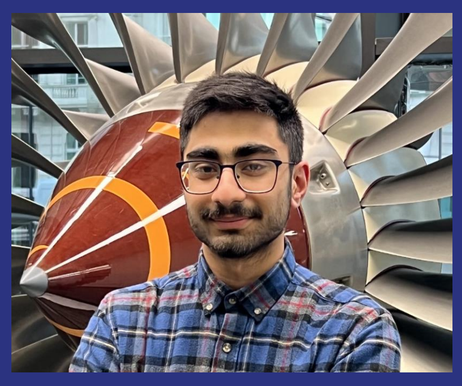
DEBONDABLE ADHESIVES FOR IMPROVED PACK DISASSEMBLY

Developing cured adhesives to test whether on-demand debonding can occur within a short time frame and help aid the disassembly of LiB batteries.



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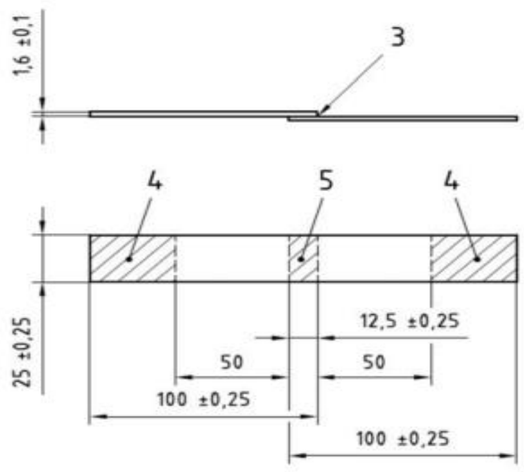
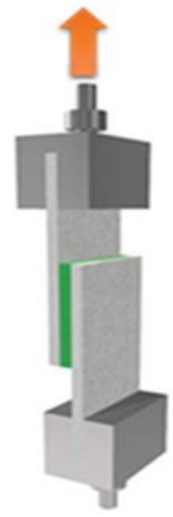
Abstract

One of the biggest barriers to recycling LIBs is the extensive use of epoxy resins in module and pack construction. The use of debondable adhesives in renewable energy generation and storage has recently been reviewed.[1] It was suggested that only chemical debonding would be appropriate for LIBs. As with all aspects of battery recycling, the process will need to fast and inexpensive and so the aim was to develop a debonding process with negligible cost that occurred within 5 min. This could be an important tool in LIB design for recycle.[2]

Testing

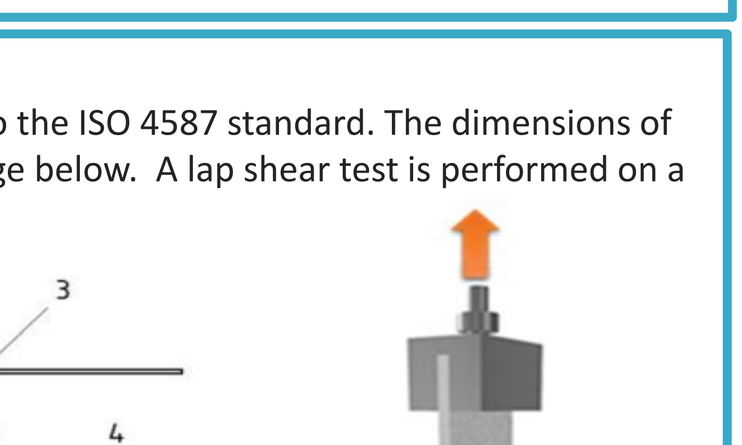
Samples are cut according to the ISO 4587 standard. The dimensions of which are shown in the image below. A lap shear test is performed on a tensile test machine.

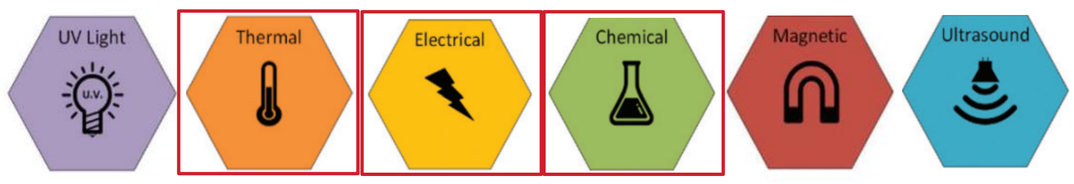




Debonding

The different stimuli available for debonding are shown below. Only those highlighted in red are viable for battery pack disassembly. The samples are subject to these stimuli for debonding to occur.





