Dye-Sensitised solar cell (Artificial Photosynthesis)

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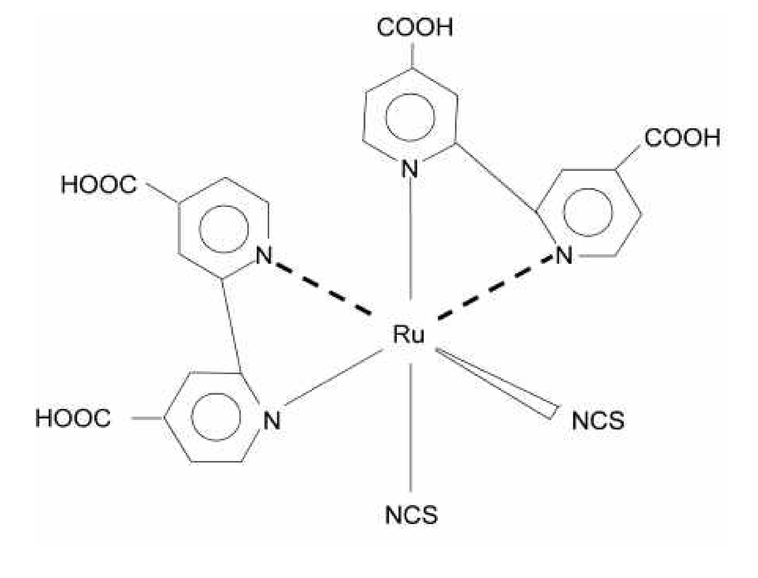
INTRODUCTION

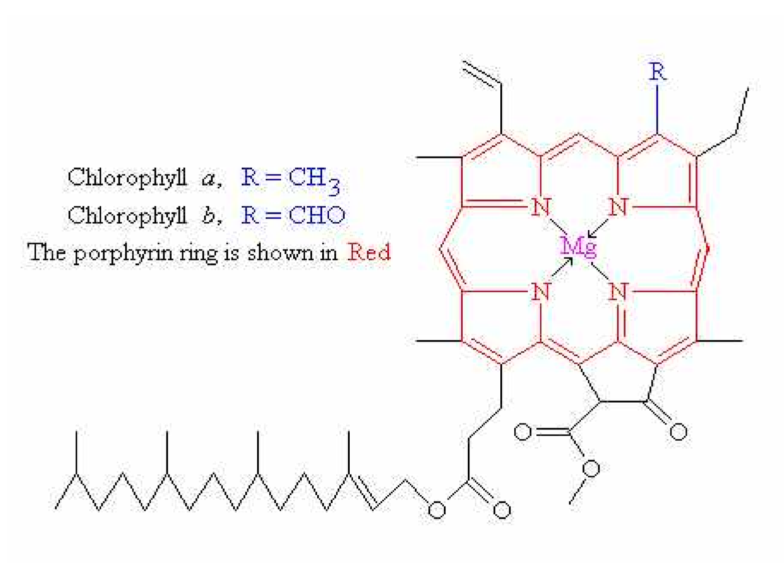
A novel system that harnesses solar energy is the nano-crystalline TiO_2 dye-sensitised solar cell (DSC), in conjunction with several new concepts, such as nanotechnology and molecular devices. An efficient and low-cost cell can be produced by using simple materials. The production process generates very small quantities of residue, resulting in environmentally friendly devices with low energy demanding production techniques. Furthermore, recent developments in the area of sensitizers for these devices have led to the production of dyes that absorb across the visible spectrum leading to higher efficiencies that hold great potential.

The CSIR is working towards DSC niche applications, which include alternative energy devices to be used in cell phone chargers, laptops and radio batteries. The prototype solar cells produced at the CSIR have shown promising results and further developments are in the pipeline, which will be elaborated upon in this paper. The formulation of a screen-printable nanoporous TiO_2 paste was developed and no cracks were observed after drying at 450 °C in the furnace. However, the paste has a tendency to become unstable with time. This is evident in the cracking of the thin films various substrates after curing at 450 °C in ambient conditions in a furnace after three days. In this presentation we will report on the stability of the particle size of the TiO_2 paste using x-ray diffraction.

