Simultaneous detection of hazardous chemicals using a novel nanocomposite system

Nafisa Mahbub[1], Samiha Sultana[1, 2], Meissam Noroozifar[2], Kagan Kerman[1, 2]

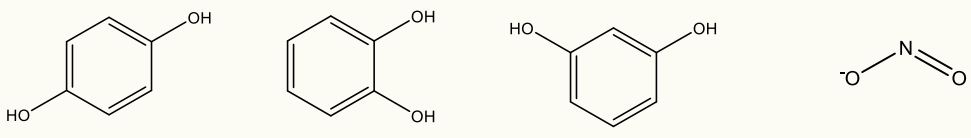
(1) Department of Physical and Environmental Sciences, (2) Department of Chemistry, University of Toronto Scarborough, Toronto, ON Canada

nafisa.mahbub@mail.utoronto.ca

BACKGROUND

- Benzenediol (BDO) isomers ($C_6O_2H_6$) of:

  hydroquinone (**HQ**), catechol (**CC**) and resorcinol (**RS**) and nitrites ($\mathbf{NO_2^-}$)

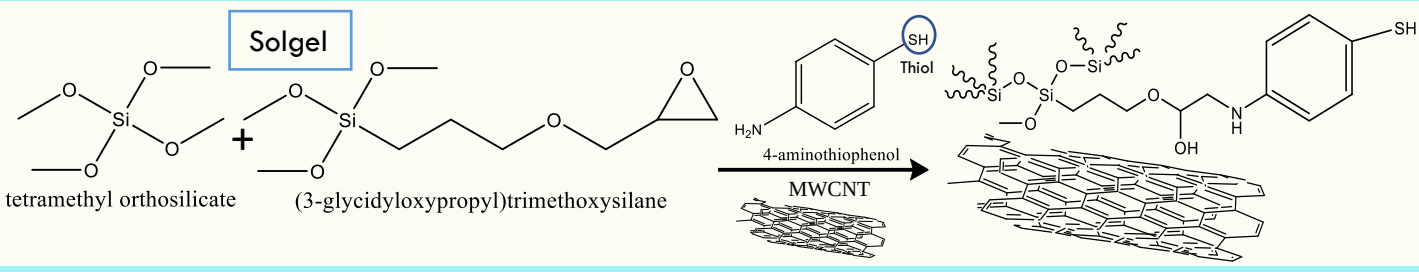


- Usage as **raw materials** or **synthetic intermediates** in multiple industries
- Acts as **environmental pollutants** and **precursors to human disease**
- Lack of methods for **simultaneous detection** of BDOs and NO_2^- at reduced costs, low time demands, high sensitivity, and high selectivity

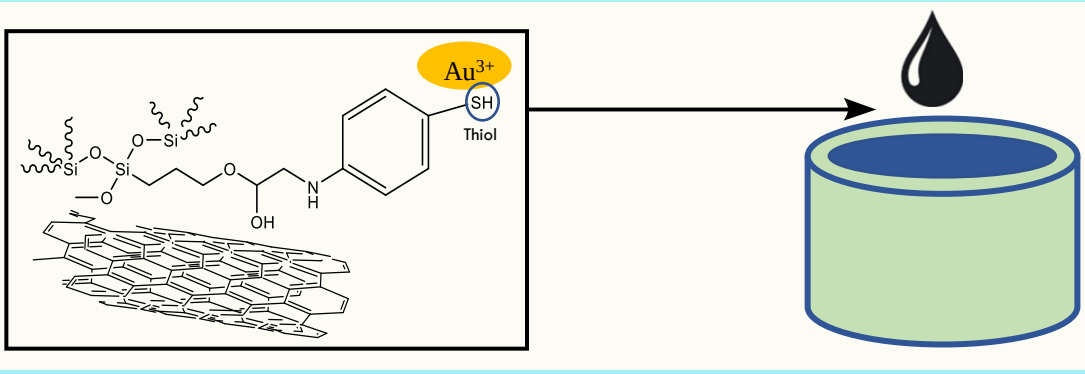
Can this electrochemical sensor effectively and simultaneously detect BDOs and NO_2^-?

