

INTRODUCTION



Photographer: Mikael Sjoberg/Bloomberg
Climate Changed
Sweden's Biggest Cities Face Power Shortage After Fuel-Tax Hike



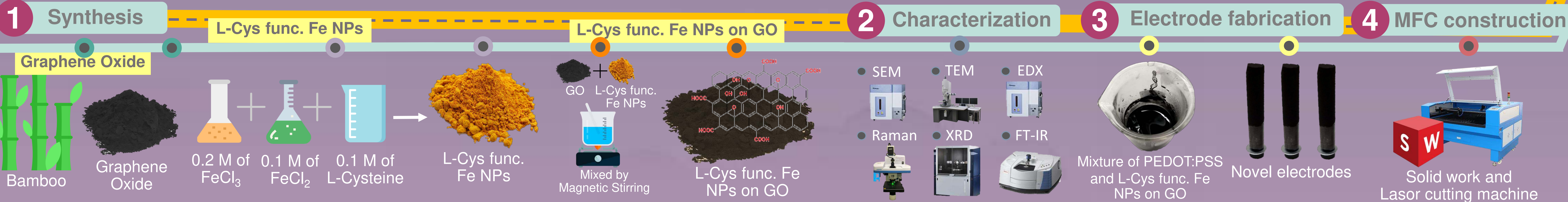
The fabrication of novel electrode developed by modified graphene oxide with L-cysteine deposited on iron nanoparticle for enhancing the electricity generation from MFCs

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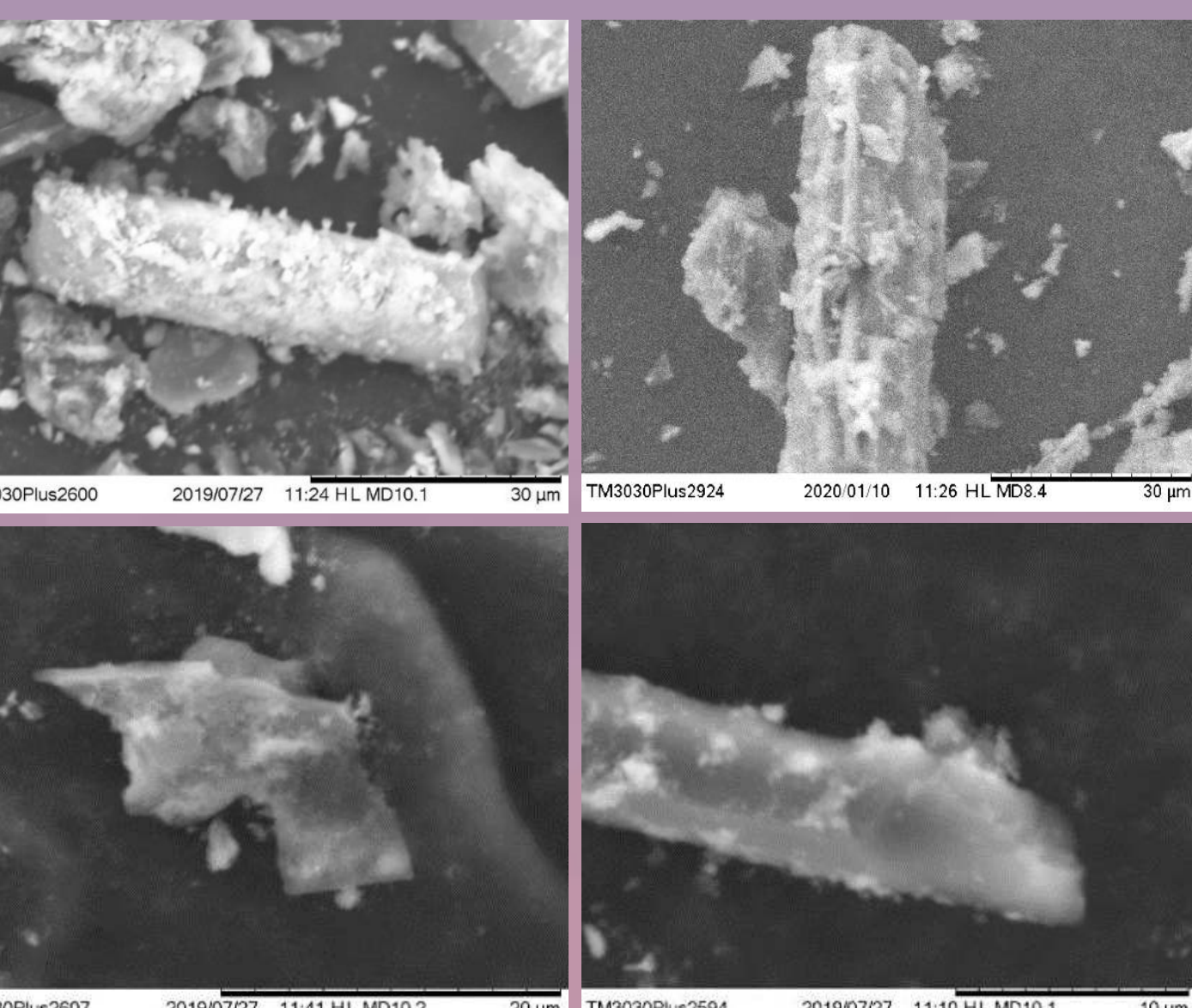
ABSTRACT

Nowadays, electricity shortage due to insufficient resources and a huge population growth rate and wastewater pollution are the main problems which severely affect the environment. In this research, Microbial fuel cell (MFCs) - novel alternative energy generators and wastewater treatment utilizing organic wastes in wastewater as substrates – was introduced. However, microbial fuel cell still inconstantly generates only low amounts of electricity. Consequently, novel electrode synthesized from modified graphene oxide with L-cysteine deposited on iron nanoparticle (L-Cys grafted Fe NPs on GO) was synthesized in order to enhance electricity production efficiency due to the higher bacteria adsorption ability. L-Cys grafted Fe NPs on GO was characterized under Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM), Fourier Transform Infrared Spectroscopy (FTIR), Energy Dispersive X-ray (EDX), X-ray Diffraction (XRD) and Raman Spectroscopy. As a result, Novel electrodes were tested under different conditions; wastewater, and bacteria solution. The results suggested that a novel electrode under condition can show the highest performance which can generate electricity up to 15.13 watts per cubic meter which is 28.5 times compared to the ordinary electrode. Furthermore, results suggested that the wastewater treatment efficiency and bacteria adsorption ability are up to 53.89% and 24.24% respectively. Additionally, generated electricity voltage is enough for charging a lead acid battery when MFCs were connected in series (8 cells).

