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Metal octacarboxyphthalocyanines/ Multi-walled carbon nanotubes hybrid for development of dye solar cells

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OUTLINE

Background and Introduction

Experimental Procedure

Characterization

Electrochemical Evaluation

Conclusions

Acknowledgements

What is dye solar cells (DSCs)

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

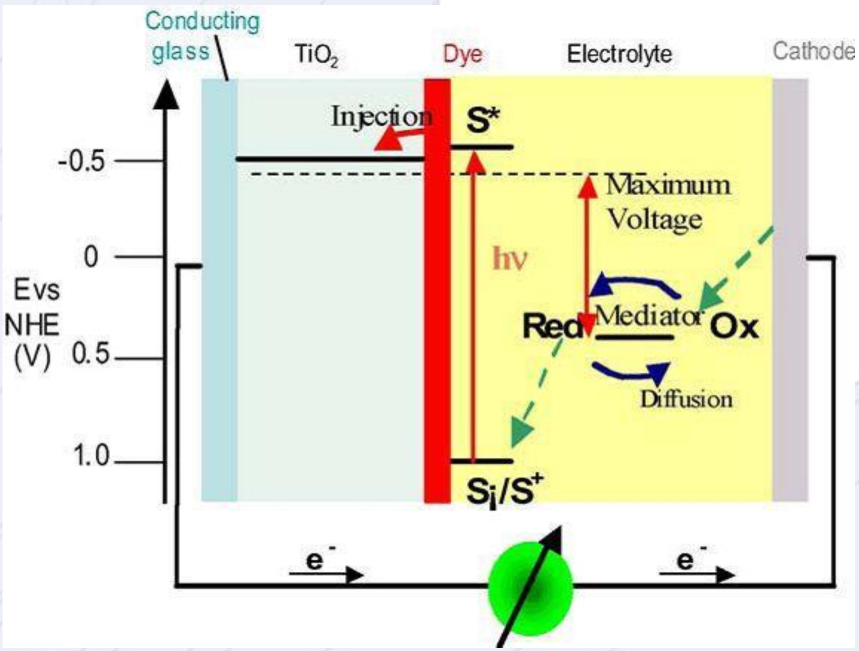
First reported in 1991, by O'Regan and Gratzel with a solar power conversion of 11%.

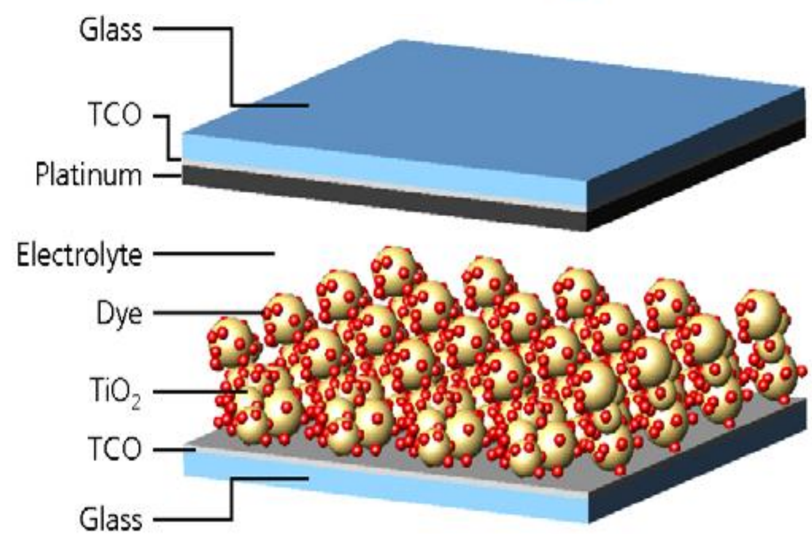
This device was achieved by using high surface area nanocrystalline TiO_2 coated with an adsorbed dye molecule in order to maximise light harvesting

DSCs

Three main components in DSCs

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





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

Major research areas

• Investigate an alternative photosensitiser

enhance the performance and efficiency of DSCs.

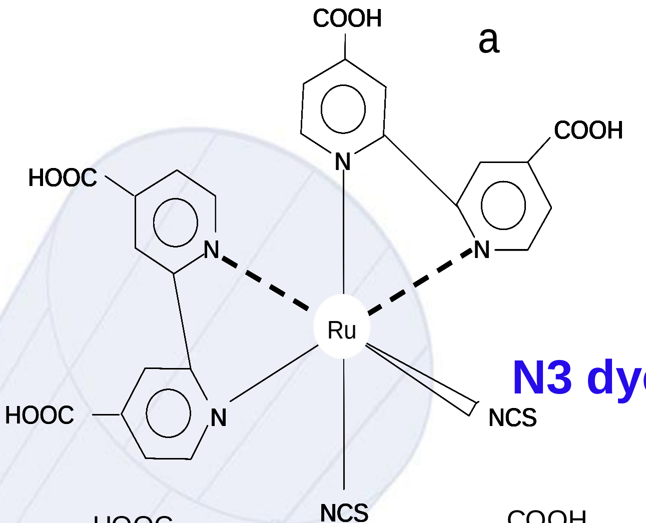
Requirements for Sensitisers

- Sensitisers should be panchromatic.
- Contain functional groups such as Carboxylic group.
- It should have suitable ground and excited state for redox properties.
- The energy level of the excited dye molecule should be well matched to the lower bound of the conduction band.
- Stable to sustain about 10^8 turnover cycles for about 20 years when exposed to light.
- Thermal and photochemical stability.

