Adhesive bonding technology in automotive battery pack manufacturing and dismantling: An overview

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Advanced Joining Processes Unit

1. Introduction

Lithium-ion (Li-Ion) EV batteries come in a variety of geometries and cell types (cylindrical, pouch or prismatic). To improve mechanical and thermal performance in batteries, OEM's opt for adhesive joints. Bonded joints are ubiquitous in the automotive industry and can be found in structural frame battery sections, sealing of the lid enclosure, gap filling in-between the modules/cells to the cooling plate and in between cells. This choice comes with the drawback of difficult serviceability, since current joints are not designed to be dismantled. The debonding-on-demand (DoD) trend could be extended to EV battery to ease serviceability when needed and allow for component and material reuse.

2. Adhesive bonding in EV battery packs

Adhesive bonding extends from the cells to the pack itself. Its use heavily depends on the pack hierarchy, cell to pack or cell to module configuration, and cell type [1]. The major applications are divided into four areas (Table 1).

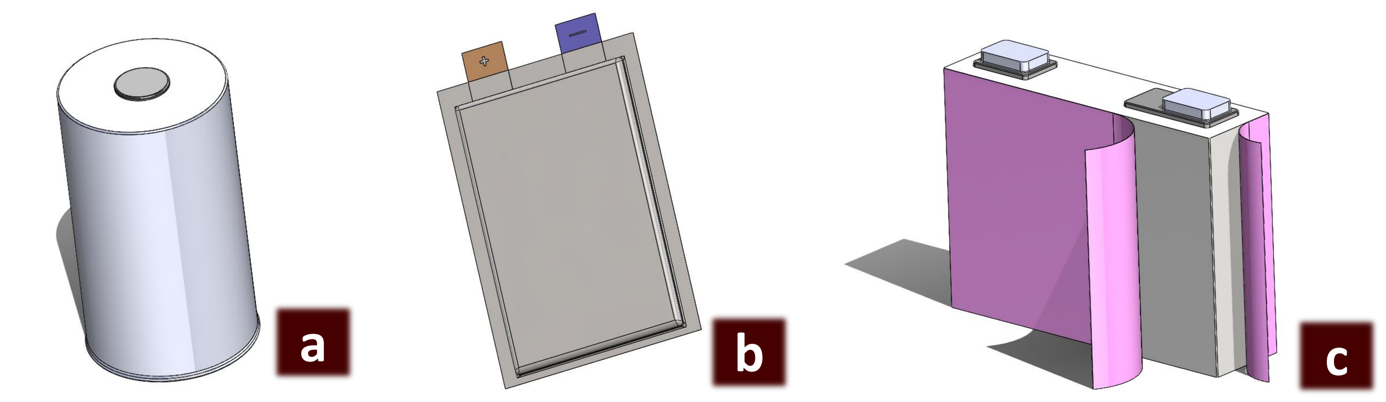

Figure 1 – Types of cells used in EV energy storage systems: a) cylindrical; b) pouch; c) prismatic

Table 1 – Adhesive main requirements in EV energy storage systems

Application	Requirements
Frame	- Structural
Lid enclosure	- Sealing + gap-filler + damping - Age resistant
Cell to cell	- Dielectric - Thermally conductive - Cushioning
Cell to cooling plate	- Gap-filler - Thermally conductive (at least 2 [W/mK]) - Semi-structural

Adhesive solutions provide overall strength to the pack. Sealants may come in 1k polyurethane (PU), silicones or saline terminated polymers (STP) formulations. Cell-to-cell bonding requires EMI shielding and grounding as well as flame retardancy, which is a key factor in the case of a thermal runaway event. Ordinarily, in pouch cells, PSA's or rubbery foams are used whereas prismatic opt for a PSA warpage sometimes followed by 2k PU. Cylindrical cells are reported to have hybrid dual curing modified acrylics or 2k structural PU [2]. TCA's come as acrylates or 2k PU formulations with technical ceramic fillers to increase electrical resistivity. Structural frame bonding is well known in the automotive industry and can combine hybrid epoxy based formulations as a paste or film. Adhesive manufacturers provide multiple adhesive solutions in EV battery pack jointing, although the automotive industry employs multiple joining technologies besides bonding.

