

**The effect of Multi-walled carbon  
nanotubes on Metal  
octacarboxyphthalocyanines for Dye  
Solar Cells application: Synthesis and  
characterisation**

***Nonhlanhla Mphahlele***

*IBSA Conference*

**CSIR**

*our future through science*

# Outline

- Background and Introduction
- Synthesis and characterisation
- Electrochemical Evaluation
- Conclusions
- Acknowledgements

# What are Dye solar cells (DSCs)?

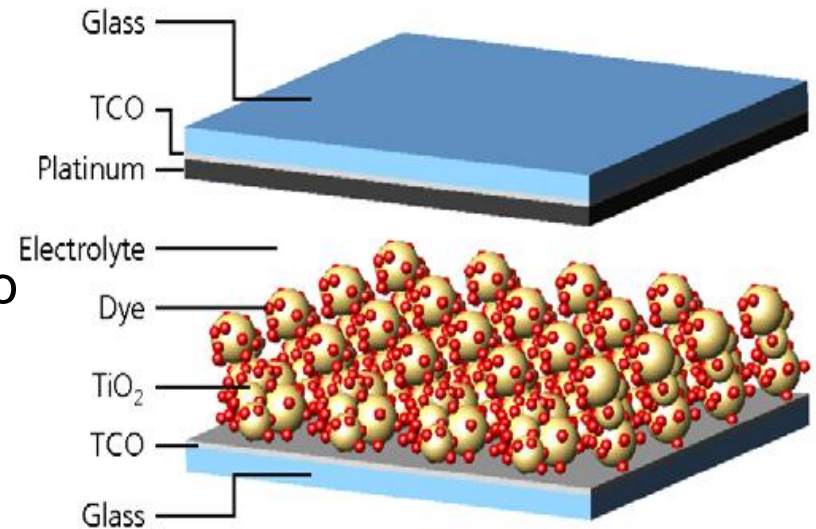
Mankind is using increasing amounts of Energy. Since 1994 the access to Electricity has increased from one third to two thirds of the population.

The use of renewable energy sources is Limited.

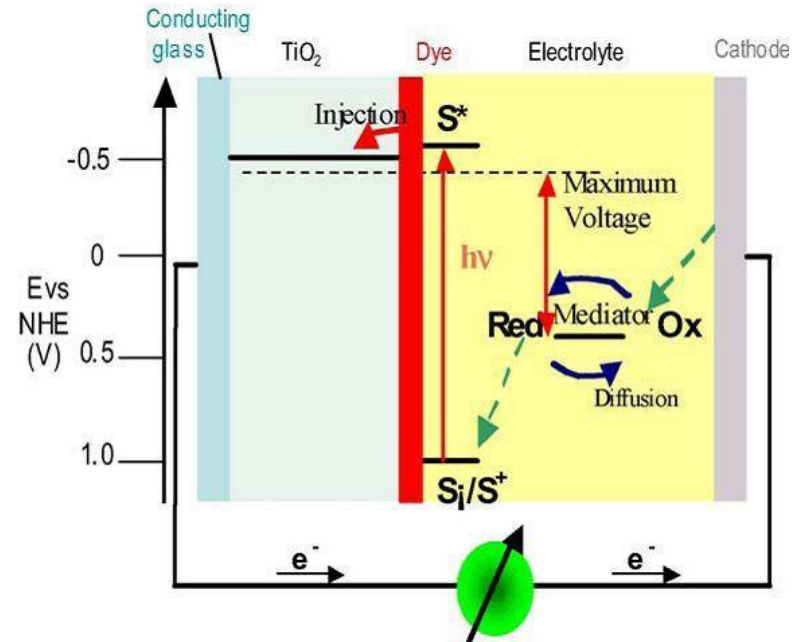
Alternative energy resources are required

