Photoeletrochemistry of Metallo-octacarboxyphthalocyanines/Multi-walled carbon nanotubes hybrid for development of Dye Solar Cells

Nonhlanhla Mphahlele

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13th Topical Meeting of the International Society of Electrochemistry

Outline

- Background and Introduction
- Experimental Procedure
- Characterization
- Electrochemical Evaluation
- Conclusions
- Acknowledgements

What is Dye solar cells (DSC)?

Dye solar cells (DSCs) have become one of the attractive devices as an alternative energy resources for the conversion of solar irradiation into electricity

- Low cost
- Easy to fabricate
- Non toxic
- Light weight and semitransparent

First reported in 1991, by O'Regan and Gratzel with a solar power conversion of 11%.

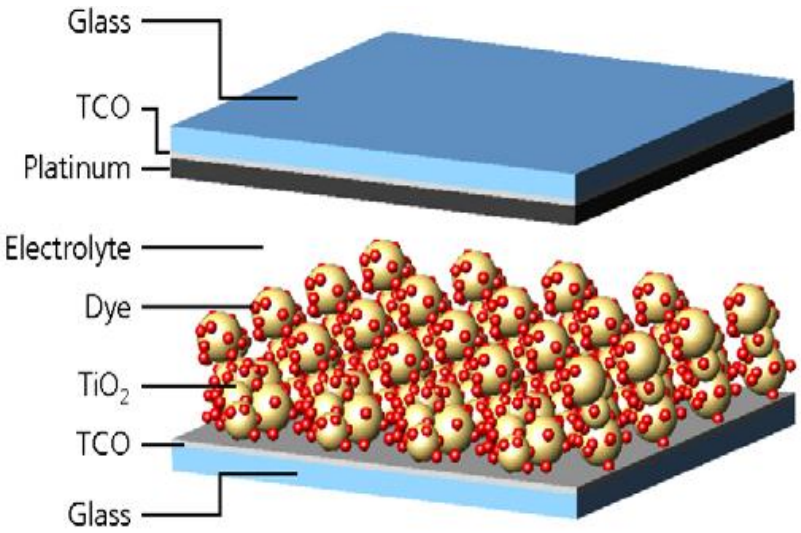
This device was achieved by using high surface area nanocrystalline TiO_2 coated with an adsorbed dye molecule in order to maximise light harvesting

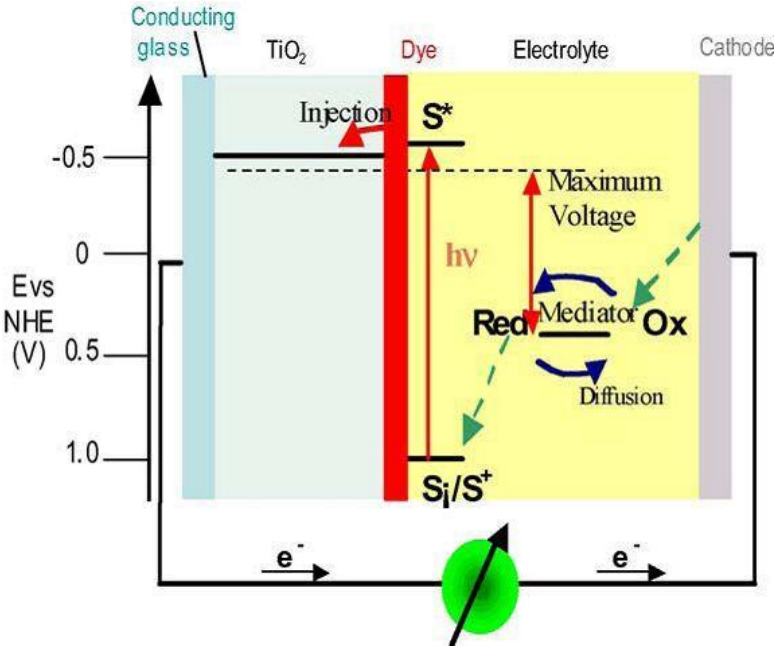
O'Regan & Grätzel, 1991. *Nature,* 486: 485; Chung *et al*, 2012. *Nature,* 486: 485

DSCs?

