Explaining the role of niobium oxides as anodes in high-power lithium-ion batteries

Developing educational resources to explain high-power battery materials

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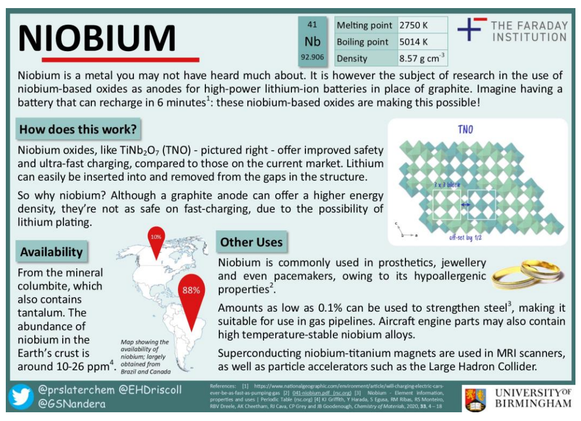
Abstract

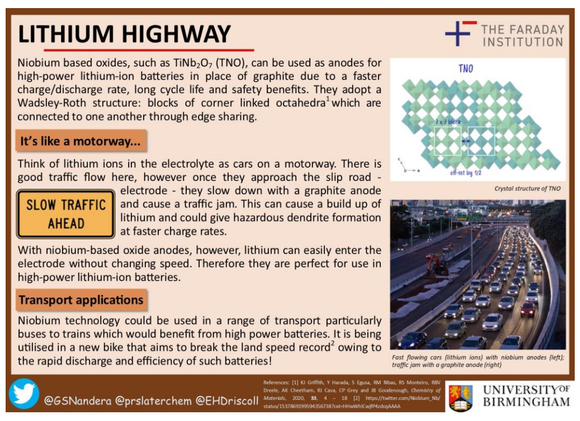
This project aimed to develop ways of explaining the structure and importance of high-power anode materials based on oxides of niobium. Two main educational resources were produced:

- **Two infographics** highlighting the role of niobium and lithium-ion transport in these structures. These were targeted at GCSE and A-level pupils but could also be used for undergraduate students and the wider public.
  - An origami information cube on niobium was also developed.
- **Origami models** were made to display the Wadsley-Roth structures of niobium-based oxides, and demonstrate the transport of lithium-ions in this anode material.
  - Video and written guides of how to make these origami octahedra were produced and edited.
  - In addition, an article was written on how origami can be used to show these crystal structures.

Infographics

- One infographic introduced the element niobium, and it's role in these high-power lithium-ion batteries.
- The second infographic focused on explaining the transport of lithium-ions in these Wadsley-Roth structures, by using a motorway analogy.
- Finally an origami fact cube about niobium was produced which was vital to showcase the element as it is absent from the GCSE and A level curricula.

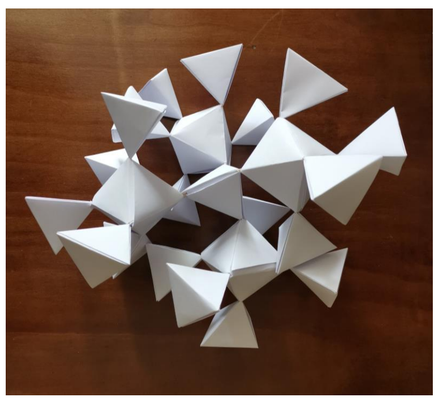




Left: an infographic on the element niobium, right: an infographic on the transport of lithium-ions in Wadsley-Roth structures.

Impact / Next steps

- The origami models and interactive making session were shown to be a useful tool at the "Meet the Scientists" event at ThinkTank Science Museum.
- Distributing infographics to schools and collecting feedback through surveys.
- Use origami to build and explain other frameworks important in high-power lithium-ion batteries, for example specific structures present in solid electrolytes.



