Investigating co-solvents for use with Sn based anode materials in SIBs

Examining carbonate solvents, glyme solvents and additives.

Rachel Gordon Dr Abhinav Tripathi, Prof John Irvine

Abstract

Electrolyte of a battery system significantly impacts the Solid Electrolyte Interface (SEI) formed on the surface of the anodes. Sn is one of the model material where the cycling performance is dominated by the class of electrolyte solvent used.[1]

In this work, we evaluate the effect of co-solvents on Sn-metal based anode materials. The primary electrolytes used in this study are – 1M $NaPF_6$ in EC:DEC (Kishida), 1M $NaClO_4$ in propylene carbonate (PC), 1M $NaPF_6$ in Diglyme (DGE). Electrolytes with binary or ternary solvents are created by mixing the electrolytes mentioned above. They are then used in Na-ion half cells with Sn metal composites. Electrolyte additive – FEC - was also evaluated as a potential enabler of high cycle life Sn metal anodes.

Motivation

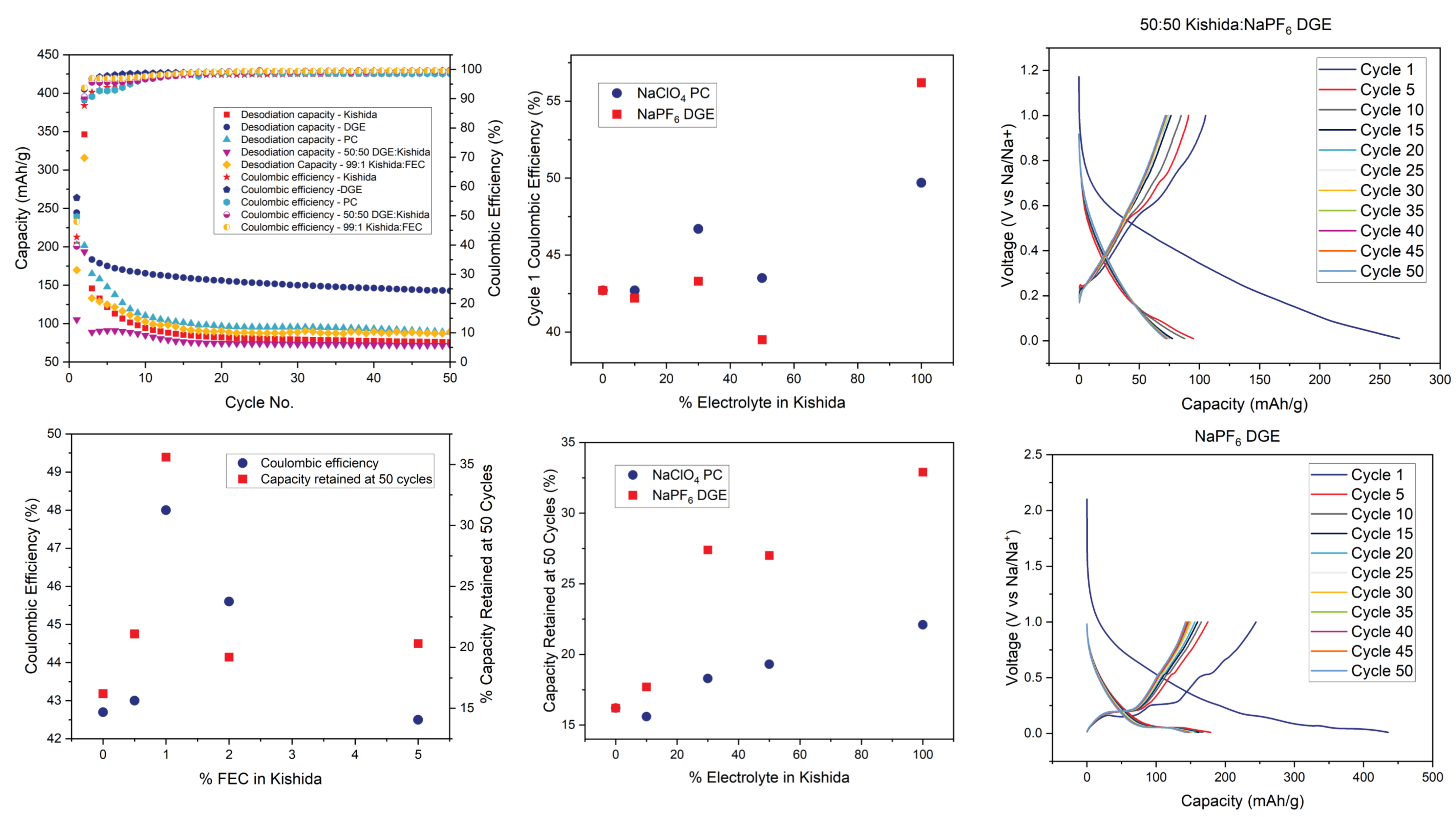
- Glyme-based electrolytes are compatible with Sn anodes at low voltages whilst carbonate-based electrolytes may be less compatible with Sn but have higher voltage stability unlike glymes. These electrolyte types and combinations were investigated in attempt to search for an electrolyte which can work with Sn and also have high voltage stability.