METHODOLOGY

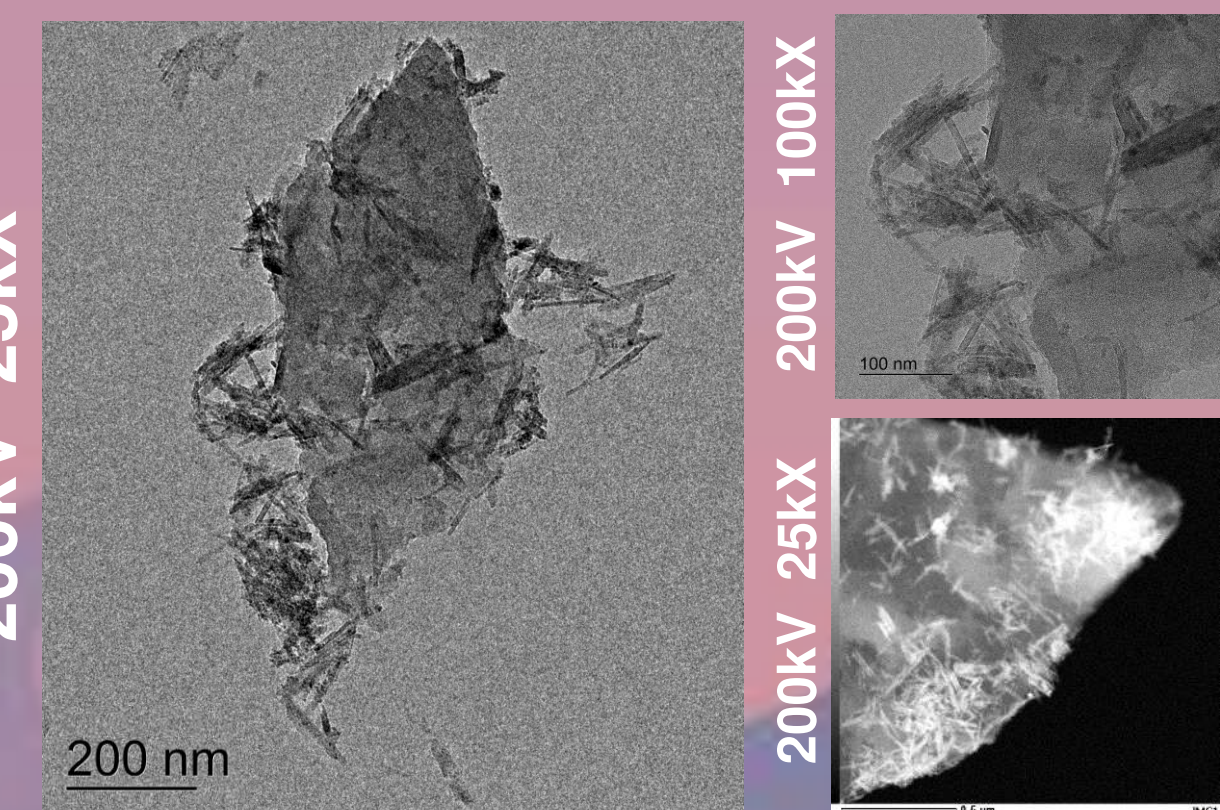


Scanning Electron Microscope (SEM)



