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**SUMMARY**

**Title :** Development of solar cells based on sensitized colloidal  $\text{TiO}_2$  films

**Institute :** Department of Chemistry, University of Peradeniya

**Period of contract :** 7-7-93 - 7-10-96

**Scientific background and scope of project :** This project describes the development of photoelectrochemical solar cells based on the dye-sensitized wide band gap semiconductors. Attempts were made to screen a large number of dyes which can be employed with special emphasis on stable and naturally occurring dyes. Their photoelectrochemical characteristics will be investigated. Extension of this approach to fabricate all solid state photovoltaic cells has also been investigated.

**Experimental method :** High surface area  $\text{TiO}_2$  films were prepared by the sol-gel processing method consisting of interconnected nanostructured films where the colloidal particles are fused together to form long and interconnected chains. Several dyes were selected ranging from organic dyes (methyl violet, crystal violet, rhodamine B), naturally occurring flower pigments (cyanidin) and metal complexes (prussian blue, ferrocyanide, ruthenium bipyridine complexes). Photoelectrochemical studies were carried out using standard three electrode configuration. The photocurrent action spectra and the I-V characteristics were obtained after suitable attachment of dyes.

**Results obtained :** Several dyes gave photocurrent action spectra with maxima corresponding to the absorption spectra of dyes. This indicates that there is indeed injection of photogenerated electrons from the excited state of the dye to the conduction band of the semiconductors. I-V characteristics show that there is photoanodic behavior consistent with this type of electron transfer. Most dye undergo photodegradation resulting in a reduction of the photocurrent. Although the observed quantum efficiencies are small there are some systems worth studying further. Naturally occurring dyes such as cyanidin and the chlorophyll analogue dye, chlorophyllin are particularly effective as sensitizer dyes.

**Conclusions:** Dye-sensitization of a wide band gap semiconductor such as  $\text{TiO}_2$  with absorbing dyes is demonstrated. Surface chelation of dyes facilitated by derivatising the dyes with carboxylate, thiocyanate or salicylate forms for cationic dyes. Although the quantum efficiencies are small there is still hope for improvement.

Although attempts to use dye sensitised photoelectrochemical cells in energy conversion have been made, the photocurrent and conversion efficiency of such devices have been extremely very low and the potential of a practical application is small. One problem is that of poor light harvesting. On a smooth surface, a monolayer of sensitizer absorbs less incident monochromatic light. Attempts to harvest more light by using multilayers of dye have in general have been unsuccessful. The remaining option is to increase the roughness of the semiconductor surface so that a larger number of dye molecules can be attached directly to the surface and simultaneously be in direct contact with the the electrolyte.

#### 4. CONCLUSIONS

This research has enabled the preparation and characterization of high surface area nanoporous colloidal titanium dioxide films. Attachment of dyes to such surfaces via surface chelation has also been successful. Although the quantum efficiencies observed are too small to be of any practical significance, fabrication of novel photovoltaic of the type  $\text{TiO}_2/\text{dye}/\text{SC}$  where SC is a p-type semiconductor with high efficiencies is a practical possibility.

#### References

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