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Technology forecast of Dye sensitized Solar Cell as a Sustainable Future Energy

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Abstract

The present study reports developments in Dye-sensitised Solar Cells (DSC) and discuss the feasibility of the technology as alternative energy resource in future. This study reports on recent developments strives, based on historical developments, to forecast the future for sensitised solar cells as a sustainable energy source.

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Keywords: Dye-Sensitised Solar Cells, Solar Cell, Future Energy.

1. Introduction

Photovoltaic technologies are an essential part of our energy production. Photovoltaic solar energy conversion can be achieved by a number of materials with different efficiencies or different structures. However, there is not yet an optimistic photovoltaic cell (PC) to be cheap enough to make a complete replacement of fossil fuel. While intensive research and development are being carried out to reduce the cost of PC devices, there is considerable interest in thin film devices which may offer an alternative investment in the longer term.

Currently, Poly Silicon-based Solar Cells (PSCs), as the most mature technology, lead the world PC market. With increase of silicon cost, other types of PCs have been developed. Under this circumstance, Dye-sensitised Solar Cells (DSCs) have been considered as the most important third generation of solar cell enabling solutions not dependent on silicon. However, DSCs have shown lower conversion efficiency comparing to PSCs despite of its low production cost.

Even with a low energy conversion rates, DSCs have been seen as enabling small and cheap ubiquitous energy production. This mostly due to the low manufacturing cost associated with DSCs. It is, however unclear, when

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DSCs could produce energy cost efficiently. As such, analysis on to what extent DSC technology could substitute for existing, more mature technologies is a challenging forecast.

A significant amount of literature has been published on emerging PC developments [1] and more specifically on DSCs [2]. In addition, the efficiency development of different solar cell technologies has been tracked [3]. These studies have often described a single advancement in evaluating the technological progression of solar cells.

Through a literature review, and by taking advantage of quantitative measures of technological progression, this paper reports the possibilities of DSC technology. The paper presents the current status of the technology, a bibliometric evaluation of research and patent databases. The study builds on previous work by several authors analysing the future of solar cell technology, focusing specifically on DSCs, and striving to balance both a technical and bibliometric estimation.

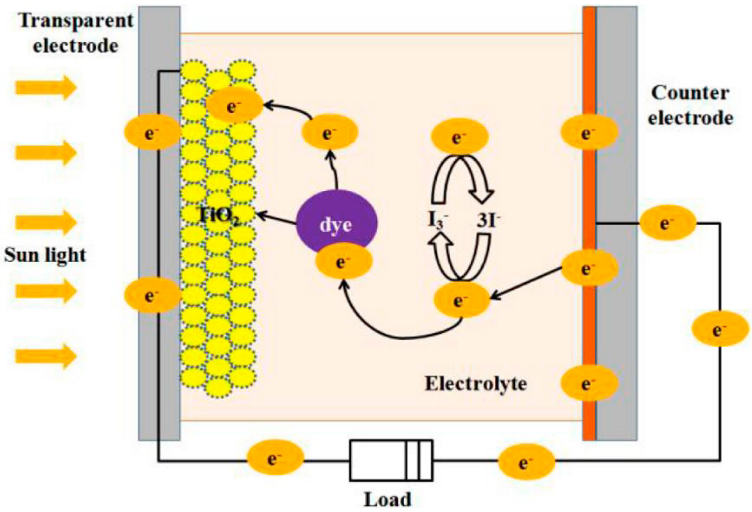

Fig. 1. Schematic illustration of DSC working mechanism [4]

2. Dye Sensitized Solar Cells

Extending the understanding of electron-transfer processes of semiconductors with various reagents, Grätzel et al. reported mechanical explanation of generating charge carriers from aqueous colloidal particles [5]. DSCs are expected to be an alternative to silicon-based solar cells, most significantly due to their low manufacturing cost.

