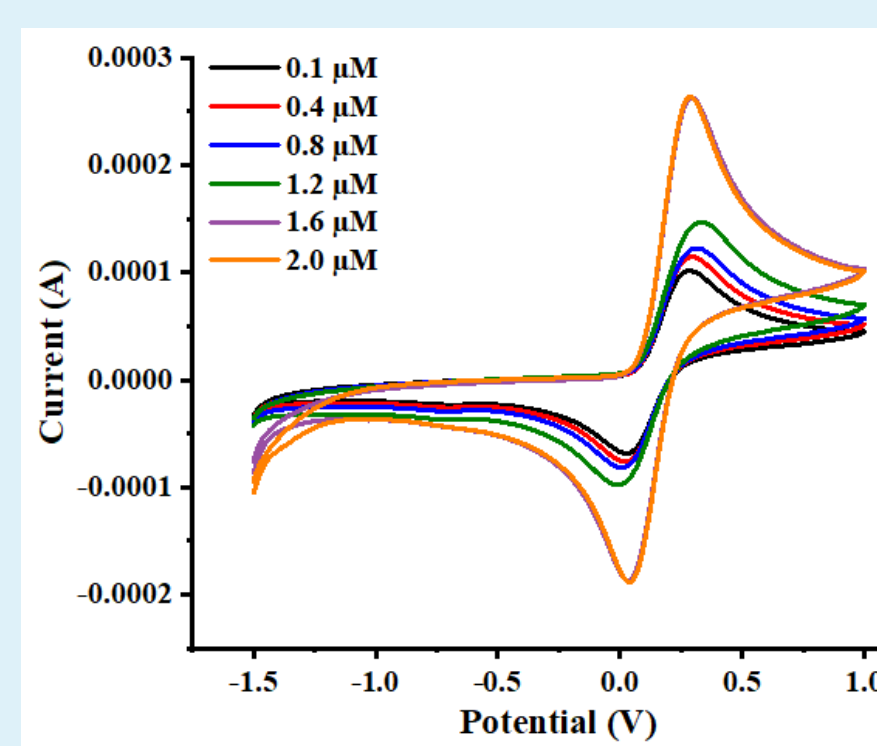


Diffusion coefficient: 1.147×10^{-6}
Electroactive surface area: 0.2064 cm^2
Roughness factor: 2.948
Surface coverage (Γ) = $3.45 \times 10^{-9} \text{ mol/cm}^2$
 Γ molecules = $2.08 \times 10^{15} \text{ molecules/cm}^2$
Sensitivity = $26.164 \mu\text{A/ng.mL}^{-1}/\text{cm}^2$