Dye solar cells are one of the examples

Direct conversion of sunlight into electricity



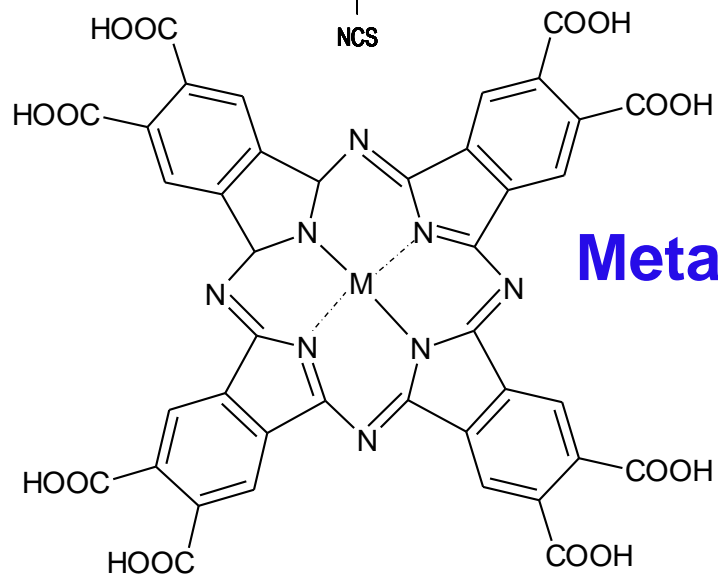
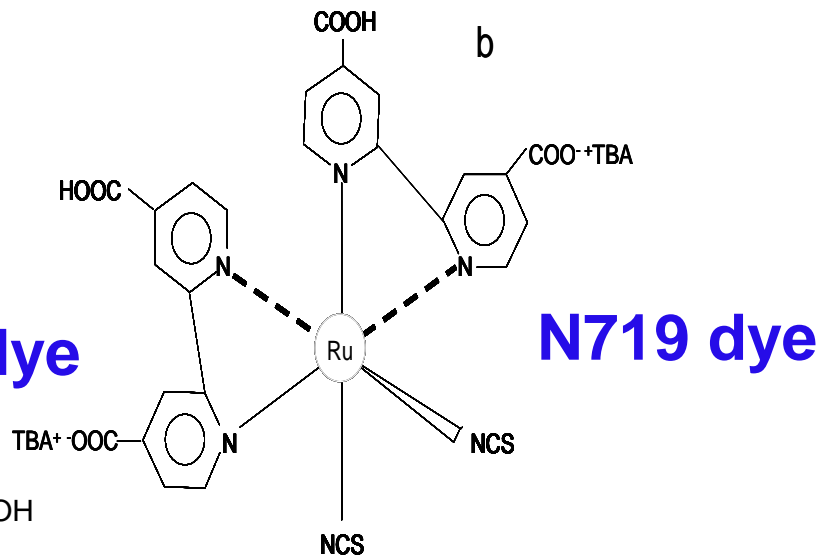
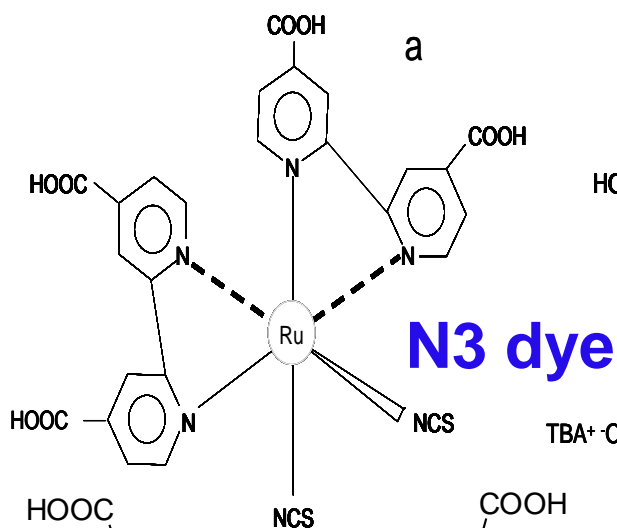
Grätzel, M. 2005, Inorg.Chem,44,6841 - 6851