Grätzel, M. 2000. *Research and Applications,* 8: 171-185

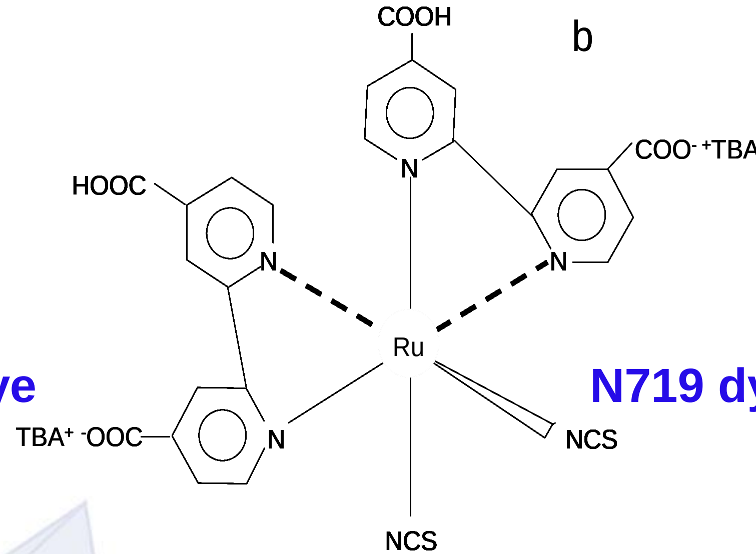
Alternative Photosensitiser

a

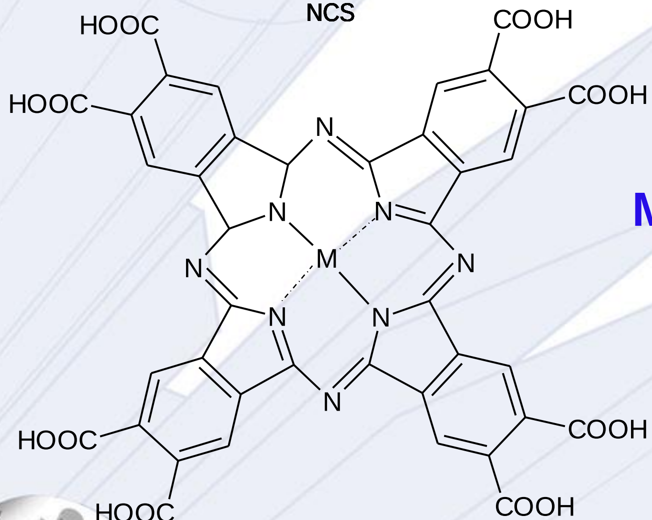


N3 dye

b



N719 dye

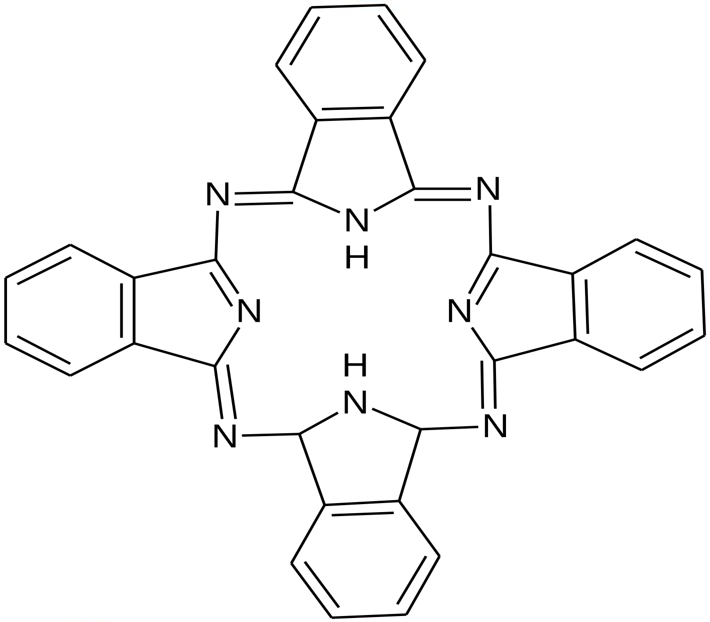


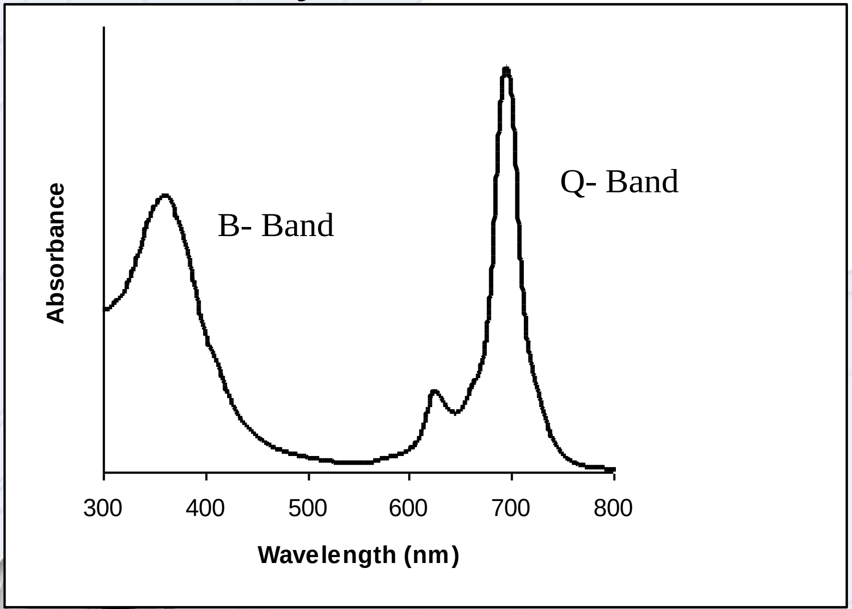
Metal octacarboxyphthalocyanines

The use of MPc in DSCs is rarely reported

Background of Phthalocyanines

•Aromatic planar complex
•Tetraazoporphyrins – four isondole unit
•Braun and Teherniac – 1907
•Pcs have been used:Pigments and dyestuff for over 70 years





