

Ultra-sensitive Electrochemiluminescent Biosensor for the Detection of Coronavirus Variants

Jarid du Plooy¹, Keagan Pokpas², Samantha Douman¹.

¹ Department of Chemistry, University of Cape Town, Rondebosch, Cape Town 7700

² Department of Chemistry, University of the Western Cape, Bellville, 7536

Dpljar006@myuct.ac.za

Abstract

The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) *aka* COVID-19 has plagued the world in recent years amassing to just under 7 million deaths worldwide. This highly infectious virus can spread freely among individuals especially those in developing countries where overcrowding and lack in healthcare are of particular concern. Current commercially available COVID-19 diagnostics focus on costly and time-consuming molecular assays thus limiting the effectiveness for sensitive and early diagnosis ¹. Herein, this work proposes the development of a novel electrochemiluminescent (ECL) biosensor that is selective and sensitive towards early detection of coronavirus antibodies with emphasis on coronavirus variants ^{2,3}. Moreover, luminescent materials will be applied as ECL luminophores to act as a signal readout in the biosensor fabrication specifically towards coronavirus variant detection ⁴. In addition, the fabricated ECL biosensor will be optimized and studies such as binding affinity, stability, selectivity, and sensitivity shall be conducted. The proposed ECL biosensor provides a novel approach to real-time coronavirus and related variants monitoring and presents a unique opportunity for gold standard sensing of other viruses and diseases in the future.