# Major research areas

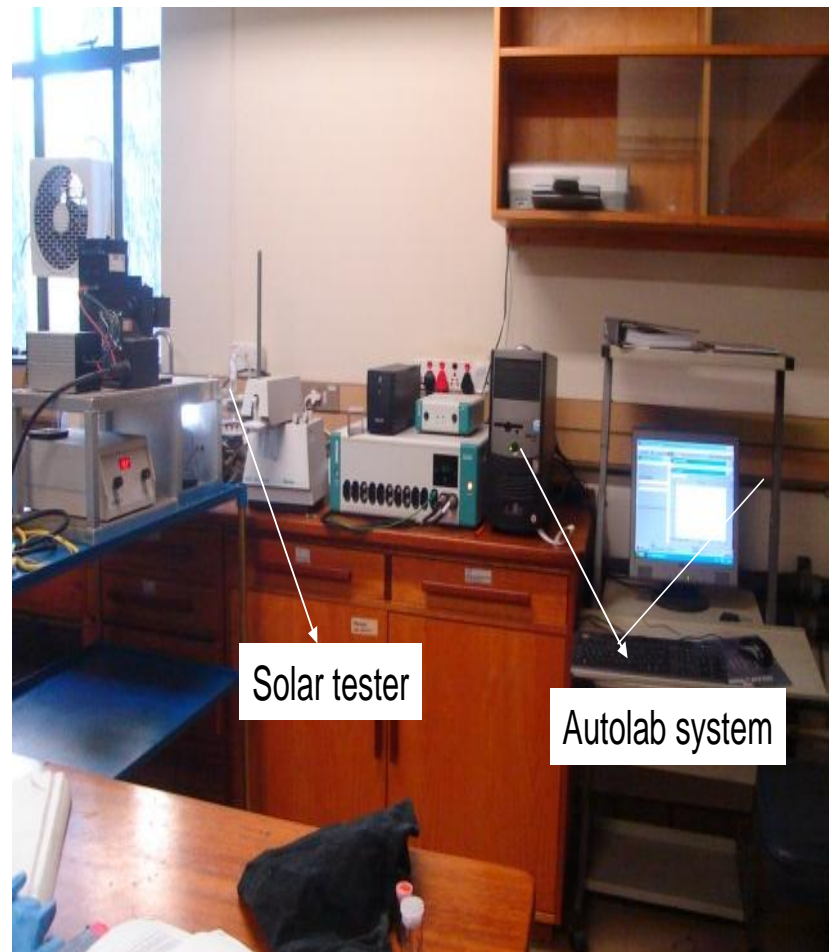


- Alternative photosensitiser to enhance the performance and efficiency of DSCs.

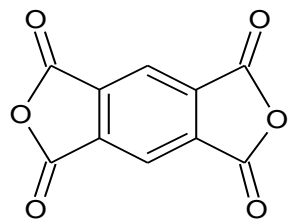


# WHY MPc?

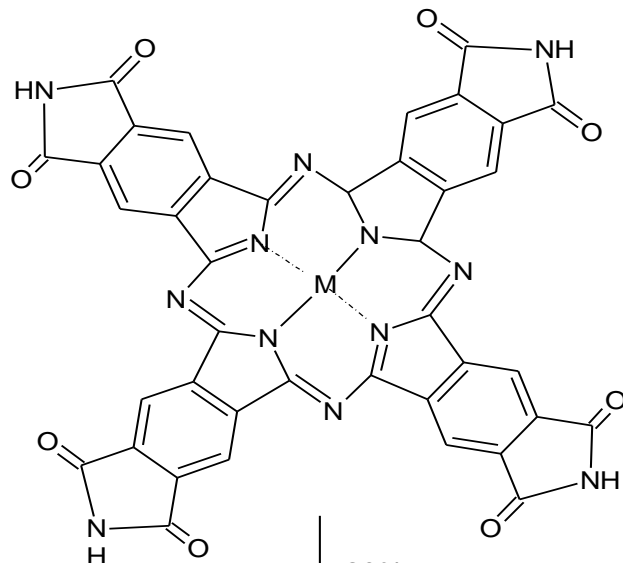
- High thermal stability
- Light thermal stability
- Chemical stability
- Absorb light at the visible region of the spectrum
- To enhance the photosensitisation of DSCs – MPc complex was modified with MWCNT
- CNTs – efficient catalyst and high conductive property



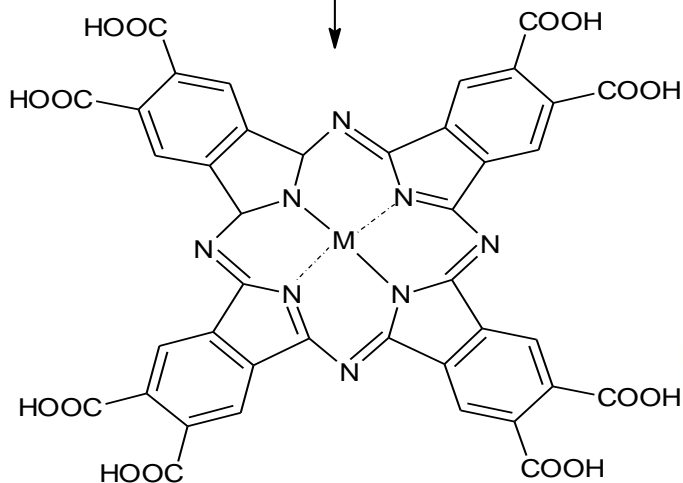
# Synthesis of Metal Octacarboxyphthalocyanines