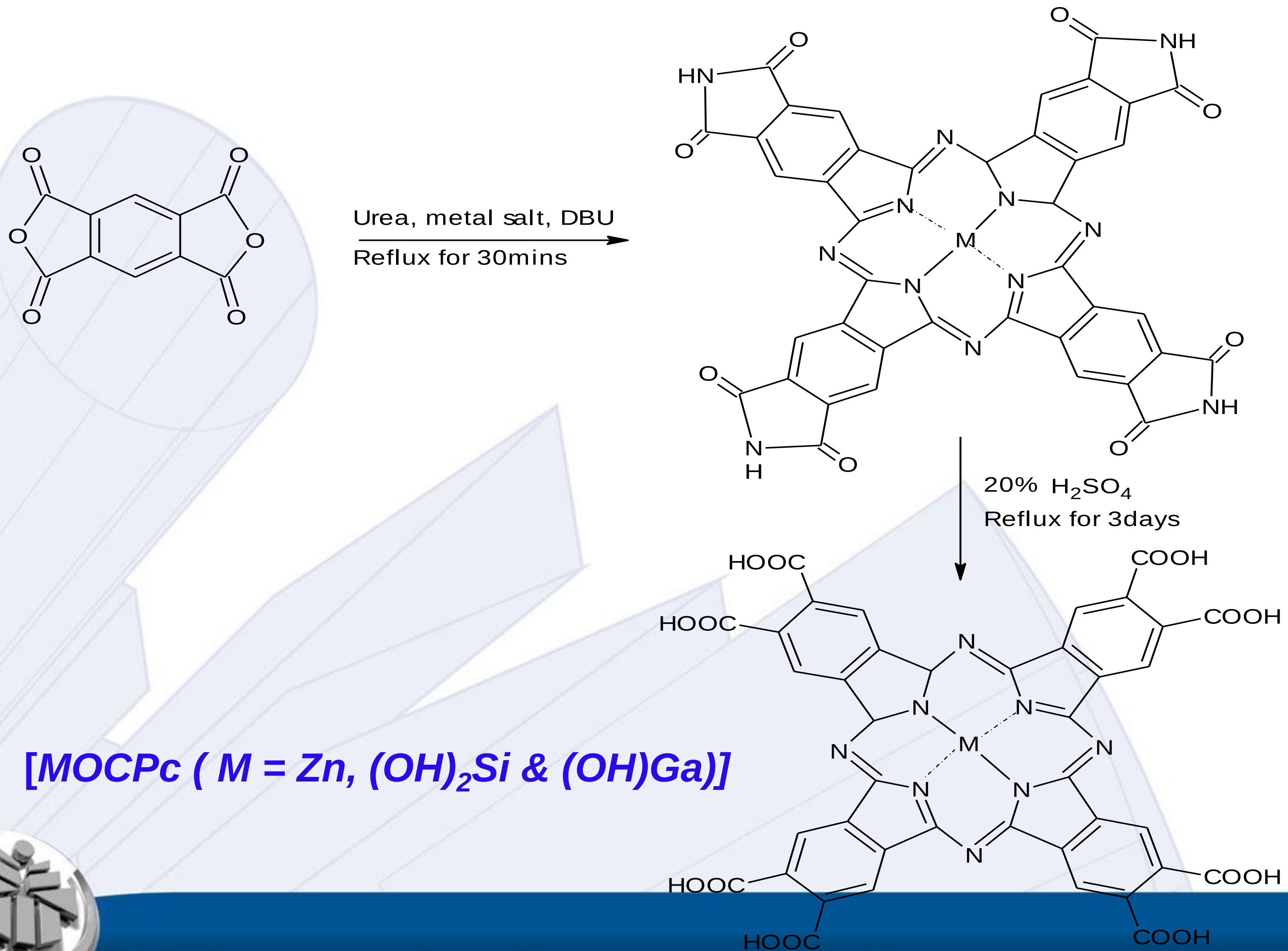
•Two isolated absorption band
•Modifying MPc with MWCNT
•CNT – efficient catalyst and conductive species

Nyokong, T. 2007. *Coord. Chem. Rev, 251*: 1707-1722.

Approach:

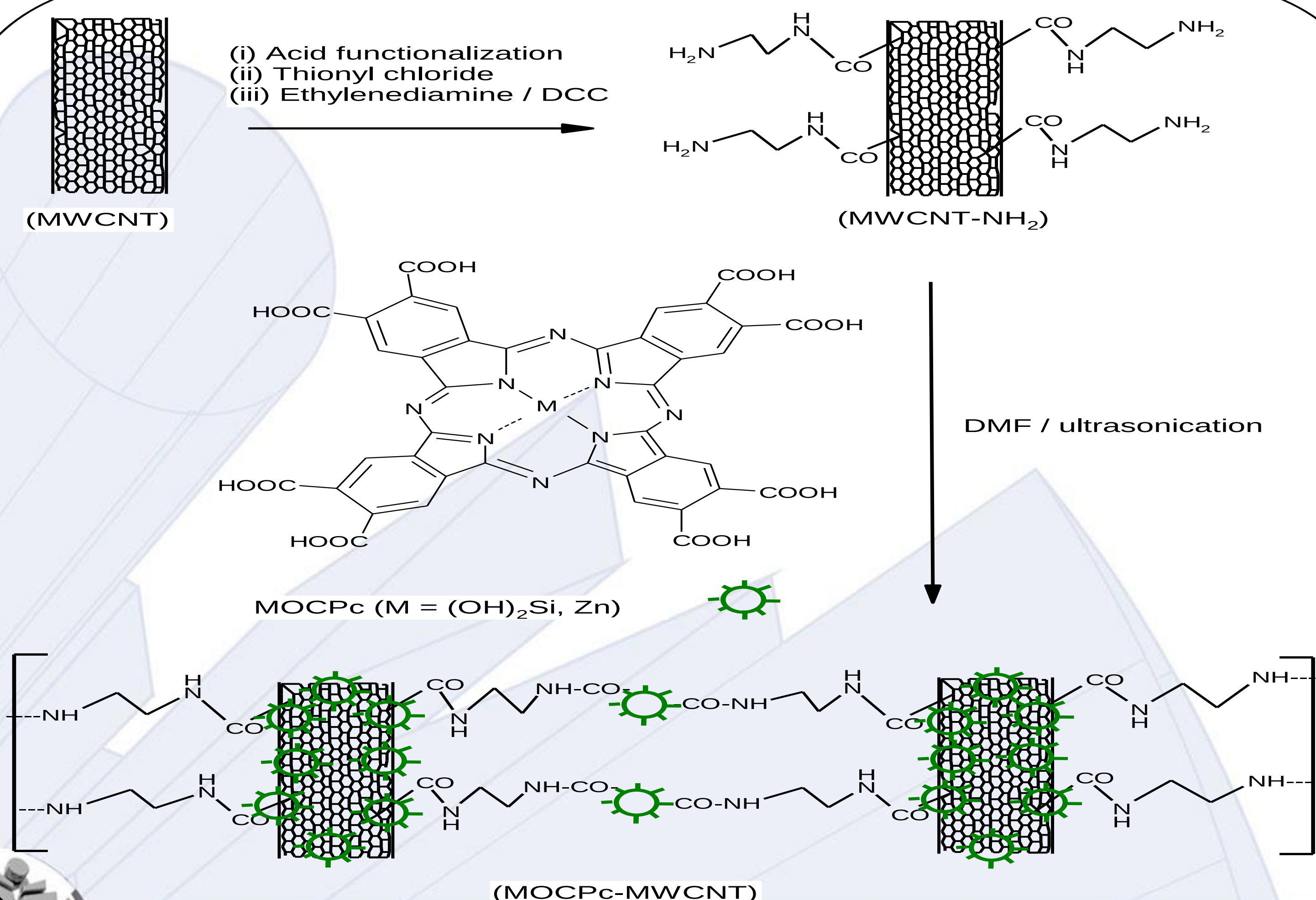
- Synthesise various metal octacarboxyphthalocyanine (M = Ga, Zn, Si);
- Modification with multiwalled carbon nanotubes;
- Investigate the spectroscopic, microscopic; determine the electrochemical behaviour of metal octacarboxyphthalocyanines supported on carbon nanotubes
- Incorporate in DSC