Working Principle

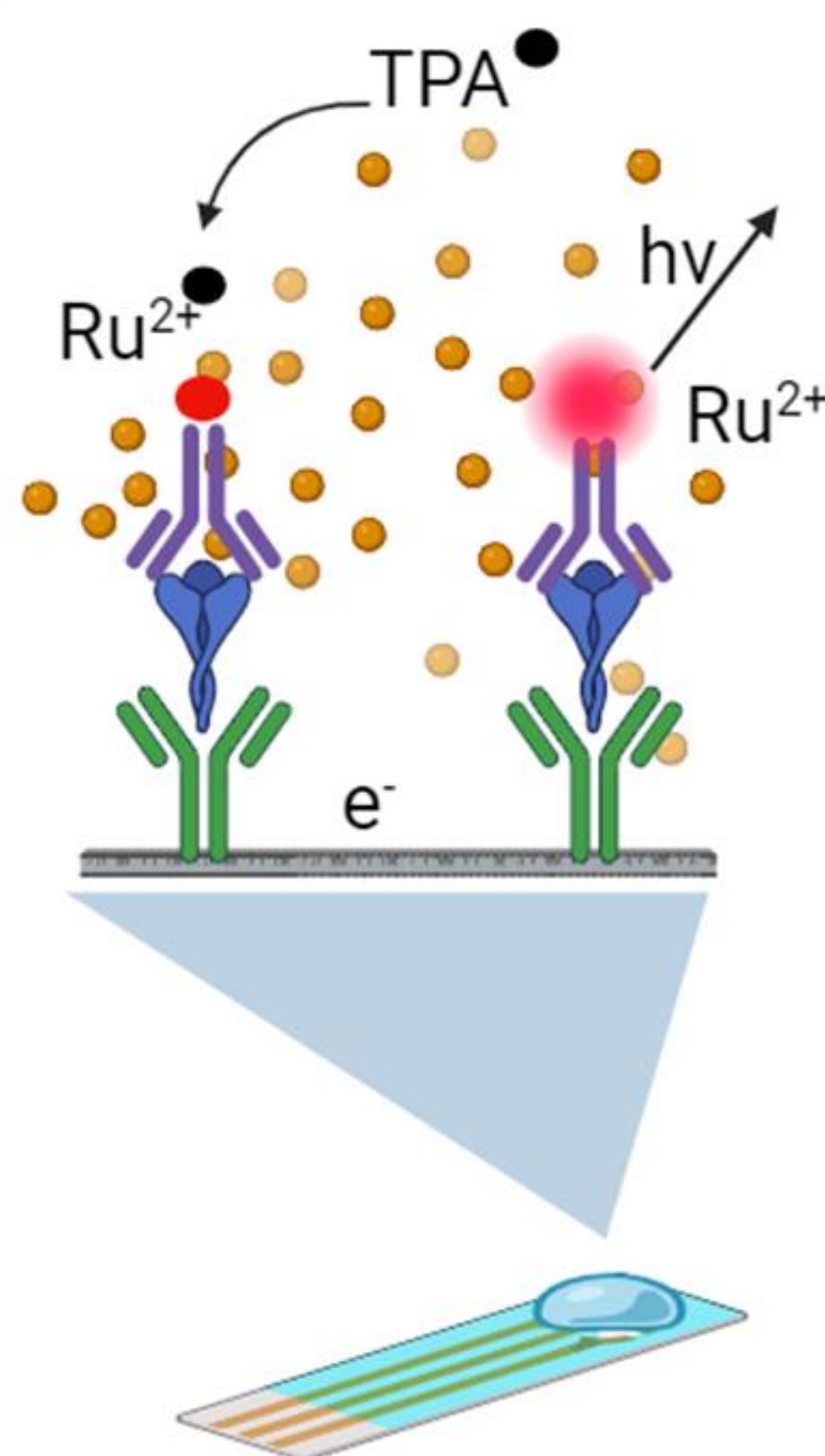


Figure 1: Schematic diagram of ECL biosensor.

ECL is described as the generation of species at an electrode surface where it undergoes an electron-transfer reaction to form excited states that emit light ⁵. ECL biosensors make use of specific biological interactions, such as antibody-antigen and DNA-aptamer interactions, to recognize analyte and produce a luminescent signal.

Important components for a successful ECL biosensor

- Electrode
- Immobilized biological material
- Target analyte
- Secondary biological material
- Sandwich format
- Conjugation strategy
- Co-reactant and **Luminophore**

Results

Copper based polypropylenimine tetra(salicylaldimine) complex (Cu-G0)