Three main components in DSCs

Working electrode, Counter electrode and Electrolyte (iodide/triiodide redox couple)





Grätzel, M. 2005, Inorg.Chem,44:6841 - 6851

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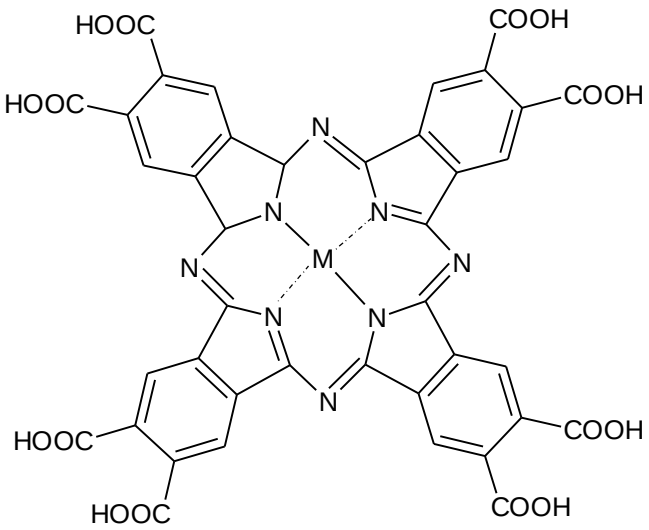
Major research focus areas

• Investigate the electron transport and recombination properties of Metal octacarboxyphthalocyanines (MPc) photosensitiser modified with carbon nanotubes in DSCs

Why MPc as a photosensitiser?

- Panchromatic
- Thermal and photochemical stable
- Large absorption coefficients ($E>10^5\ M^{-1}\ cm^{-1}$)

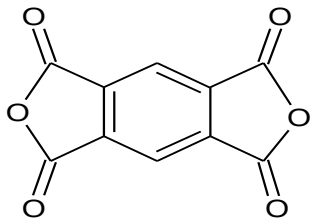


Nyokong, T. 2007. *Coordination Chemistry Reviews*, 251(13-14): 1707-1722

Approach:

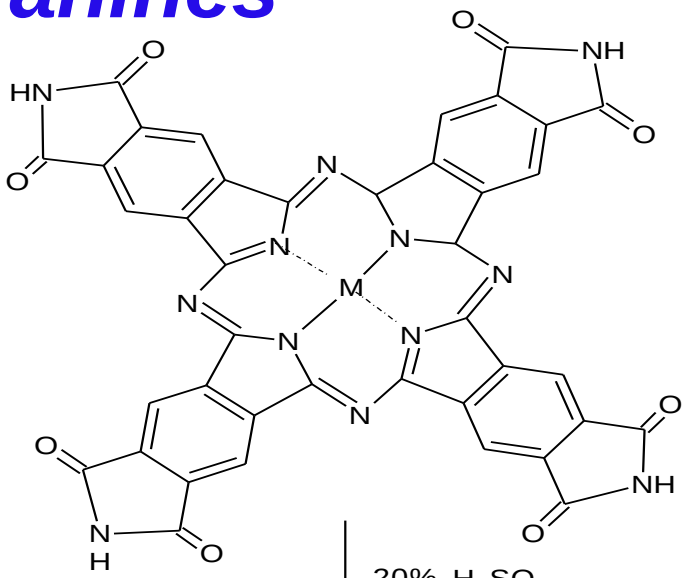
- Synthesise various metal octacarboxyphthalocyanine (M = Ga, Zn, Si);
- Modification with multiwalled carbon nanotubes;
- Investigate the spectroscopic, microscopic; determine the electrochemical behaviour of metal octacarboxyphthalocyanines supported on carbon nanotubes
- Incorporate in DSCs

Synthesis of Metal Octacarboxyphthalocyanines



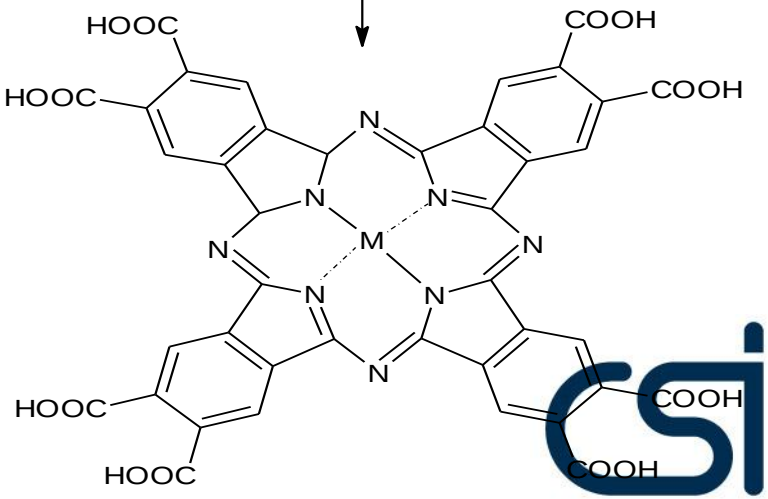
Urea, metal salt, DBU

Reflux for 30mins



20% H_2SO_4

Reflux for 3days



[MOCPc (M = Zn, $(OH)_2$Si & (OH)Ga)]

