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"Maa"*





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LIST OF ABBREVIATIONS

UV	Ultraviolet
FTIR	Fourier transforms infrared spectroscopy
SEM	Scanning Electron Microscopy
TEM	Transmission Electron Microscopy
DLS	Dynamic Light Scattering
CV	Cyclic Voltammetry
J_{sc}	Short circuit current density
V_{oc}	Open Circuit Voltage
FF	Fill Factor
PCE	Photovoltaic conversion efficiency
η	Efficiency
CE	Counter electrode
PTMG	Polytetramethyleneglycol
HMDI	Hexamethylene diisocyanate
CE	Counter electrode
P_{MAX}	Maximum power density
HOMO	Highest occupied molecular orbital
LUMO	Lowest unoccupied molecular orbital
QDSSCs	Quantum dots sensitized solar cells
E_g	Energy gap
R_{redox}	Redox potential
σ	Ionic conductivity

HSC	Hard segment content
PU	Polyurethane
PUI	Polyurethane ionomer
PE	Polyelectrolyte
SPU	Sulfonated polyurethane
SPUIG	Sulfonated polyurethane ionomer gel
LE	Liquid electrolyte
GPE	Gel polymer electrolyte
R_{CT}	Charge transfer resistance
GO	Graphene Oxide
SGO	Sulfonated grapheme Oxide
ESI	Electrochemical impedance spectroscopy
LSV	Linear seep Voltammetry
TGA	Thermogravimetric analysis
DTA	Differential temperature analysis
DSC	Differential scanning Calorimetry
T_{Gel}	Gel transition temperature
T_g	Glass transition temperature
T_m	Melting Temperature
PS	Photosensitizer
ETL	Electron transport layer
HTL	Hole transport layer
CEM	Counter electrode material

PREFACE

Recently, the renewable energy sources such as Solar Energy, Biomass Energy, Wind Energy, Geothermal Energy and Hydropower Energy have great attention for the world energy society. Solar energy is more attracted as compared to other resources due to endless availability of the solar energy radiation which can be used for solar cell application. The third-generation solar cell technology is the hot topic for the research and development, and the QDSSC is more promising candidate because of multiple exciton generation, hot electron transfer, low cost, easy fabrication process and its theoretical efficiency is higher than Shockley- Queisser limit. The QDSSCs are consist with photoanode, counter electrode and an electrolyte i.e., hole transport materials. Electrolytes play an important role in the QDSSCs, it behaves as redox active couple / hole transport materials i.e., the holes are transported from the photoanode to counter electrode via electrolytes in photovoltaic devices, resulting in generation of electricity. The liquid electrolytes such as polysulfide and iodide / triiodide are more common for the QDSSCs. The shortcomings of liquid electrolytes are easy vaporization, leakage, performance instability and corrosive in nature. Hence, to remove these shortcomings, some research groups have introduced the solid-state electrolyte as hole transport material in QDSSCs and but due to low ionic conductivity and poor performance of such kind of the devices, it required some modification to enhance the photovoltaic performance. The gel state electrolytes are good candidate for the QDSSCs because it has high ionic conductivity and good adhesive characteristics behavior due to which it becomes more suitable as a hole transport material for the fabrication QDSSCs. Some researchers have used the additive in gel electrolytes to enhance the photovoltaic performance of the fabricated solar cell. The main objective of this thesis work is to develop the thermoplastic plastic polyurethane polymer ionomer as a hole transport material for the quantum dots sensitized solar cell. The thermoplastic

polyurethane polymer was used due to active urethane linkage present in the polymer moiety that have flexible behavior and for synthesis purpose a variety of monomers are available. The polyurethane properties were tuned by using various type of monomers and chain extenders for the synthesis of polyurethane polymers. The polyurethane polymers are composed of diisocyanate and polyol moieties using suitable chain extenders. The sulfonate group was attached as a pendent group at polymeric chain and thermoplast polyurethane gel electrolytes was developed as a hole transport material for QDSSCs with CdS/CdSe photoanode. Further graphene oxide was tagged with polyurethane chain and enhanced the polymeric properties, and GO-tagged polyurethane polymer converts in to polyurethane ionomer and prepared a gel electrolyte. The passivation layer was also used for enhanced photovoltaic performance of the fabricated photovoltaic devices, using the suitable passivation layer which prohibits the back electron transfer and facilitate the transportation of the hole in the photovoltaic devices. Further, Carbon nanotube-tagged functionalized polyurethane ionomer was developed as a hole transport material for QDSSCs. The cadmium free zero toxic quantum dots such as copper indium sulfide quantum dots were used to fabricate the green photovoltaic devices. The rheological properties of the prepared gels give information about the gel behavior and viscosity flow behavior of the gel. The stress relaxation measurement and gelation kinetics was also evaluated through the rheological analysis. The relaxation time another important parameter was used to analyze the gel properties.

This thesis has been divided in seven chapters. The first chapter is introduction and literature review which gives the understanding about solar cells devices, fabrication techniques, solar cells components, electrolytes (liquid, solid and gel), power conversion efficiency and detailed literature survey. The second chapter presents the different experimental techniques used for the characterization. The third chapter “Functionalized Thermoplastic Polyurethane Gel Electrolyte

for Cosensitized TiO₂/CdS/CdSe Photoanode Solar Cells with High Efficiency” (work published in *Energy & Fuels*, (2020);34: 16847-16857) present the hole transport behavior of the developed gel electrolyte and devices performance of the fabricated QDSSCs. The fourth chapter “Functionalized Polyurethane Composite Gel Electrolyte with Cosensitized Photoanode for Higher Solar Cell Efficiency Using a Passivation Layer” (work published in *Nanoscale Advances*, (2022); 4: 1199-1212) discusses the effect of chemical tagging of Graphene oxide with polymer chains and use of passivation layer to improve the devices performance. The fifth chapter “Non-toxic CuInS₂ Quantum Dots Sensitized Solar Cell with Functionalized Polyurethane Gel Electrolyte” discusses the green quantum dots sensitized solar cell and multiwalled carbon nanotubes was tagged with polyurethane chain to developed as a hole transport material for cadmium free quantum dots sensitized solar cells (*Communicated*). The sixth chapter “The Effect of Chemical Tagging of Graphene Oxide in Thermoplastic Polyurethane on Gelation Behavior” (*Communicated*). The last chapter present the major conclusions drawn from this work and suggestion for the future work in this field. The reference work is given at the end.