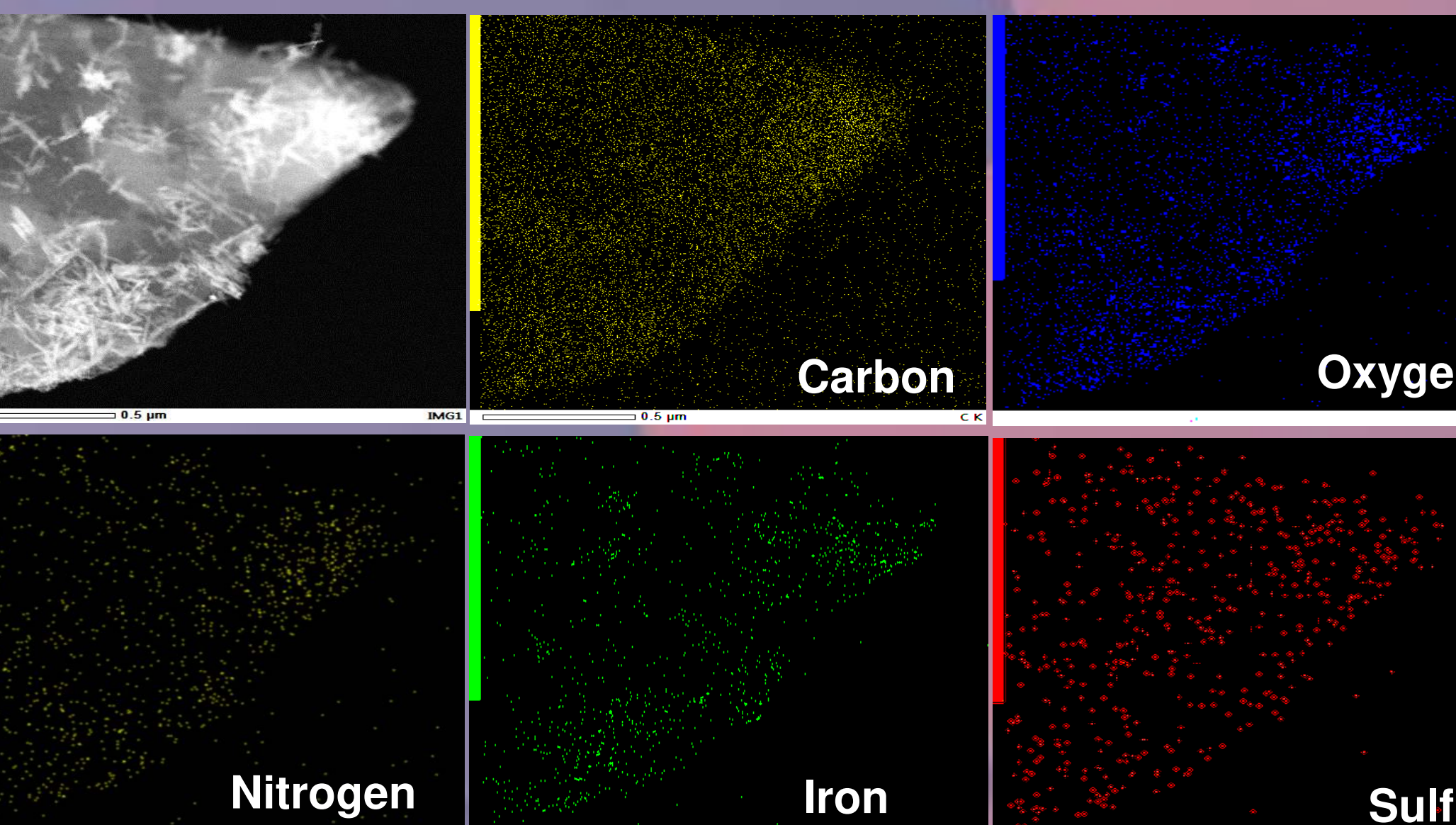
L-Cys func. Fe NPs on GO
✓ Exfoliated Graphene
✓ Fe NPs
✓ Fe NPs on GO
- Graphene oxide was successfully synthesized from bamboo via Hummer's method

Transmission Electron Microscope (TEM)

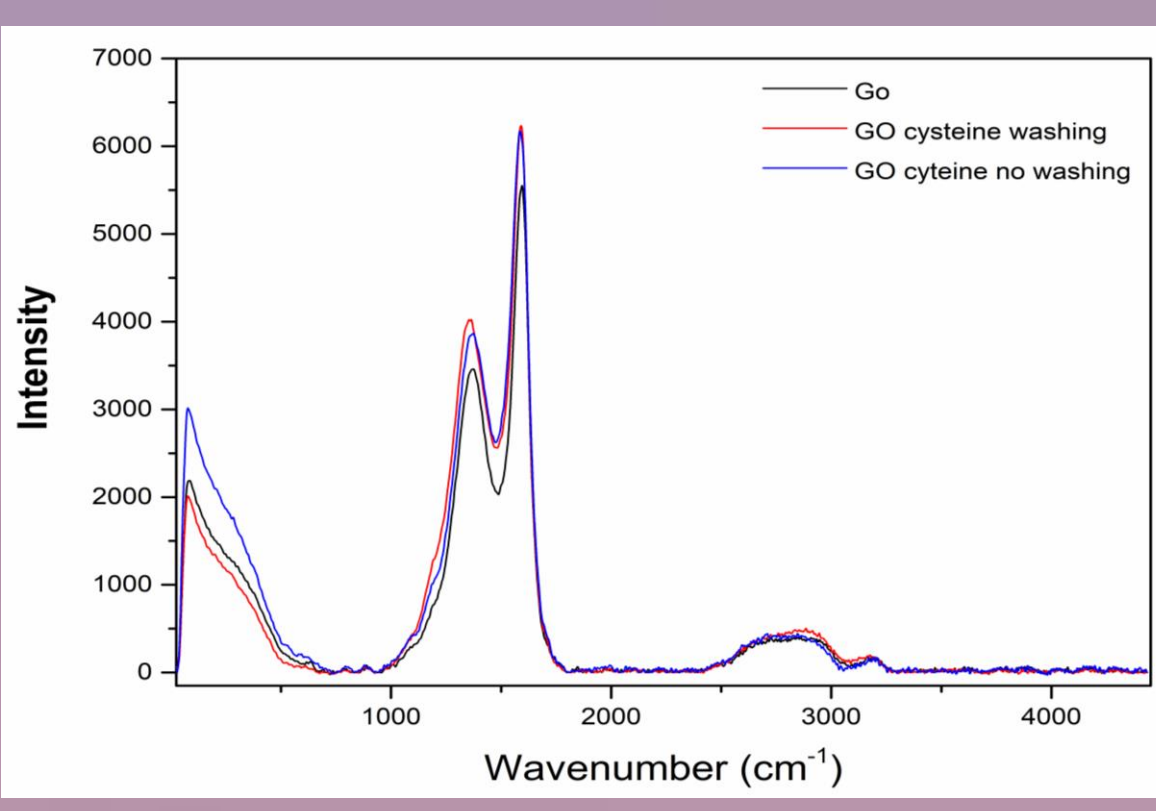


L-Cys func. Fe NPs on GO
✓ Exfoliated Graphene sheet
✓ Fe nanoparticles
✓ Fe nanoparticles on GO sheet

Energy Dispersive X-ray (EDX)