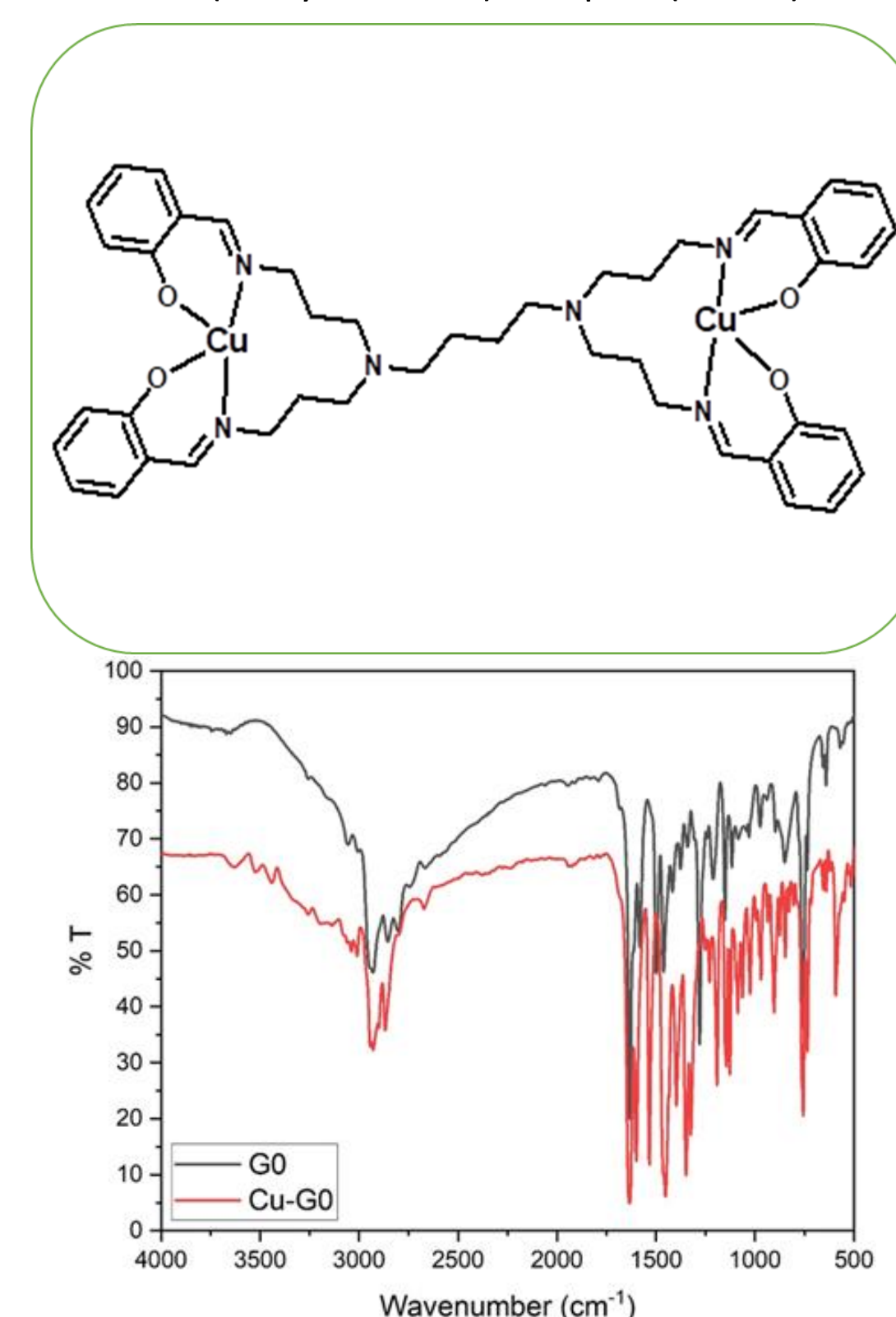


Figure 2: FTIR analysis of CuG0.

Copper based polypropylenimine octa(salicylaldimine) complex (Cu-G1)