Scan Rate Analysis

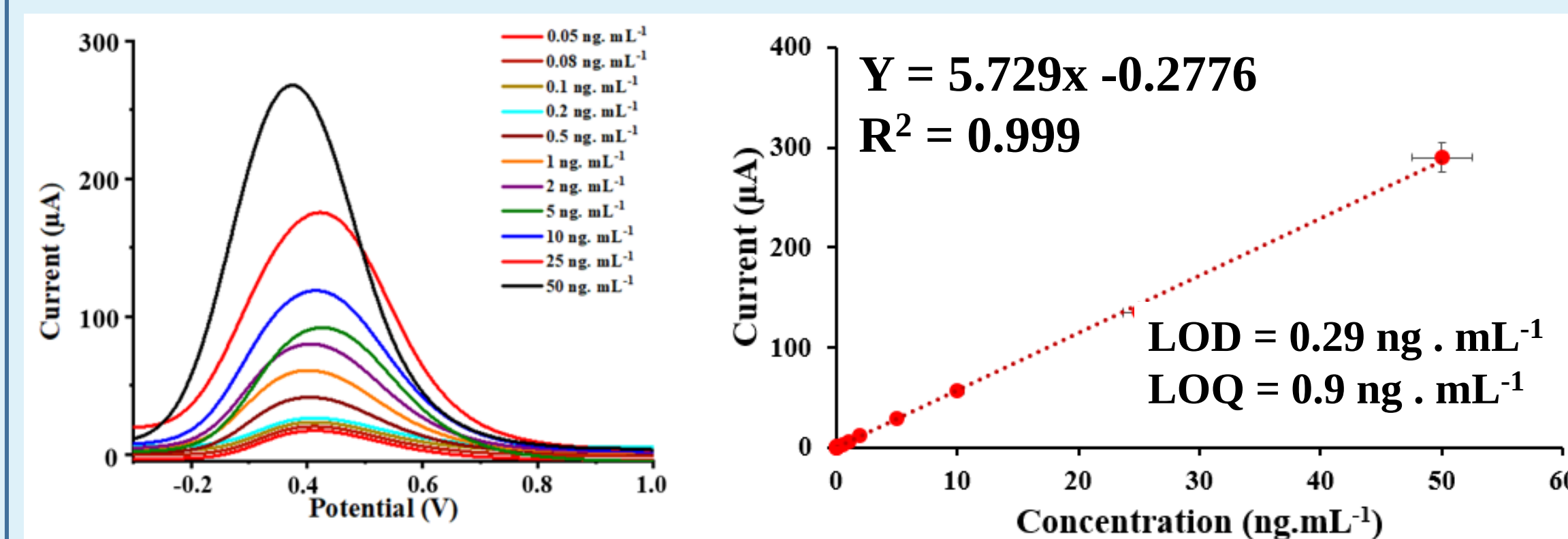


Concentration Studies

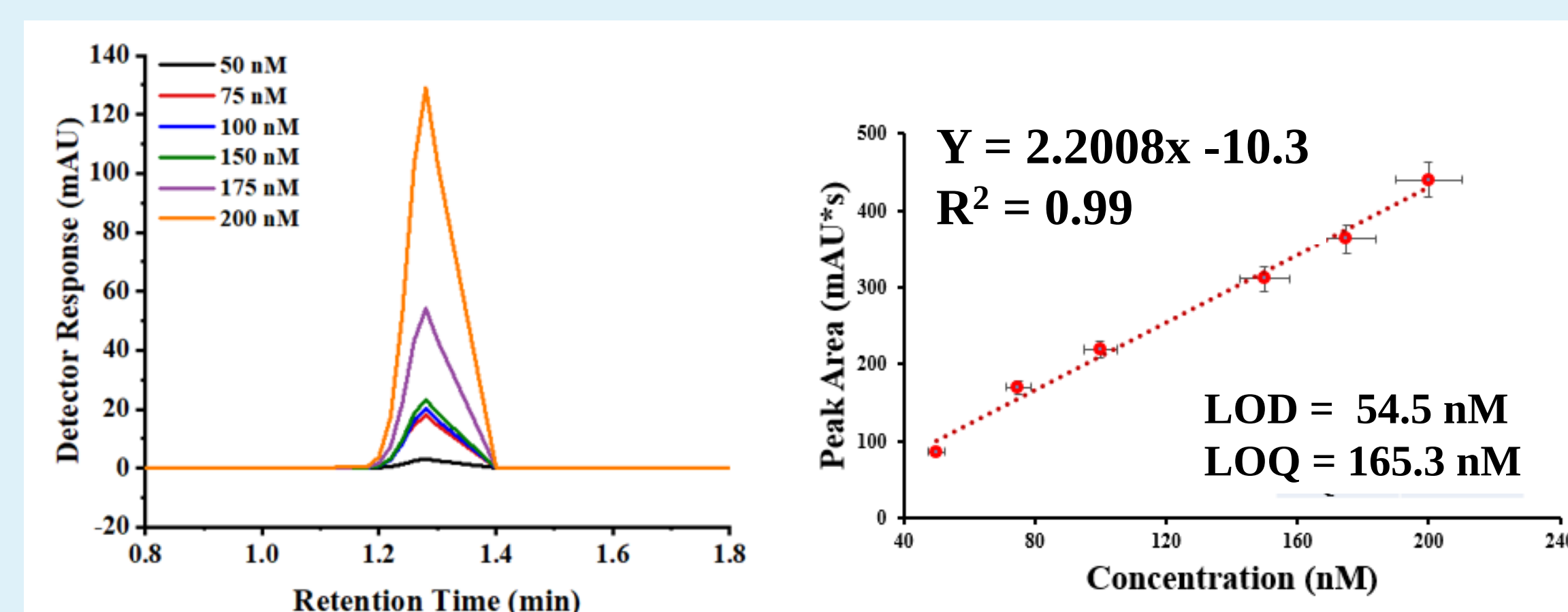


Electrode	Ip (αA)	Epa (mV)	Epc (mV)	ΔEp (mV)	E _{1/2} (mV)	Ipa/Ipc	Ipc (αA)
Bare	39.74	100	220	120	160	0.98	40.2
P3HT	140	60	260	200	160	1.01	148
Pd-P3HT	191.17	30	280	250	155	1.04	183