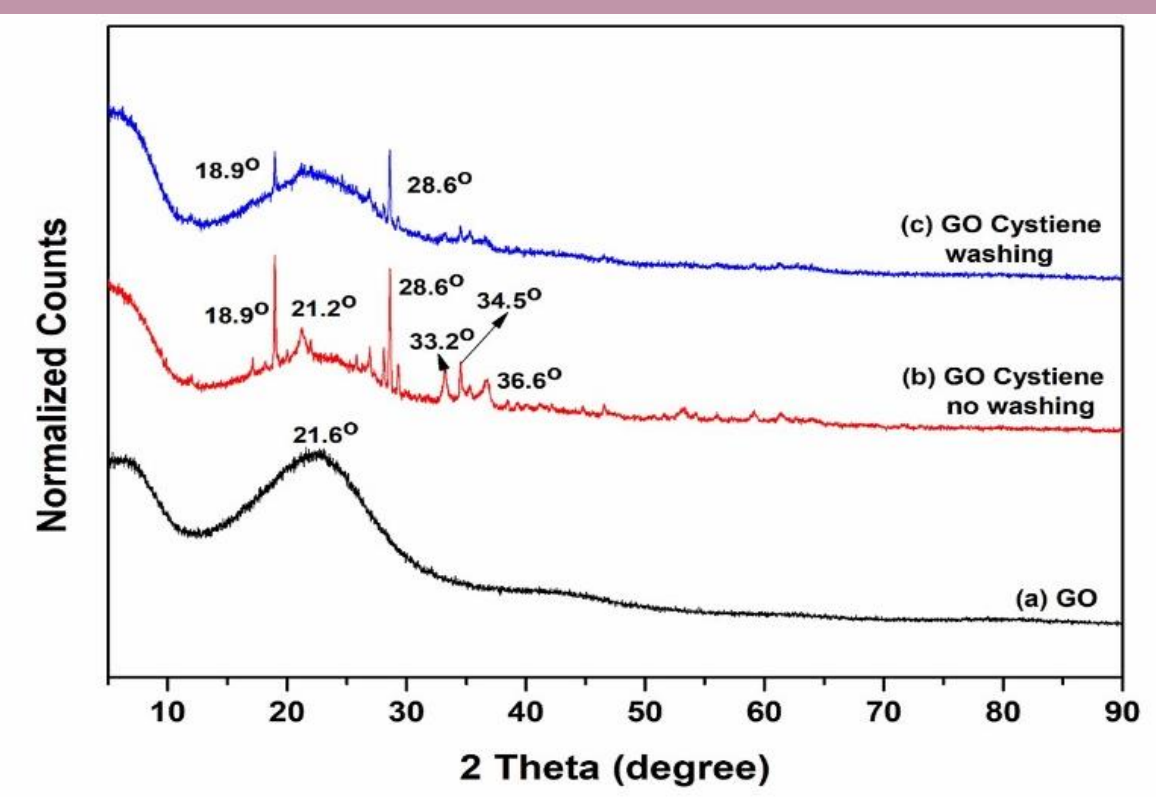


Raman Spectroscopy



Raman spectra shows D peaks 1327 cm⁻¹ and G peaks 1581 cm⁻¹, confirming the graphene oxide crystalline due to the hybridization change and partially disordered crystal structure of graphene.

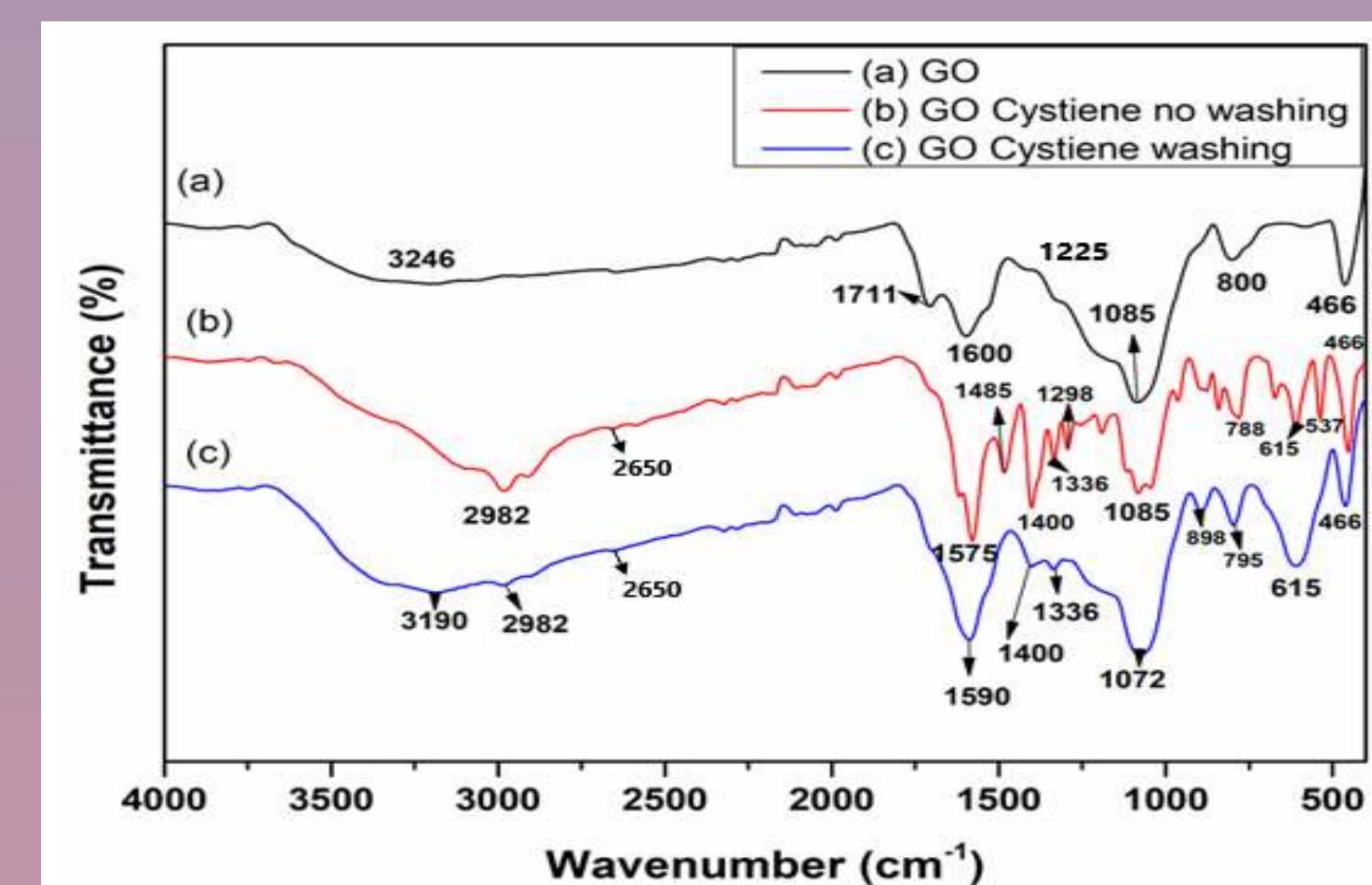
X-ray Diffraction (XRD)