Synthesis of Metal Octacarboxyphthalocyanines

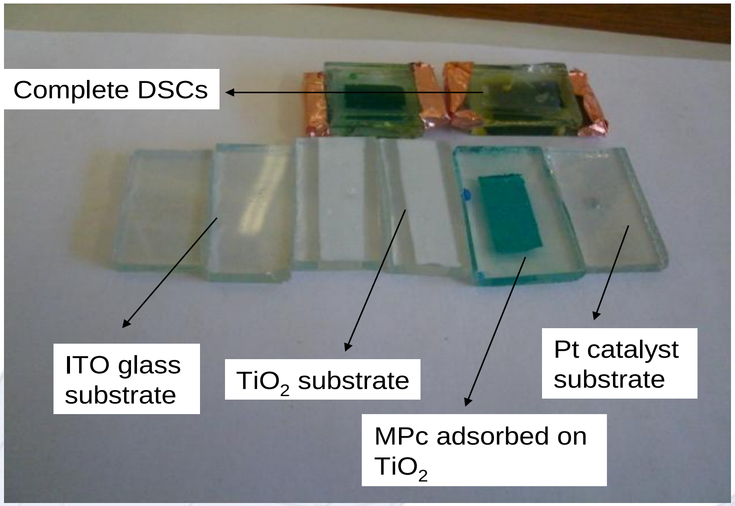


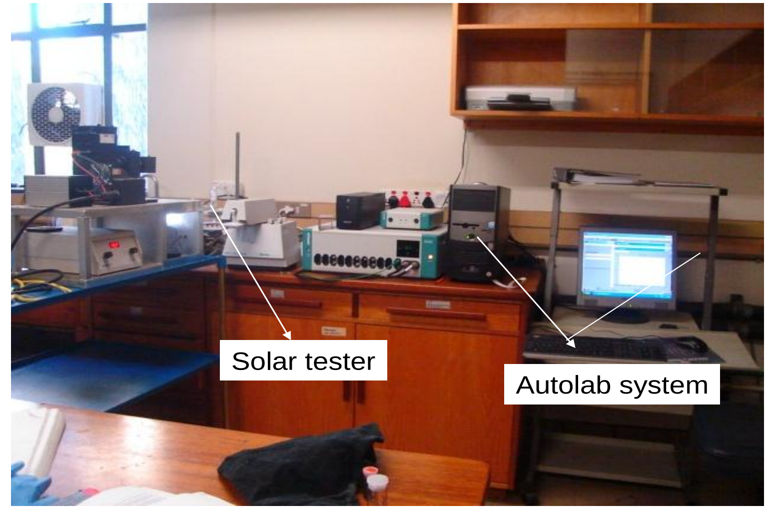
[MOCPc (M = Zn, $(OH)_2$Si & (OH)Ga)]