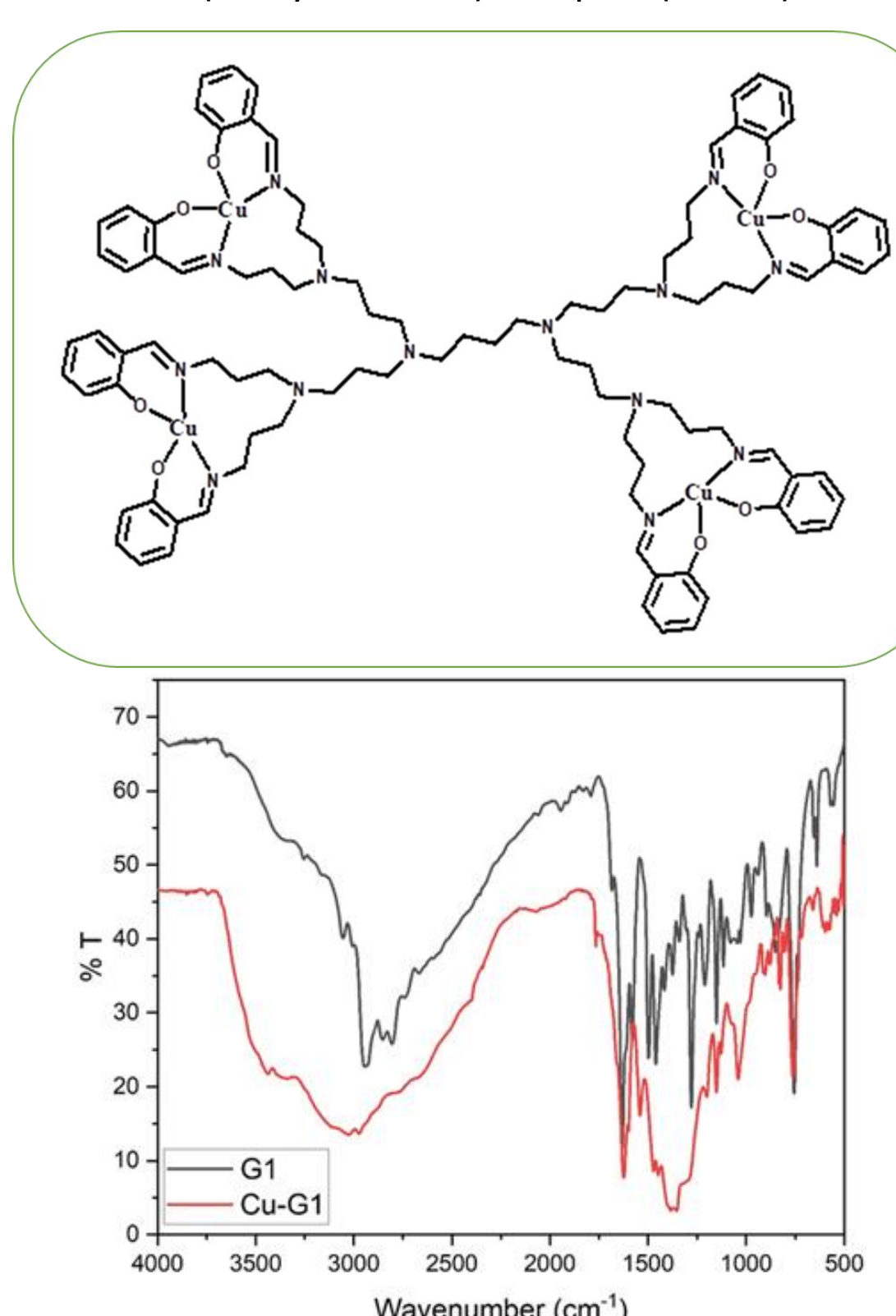


Figure 3: FTIR analysis of CuG1.

Copper based polypropylenimine hexadeca(salicylaldimine) complex (Cu-G2)