✓ Magnetic nanoparticles
✓ Graphene oxide

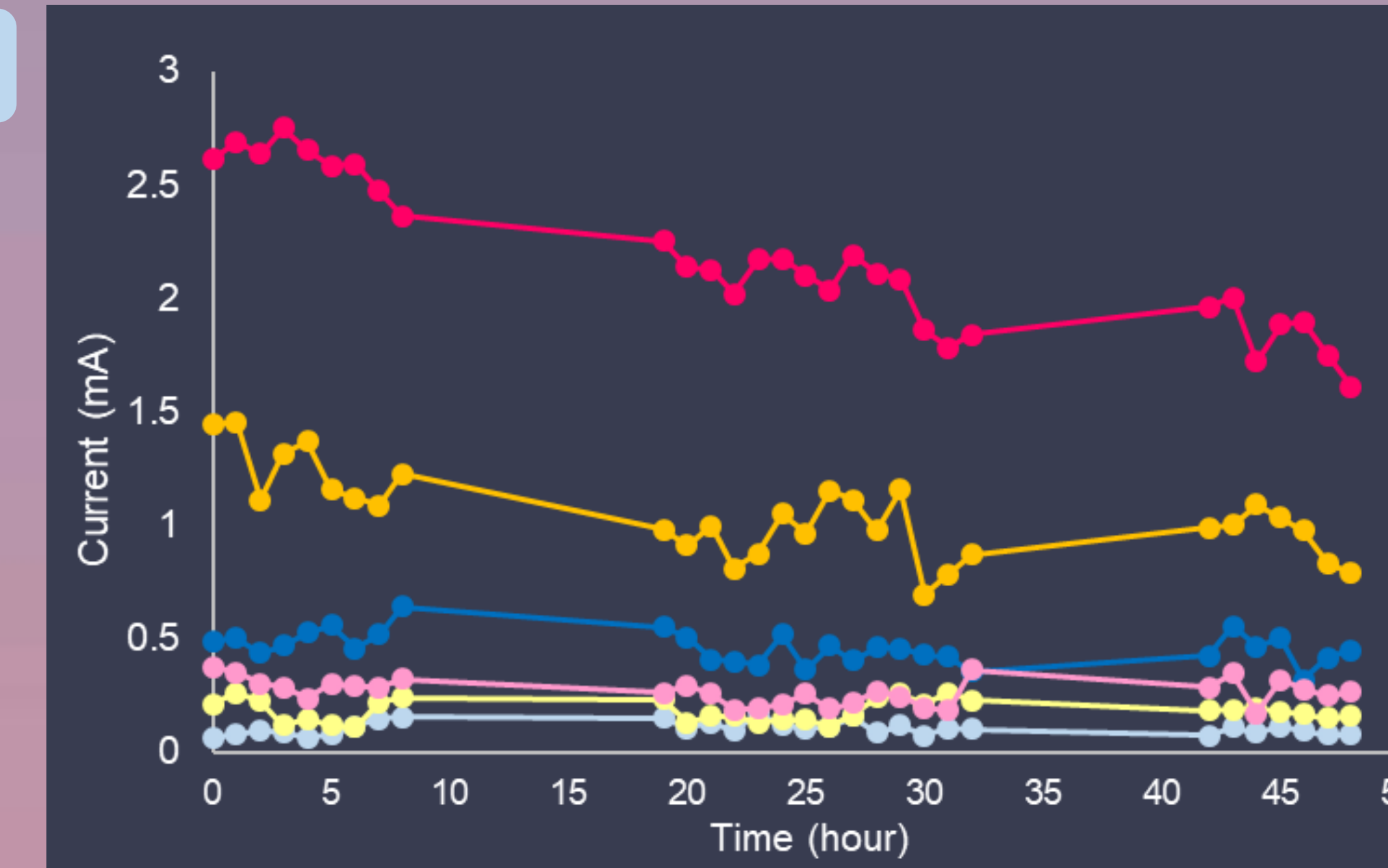
RESULTS

FTIR Spectroscopy



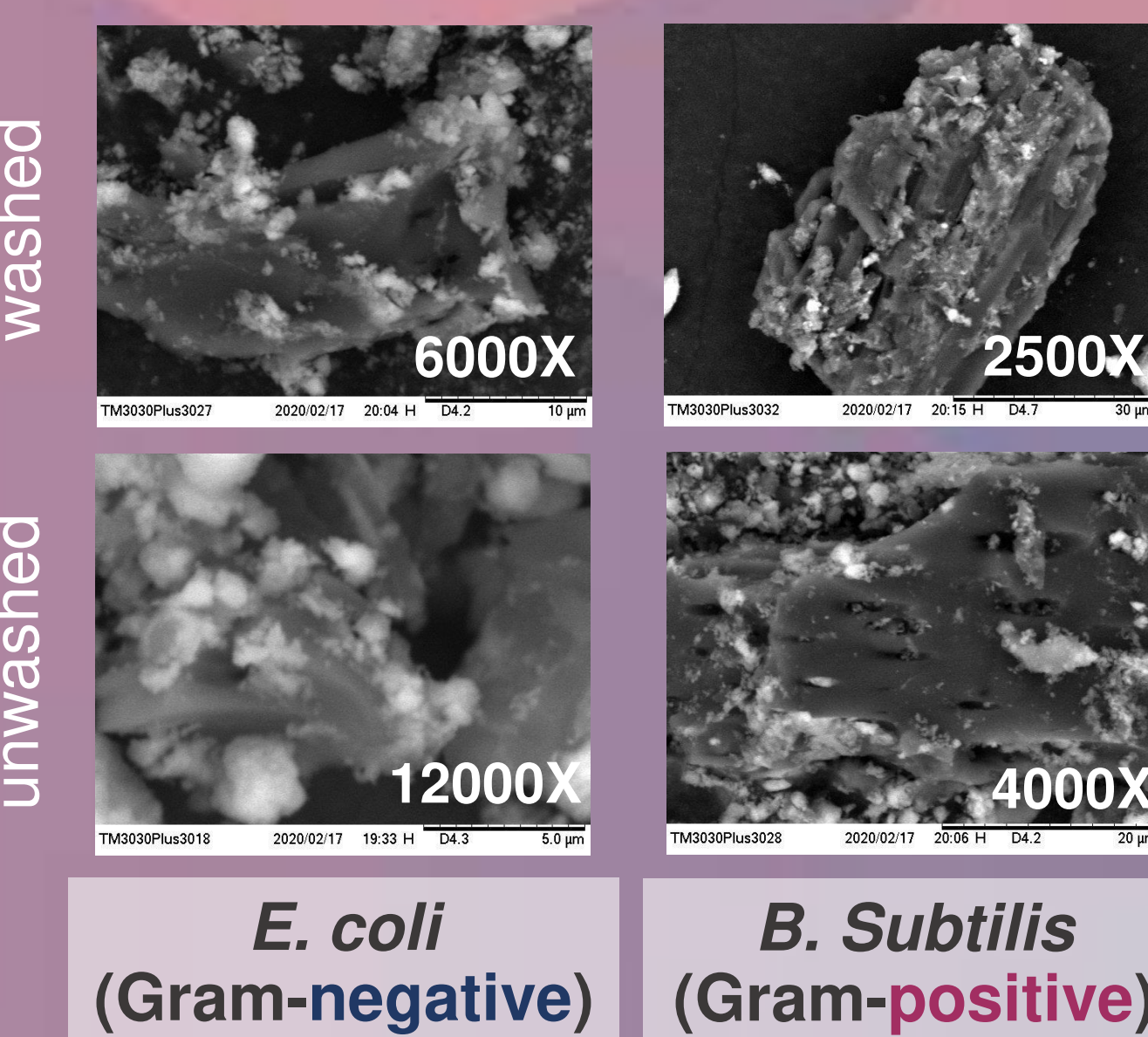
Samples	Main functional group	Wave number (cm ⁻¹)
Graphene oxide (GO)	-OH, C=O, C=C, C-O, C-H	3246, 1711, 1600, 1225, 800
Unwashed L-cysteine func. Fe NPs on GO	N-H, -SH, others	2982, 2650, others