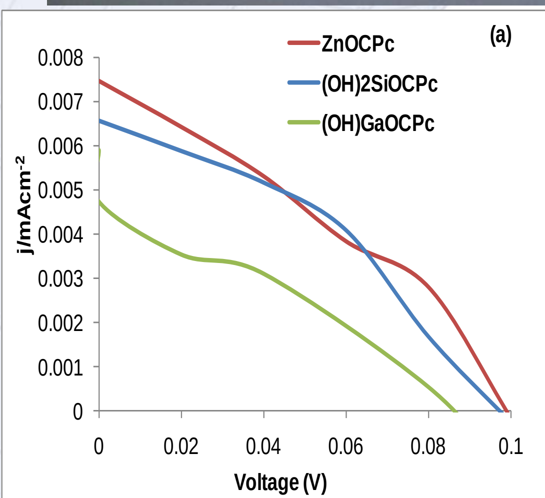
Synthesis route for the MOCPc - MWCNT

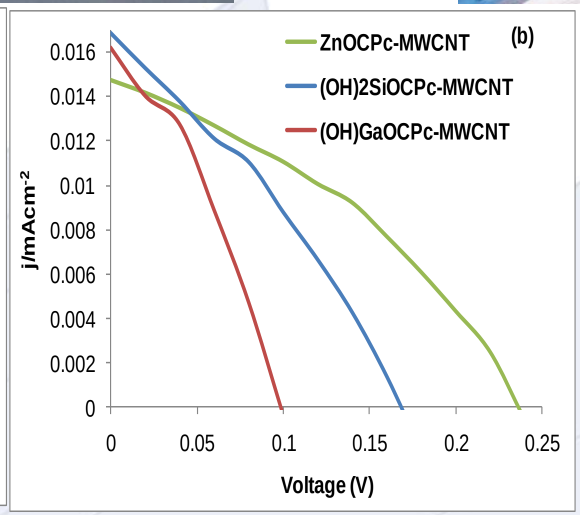


Fabrication of DSCs using MOCPc-MWCNT hybrid

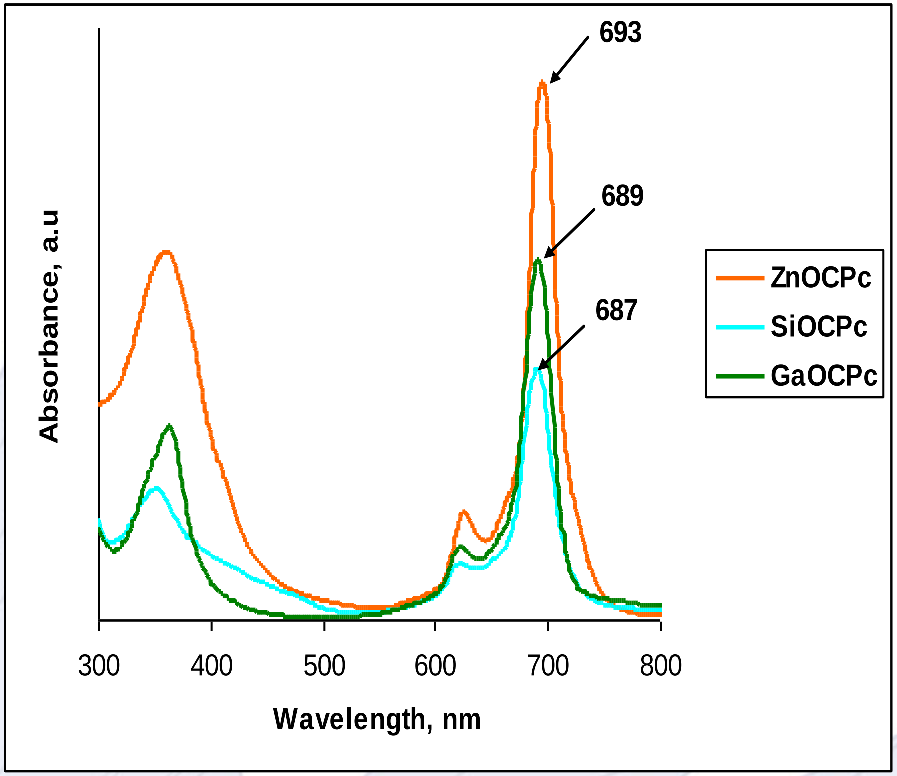


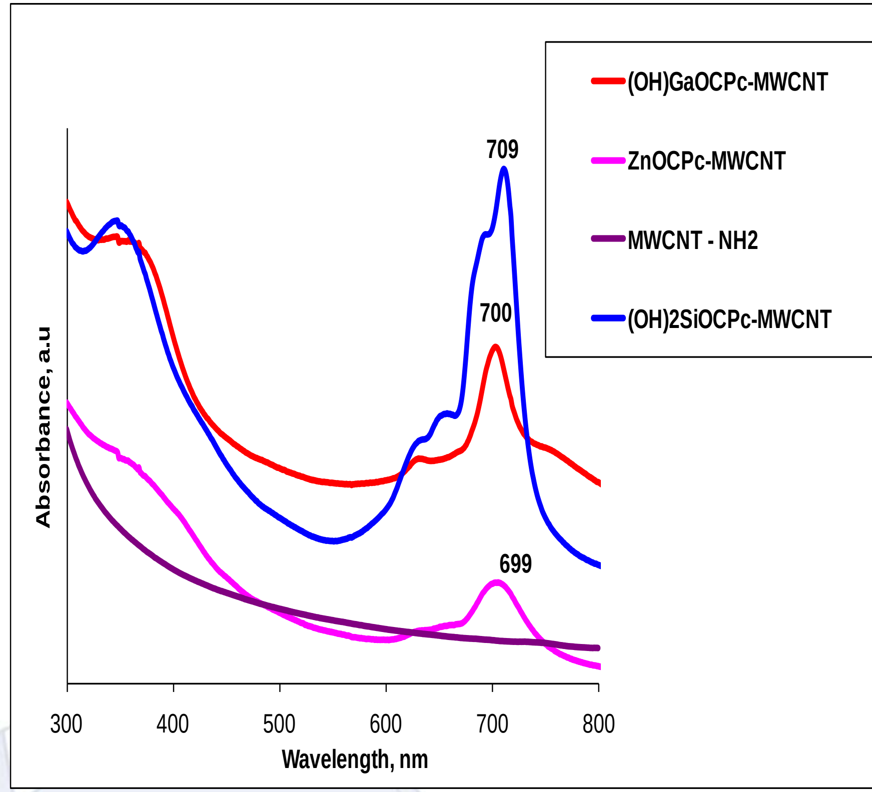






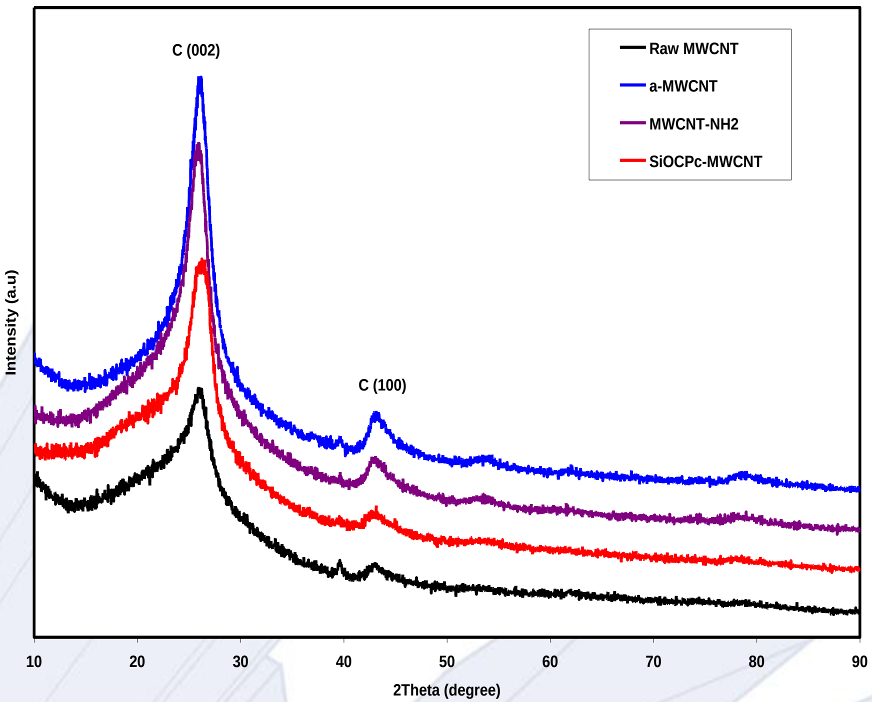
UV/VIS SPECTRA



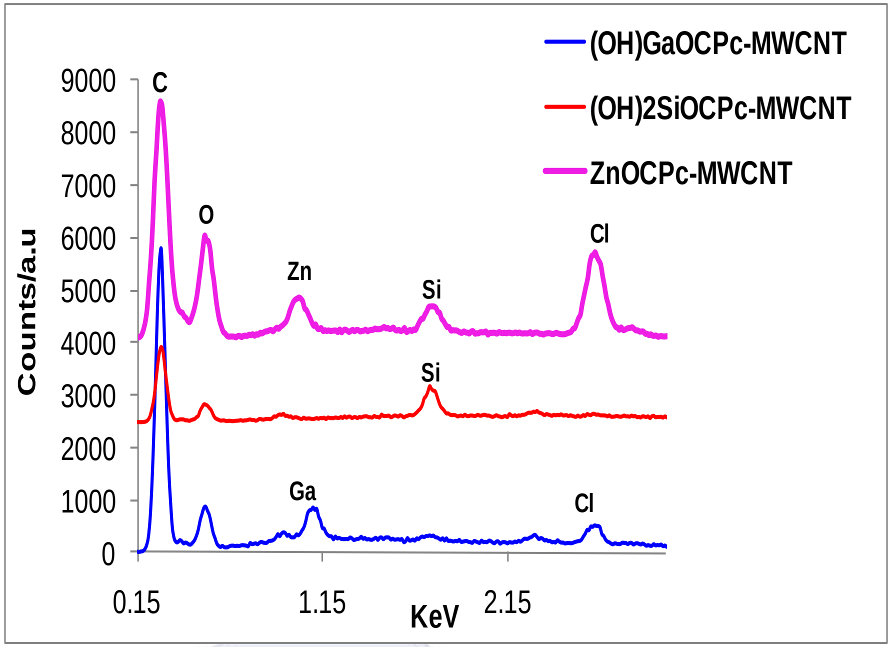