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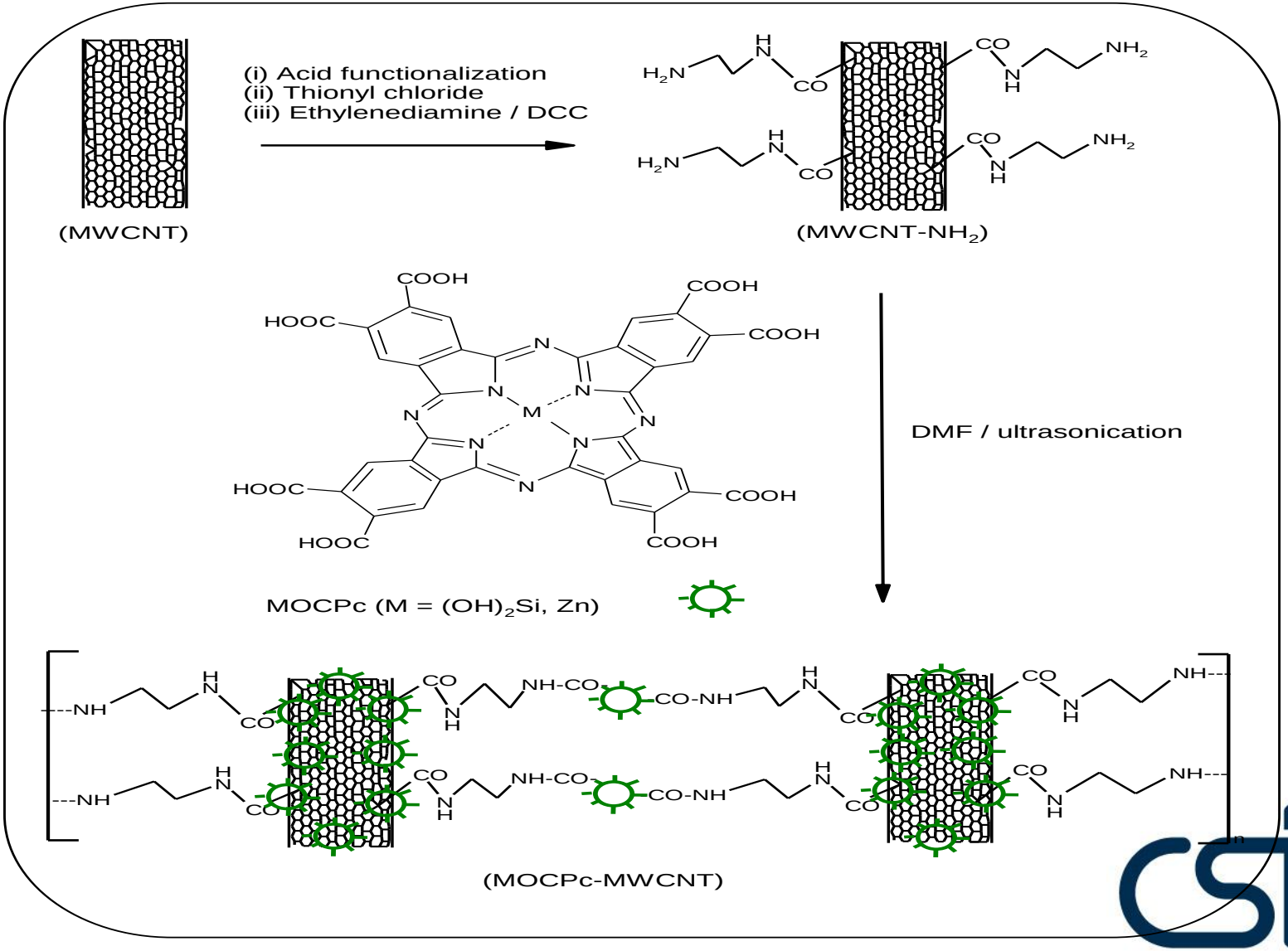
Synthesis route for the MOCPc – MWCNT