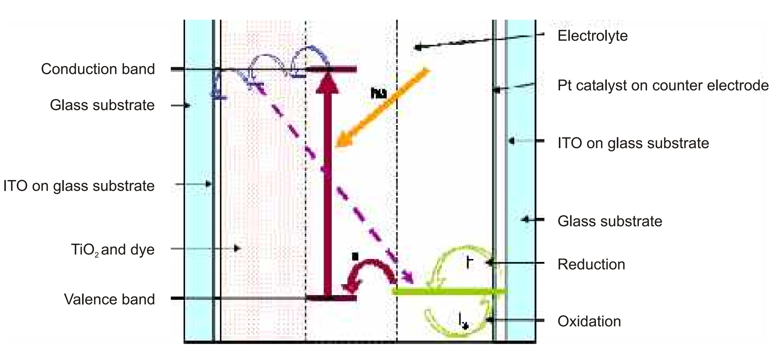
THEORY



Ruthenium dye (N3)



Chemical Structure of Chlorophyll



Diagrammatic scheme of a DSC

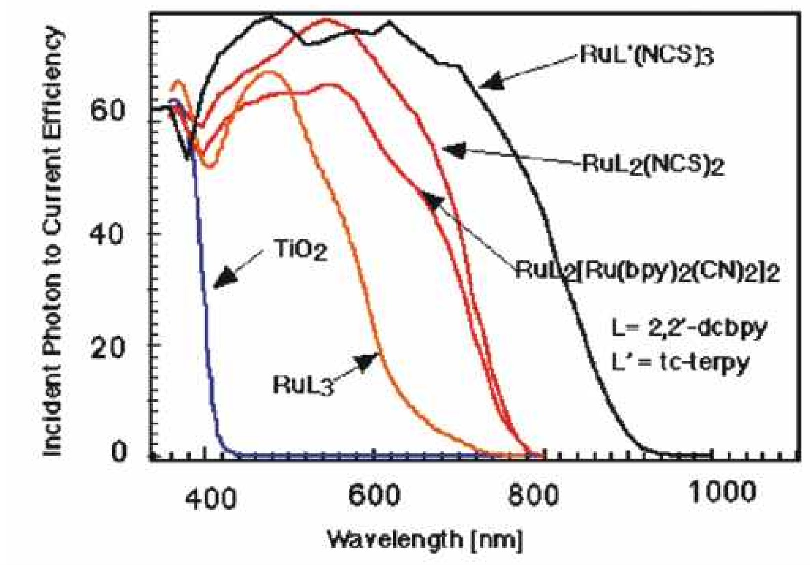
$Ru(II) \xrightarrow{h\nu} Ru(II)^*$ Photo excitation of the Ruthenium complex

$TiO_2 + Ru(II)^* \longrightarrow TiO_2(e) + Ru(III)$ electron injection

$3I^- \xrightarrow{2Ru(III)} 2Ru(II)$ regeneration of Ru(II) by iodide at TiO_2 film

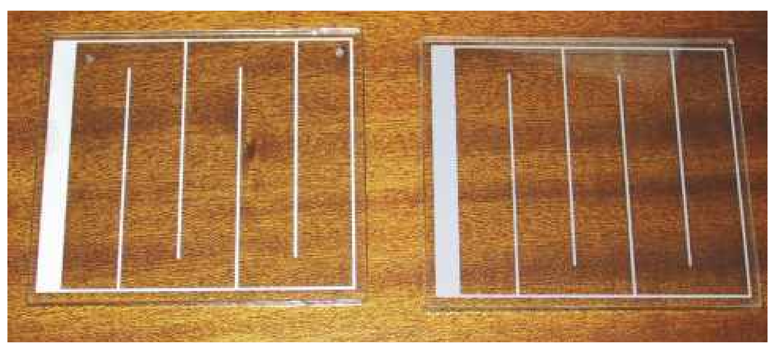
$I_3^- + 2e^- \longrightarrow 3I^-$ regeneration of iodide from triiodide at Pt electrode

Chemical reactions as they occur in the DSC



UV-Vis spectra of TiO_2 and various dyes [1]

TiO_2 does not interfere with the dye absorption bands.