Electronic spectra of MOCPc and MOCPc-MWCNTs in DMF. Upon integration with MWCNT , Q band red shifted.

XRD & EDX

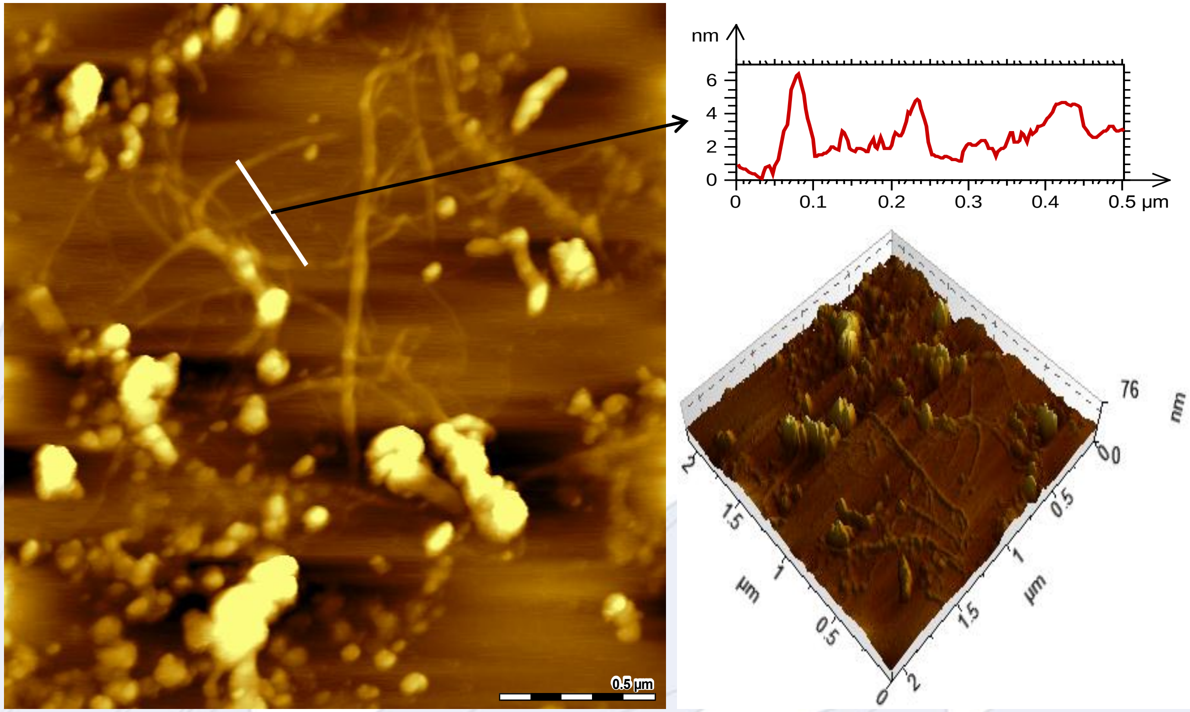


C (002)
C (100)
Raw MWCNT
a-MWCNT
MWCNT-NH2
SiOCPc-MWCNT
Intensity (a.u)
10
20
30
40
50
60
70
80
90
2Theta (degree)



(OH)GaOCPc-MWCNT
(OH)2SiOCPc-MWCNT
ZnOCPc-MWCNT
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Counts/a.u
C
O
Zn
Si
Cl
Si
Ga
Cl
0.15
1.15
2.15
KeV

