ABSTRACT

With the tremendous increase in the global population, the inflation of energy consumption is inevitable, which will lead to a dark era with no energy resources. Therefore, to avoid the situation of energy crisis, it is important to select an energy source which we can rely on for a long time and is cheaper and eco-friendly, the answer is **Solar and Photovoltaic.**

PV technology is a renewable power source with the capacity to fulfil the energy needs of the world population with the least impact on the environment. Among the third generation of PV, the Dye sensitised solar cells have succeeded in gaining attention due to their easy fabrication process, low production cost, and use of eco-friendly materials. The DSSCs are so far the most economical and eco-friendly with an efficiency of 15%. Though the efficiency is low, unlike other PVs, it holds the capacity to operate under low light conditions, i.e., indoors. Supplementarily, the performance of DSSC is divided among its components, therefore, medium to low-purity materials can achieve reasonable efficiency which makes them competent in the solar market. Contrastingly, the performance of Si-based solar cells relies on the purity of Si used, hence Si-based solar cells are expensive and consume more energy during the manufacturing process.

Due to the flexibility of DSSCs, they are used in wearable solar panels like backpacks and bags. In addition, large modules of DSSCs are built-in tents for military purposes with 1 kW of energy enough to operate a few lights and communication devices. However, the commercial success of DSSCs demands better efficiency with a better understanding of ageing and the cause of degradation under different stress factors with time which is the focus of the research.

The first stage of my work aims to understand the dye anchoring modes of the dyes of my interest N719, on the TiO_2 substrate using Angle-Resolved XPS and FTIR. FTIR being a chemically sensitive technique helps in identifying the dye conformation and anchoring modes. Further, the application of ARXPS which is a surface-sensitive technique provides insights into the concentration profile of the dye-TiO_2 configuration. A better clarification of available and possible anchoring modes of dye will unveil a better understanding of the interfacial properties N719-TiO_2 configuration of interest.

The application of the procedure to understand anchoring can be applied to a wide range of absorbent and absorbate.

The second stage of this work targets to establish a technique that can be applied to understand ageing in DSSCs better. The study aims to investigate the application of different surface analytical techniques to observe the change introduced in the dye-TiO_2 interface and dye-TiO_2-electrolyte interface with ageing. Initially, an effective approach to accessing the cell interface was developed. A procedure for opening the cell and rinsing off the electrolyte layer to excess of the dye layer was used. Further, the impact of the procedure on the dye layer was investigated. The rinsed-off solution was tested by drop-casting the rinsed-off solution onto the blank TiO_2 substrate. The alterations induced into the photoanodes by the methods were quantified using surface-sensitive techniques such as XPS, MIES, and UPS. The results conclude that the ethanol rinsing procedure has negligible impact on the photoanodes. Thus, a systematic methodology for investigating changes made at the cell interface over time is also devised, which will aid in correlating the decline in cell performance with interfacial deterioration. The study focussed on the application of various techniques to understand different aspects of ageing. The techniques include JV characterisation to track the changes in the PV performance overtime followed by XPS, UPS, MIES, and NICISS to observe the changes in dye/TiO_2 interface. Thus, after establishing an effective ageing technique, an ageing investigation was performed on sample cells under two stress factors: dark and light. The main target of the study is to identify the main causative for the decrease in cell performance under different stress factors and to understand the impact on the cell interface. The device-level performance was traced down by the application of JV characterisation. Additionally, the change in the interfacial impedance was tracked by the application of EIS. The changes in the elemental and chemical composition of the aged sample were investigated using XPS. Furthermore, via the application of UPS, the changes in the DOS of the aged photoanode were explored. Followed by the implementation of NICISS to examine the changes in the concentration of electrolyte and dye elements overtime. Likewise, the change in the dye functional group was determined by the application of FTIR and the impact on dye absorption was observed using UV-Vis DRS.

Overall, the main reason for cell degradation was identified as the penetration of I species into the dye-layer. The I function at regenerating the dye and itself during the cell

operation. Over time especially under light irradiation, the iodine species penetrates and gets stuck into the dye layer resulting in some irreversible reaction which impedes the photo generation by the dye molecule and thus, results in efficiency loss of the cell.