Calibration Curve



Recovery & Validation of Method

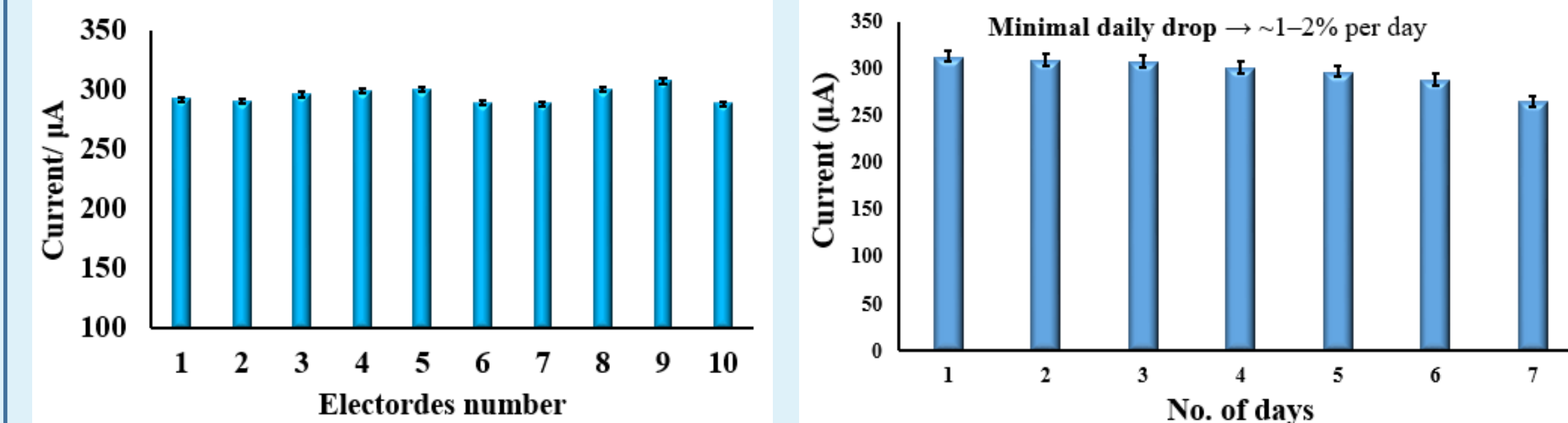


Samples	Natural cholecalciferol concentration (ng.mL⁻¹)	Spiked Cholecalciferol concentration (ng.mL⁻¹)	PdNPs-P3HT method			HPLC method		
			Found cholecalciferol concentration (ng.mL⁻¹)	RSD (%)	Recovery (%)	Detected cholecalciferol concentration (ng.mL⁻¹)	RSD (%)	Recovery (%)
Blood serum	80.0	2.0	81.04 ± 1.82	2.0	92.00	80.08 ± 2.70	3.0	84.00
		25.0	101.9 ± 3.47	2.5	95.00	99.42 ± 4.77	3.5	91.00
		50.0	129.12 ± 5.73	3.0	99.21	127.76 ± 7.59	4.0	98.00
Tears	42.0	2.0	41.2 ± 1.06	2.0	93.17	40.11 ± 1.56	3.0	84.25
		25.0	66 ± 2.58	2.5	98.39	65.91 ± 3.60	3.5	98.24
		50.0	93.02 ± 4.65	3.0	100.91	89.55 ± 6.06	4.0	97.81

