

## Platinized counter electrodes for dye sensitized solar cells through the redox replacement of a low power electrodeposited lead sacrificial template

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Dye sensitized solar cells are photoelectrochemical devices which consist of dyed mesoporous TiO<sub>2</sub>, an electrolyte for charge transfer and a catalyst to facilitate the charge transfer on the anode. The operating cycle consists of excitation of the dye by light, injection of electrons into the TiO<sub>2</sub>, followed by migration through the mesoporous TiO<sub>2</sub> network where they are then conducted to an external circuit through a conducting substrate. The electron is then returned to the excited dye through the counter electrode and then the electrolyte by the reduction of the triiodide species to iodide by the facilitating platinum catalyst [1].

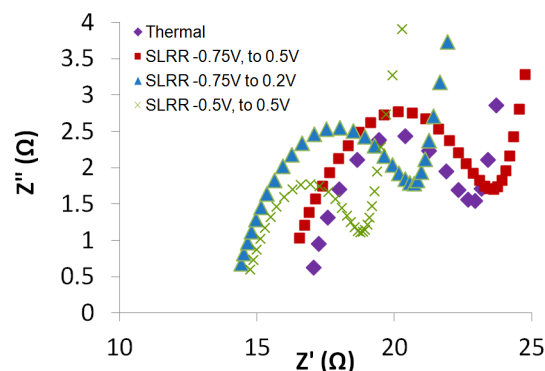
The redox catalyst for liquid based dye sensitized solar cells is one that needs careful thought, especially on temperature sensitive substrates. A DSC catalyst must be efficient to avoid large overpotential losses at the counter electrode. In addition a low charge transfer resistance at the CE will have a positive effect on the fill factor of the DSC and as such, will improve device efficiency.

The highest performing catalyst currently in use is a thermally applied platinum nano cluster catalyst [2]. However, this is not feasible for use on polymer substrates, such as those used in a roll-to-roll production line, due to the high processing temperatures (385°C) required, therefore alternatives must be sort. Currently there are three alternative methods: Chemically reduced chloroplatinic acid, sputtered platinum and electrodeposition from solution. Each has drawbacks; hazardous chemicals, specialist equipment, vacuum conditions and limited size and shape of the work piece.

Electrochemical deposition from supported aqueous solution has more appeal, due to industrial familiarity with electrocoating methods. Here we present a fast electrochemical technique that allows the deposition of small highly catalytic nano-scale Pt on an FTO-glass surface with the potential of transferring this to polymeric substrate. A sacrificial Pb nano-scale template is first electrodeposited on the substrate using low power and short timescales [3]. Following this, the substrate is returned to OCP and left in solution for the redox replacement action to occur and the Pt to replace the Pb on the substrate surface. As Fig 1 shows, this technique has a catalytic performance comparable to that of the standard thermally decomposed platinum catalyst.

While this technique may seem problematic, due to the inclusion of lead which is vulnerable to attack from the electrolyte, it was found that an optimized immersion time in the deposition solution removes the majority of the lead template, giving a stable catalytic counter

electrode. This method uses a vastly lower concentration of platinum than required in normal platinization solutions and reduces power usage through only being needed to deposit the lead template. In addition, the lead is recycled back into solution by the redox replacement step.



**Fig 1:** Comparison of Nyquist plots for thermally and electrodeposited platinum redox catalysts

- [1] B. O'Regan and M. Gratzel, "A low-cost, high-efficiency solar cell based on dye-sensitized colloidal TiO<sub>2</sub> films," *Nature*, 353, 6346, 737–740, 1991.
- [2] N. Papageorgiou, "An Iodine / Triiodide Reduction Electrocatalyst for Aqueous and Organic Media," *J. Electrochem. Soc.*, 144, 3, 876–884, 1997.
- [3] K. Yliniemi, D. Wragg, B. P. Wilson, H. N. McMurray, D. A. Worsley, P. Schmuki, and K. Kontturi, "Formation of Pt/Pb Nanoparticles by Electrodeposition and Redox Replacement Cycles on Fluorine Doped Tin Oxide Glass," *Electrochim. Acta*, 2010, 2012.