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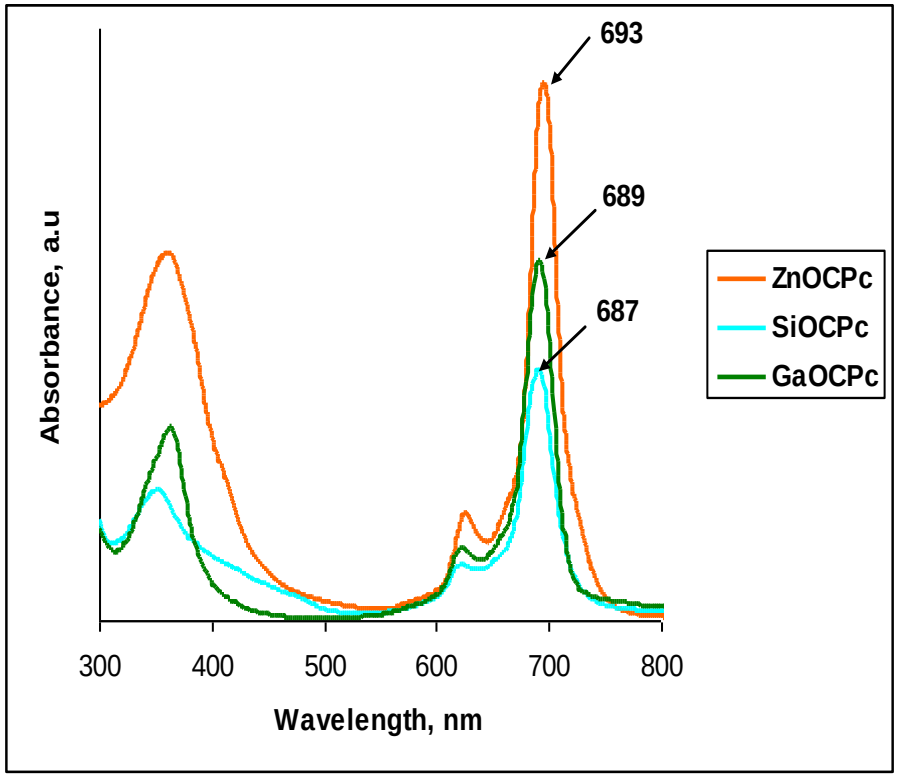
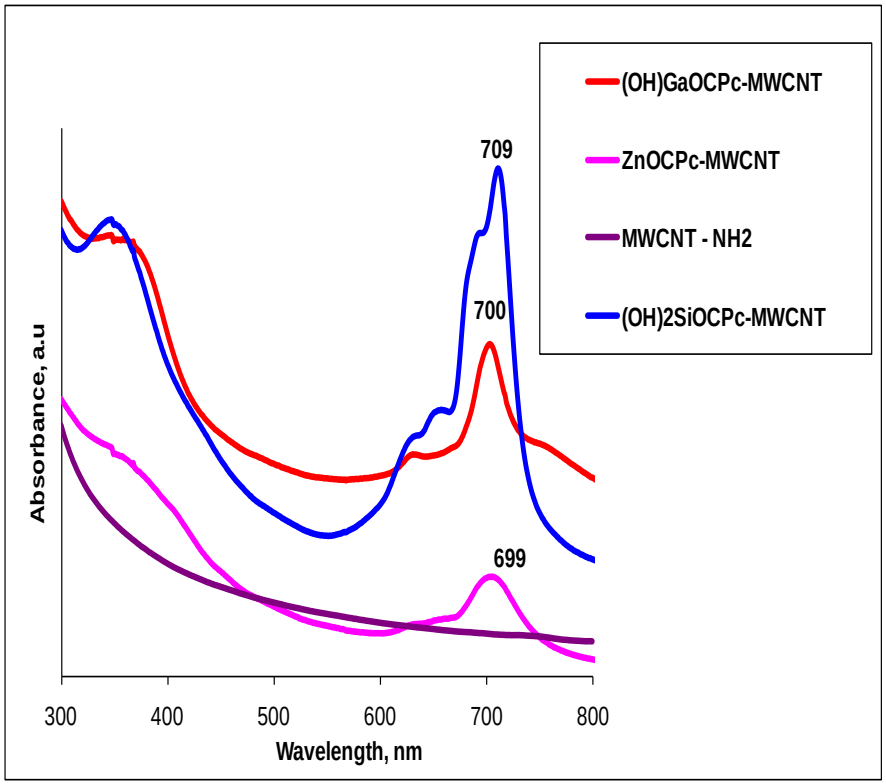
UV/VIS SPECTRA





Electronic spectra of MOCPc and MOCPc-MWCNTs in DMF.
Upon integration with MWCNT, Q band red shifted.