The electricity in DSCs is generated on photo-electrodes made of nanoporous thin films of TiO2. Figure 1 shows the operation mechanism of a DSC. As seen in this Figure 1, electrons are injected by the excited dye molecules into the TiO2 conduction band. The electrons penetrate the nanocrystalline film with a little defect and are gathered at the TCO. Passing through the external circuit and transmitting the power along to the load, the electrons enter the cell at the counter electrode and reduce the iodide/tri-iodide couple (I3 /I) [6].

3. Methodology and Data Collection

The approach taken in this study focuses on analysing the technological progression of DSC and bibliometric evaluation. The study focuses on the technical aspects of DSC development, while the bibliometric approach focuses on uncovering research and industry trends.

The quantitative approach used in this study is a bibliometric evaluation of developments. Among the more quantitative approaches methods, bibliometric data has been more recently used as a basis for technological forecasts. In contrast to forecasts based on tangible technological development, such as Moore's law on computing hardware, development tables such as those gathered by Green et al [3] on solar cells, bibliometric approaches analyse textual databases with quantitative methods to gather data on technological development. Bibliometrics have been used to extract information from large databases.

4. Analysis

Forecasting the future development of both research and patents, a trend extrapolation was made. Using both the Fisher-Pry and Gompertz models to extrapolate the future developments, a suitable model was selected based on MAPE model fit. Modelling resulted in Figure 2, which would suggest a rapid saturation of IPR and a slower research development. The saturation period in the extrapolation is in both cases reached within the timeframe of ten years. This goes to show the rapid increase in technological maturity.

Comparing to results by Kajikawa et al. [7] the difference in publication activity for DSC has increased even more. Kajikawa et al. already pointed out the significant number of papers relating to DSC within a short timeframe. With the results gathered in this paper, it is apparent that DSC has grown in research interest in comparison to more mature technologies. The immaturity of DSC was clearly seen in the results of Shibata et al. [8]. Studying solar cell technology overall, they found seven major solar cell patent clusters, none of which was focused on DSC technology. Shibata et al. went on to argue that the number of DSC in the data set was low. As seen in Figure 2, the number of patents is still low. However, the strong upward trend of development cannot go unmentioned.

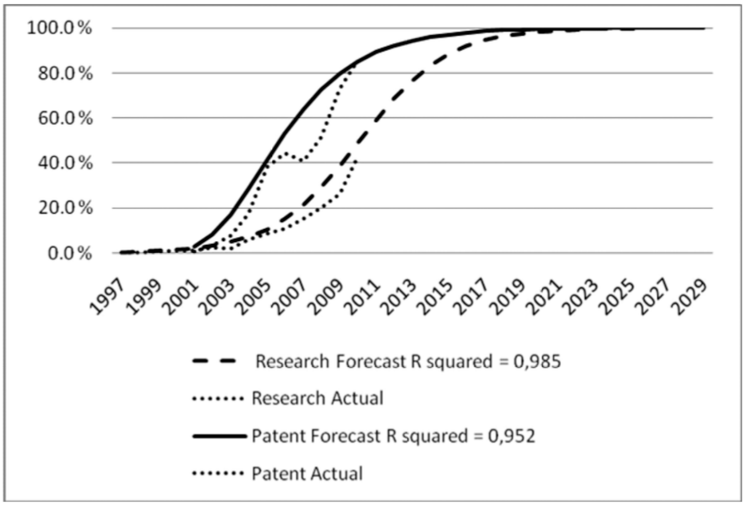

Fig. 2. Fisher-Pry and Gompertz models from research publications and patents [4]

5. Conclusion

Solar cell technology has been available for decades, but just in recent years has it become an alternative to other technologies. This is because of the invention of cheap solutions such as DSCs. Even though their efficiency is still much lower than silicon-based solar cells, there is no need for clean rooms and in manufacturing, roll-to-roll technology can be applied, thus reducing the price to a reasonable level. The number of publications and patents granted to DSCs indicates the importance of DSC technology as a future ubiquitous source of electricity.

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