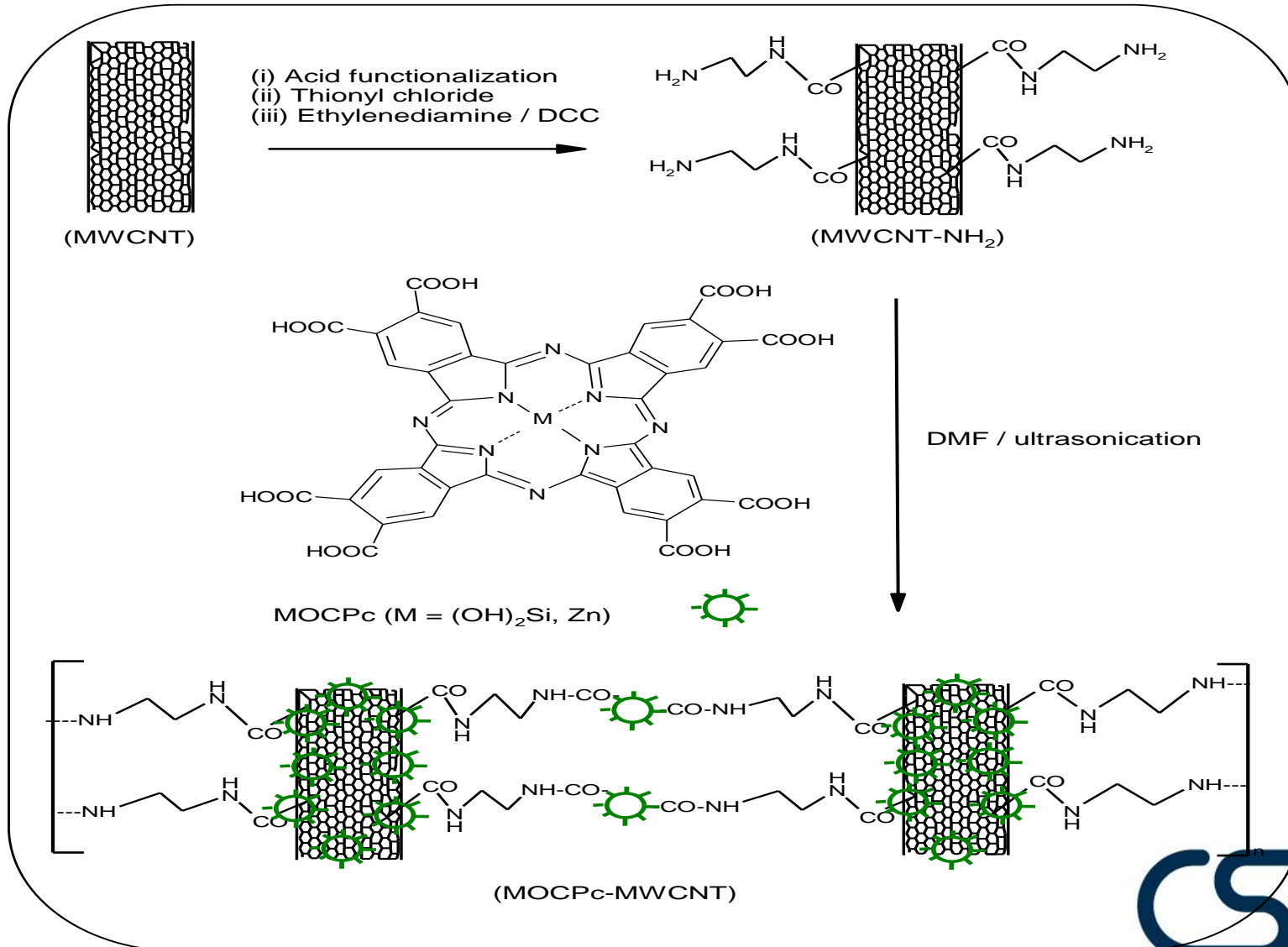
Urea, metal salt, DBU  
Reflux for 30mins