AFM IMAGE



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

CHRONOAMPEROMETRY

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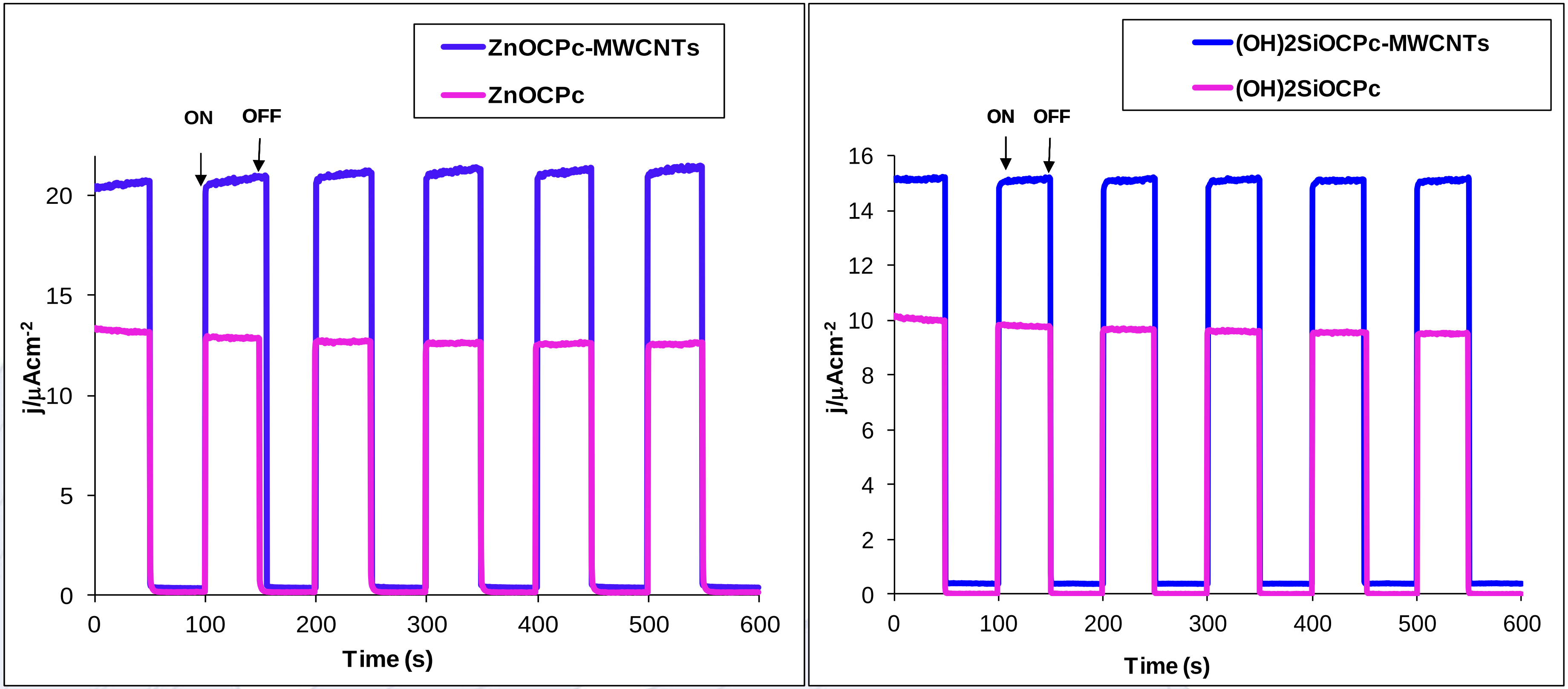
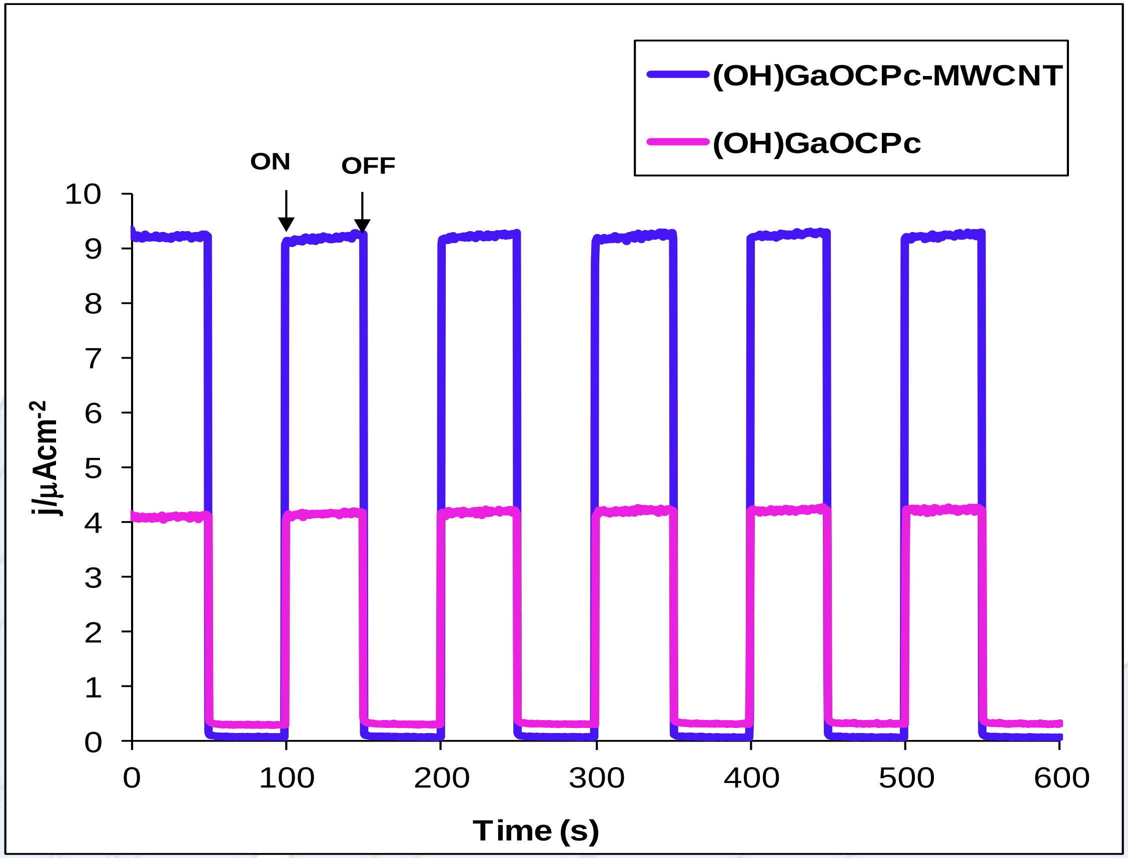
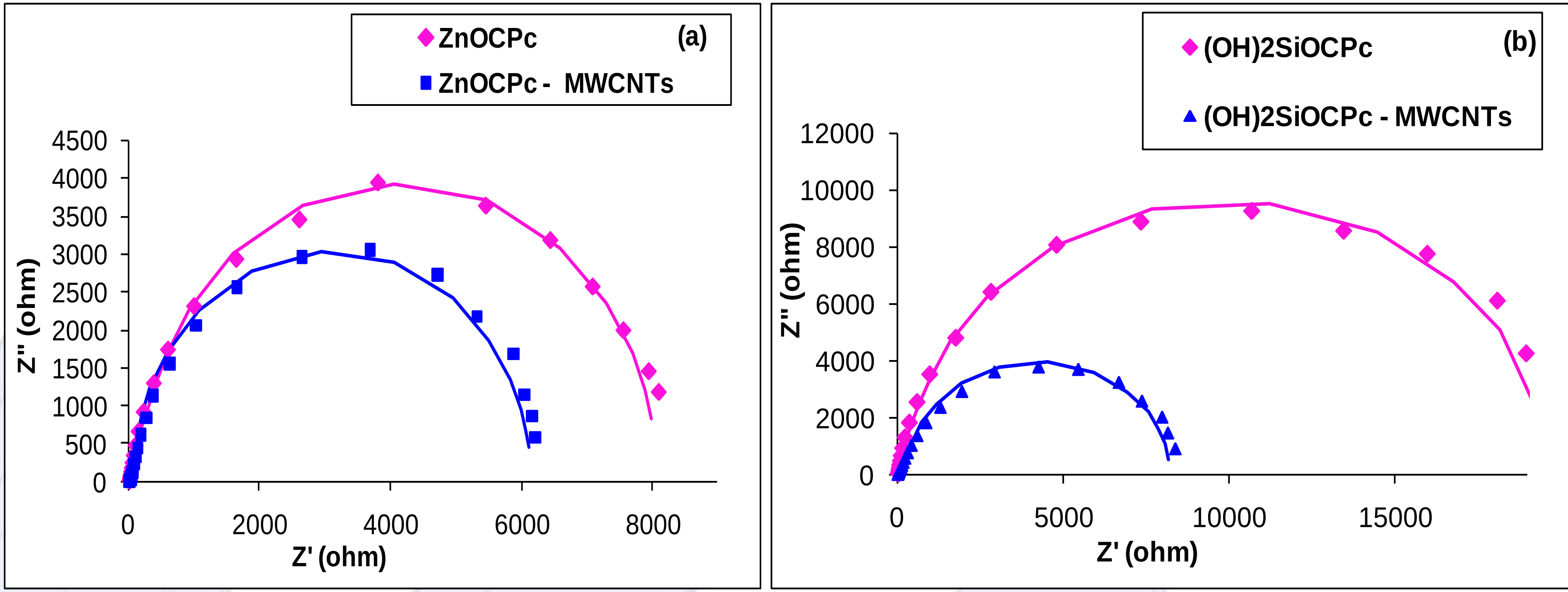


