

A CADMIUM SULPHIDE-SOLID ELECTROLYTE PHOTOELECTRO-CHEMICAL SOLAR CELL

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Summary

Cadmium sulphide thin film was prepared by a chemical bath deposition technique. This semiconducting film was used to fabricate a photoelectrochemical solar cell with a solid electrolyte prepared by capturing a ferrous/ferric cyanide redox couple in an agar-agar gel matrix. The performance of this solid electrolyte photoelectrochemical solar cell has been studied and compared with a liquid electrolyte-CdS photoelectrochemical solar cell containing the same redox couple.

Introduction

A photoelectrochemical solar cell (PESC) consists of a semiconductor/electrolyte interface [1 - 3]. The electrolyte contains a redox couple. Charge transfer between the photogenerated charge carriers in the semiconductor and the redox species in the electrolyte yields a photovoltage/photocurrent. There has been considerable progress in the fabrication of liquid electrolyte PESC's [3]. Cadmium sulphide is a promising solar cell material and liquid electrolyte-CdS PESC's have been fabricated and studied extensively by employing CdS films deposited by anodisation [4], sputtering and spraying [5], and by chemical bath deposition techniques [6, 7]. However, use of liquid electrolyte in a PESC poses many problems. There is potential leakage of the electrolyte and liquid electrolyte corrodes the semiconductor electrode. This considerably reduces the life of the solar cell. Recently, there have been attempts to use a solid electrolyte in place of a liquid electrolyte in PESC's [8 - 11]. However, the photocurrents of such cells were small due to low conductivity of the electrolyte. In the present study fabrication of a solid electrolyte-CdS PESC is described. The electrolyte was prepared by capturing the ferrous/ferric cyanide redox couple in an agar-agar gel matrix. The performance of this PESC has been compared with a liquid electrolyte-CdS PESC containing the same ferrous/ferric cyanide redox couple.

Experimental

A CdS thin film was prepared by a chemical bath deposition technique [7]. The experimental arrangement for producing the film is shown in Fig. 1. A 50 ml beaker formed the reaction cell which was placed in a constant temperature bath at 80 °C. The reaction cell contained 5 ml of 1 M CdSO₄ + 25 ml of 2 M NH₄OH + 5 ml of 1 M thiourea. Carefully cleaned titanium substrates were dipped in this solution from a rotating shaft to ensure a uniform deposition of CdS. In about 0.5 h, a CdS film approximately 2 μm thick was obtained, which was then washed and dried.

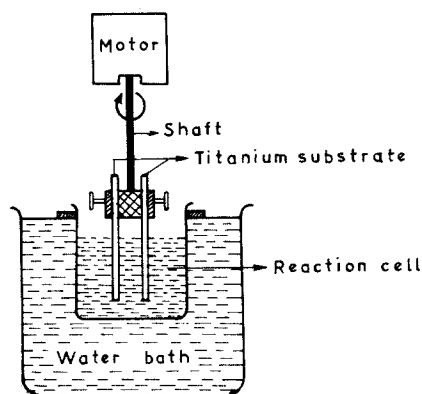


Fig. 1. Diagram for the experimental preparation of CdS film by a chemical bath deposition technique.

Figure 2(a) shows the liquid electrolyte photoelectrochemical solar cell. Cadmium sulphide deposited on a titanium substrate formed one electrode and a platinum plate was used as counter electrode. A liquid electrolyte of ferrous/ferric cyanide was prepared by mixing 0.5 mM K₃Fe(CN)₆ + 10 mM K₄Fe(CN)₆ + 0.4 M KCl in triply-distilled water.

Figure 2(b) shows the solid electrolyte photoelectrochemical solar cell. A solid electrolyte was prepared by capturing a ferrous/ferric cyanide redox couple in an agar-agar gel matrix. 0.5 mM K₃Fe(CN)₆, 10 mM K₄Fe(CN)₆, and 0.4 M KCl were mixed in an agar-agar aqueous solution. This solution was heated to 50 °C and then cooled slowly. When the solution temperature reached 40 °C, it was uniformly spread on a Petri dish. After 2 h a jelly-type film was obtained. A small portion of this electrolyte film was cut and sandwiched between the CdS film and a conducting glass plate. The edges of the cell were sealed so that the cell was air-tight.

A tungsten – halogen lamp was used to illuminate the cell. The solid electrolyte PESC was illuminated from the conducting-glass side. Open circuit voltage (V_{oc}) and short circuit current (J_{sc}) were measured at different illumination intensities. J - V characteristics of these PESCs were also recorded at 100 mW cm⁻² illumination intensity.

