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Monitoring the effect of N-heterocyclic compound additives in dye sensitized solar cell electrolytes for corrosion inhibition

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Dye sensitized solar cells (DSC) are a third generation solar PV technology based on low cost components. A DSC operates through the excitation of dyed TiO_2 semiconductor, followed by the transfer of electrons through to the conducting substrate and then the external circuit. The electron is returned to the excited dye through a redox mediator, in this case iodide/triiodide a redox reaction that is facilitated by a platinum catalyst on the counter electrode.

One of the most exciting developments has been the progress of building integrated photovoltaic solutions (BIPV) and the use of industrial metal in place of the most common glass or polymeric substrates. The DSC cells that would be used in this manner contain a liquid iodide/triiodide electrolyte as the charge transfer medium which attacks certain metallic substrates [1].

In order to improve the performance of DSCs containing an iodide/triiodide electrolyte, various groups have introduced the use of additive compounds in the electrolyte solution. The use of nitrogen containing heterocyclics in particular to improve dye sensitized solar cell performance has been well documented in literature [2]. These compounds raise the V_{oc} of cells by decreasing the recombination back reaction at the TiO_2/electrolyte interface and by pushing the TiO_2 flat band potential in the negative direction – thus increasing the gap between that and the redox potential of the electrolyte.

A time-lapse image analysis technique introduced by Watson *et al.* was used to study the corrosion of metallic substrates [3]. This technique uses a DSLR camera to monitor the colour change of electrolyte in contact with metallic substrate over a determined time period. The average RGB and intensity data for the area of interest can then be determined through image analysis. This can be plotted against time to show the depletion of triiodide in the electrolyte as it attacks the metallic substrate. The main points raised here, were that iron and iron based industrial metals were vulnerable to rapid corrosion and as a result, any DSCs using these materials will have stability issues. Reynolds *et al.* performed a similar study on metals and using no electrolyte additives, but in this instance the analysis method was UV-VIS reflectance changes [4]. Our study showed that the presence of additives such as 4-*tert*-butylpyridine was seen to inhibit corrosion of some industrial metals at certain concentrations.

This study analyzed three nitrogen containing heterocyclic additives in an I^-/I_3^- electrolyte: 4-*tert*-butylpyridine, 1-methylbenzimidazole and 1, 3, 5-traizine at 0M, 0.5M and 1M concentrations. A variety of industrially used metals such as Titanium, iron and aluminium were tested using the set up shown in Fig 1.

[1] M. Toivola, F. Ahlskog, P. Lund, "Industrial sheet metals for nanocrystalline dye-sensitized solar cell structures," *Solar Energy Materials and Solar Cells*, 90, 17, 2881–2893, 2006.

[2] H. Kusama, M. Kurashige, H. Arakawa, "Influence of nitrogen-containing heterocyclic additives in I− I3−redox electrolytic solution on the performance of Ru-dye-sensitized nanocrystalline TiO2 solar cells," *Journal of Photochemistry and Photobiology A: Chemistry*, 169, 169–176, 2005.

[3] T. Watson, P. Holliman, D. Worsley, "Rapid, continuous in situ monitoring of dye sensitisation in dye-sensitized solar cells," *Journal of Materials Chemistry*, 21, 12, 4321, 2011.

[4] G. J. Reynolds, T. M. Watson, G. Williams, and D. Worsley, "Corrosion Resistance of Metallic Substrates for the Fabrication Dye-Sensitized Solar Cells," *ECS Transactions*, 33, 17, 129–138, 2011.

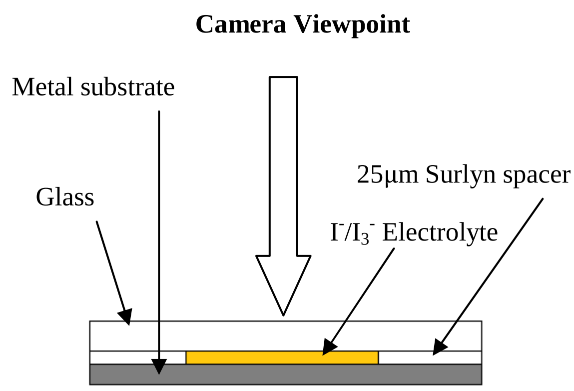

Fig 1: Schematic of monitoring set up for encapsulated electrolyte on metallic substrates