RESULTS

Figure 1a: SEM photo on day 1

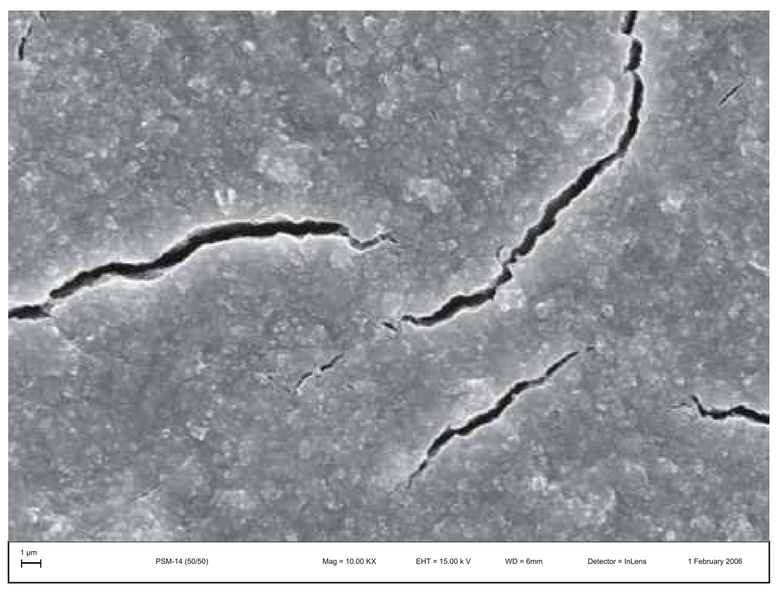


Figure 1b: SEM photo on day 6

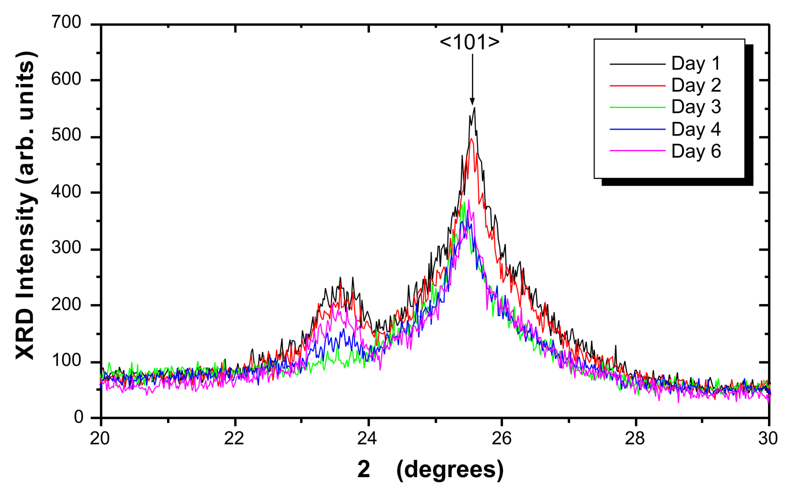


Figure 1: XRD results from thin film

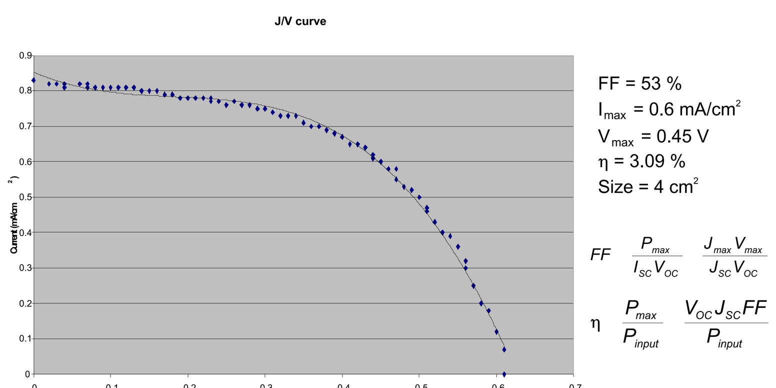


Figure 2: Efficiency testing

TiO_2 paste

Figure 1a and b: SEM photographs. Thin film cracks when paste ages (progressively worse with time; 1 to 6 days)