Both the MPc and MPc-MWCNT hybrids on the ITO substrate show photocurrent response under visible light illumination, a reversible rise/decay of the photocurrent in response to the on/off illumination. The measurements show an almost rectangular photoresponse when switching on and off the illumination.

CHRONOAMPEROMETRY



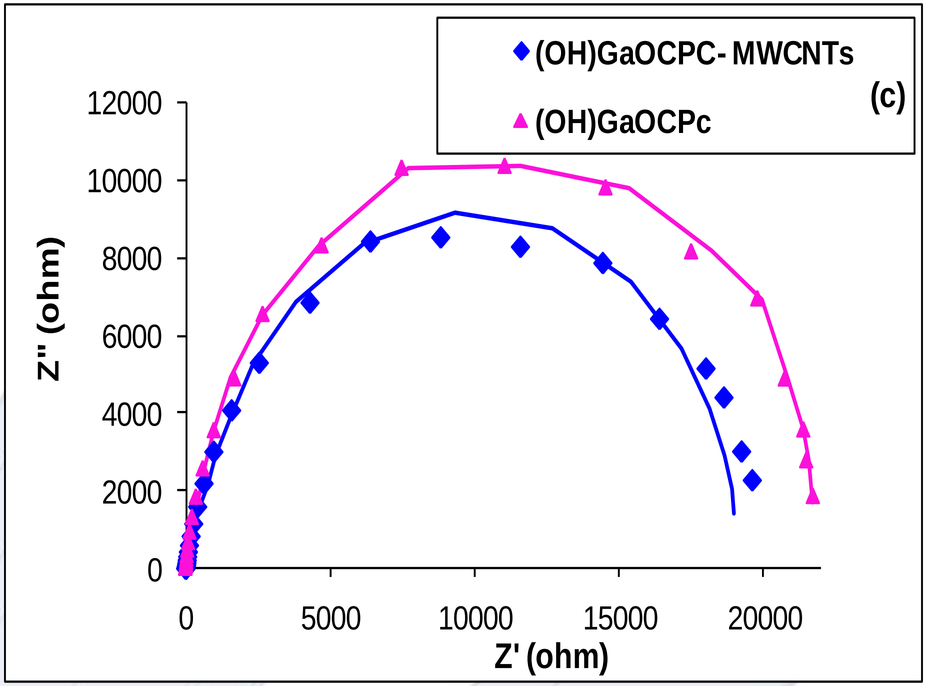
NYQUIST PLOTS

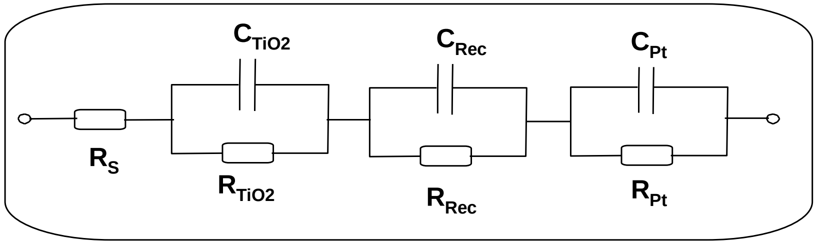


Nyquist plots of DSCs fabricated with a) TiO_2/ZnOCPc, b) $TiO_2/(OH)_2$SiOCPc and their corresponding MWCNT-integrated hybrids.

Investigate the electron transport and recombination mechanism of DSCs

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.

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.

Therefore, ZnOCPc - MWCNT showed high photocurrent response than $(OH)_2$SiOCPc – MWCNT and (OH)GaOCPc – MWCNT.

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- *Dr Mkhulu Mathe: Competence area manager*
- *Tohoku university = Japan*

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Thank You



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