Karlsruhe Institute of Technology

Ionic Liquid Based Electrolytes for Dye Sensitized Solar Cells

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Summary

- New ionic liquid based electrolyte possesses better performance than commercial ionic liquid based one at 25°C
- Improved stability up to 600 h at 65°C demonstrated

Motivation

Since the invention of the dye sensitized solar cell almost 20 years ago this very promising energy harvester suffers from the limited efficiencies around 12% considering lab-size cells and reduced long-term stability under environmental conditions. Especially the **presence of volatile electrolyte components** with considerable vapour pressure under operation conditions (20-80°C) during a sunny day can cause a pronounced negative impact on the device sealing stability. One possible solution to overcome the electrolyte volatility is the use of iodide-based **ionic liquids (IL)** in combination with low vapour pressure solvents like **propylene carbonate (PC)**. This mixture enables **a low electrolyte viscosity** which ensures a high ionic conductivity according to the Walden rule established in electrolyte development for lithium-ion-batteries.

General electrolyte features

Walden Rule

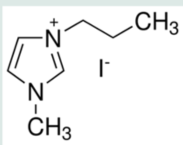
$$\lambda(T)\,\eta(T) = \text{const}$$

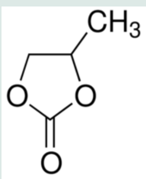
- High ionic conductivity
- Low viscosity (mPas-range)
- Good solubility for iodine enabling I_3^- complex
- Low vapour pressure under operation conditions (20-80°C)
- Long-term stability at 80°C

Materials and Methods

- **Reference electrolyte: IoLiLyte SP-163:**
  - 0.60 M 1-Butylmethylimidazolium iodide (BMIM-I)
  - 0.03 M Iodine

  - Additives:
    0.10 M Guanidinium thiocyanate
    0.50 M 4-*tert*-butylpyridine
  - Solvent mixture: 85% Acetonitrile (bp.: 81°C)
    15% Valeronitrile (bp.: 139°C)
- **New electrolytes:**
  - 1-Butylmethylimidazolium iodide **(BMIM-I)** or 1-Propylmethylimidazolium iodide **(PMIM-I)**
  - Iodine
  - Additives: same as in reference
  - Solvent: Propylene carbonate **PC** (bp.: 240°C)

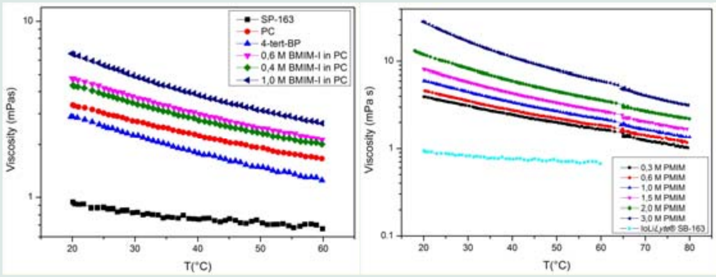




- Investigations on:
  - Viscosity
  - Ionic conductivity
  - Functional tests in commercial DSSC at different temperatures

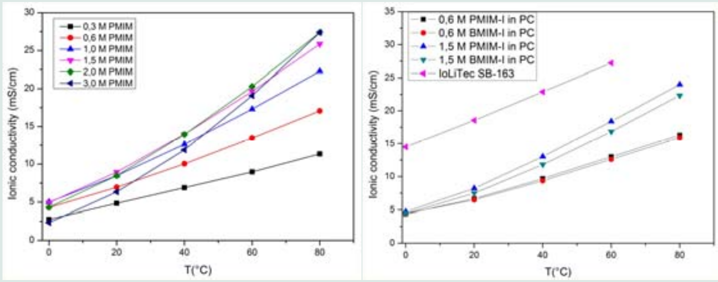
Results

- **Electrolyte viscosity**



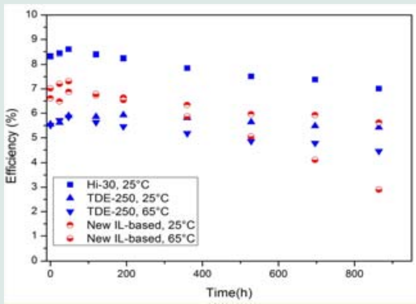
- All components possess a higher viscosity than the reference electrolyte, especially at low temperatures
- Increasing ionic liquid content increases viscosity

- **Electrolyte conductivity**



- Increasing ionic liquid content increases conductivity
- PMIM-I induces higher conductivity than BMIM-I
- Conductivity at 80°C comparable to reference at 60°C

- **Functional tests in commercial DSSC @Solaronix**



- Comparison with two commercial electrolytes, both from Solaronix
  - HI-30 (acetonitrile based)
  - TDE-250 (IL-based)
- Measurement temp.: 25°C, 65°C

- 25°C and 65°C: New electrolyte exhibits higher efficiency than commercial IL-based system
- 65°C: New electrolyte shows reduced long-term stability > 600h

Conclusions

- Viscosity and ionic conductivity increases with IL content
- Molecular structure of the IL influences conductivity
- **New electrolyte composition with improved DSSC efficiencies even at elevated temperatures found**

Acknowledgements

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