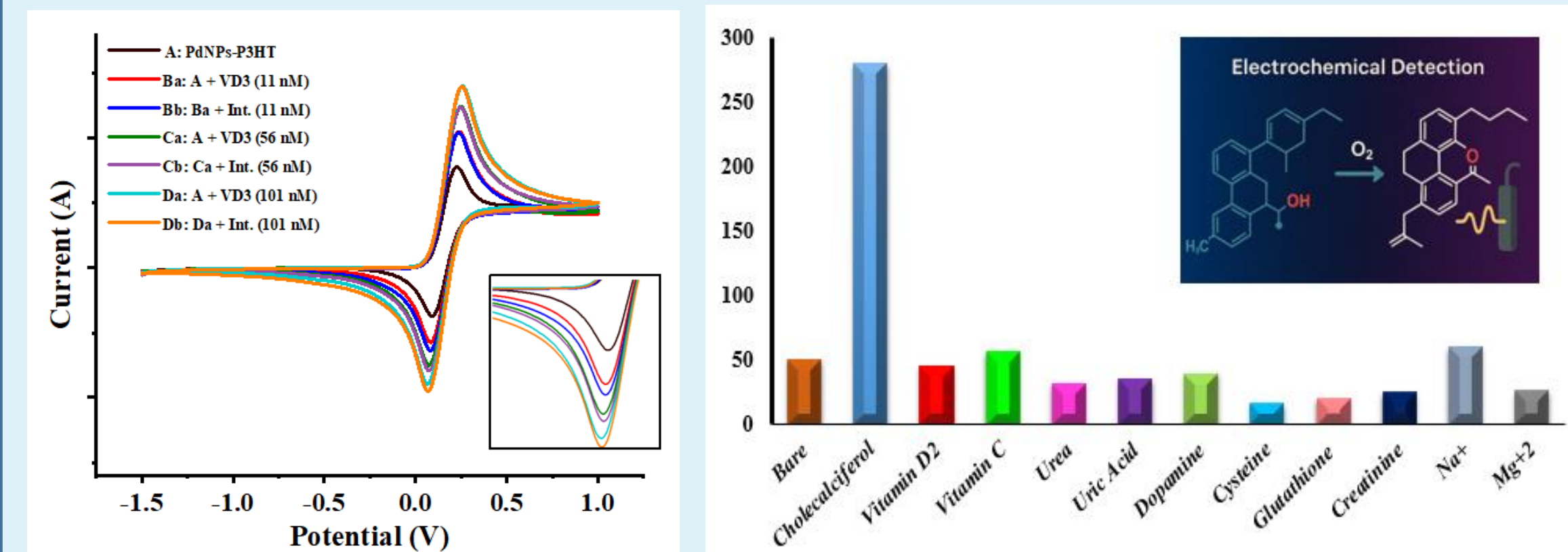
Conclusion

- LOD: 0.29 ng.mL^{-1}
- LDR: $0.05\text{--}50 \text{ ng.mL}^{-1}$ (DPV), $0.1\text{--}2 \mu\text{M}$ (CV)
- Capable of detecting trace levels of cholecalciferol
- Promising for non-invasive, sensitive, and cost-effective biomedical analysis

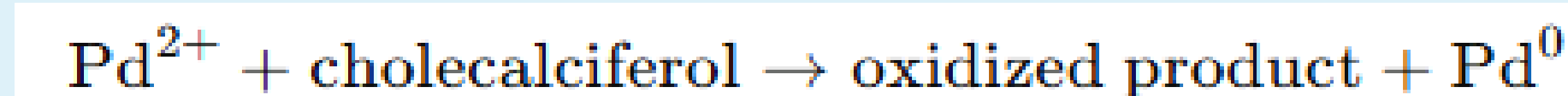
Reproducibility



Interference & Selectivity



Cholecalciferol (solution) → Cholecalciferol (adsorbed on PdNPs)



Biological Samples Analysis

Samples	Calculated concentration of cholecalciferol in blood serum nmol/L	Calculated concentration of cholecalciferol in Tears nmol/L	Calculated concentration of cholecalciferol in blood serum nmol/L	Calculated concentration of cholecalciferol in blood Tears nmol/L
Patients with low cholecalciferol level	6.04 43.8	4 22.6	- -	- -
Normal	80 122.4	42 64.5	72.6 117	31.1 52.8
Borderline	161	83.2	152	77
Patients with elevated cholecalciferol level	199.6 239 278	104 120.05 122.5	178.2 231.8 260	91 101.2 128.1