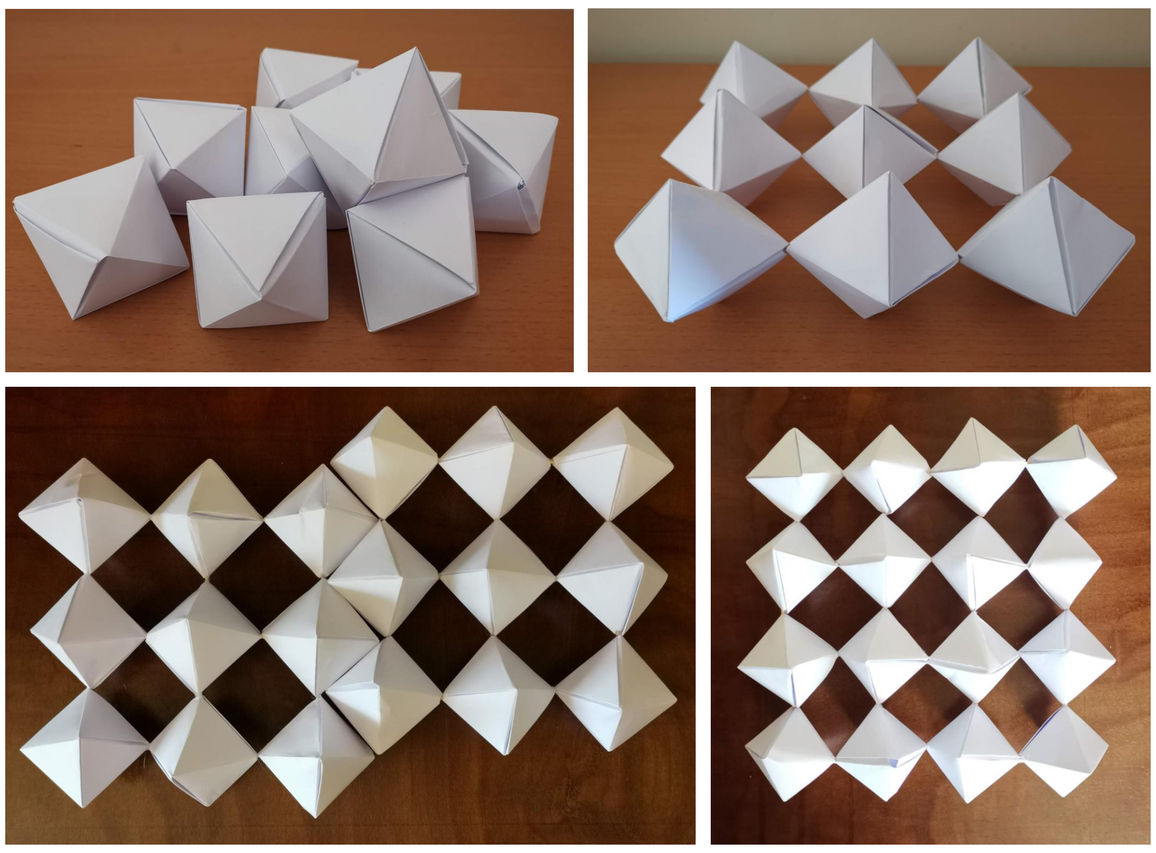
Origami model of garnet/NASICON inspired frameworks which can potentially be used as solid electrolytes for lithium-ion batteries, allowing high ionic conductivity[3].

Motivation

- Showcase the importance of these high-power anode materials in fast-charging of just 6 minutes[1] and improved safety over traditional graphite due to the lack of dendrite formation[2].
- Encourage and inspire the next generation of battery scientists.
- Turn academic literature into meaningful, comprehensible resources for a wide range of audiences.

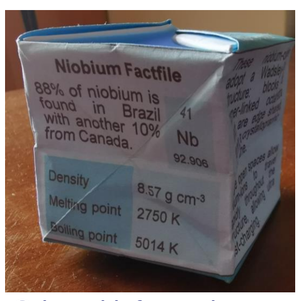
Origami

- Many Nb_2O_5 based compounds adopt Wadsley-Roth structures consisting of blocks of corner linked octahedra which are in turn edge shared, forming a crystallographic shear plane.
- Origami is a powerful tool which can be used to show the structure and how the crystallographic shear planes are formed, as well as demonstrate how lithium-ions travel through the structure during the charging/discharging cycle in simplified terms.



Top left: making origami octahedra, top right: assembly of origami octahedra into 3 x 3 blocks, bottom left: introduction of a crystallographic shear plane with two 3 x 3 blocks, bottom right: demonstrating that other block sizes exist.

- Resources trialled at the "Meet the Scientists" event at ThinkTank Science Museum and were discussed with members of the public who also engaged in an origami making session to learn more about how origami can be used as a visual learning tool.
- Video and written guides were made of how to reproduce these origami octahedra and an article was written on the topic.



Origami information cube.

Intern bio

Gagandeep is studying Chemistry at the University of Birmingham.

Interested in:

- Materials with improved and sustainability and efficiency,
- Creating educational resources to simplify the understanding of new materials.

Aspire to:

- Have a career in education and science communication.

References

1. Will charging electric cars ever be as fast as pumping gas? (nationalgeographic.com)
2. KJ Griffith, Y Harada, S Egusa, RM Ribas, RS Monteiro, RBV Dreele, AK Cheetham, RJ Cava, CP Grey and JB Goodenough, *Chemistry of Materials*, 2020, **33**, 4 – 18
3. Y Xiao, K Jun, Y Wang, LJ Miara, Q Tu and G Cedwer, *Advanced Energy Materials*, 2021, **11**, 37

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