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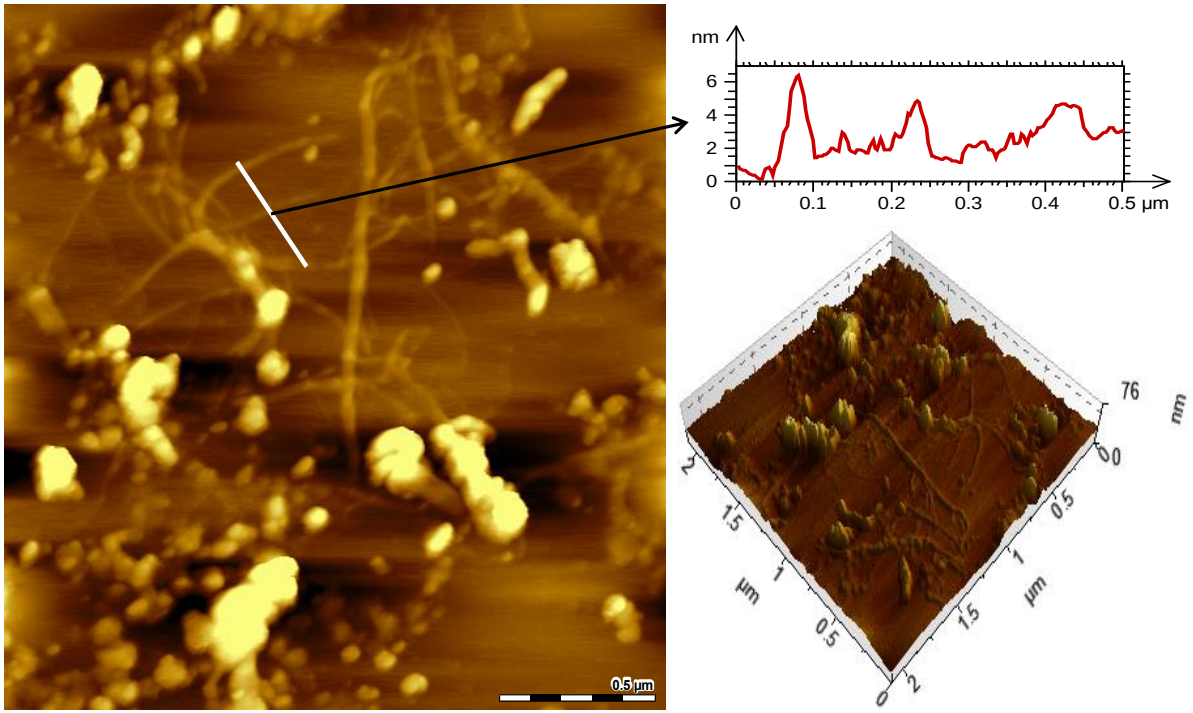
AFM IMAGE



Clearly showing the attachment of ZnOCPc molecules on the walls and edge-plane sites of the MWCNTs.