Washed L-cysteine func. Fe NPs on GO	N-H, -SH	2982, 2650

Coulombic Efficiency



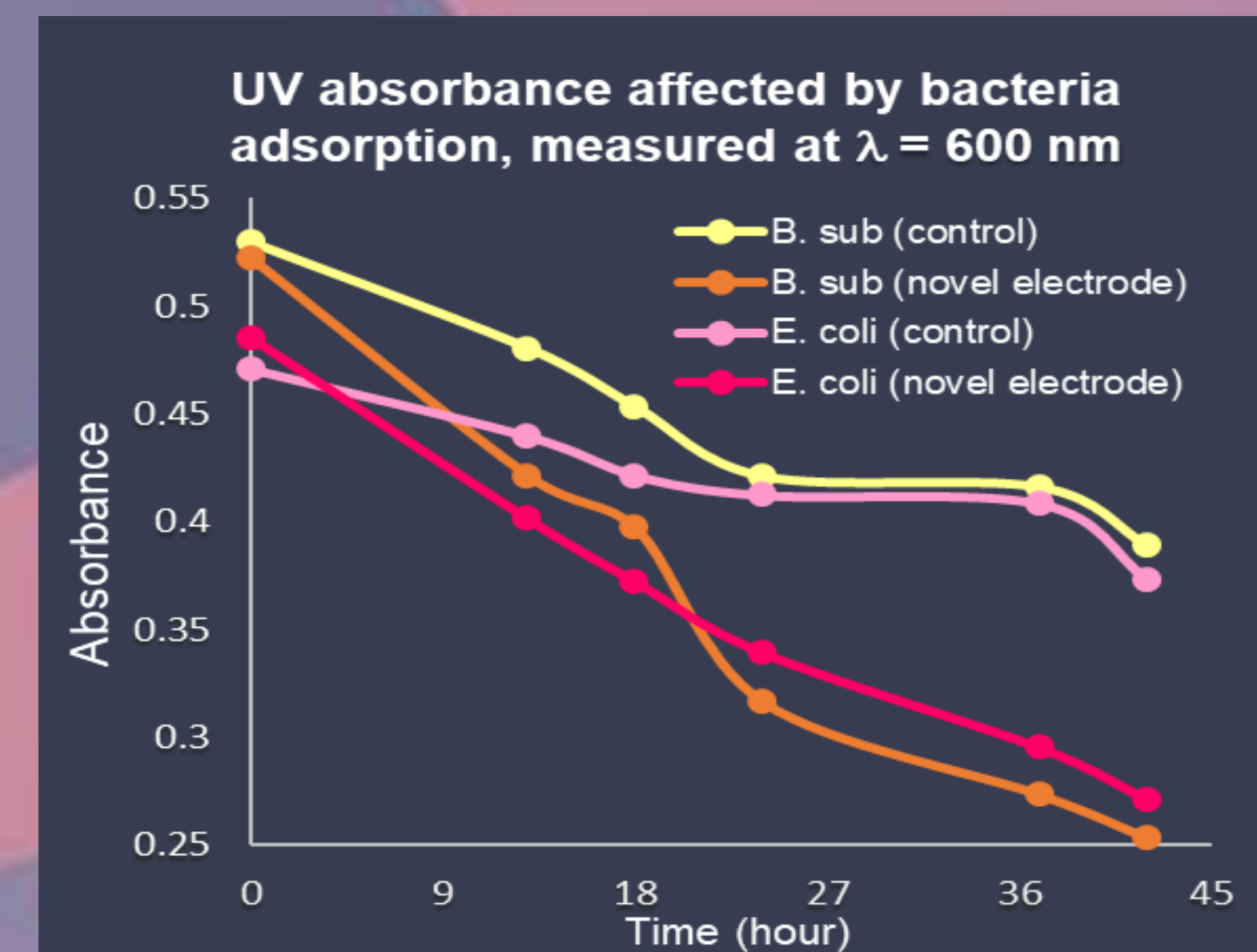
condition	broth	E. coli	wastewater
electrode	Graphite, func. GO	Graphite, func. GO	Graphite, func. GO
color	● ●	● ●	● ●
CE(%)	0.09, 0.28	3.78, 2.50	0.20, 0.84