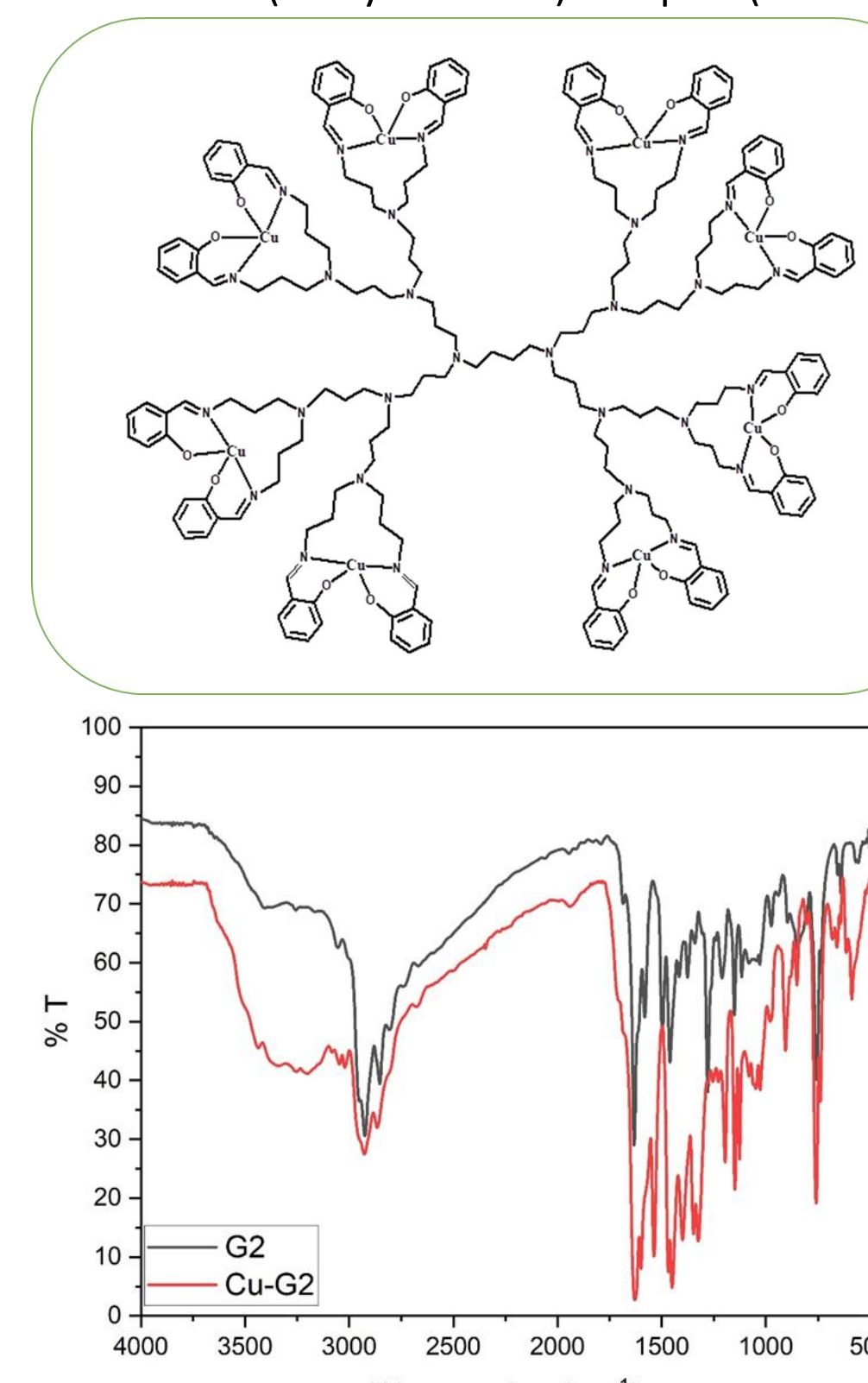


Figure 4: FTIR analysis of CuG2.

	cm ⁻¹		
Functional Groups	CuG0	CuG1	CuG2
C-N (Tertiary nitrogen)	1399, 1349 & 1326	1403, 1384 & 1354	1400, 1349 & 1328
Schiff base (C=N)	1637	1625	1635
Phenolate Character	1191	1152	1197
C-O (Phenolate)	1126	1128	1127
Aromatics (C-H)	Bending: 757 & 735 Ring vibrations: 1533 & 1453 Stretching: 3011 & 3040	Bending: 824 & 761 Ring Vibrations: 1543 & 1450 Stretching: 3033	Bending: 904 & 759 Ring Vibrations: 1534 & 1453 Stretching: 3050 & 3021
Alkane (C-H)	Stretching: 2945 & 2870 Scissoring: 1455	Stretching: 2972 Scissoring: 1472	Stretching: 2936 & 2867 Scissoring: 1468

Table 1: Functional group summarization from FTIR spectra for CuG0, CuG1 and CuG2.