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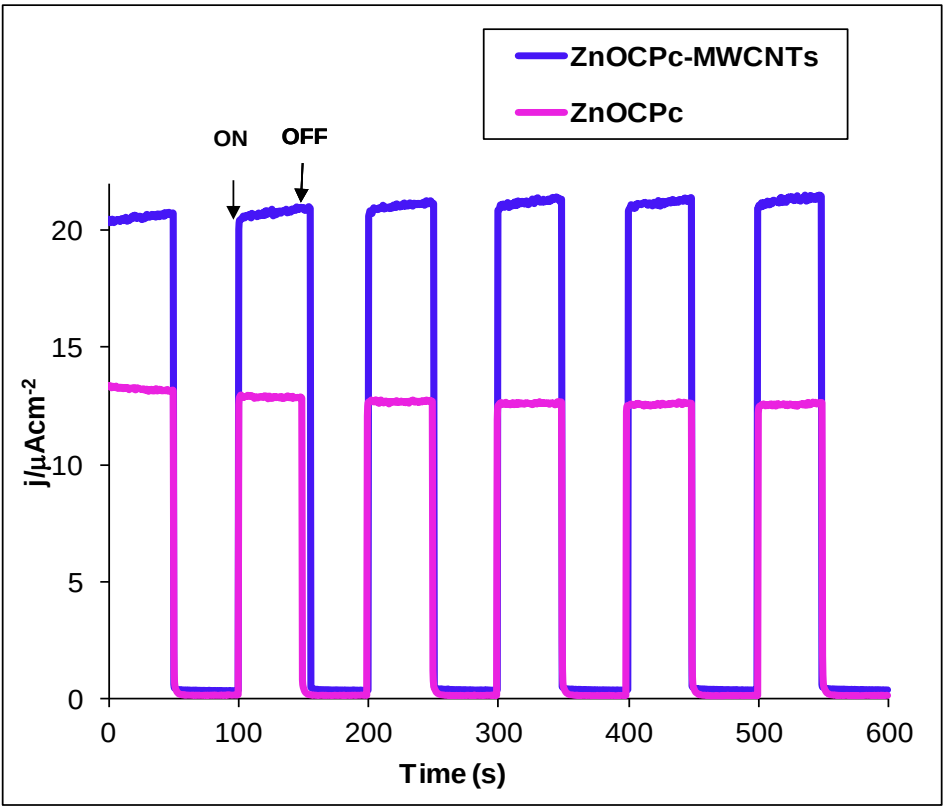
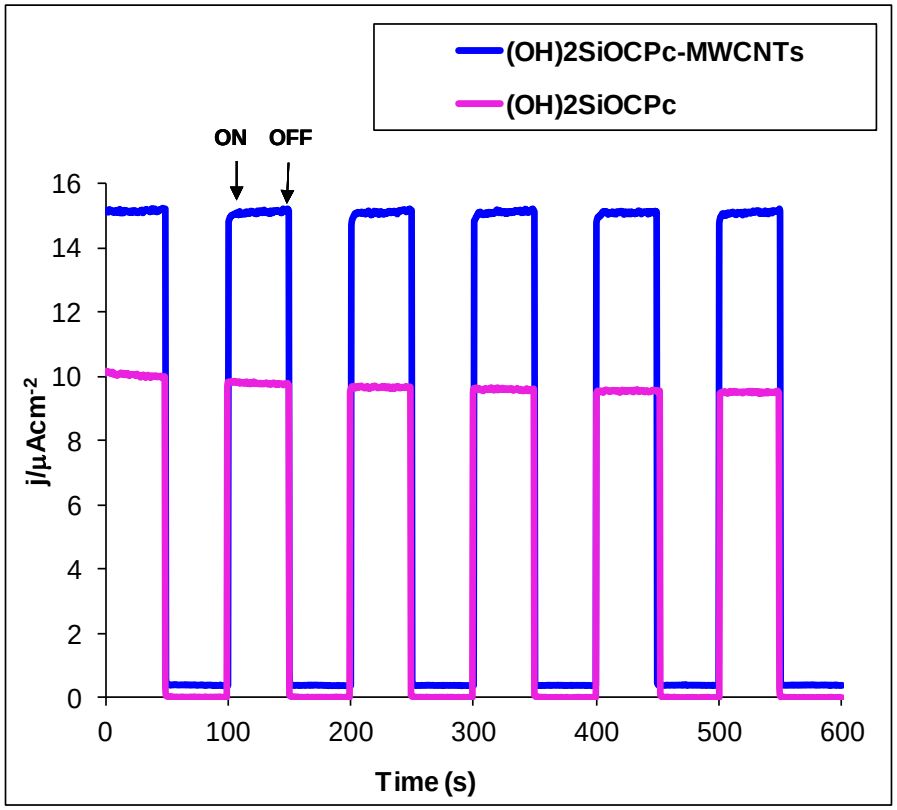
CHRONOAMPEROMETRY





Figures present the MPc and MPc-MWCNT hybrids on the ITO substrate with photocurrent response under visible light illumination, a reversible rise/decay of the photocurrent in response to the on/off illumination.

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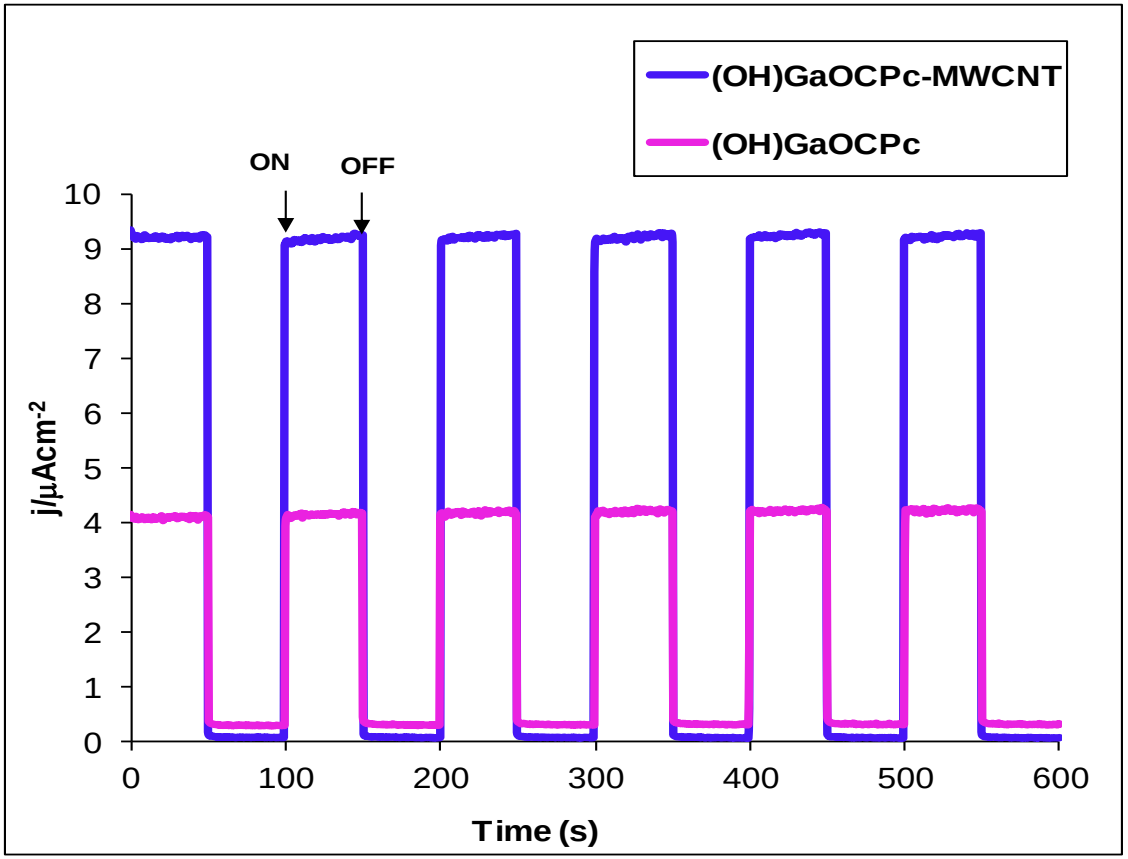