Bacteria Adsorption Ability

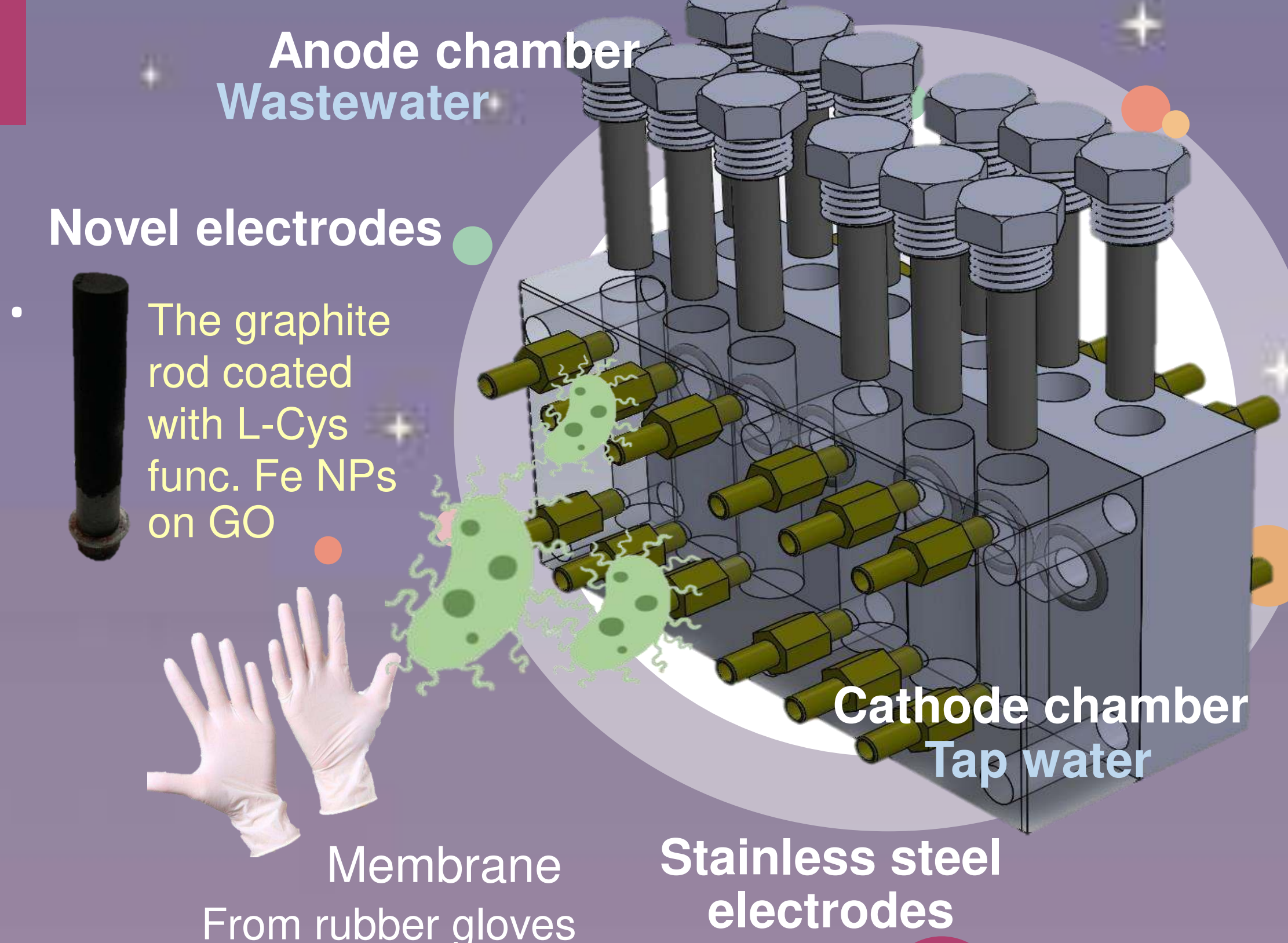


Zeta Potential Measurement

Sample	zeta potential (mV)
L-Cys func. Fe NPs on GO	-11.36
L-Cys func. Fe NPs on GO + PBS	-32.03
L-Cys func. Fe NPs on GO + B.Sub	-39.83
L-Cys func. Fe NPs on GO + E.coli	-39.73