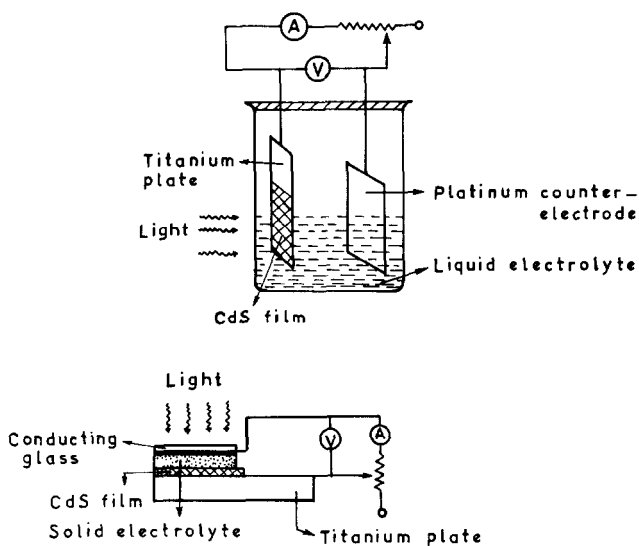


Fig. 2. (a) Liquid electrolyte-CdS photoelectrochemical solar cell; (b) solid electrolyte-CdS photoelectrochemical solar cell.

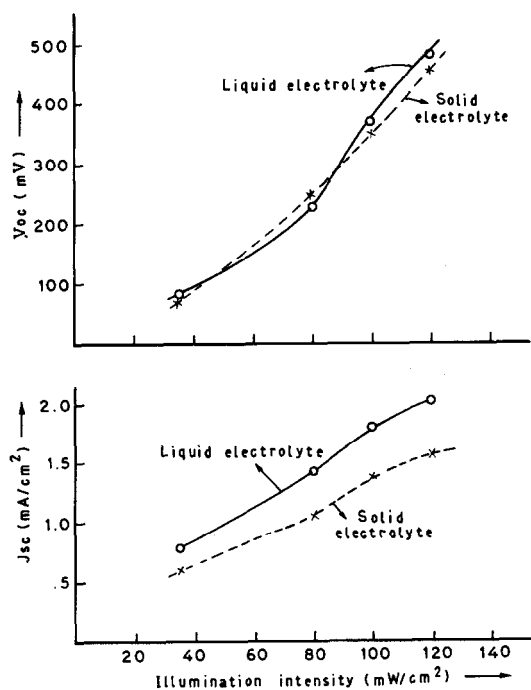


Fig. 3. Variation of open circuit voltage (V_{oc}) and short circuit current (J_{sc}) of the CdS-PESCs with illumination intensity.

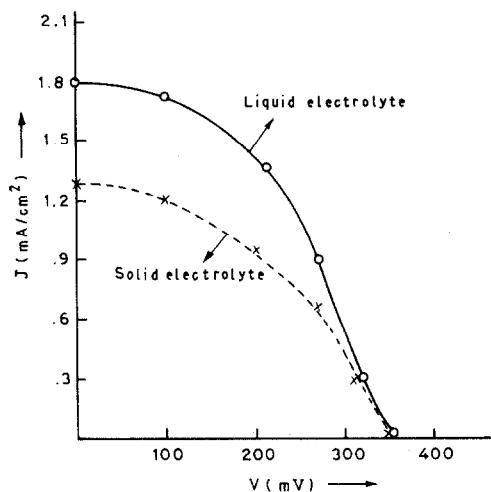


Fig. 4. J - V characteristics of the CdS-PESCs (illumination intensity 100 mW cm^{-2}).

Result

Figure 3 shows the variation of the V_{oc} and J_{sc} of the CdS-solid electrolyte PESC with illumination intensity. The variation of the V_{oc} and J_{sc} of the CdS-liquid electrolyte PESC with illumination intensity is also shown in Fig. 3. Figure 4 shows the J - V characteristics of both the CdS-solid electrolyte and the CdS-liquid electrolyte PESCs. Results shown in Figs. 3 and 4 indicate that the performance of the solid electrolyte PESC is comparable with that of a liquid electrolyte PESC. The V_{oc} of the solid electrolyte PESC is the same as that of the liquid electrolyte PESC. However, the photocurrent of the solid electrolyte PESC is slightly lower than that of the liquid electrolyte PESC. This is probably due to the lower conductivity of the solid electrolyte in comparison with the liquid electrolyte.

Conclusion

Redox couples trapped in an agar-agar gel matrix can be used to make an operational photoelectrochemical solar cell.

Acknowledgement

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