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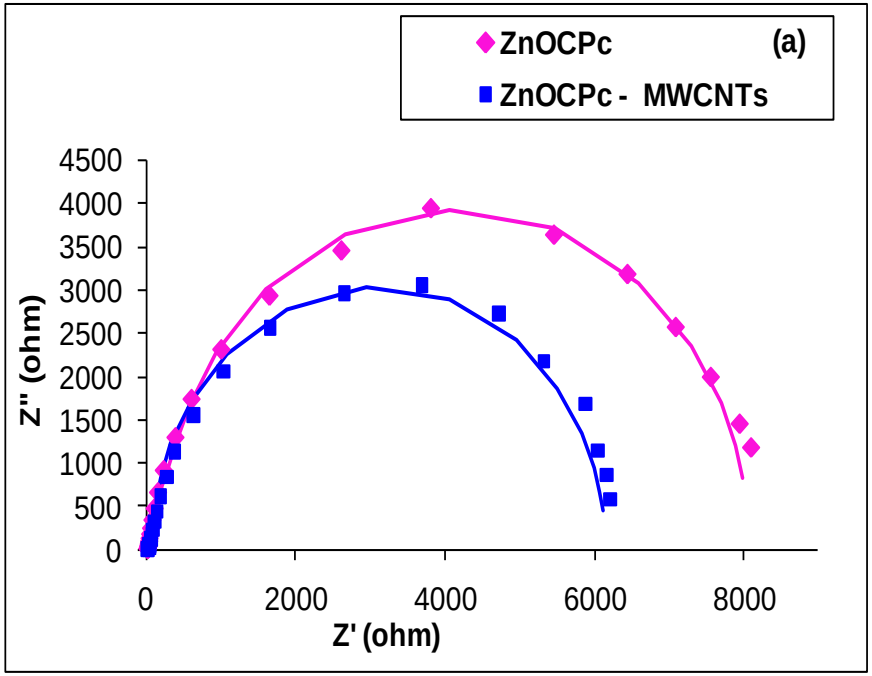
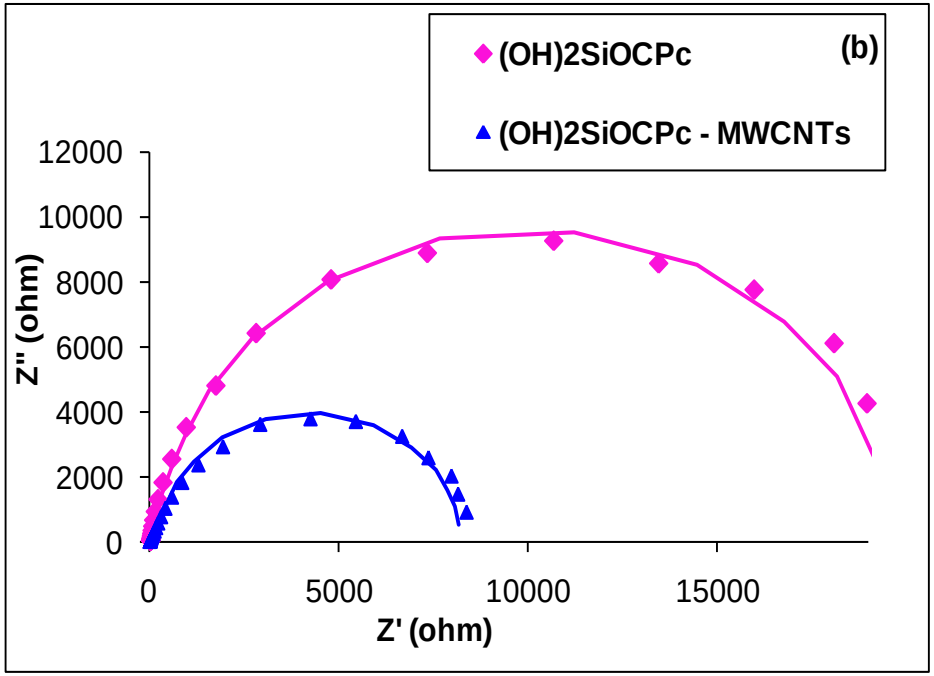
NYQUIST PLOT