METHODS

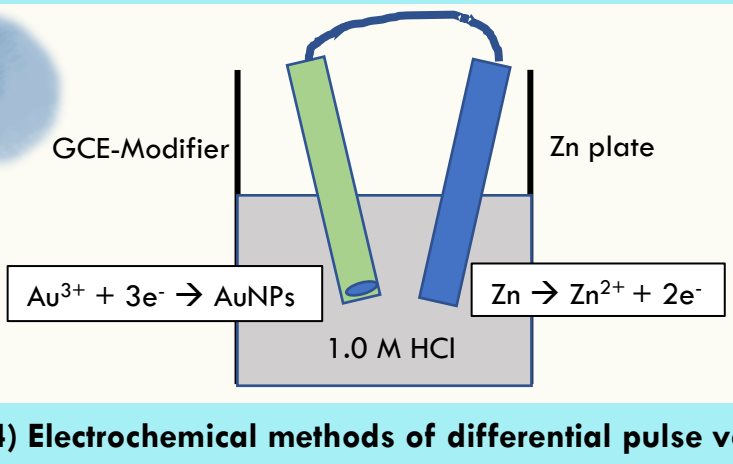
(1) Synthesized of 4-aminothiophenol in sol-gel and multiwall carbon nanotubes (MWCNTs).

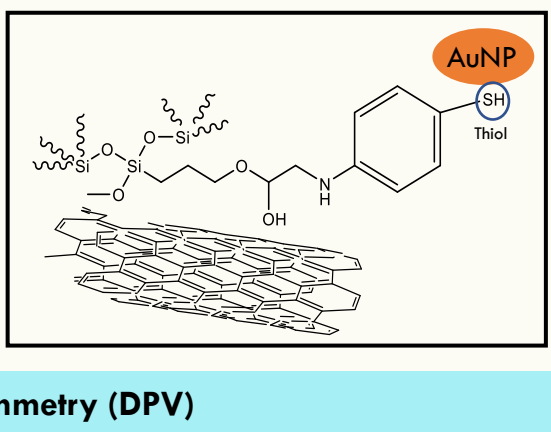


(2) Added gold cations to modifier and drop casted onto glassy carbon electrode (GCE)



(3) Converted gold cations on modifier into gold nanoparticles for final structure





(4) Electrochemical methods of differential pulse voltammetry (DPV)

RESULTS

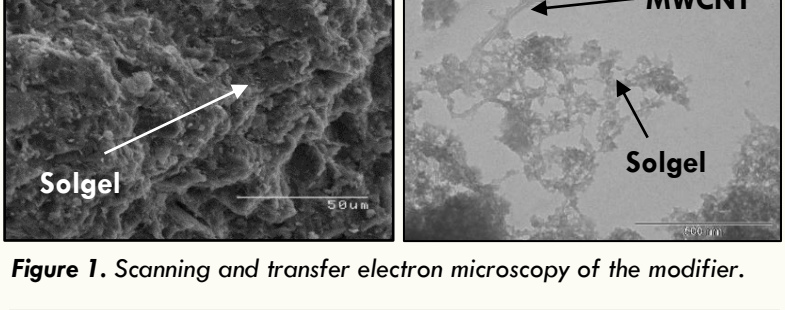


Figure 1. *Scanning and transfer electron microscopy of the modifier.*

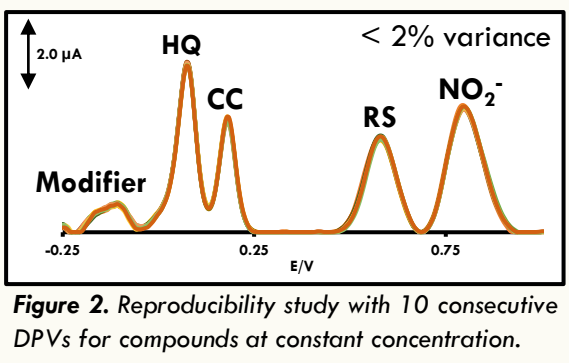


Figure 2. *Reproducibility study with 10 consecutive DPVs for compounds at constant concentration.*