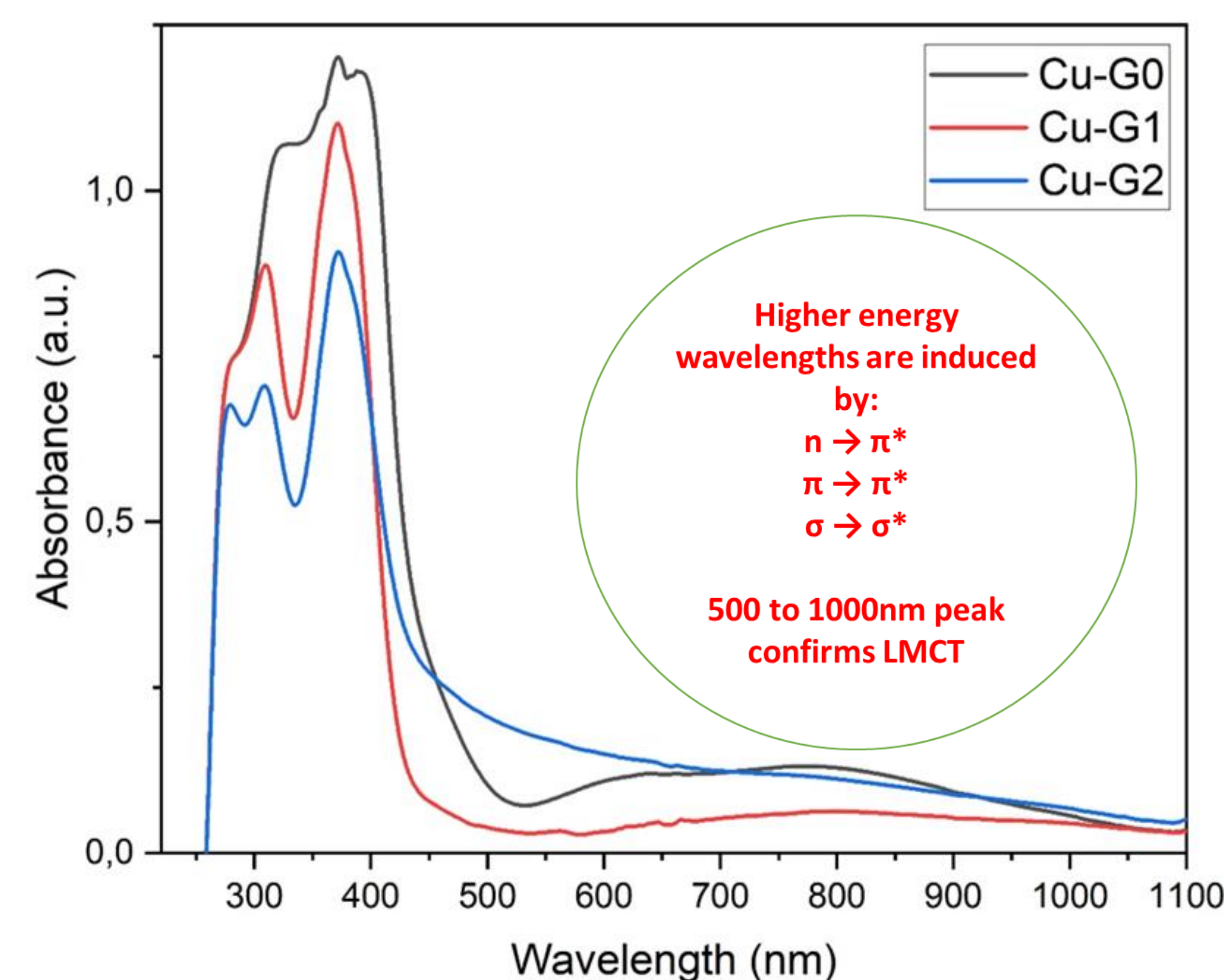


Figure 5: UV-Vis analysis of CuG0, CuG1 and CuG2 ranging from 200 to 1100 nm.