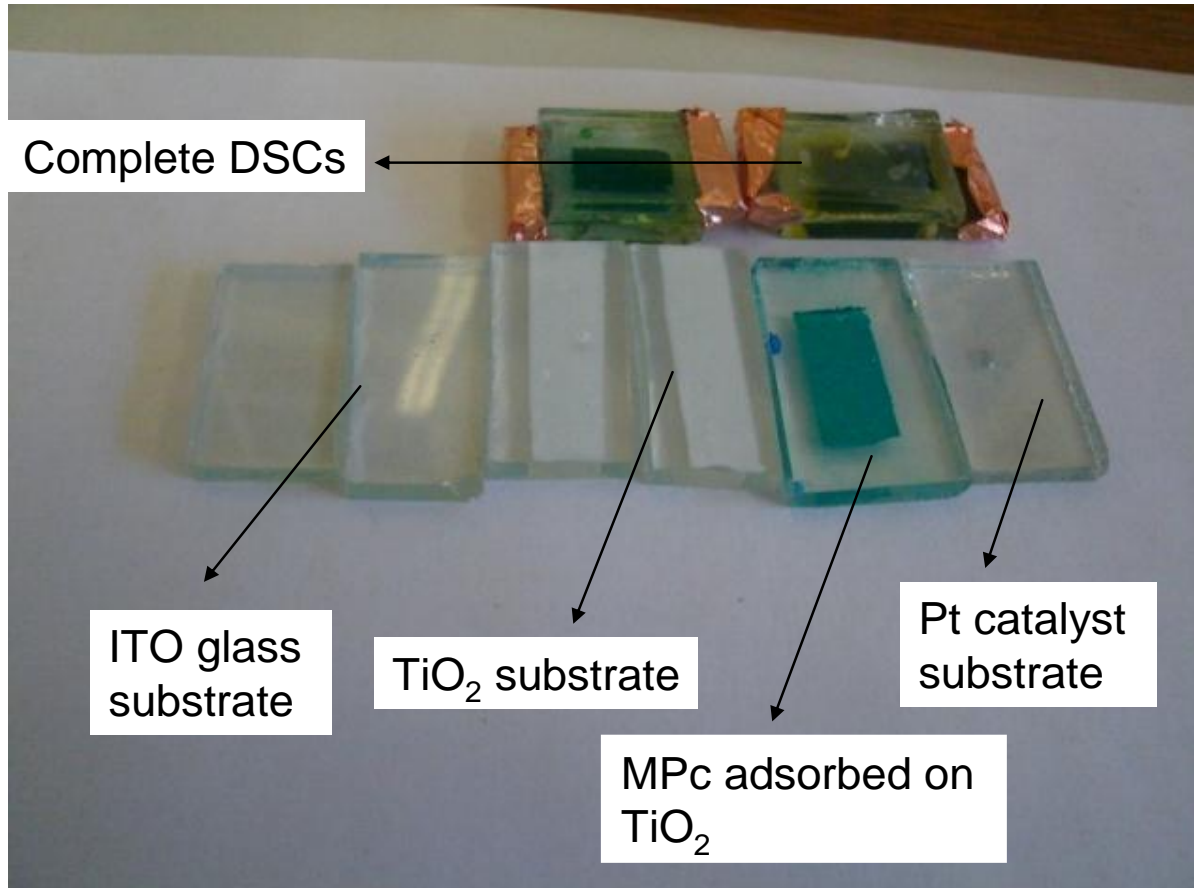
20% H<sub>2</sub>SO<sub>4</sub>  
Reflux for 3days