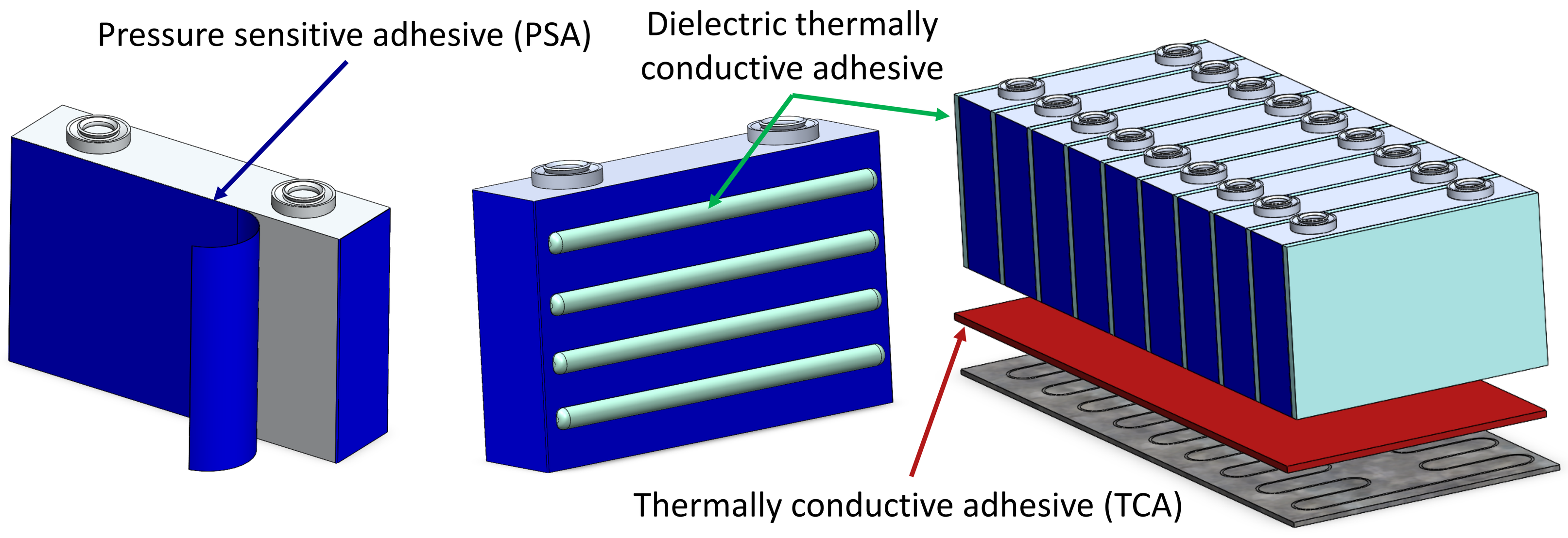

Figure 2 – Applications of adhesive bonding at the cell level

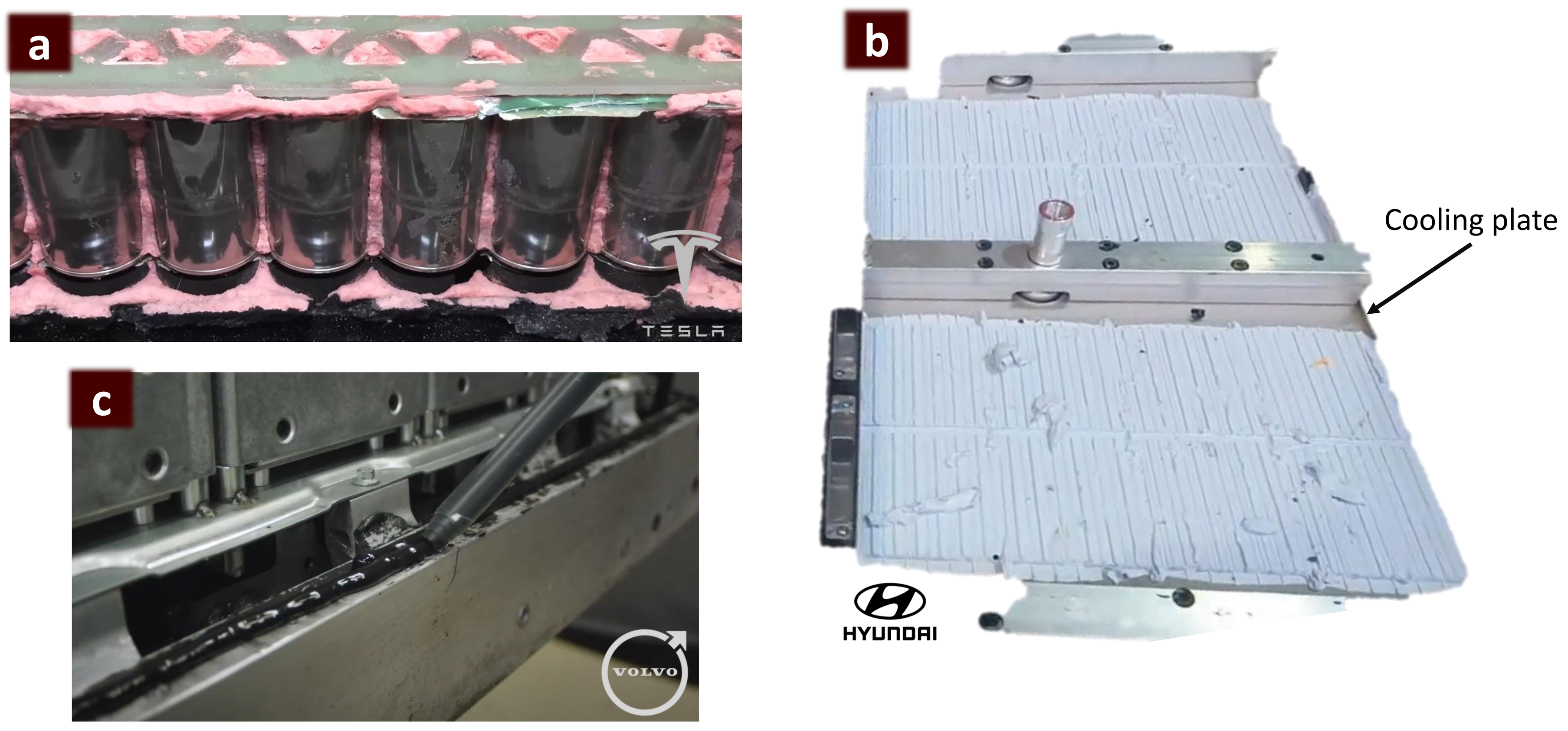

Figure 3 – Adhesive bonding in commercial energy storage systems: a) structural adhesive within Tesla 4680 LFP cylindrical cells; b) TCA in Hyundai IONIQ pouch cells bonding to cooling plate; c) lid enclosure using a 1k PU in Volvo XC40 Recharge

3. Debonding adhesive joints

Debonding on command of adhesively bonded joints requires an external trigger mechanism that modifies the joint behaviour. The six most reported stimuli types are listed in figure 4.