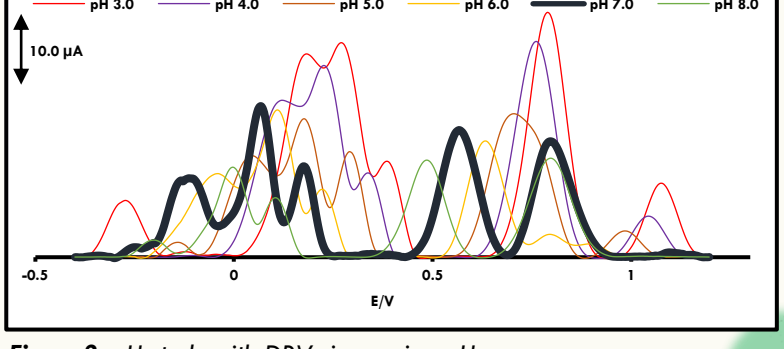


Figure 3. *pH study with DPVs in varying pH.*

Analyte	Limit of Detection (µM)	Recovery Rate in Waste Water (%)	Recovery Rate in Hair Dye (%)
HQ	0.016	102	88
CC	0.071	101	95
RS	0.062	103	110
NO_2^-	0.166	104	108

Figure 5. *Calculated limits of detection in control and real samples.*

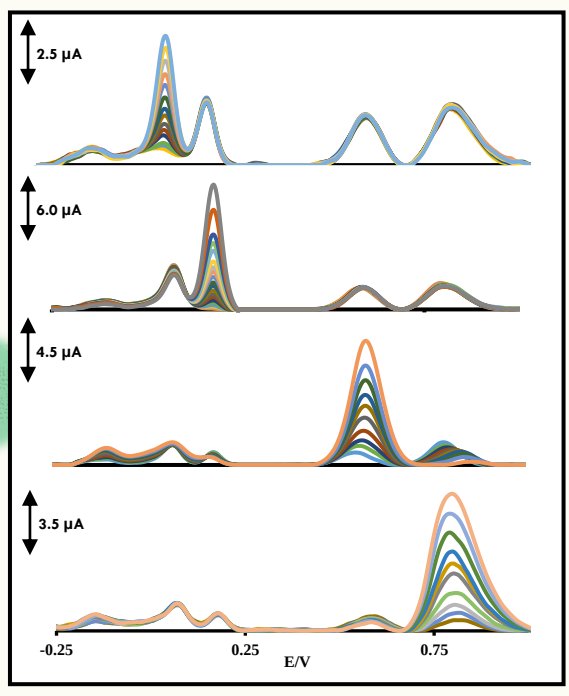


Figure 4. *Interference study with DPVs at pH 7 under varying concentration of one analyte and constant concentration of others.*

DISCUSSION

The novel sensor presents as an effective detection system for benzenediol isomers and nitrites, which pose as a major threat to environmental sustainability and human health.

- Simple, **cost-effective** method of preparation and maintenance
- Strong analytical performance with a wider **linear range**, low **detection limits**, high **selectivity** and significant **stability** and **reproducibility**
- Promising **recovery values** for determination of compounds in **real samples**
- Foundation for **future work** in constructing detection systems for harmful chemicals

