CHAPTER 9 : CONCLUSIONS AND SUGGESTION FOR FURTHER WORK

PVA has been chosen as the polymer host this work due to its high dielectric constant of 8.1 indicating that it is able to solvate large amount of mobile ions. PVA–LiBOB complexes revealed room temperature conductivity ($\sigma_{RT}$) of $10^{-3}$ S cm$^{-1}$, which was in line with the main objective of this work to produce a high conducting electrolyte. The highest $\sigma_{RT}$ PVA–LiBOB solid electrolyte was $2.83 \times 10^{-4}$ S cm$^{-1}$ at 40 wt.% LiBOB loading. On jellifying this electrolyte with DMF, $\sigma_{RT}$ increased to $7.31 \times 10^{-3}$ S cm$^{-1}$. As one the objectives in this work was to fabricate DSSCs using LiBOB containing electrolyte, TBAI and I$_2$ were added to provide the iodide/triiodide redox couple and the total salt concentration was fixed but the ratio between TBAI and LiBOB was varied. The electrolyte with composition 17.53 wt.% PVA–1.75 wt.% LiBOB–9.93 wt.% TBAI–0.68 wt.% I$_2$–70.11 wt.% DMF (B5 electrolyte, $\sigma_{RT}$ = $5.13 \times 10^{-3}$ S cm$^{-1}$) gave the highest efficiency of 6.11%. A second iodide salt i.e. BMII was added in B5 electrolyte to enhance solar efficiency and electrolyte conductivity. The electrolyte with composition 15.95 wt.% PVA–1.59 wt.% LiBOB–9.04 wt.% TBAI–9 wt.% BMII–0.62 wt.% I$_2$–63.8 wt.% DMF ($\sigma_{RT}$ = $7.52 \times 10^{-3}$ S cm$^{-1}$) exhibited the highest efficiency of 7.28%.

Transport parameters of mobile ions for all electrolytes at room temperature were determined quantitatively by fitting the complex impedance plot obtained experimentally to the impedance of an appropriate equivalent circuit. The diffusion coefficient ($D$) and mobility ($\mu$) of free ions in PVA–LiBOB solid electrolyte system increased with LiBOB concentration up to 40 wt.%. Beyond this salt concentration, $D$ and $\mu$ decreased. The mobile ion number density ($n$) increased with LiBOB
concentration up to 50 wt.%.

On transforming the electrolyte from the solid to gel form, $D$ increased from $2.46 \times 10^{-8}$ (solid form) to $2.16 \times 10^{-6}$ cm$^2$ s$^{-1}$ (gel form) and $\mu$ from $9.58 \times 10^{-7}$ to $8.41 \times 10^{-5}$ cm V$^{-1}$ s$^{-1}$ due to solid–liquid properties of the gel, but $n$ decreased from $1.85 \times 10^{21}$ to $5.42 \times 10^{20}$ cm$^{-3}$. Reducing LiBOB and replacing it with TBAI, but keeping the salt content to 40 wt.% in the gel electrolyte, $D$ increased to $2.47 \times 10^{-6}$ cm$^2$ s$^{-1}$ and $\mu$ to $9.60 \times 10^{-5}$ cm V$^{-1}$ s$^{-1}$ while $n$ decreased to $2.83 \times 10^{20}$ cm$^{-3}$. In the BMII electrolyte system, however, $D$ decreased from $2.46 \times 10^{-6}$ to $2.44 \times 10^{-6}$ cm$^2$ s$^{-1}$, $\mu$ decreased from $9.58 \times 10^{-5}$ to $9.52 \times 10^{-5}$ cm V$^{-1}$ s$^{-1}$ and $n$ increased from $3.35 \times 10^{20}$ to $4.93 \times 10^{20}$ cm$^{-3}$ indicated that more mobile ions as BMII added. On increasing temperature of the electrolyte environment, $D$ and $\mu$ decreased and $n$ increased in the second and third electrolyte systems.

As mentioned above, the highest solar conversion efficiency obtained in second and third electrolyte systems is 6.11% and 7.28%, respectively. The solar conversion efficiency of DSSC was dominantly influenced by the short circuit current density, $J_{sc}$ of the cells where high $J_{sc}$ revealed high solar efficiency. The increase of $J_{sc}$ of the cell was influenced by the cations [(Li$^+$ for system 2) and (BMII$^+$ for system 3)] that accumulated on the surface of TiO$_2$ mesopores and its pores walls. Adsorption of these cations downshifted the Fermi level of the TiO$_2$ towards positive potential and indirectly increased the energy gap between the dye excited state and TiO$_2$ conduction band. Also the high concentration of iodide anion helps in transferring the electrons from counter electrode to the ionized dye at a faster rate. One of the objectives of this work was achieved where the use of non–iodide salt i.e. LiBOB had affected the performance of the DSSCs. The Li$^+$ dissociated from LiBOB made the potential of the Fermi level of TiO$_2$ more positive and shifted the Fermi level towards the redox potential in the DSSC employing electrolyte from the second system. This effect increased the $J_{sc}$ as well as
the solar conversion efficiency. The BMII ionic liquid was observed to help increase the energy gap between the dye excited state and conduction band of TiO\textsubscript{2} as well as increased the conductivity of redox mediator for electron transfer from counter electrode to the ionized dye.

This research work has given some ideas to further pursue a more in-depth study. Some suggestions for further work based on these research findings are:

- maintain the composition of the PVA–LiBOB–TBAI–BMII–DMF electrolyte with I\textsubscript{2}, but study other parameters such as transference number, linear sweep voltammetry and cyclic voltammetry to increase the literature of knowledge on this material,
- study the stability of the DSSC,
- study more on the DSSC such as (i) the IPCE and (ii) modifying DSSC electrode in order to obtain higher solar conversion efficiency by using nanowire TiO\textsubscript{2} photoanode prepared using electrospining method,
- using other measurement technique to determine diffusion coefficient, mobility and number density of charge carriers of electrolyte and comparing the results from the method developed in this work,
- extend the Nyquist plot fitting method developed in this work to determine transference number of electrolyte.