# Synthesis route for the MOCPc – MWCNT

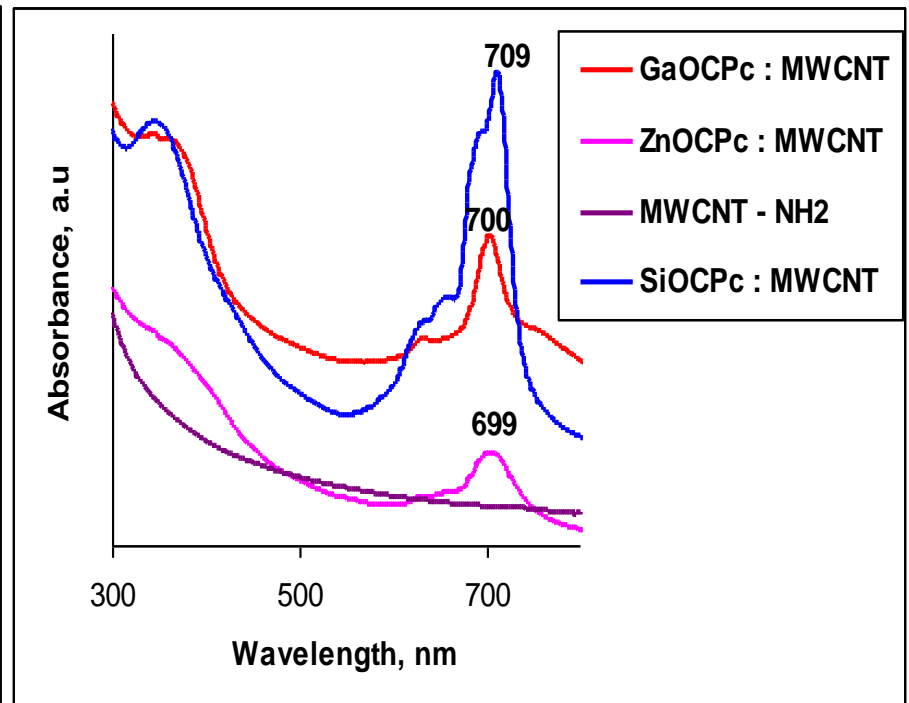
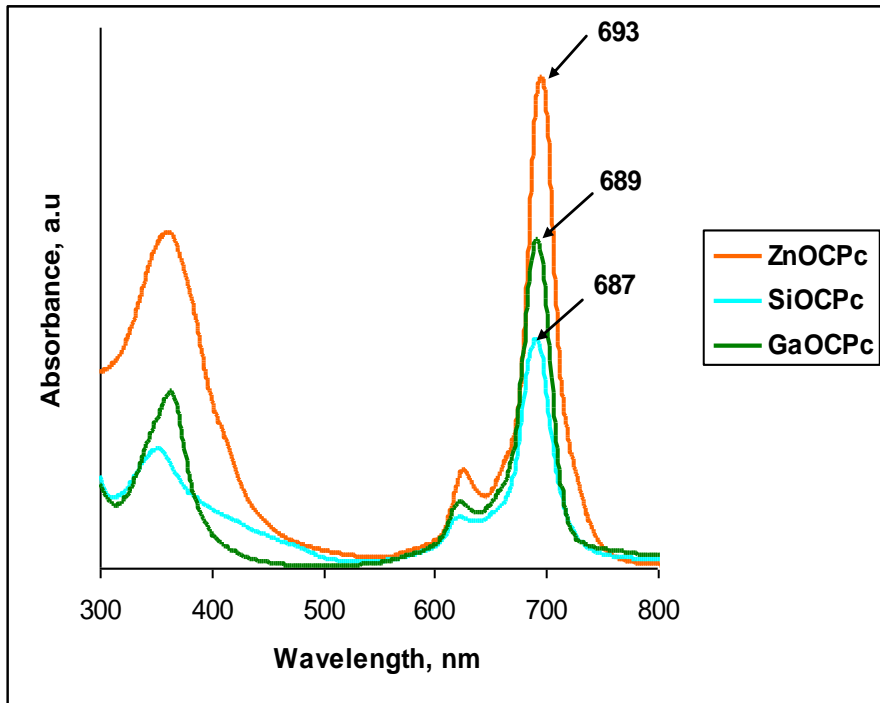