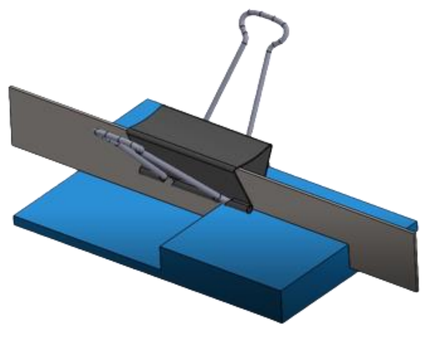
Cost

- Given that on-bulk most epoxy resins cost $ 4-5 / kg it is clear that the cost of the additive must be of a comparable (or preferably lower cost) to that of the resin.

Additive	1	2	3
Cost $/kg	0.05- 0.10	0.10 – 0.25	1.50 – 2.50

- In all cases the additive will significantly decrease the cost of the resin and decrease the amount of polymer used. The additives are all non-toxic and biocompatible.

Making the samples



- 316 stainless steel was used a substrate for adhesion testing.
- A weighed amount of adhesive was placed on one of the substrates. Adhesives with different additives were made and mixed for 30 seconds before applying.
- Non-stick paper was placed on top of the substrate.
- A bull dog clip was used to apply even pressure for the curing time of 24 hrs.
- A jig was used to speed up the process (see Figure 1).
- Repeats were made for 10, 25 and 50 wt.% of additives.

Results

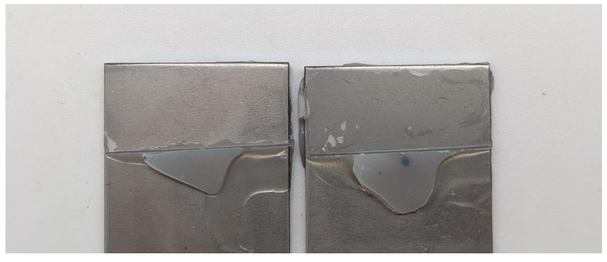
Additive	1	2	3
10 wt%	-23%	+11%	+3%
25 wt%	-8%	+35%	-5%
50 wt%	-20%	+15%	-98%

Relative strength change as a function of additive loading

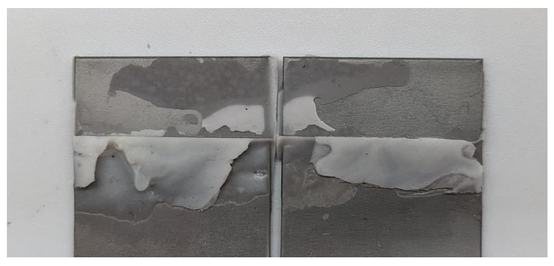
Additive	1	2	3
10 wt%	>1day	>1day	<1 day
25 wt%	>1day	>1day	<10minutes
50 wt%	>1day	>1day	<2minutes

Debonding time as a function of additive loading

Additive 3 at a loading of 25 wt% was found to be the best formulation as it significantly decreased the cost of the epoxy by approximately 60%, it made no change to the adhesion strength and still debonded in <10 min.



Additive 3 @ 25 wt % : Control



Additive 3 @ 25 wt % : Post-treatment

Impact / Next steps

- This will be applied to dummy battery packs and tested for practical debonding.
- This technology can be applied to larger structures such as fibreglass for wind turbines.
- Aim is to demonstrate the requirement for 2 stimuli e.g., heat and chemical to prevent accidental or ambient condition debonding.

References

[1] K. R. Mulcahy, A. F. R. Kilpatrick, G. D. J. Harper, A. Walton and A. P. Abbott, Debondable adhesives and their use in recycling, *Green Chem*., 2022, 24, 36 – 61

[2] D. L. Thompson, J. M. Hartley, S. Lambert, M. Shiref, G. D. J. Harper, E. Kendrick, P. Anderson, K. S. Ryder, L. Gaines and A. P. Abbott, The Importance of Design in Lithium Ion Battery Recycling, *Green Chem.,* 2020, 22, 7585 – 7603

Intern Bio

Punit Jivan is in his 3rd year studying Mechanical Engineering at Imperial College London. He is interested in renewable energy technology and striving towards a greener future. After graduating, he is hoping to enter this sector where the scope of research and development is immense. Outside of studies, he is a keen sports player and enjoys watching cricket.

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