Innovate • Sustain • Promote

References

1. Kahru, A.; Maloverjan, A.; Sillak, H.; Põllumaa, L. The Toxicity and Fate of Phenolic Pollutants in the Contaminated Soils Associated with the Oil-Shale Industry. *Environmental Science and Pollution Research* **2002**, *9* (1), 27–33. https://doi.org/10.1007/BF02987422.
2. Enguita, F. J.; Leitão, A. L. Hydroquinone: Environmental Pollution, Toxicity, and Microbial Answers. *Biomed Res Int* **2013**, *2013*, 542168–542168. https://doi.org/10.1155/2013/542168.
3. Parvizishad, M.; Dalvand, A.; Mahvi, A.; Goodarzi, F. A Review of Adverse Effects and Benefits of Nitrate and Nitrite in Drinking Water and Food on Human Health. *Health Scope* **2017**, *In Press*. https://doi.org/10.5812/jhealthscope.14164
4. Suresh, S.; Srivastava, V. C.; Mishra, I. M. Adsorption of Catechol, Resorcinol, Hydroquinone, and Their Derivatives: A Review. *International Journal of Energy and Environmental Engineering* **2012**, *3* (1), 32. https://doi.org/10.1186/2251-6832-3-32.
5. McGregor, D. Hydroquinone: An Evaluation of the Human Risks from Its Carcinogenic and Mutagenic Properties. *null* **2007**, *37* (10), 887–914. https://doi.org/10.1080/10408440701638970
6. Miura, T.; Muraoka, S.; Fujimoto, Y.; Zhao, K. DNA Damage Induced by Catechol Derivatives. *Chem Biol Interact* **2000**, *126* (2), 125–136. https://doi.org/10.1016/s0009-2797(00)00156-3.
7. Lofrano, G.; Rizzo, L.; Grassi, M.; Belgiorno, V. Advanced Oxidation of Catechol: A Comparison among Photocatalysis, Fenton and Photo-Fenton Processes. *Desalination* **2009**, *249* (2), 878–883. https://doi.org/10.1016/j.desal.2009.02.068.
8. Toxicology and Carcinogenesis Studies of Resorcinol (CAS No. 108-46-3) in F344 Rats and B6C3F1 Mice (Gavage Studies). *Natl Toxicol Program Tech Rep Ser* **1992**, *403*, 1–234.
9. Lynch, B. S.; Delzell, E. S.; Bechtel, D. H. Toxicology Review and Risk Assessment of Resorcinol: Thyroid Effects. *Regul Toxicol Pharmacol* **2002**, *36* (2), 198–210. https://doi.org/10.1006/rtph.2002.1585.
10. Grosse, Y.; Baan, R.; Straif, K.; Secretan, B.; Ghissassi, F. E.; Cogliano, V. Carcinogenicity of Nitrate, Nitrite, and Cyanobacterial Peptide Toxins. *The Lancet Oncology* **2006**, *7* (8), 628–629. https://doi.org/10.1016/S1470-2045(06)70789-6.
11. Hu, F.; Chen, S.; Wang, C.; Yuan, R.; Yuan, D.; Wang, C. Study on the Application of Reduced Graphene Oxide and Multiwall Carbon Nanotubes Hybrid Materials for Simultaneous Determination of Catechol, Hydroquinone, p-Cresol and Nitrite. *Analytica Chimica Acta* **2012**, *724*, 40–46. https://doi.org/10.1016/j.aca.2012.02.037
12. Wang, C.; Yuan, R.; Chai, Y.; Hu, F. Simultaneous Determination of Hydroquinone, Catechol, Resorcinol and Nitrite Using Gold Nanoparticles Loaded on Poly-3-Amino-5-Mercapto-1,2,4-Triazole-MWNTs Film Modified Electrode. *Anal. Methods* **2012**, *4* (6), 1626–1628. https://doi.org/10.1039/C2AY25097G
13. Tian, F.; Li, H.; Li, M.; Li, C.; Lei, Y.; Yang, B. Synthesis of One-Dimensional Poly(3,4-Ethylenedioxythiophene)-Graphene Composites for the Simultaneous Detection of Hydroquinone, Catechol, Resorcinol, and Nitrite. *Synthetic Metals* **2017**, *226*, 148–156. https://doi.org/10.1016/j.synthmet.2017.02.016.
14. Sabbaghi, N.; Noroozifar, M. Nanoraspberry-like Copper/ Reduced Graphene Oxide as New Modifier for Simultaneous Determination of Benzenediols Isomers and Nitrite. *Analytica Chimica Acta* **2018**, *1056*. https://doi.org/10.1016/j.aca.2018.12.036.

UNIVERSITY OF TORONTO SCARBOROUGH