# Fabrication of Dye Solar Cells using MOCPc-MWCNT hybrid





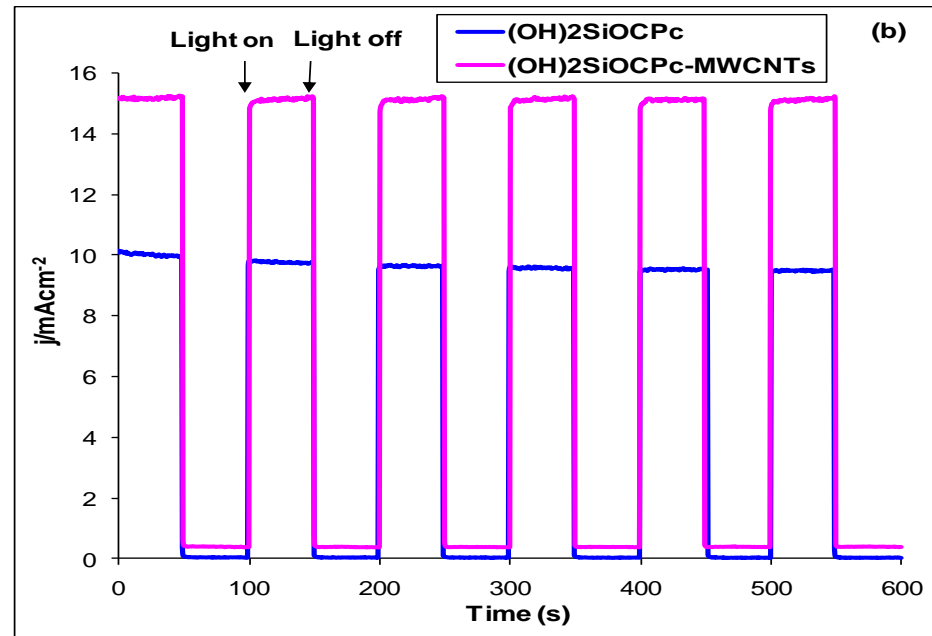
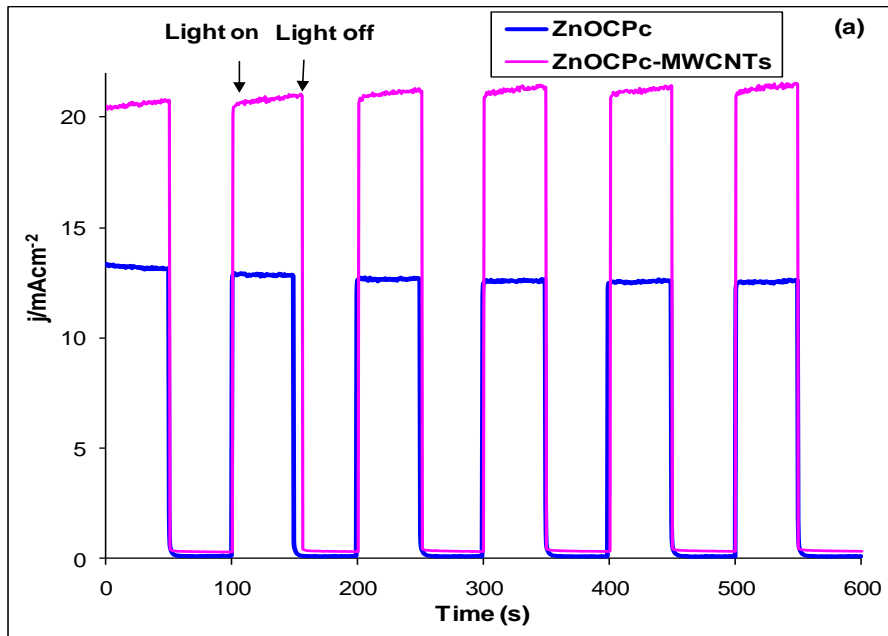
# Spectroscopic evaluation



Electronic spectra of MOCPC and MOCPC-MWCNTs in DMF.

