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
- 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
  - 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

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