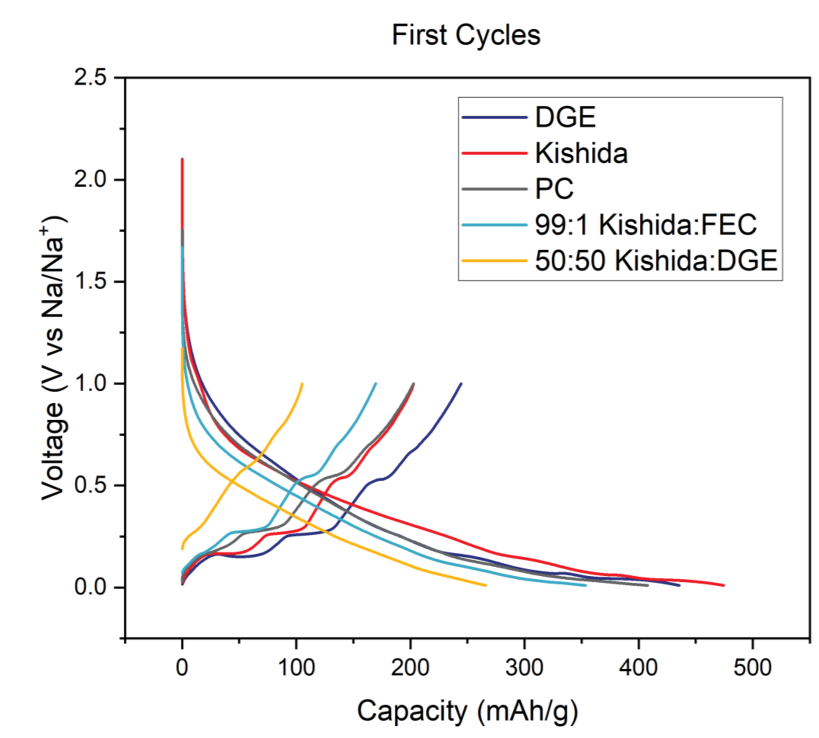
Methods

- Electrode slurries of Sn-HC, hard carbon and CMC binder (8:1:1) were prepared. These were then cast using a blade onto aluminium foil, dried and punched.
- Various mixtures of DGE:Kishida and PC:Kishida were prepared in an argon filled glovebox as well as mixtures of Kishida and FEC additive.
- Half cells against Na metal were prepared in an argon filled glovebox

Section 1 – Cycling Performance

- DGE based electrolyte perform the best.
- 50:50 electrolyte combinations perform the worst.
- FEC additive improves Kishida's performance slightly with 1% being the optimum amount.