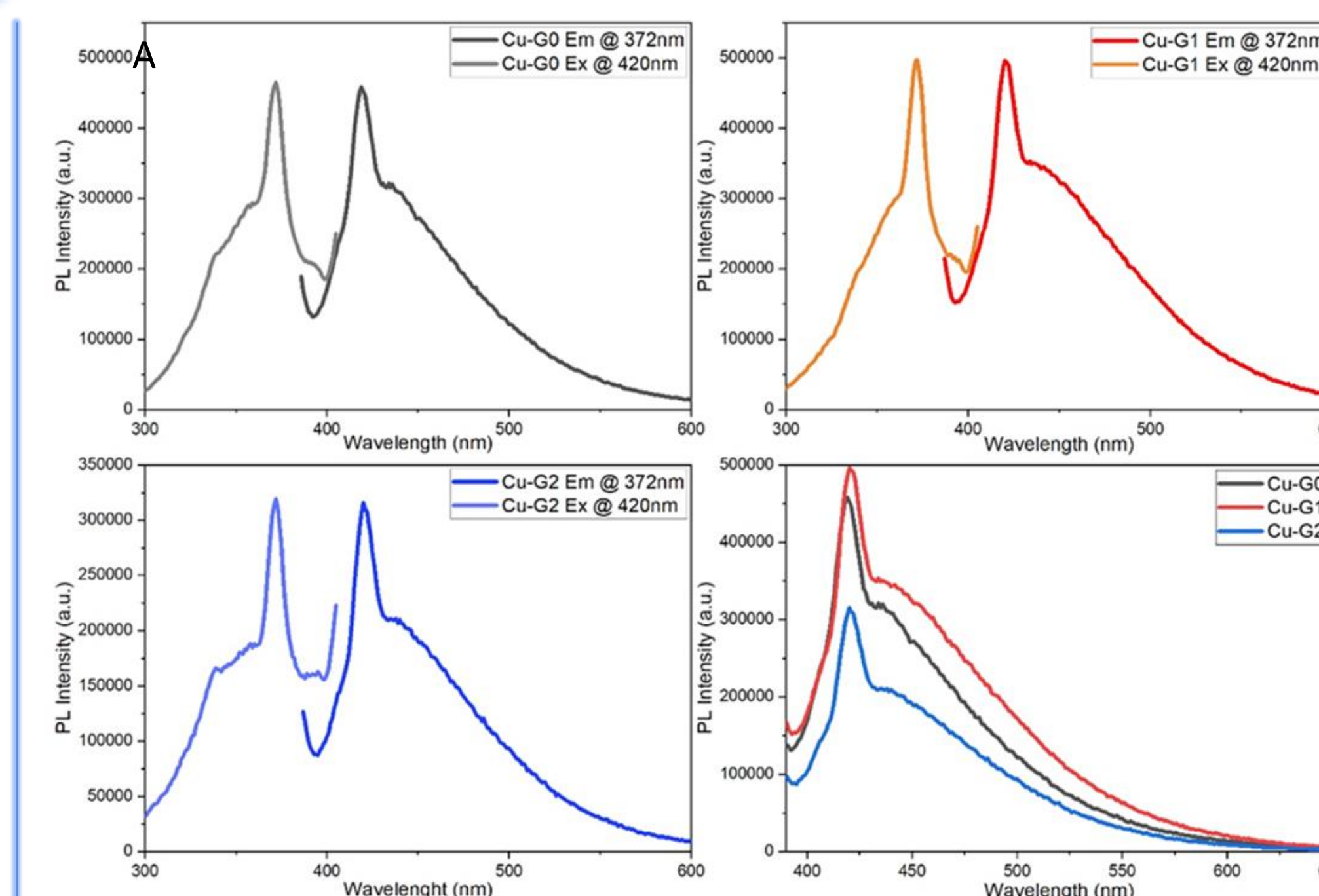


Figure 6: PL analysis of (A)CuG0, (B)CuG1 and (C)CuG2 ranging from 200 to 1100 nm. (D) Emissions plot of CuG0, CuG1 and CuG2.

	Wavelength (nm)		
PL Property	CuG0	CuG1	CuG2
Emission	419	420	420
Excitation	372	372	372
Stokes Shift (Emission – Excitation)	47	48	48

Table 2: PL property summarization for CuG0, CuG1 and CuG2.

Future Work

The quantum yield of the three Cu dendrimer structures need to be conducted. Additionally, novel low-cost ECL luminophores will be explored and comparison studies will be conducted and compared with the traditional systems. The selected ECL luminophores that are promising will be subjected to ECL studies. Finally, the candidates which produce excellent ECL character will then be conjugated to SARS-CoV-2 antibodies. Furthermore, develop the ECL sensor.

The ECL system created will then be tested toward other diseases and biomolecules to determine if the format is viable, reliable and reproducible.

Acknowledgement

I would like to thank my supervisor Dr. Samantha Douman as well as Dr. Emmanuel Ramoroka for the guidance and expertise thus far. Additionally, a special thank you to the Chemistry Department of the University of Cape Town.

References

1. R. Misra, S. Acharya and N. Sushmitha, *Rev. Med. Virol.*, 2022, **32**, e2267.
2. Y. Zhao, J. Huang, L. Zhang, S. Chen, J. Gao and H. Jiao, *Environ. Res.*, 2022, **206**, 112240.
3. M. O. Aydogdu, J. L. Rohn, N. V. Jafari, F. Brako, S. Homer-Vanniasinkam and M. Edirisinghe, *Adv. Sci.*, 2022, **9**, 2104495.
4. S. O'Connor, L. Dennany and E. O'Reilly, *Bioelectrochemistry*, 2023, **149**, 108286.
5. M. M. Richter, *Chem. Rev.*, vol. 104, no. 6, pp. 3003–3036, Jun. 2004, doi: 10.1021/CR020373D/ASSET/IMAGES/LARGE/CR020373DF00025.JPEG.