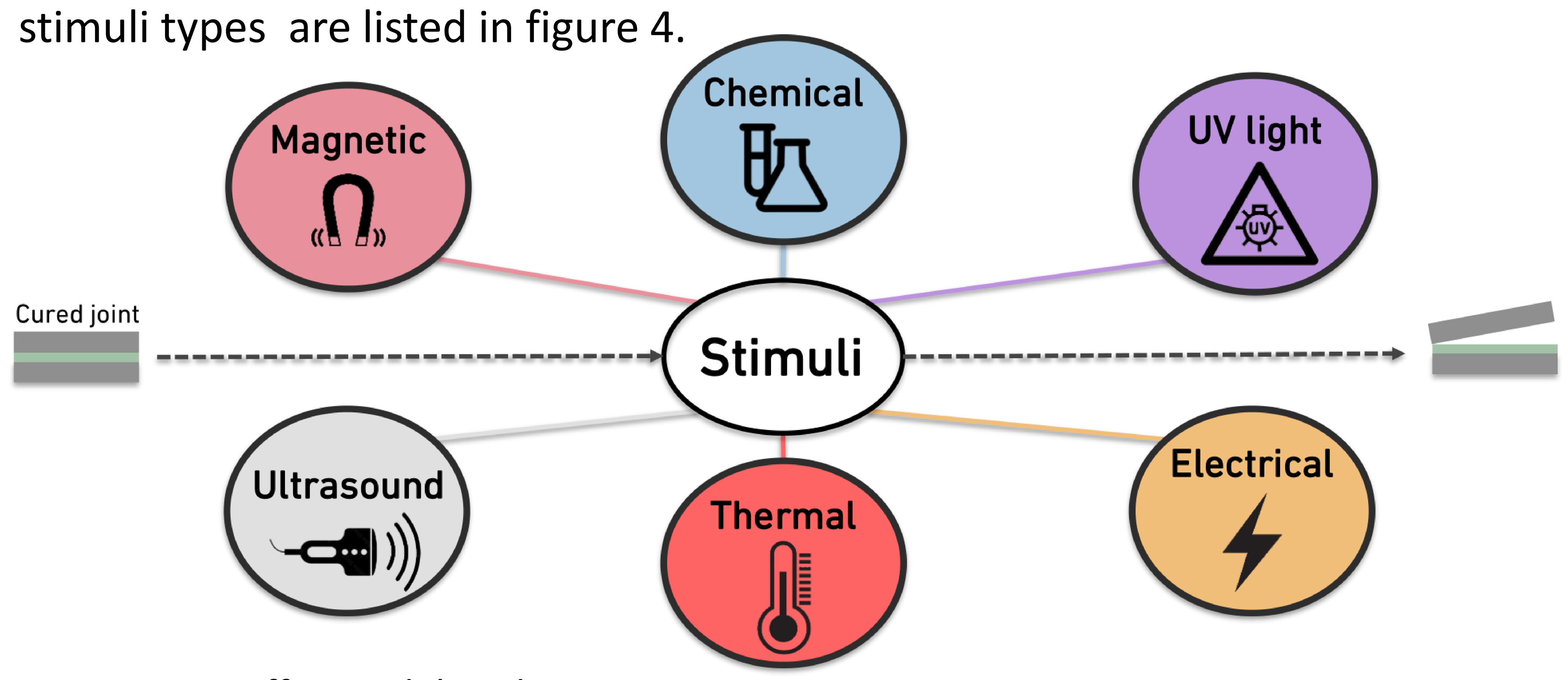

Figure 4 – Different debonding triggers

EV energy storage systems are a case study due to the limited DoD triggers that can be applied and the fact that the battery must only experience debonding triggers at the end-of-life. Thermal, electrical and magnetic stimulus are unsuitable due to the sensitivity of cell chemistry to temperatures above 65ºC and to the existence of electrically and magnetic components within the battery system. The opacity of battery components configures a barrier for UV light to irradiate photo-debondable solutions. Ultrasounds are a newer trigger but promising since the pack does not experience such stimuli during service life and does not interfere with electrical components. Chemical debonding demands a reaction with the adhesive or interface coating but is limited due to reagents incompatibilities and the possible release of toxic solvents [3].

4. Conclusions

- Adhesives are being used in EV storage systems to enhance mechanical strength and thermal properties, nonetheless battery serviceability and end-of-life oblige for adherend components debonding.
- The trend of DoD has been increasing reported in scientific papers, nonetheless its applicability to EV battery pack is still premature and commercial triggered adhesive solution are nonexistent.
- Its dependency on material chemistry is a barrier to rapid application since adhesives must be tuned to make them sensible to trigger mechanisms.

References

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[3] Mulcahy, K. R., Kilpatrick, A. F., Harper, G. D., Walton, A., & Abbott, A. P. (2022). Debondable adhesives and their use in recycling. Green Chemistry, 24(1), 36-61.

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