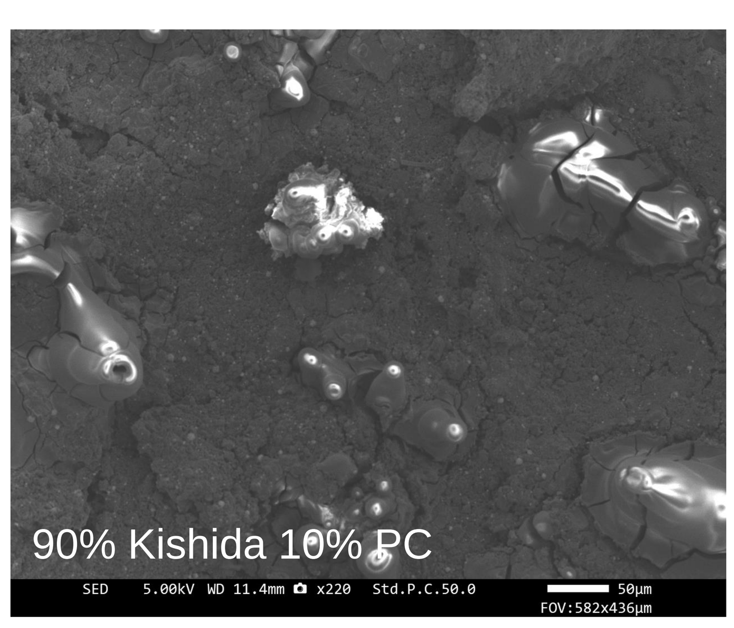


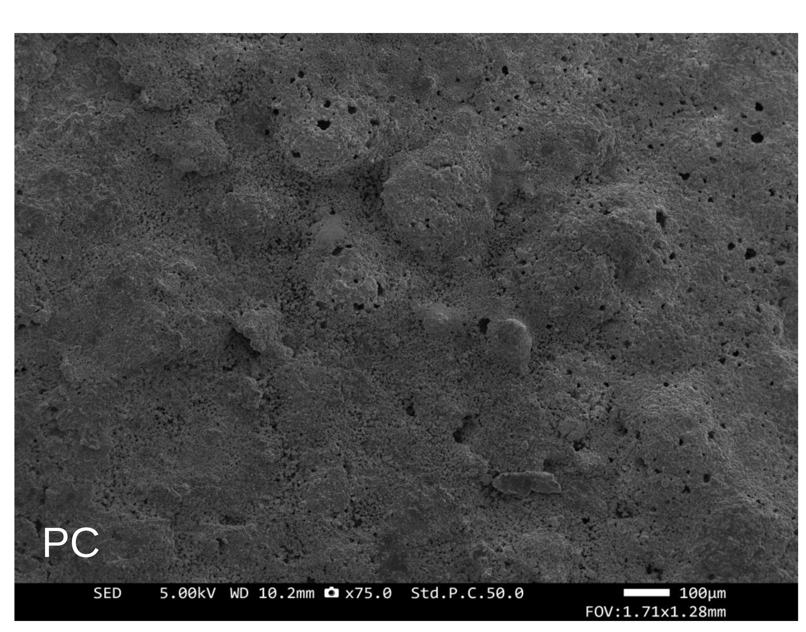
Conclusions

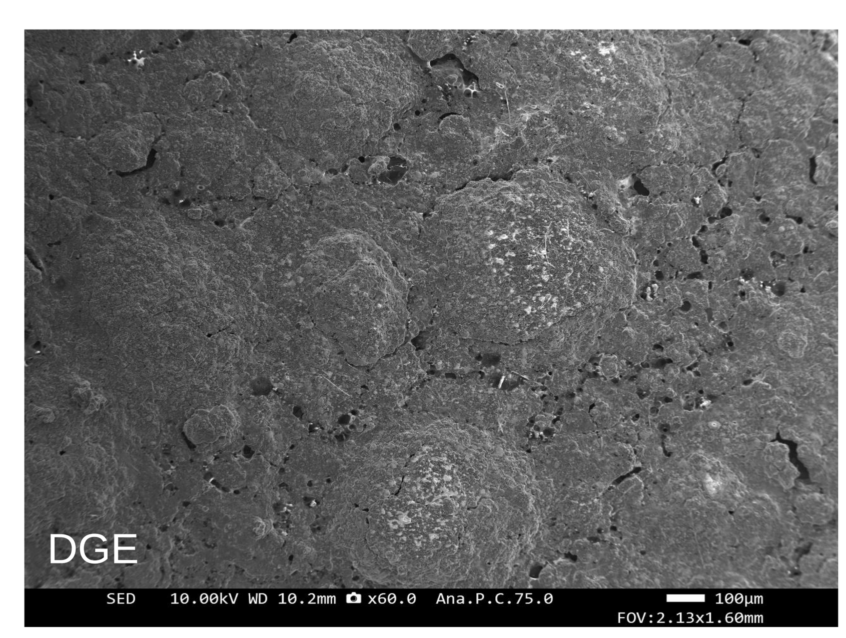
- Combinations of carbonate and glyme electrolytes have performance similar to pure carbonate based electrolytes. SEI chemistry in electrolyte mixtures is dominated by carbonate electrolytes.
- Among the poorest performing mixtures was 50:50 Kishida:DGE, which seems due to the formation of a higher resistance, lower conductivity SEI.
- The most effective electrolyte for these Sn metal-based anode materials is DGE. SEM and EDAX analysis shows that SEI morphology and chemistry is quite different in DGE.

Section 2 – SEI Imaging

- SEM imaging shows the SEI formed is very different for each electrolyte.
- Kishida contains large protrusions consisting largely of P, F and Al. [EDAX analysis, not shown here]
- PC shows a disintegrated SEI with many pinholes indicating significant gas formation.
- DGE shows the most continuous SEI – although still with some pinholes. EDAX analysis shows that the SEI consists of an Sn containing species.







Impact / Next steps

- Research into how $NaPF_6$ DGE performs with these anodes in full cells should be investigated.
- Since combinations of these existing electrolytes do not improve their properties, new electrolytes that allow for stable cycling and high voltages should be developed.
- More research into the composition of the SEI formed with each electrolyte could provide useful information.

References

1. B. Zhang, G. Rousse, D. Foix, R. Dugas, D. A. D. Corte and J.-M. Tarascon, *Adv. Mater.*, 2016, **28**, 9824-9830.

Intern bio

Rachel is studying for an Integrated Masters in Chemistry at the University of St Andrews with one year remaining. Throughout her time at university her interest in how chemistry can help lead us to a more sustainable world has developed, leading to a particular interest in batteries. She is eager to continue her passion for sustainable chemistry either within academia or in industry after completing her degree.

THE FARADAY INSTITUTION NEXGENNA NEXT GENERATION SODIUM-ION BATTERIES

University of St Andrews

UK Research and Innovation