Upon integration with MWCNT, Q band red shifted

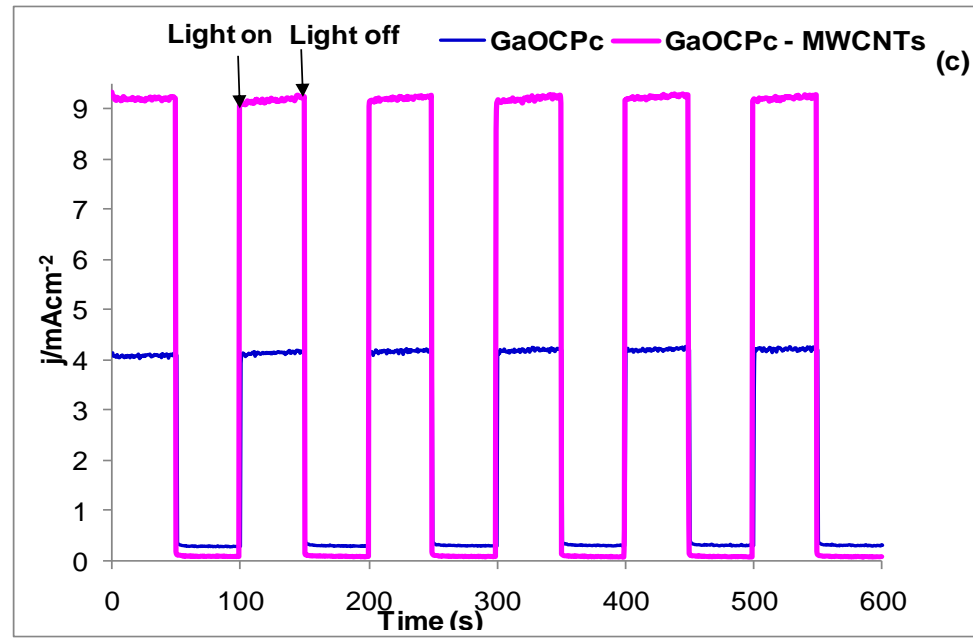
# Electrochemical evaluation



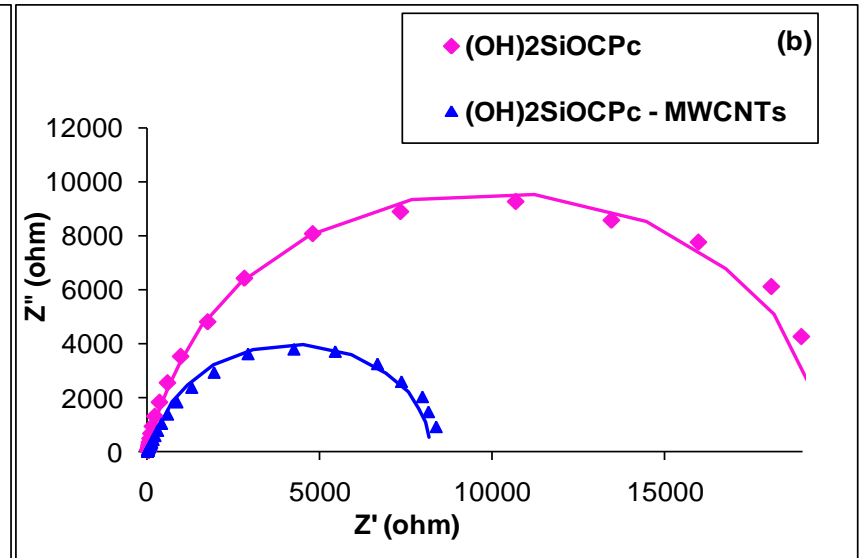
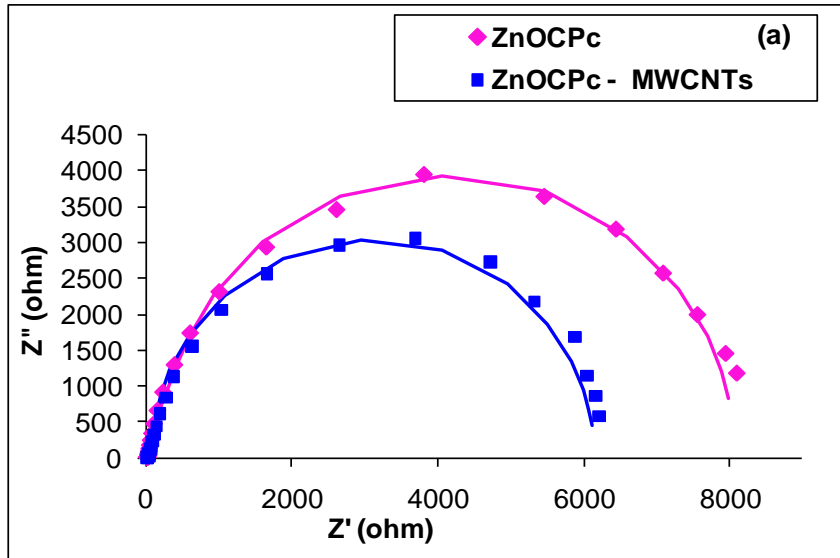
**Photo-chronoamperometric measurements of Lab fabricated DSCs with MOCPC and MOCPC – MWCNTs**

(M = Zn, SiOCPc(OH)<sub>2</sub>, Ga(OH)) at an applied potential of 10mV recorded at 50 s interval.

- Rectangular photocurrent response
- ZnOCPc results in an increase in photocurrent

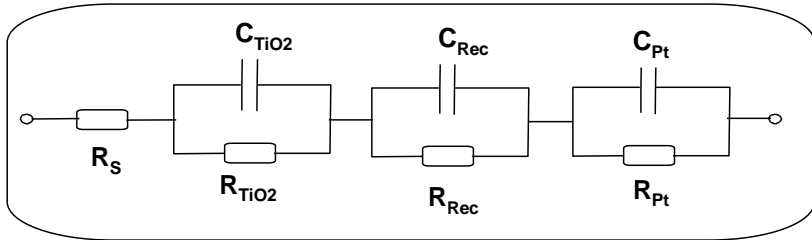


# Electrochemical Evaluation



Nyquist plots of DSCs fabricated with

a)  $\text{TiO}_2/\text{ZnOCPc}$ , b)  $\text{TiO}_2/(\text{OH})_2\text{SiOCPc}$  and their corresponding MWCNT-integrated hybrids.



Efficient electron transfer process occurred

The equivalent circuit to fit the nyquist plot

• Compose of 3 RC elements in series

# Conclusions

- MOCPc (M = Ga, Si, Zn) complexes were successfully synthesised
- As confirmed by FTIR, UV/Vis and electrochemistry characterisation.
- Amine functionalised multiwalled 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  $(\text{OH})_2\text{SiOCPC} - \text{MWCNT}$  and  $(\text{OH})\text{GaOCPC} - \text{MWCNT}$
- Busy with the DSCs testing using Solar simulator

# Acknowledgements

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*Thank You*