Nyquist plots of DSCs fabricated with a) TiO_2/ZnOCPc, b) TiO_2/$(OH)_2$SiOCPc and their corresponding MWCNT-integrated hybrids.

- Investigate the electron transport and recombination mechanism of DSCs

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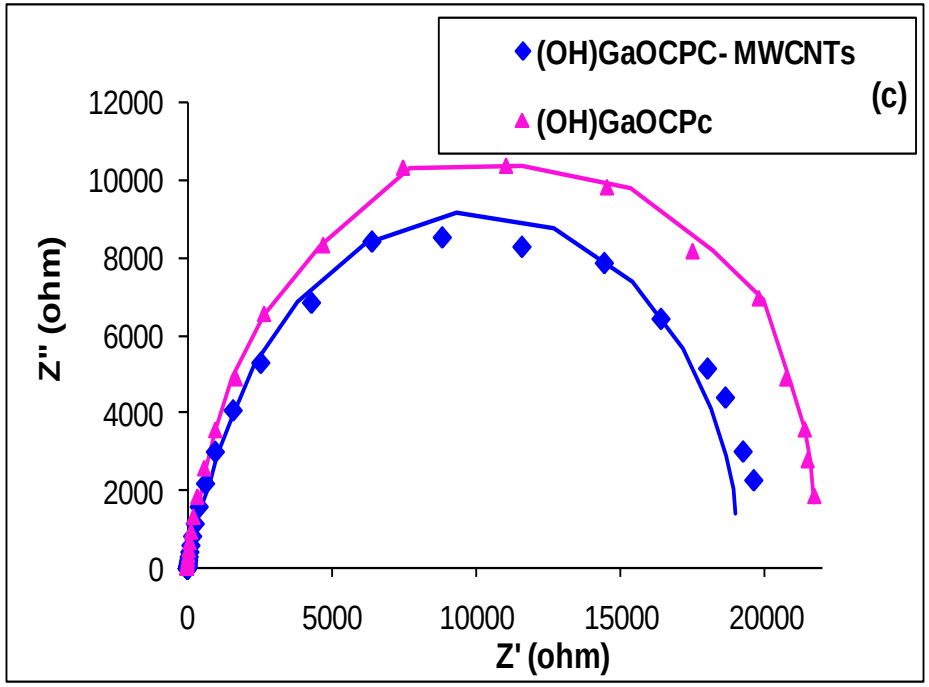
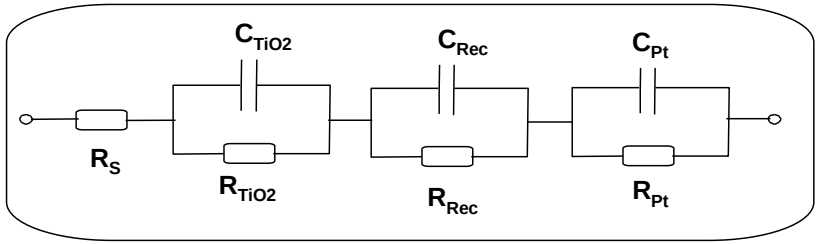
NYQUIST PLOT





Vogit circuit comprising three RC elements in series to fit the circuit

Nyquist plots of DSCs fabricated with c) TiO_2/OHGaOCPc and their corresponding MWCNT-integrated hybrids.

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CONCLUSIONS

- MOCPc (M = Ga, Si, Zn) complexes were successfully synthesised.
- As confirmed by FTIR, UV/Vis and electrochemistry characterisation.
- Amine functionalised multi-walled carbon nanotubes were successfully incorporated with MOCPc to produce MOCPc - MWCNTs hybrid and satisfactory characterisations were obtained.
- The incorporation of MWCNTs improved the photocurrent response of MOCPc and electron transfer properties of MOCPc in DSCs .
- Therefore, ZnOCPc - MWCNT showed high photocurrent response than $(OH)_2$SiOCPc – MWCNT and (OH)GaOCPc – MWCNT.

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Thank You