Both negative and positive gram bacteria can attach on the novel electrode



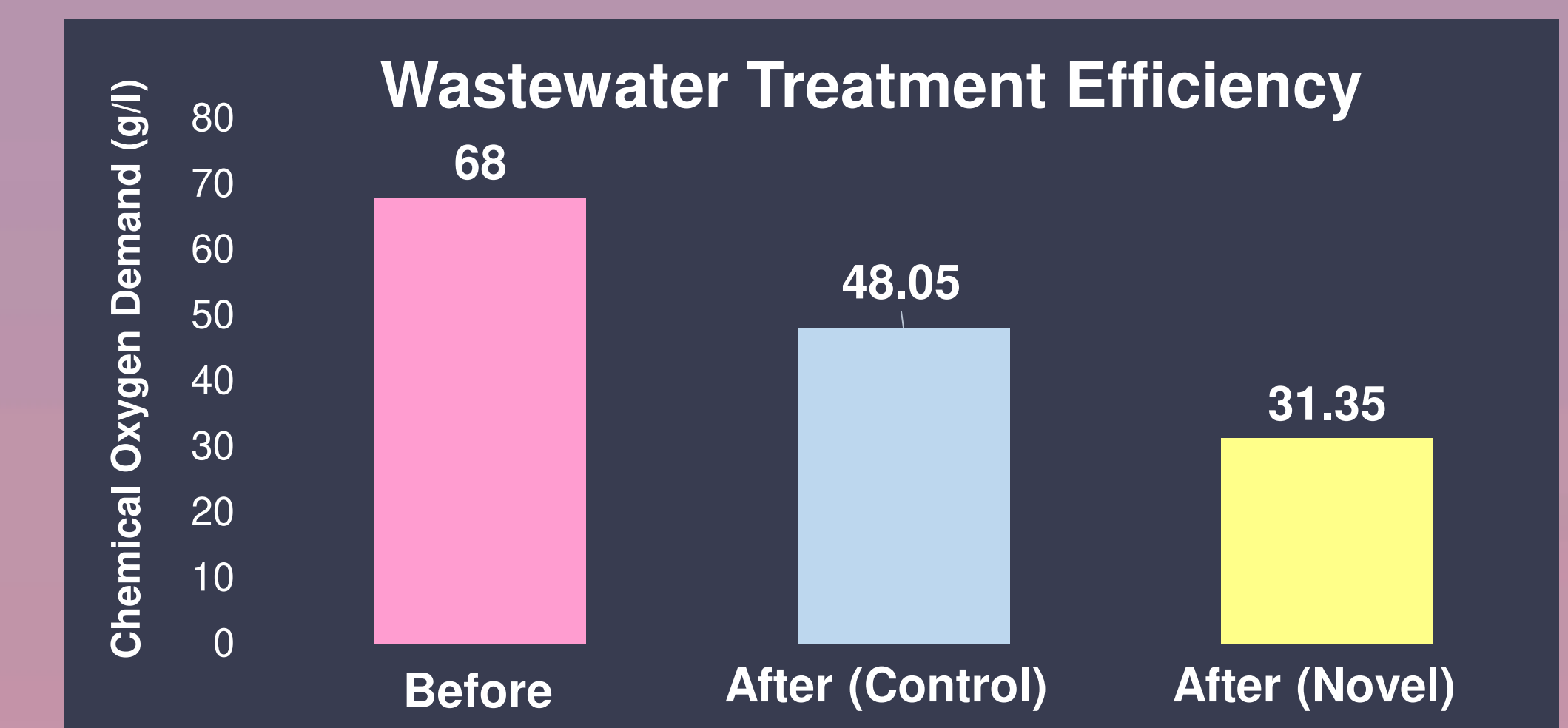
Electricity Test and Bacteria adsorption Test

Electricity Test: Measured electricity Production by using multimeter.
Bacteria adsorption Test: Collected E. coli solution every 6 hour for 6 times.

Electricity Production Efficiency

Condition	Maximum voltage (V)	Maximum current (mA)	Power density (W/m ²)
Graphite(wastewater)	0.142	0.374	0.53
L-Cys func. Fe NPs on GO (broth)	0.128	0.64	0.82
L-Cys func. Fe NPs on GO (E. coli)	0.291	1.46	4.23
L-Cys func. Fe NPs on GO (wastewater)	0.550	2.75	15.13

Wastewater Treatment Efficiency



CONCLUSION

- Modified graphene oxide with L-cysteine functionalized on iron nanoparticle was successfully synthesized from bamboo
- The synthesized powder was coated appropriately on graphitic electrode as electrodes for utilizing in MFCs.
- Novel MFC exhibited high electricity generation (4.2 times coulombic efficiency, 28.5 times power density), high bacteria adsorption ability (24.24%), and high wastewater treatment efficiency (53.9%).

References

[1] Tancredi, P., Moscoso Londoño, O., Rivas Rojas, P. C., Knobel, M., & Socolovsky, L. M. (2018). Step-by-step synthesis of iron-oxide nanoparticles attached to graphene oxide: A study on the composite properties and architecture. *Materials Research Bulletin*, 107, 255-263.
[2] Bagbi, Y., Sarawat, A., Mohan, D., Pandey, A., & Sotanki, P. R. (2017). Lead and Chromium Adsorption from Water using L-Cysteine Functionalized Magnetite (Fe₃O₄) Nanoparticles. *Scientific Reports*, 7(1).
[3] Hnalein, M., Hassen, W. M., Abdelghani, A., Fournier-Wirth, C., Coste, J., Bessueille, F., ... Jaffrezic-Renault, N. (2008). A conductometric immunosensor based on functionalized magnetite nanoparticles for E. coli detection. *Electrochemistry Communications*, 10(8), 1152-1154.