Figure 1: XRD shows peak narrowing after day 2 which indicates an increase in particle size

Efficiencies

3.09% with CSIR particles (average particle size 6 nm) and water based paste. The glass was obtained from Solaronix (3mm, 8 Ω / □)

FUTURE WORK

More work to be done to stabilise the paste formulation

Effects of reverse bias on the ruthenium dye (Electrochemical Impedance Spectroscopy EIS)

Cyclic voltammetry

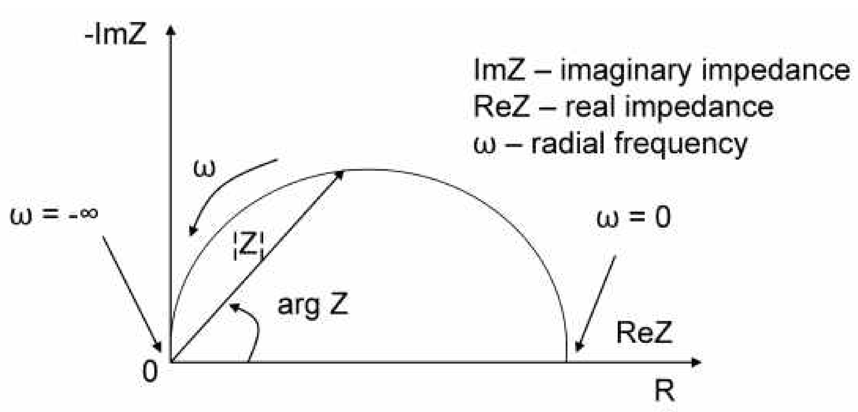
Impedance spectroscopy

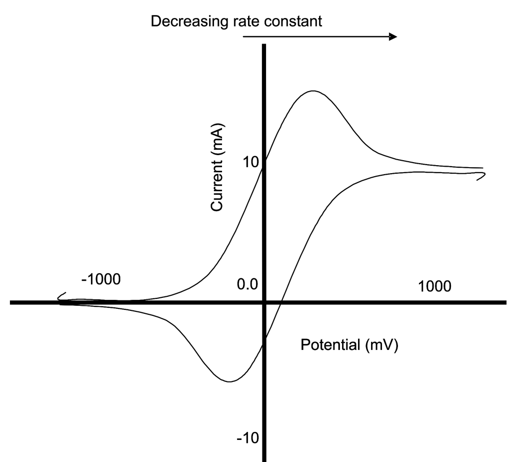
(Nyquist plot of the Impedance vector)

The semicircle is characteristic of a single "time constant". Electrochemical Impedance plots often contain several semicircles. Often only a portion of a semicircle is seen.

Cyclic voltammogram:

Measurement of electron transfer kinetics and transport properties of electrolysis reactions as well as determination of the redox potentials and position of HOMO energy levels.





CONCLUSION

Particle size increases with time (water-based formulation)

Working cells with an efficiency of above 3% can be assembled with CSIR nanoparticles and paste

BIBLIOGRAPHY

[1] Grätzel M. and McEvoy A.J. **Hydrogen Production by Solar Photolysis of Water.** *American Physical Society Symposium*, Montreal, Canada. March 2004.

[2] Wang, Q.; Moser, J.-E.; Grätzel, M. Electrochemical Impedance Spectroscopic Analysis of Dye-Sensitized Solar Cells *J. Phys. Chem B, 109, 31, 2005*

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