

An innovative and sustainable battery case design made from wood, steel and cork

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EXTENDED ABSTRACT

The global transition towards electro-mobility is a pivotal strategy in addressing climate change and reducing the environmental footprint of transportation. However, while electric vehicles (EVs) are widely recognised for their lower operational emissions compared to conventional vehicles, their production introduces new sustainability challenges, particularly regarding the sourcing and processing of materials. Currently, much attention is focused on the environmental and social impacts of raw materials used in EV batteries, such as lithium, cobalt, and nickel. However, sustainability concerns related to structural materials—those used throughout the vehicle, including the battery housing—are increasingly significant. These materials contribute substantially to the vehicle's overall carbon footprint and resource consumption.

Current state of the art battery housings are typically fabricated from high grade aluminium alloys like EN AW 6061-T4 [1]. While aluminium offers advantages in terms of weight reduction and crash safety, its production is energy-intensive and a major source of CO₂ emissions, contributing significantly to the environmental footprint of EVs. Further, these alloys are typically not recycled in a sorted fashion, resulting in lower aluminium qualities after the recycling process [2]. This down cycling does necessitate the need

for further primary aluminium production and therefore an increase in carbon emissions.

To address this issue, the preceding research project BioLIB! introduced a novel battery housing architecture that replaced aluminium structures with bio-based hybrid materials. Specifically, a wood-steel hybrid battery housing was proposed. The housing further incorporated a cork-based cell holder in order to substitute synthetic foams and resins. Overall the concept offered a significantly reduced environmental impact [3] while still satisfying critical safety requirements related to mechanical integrity [4], crash resistance and noise, vibration and harshness requirements [5].

Building on these findings, the research project SMADBatt (**S**ustainable **MA**-terials and **D**esign for electric vehicle **B**atteries), aims to further enhance both the sustainability and functionality of such hybrid battery housings.

The present aims to optimise both the ecological and economic performance of the battery housing by integrating secondary biobased materials. The proposed concept features a cell holder made from recycled cork material. Further, wood gathered by forest thinning, which is currently an underutilised resource and traditionally designated only for energy recovery through combustion, is explored as a structural filler to reinforce thin-walled steel profiles. This hybridisation is evaluated through three point bending experiments in order to assess the mechanical potential of secondary wood products for reinforcement purposes within a vehicle structure. The hybridisation strategy seeks to adopt low-value by-products for high-performance applications in the automotive sector, thereby increasing material circularity and reducing reliance on virgin resources.

Moreover, improved recyclability at the end-of-life is enabled through modular design and ease of disassembly of the battery housing. This is facilitated through detachable mechanical connections and advanced adhesive systems that can be separated or “triggered” to allow for clean disassembly of parts. Multiple triggered adhesives are assessed for their suitability for their mechanical properties as well as their trigger mechanism, such as thermal, UV, magnetic and solvent separated adhesives. This design-for-disassembly strategy supports future reuse, recycling, and recovery of both structural and electronic components, enabling circular economy.

In addition to structural design, this work addresses another key contributor to battery efficiency and longevity with an optimised thermal management system. Since batteries operate within narrow temperature ranges for optimal performance and longevity (15-35°C) [6], improved heat dissipation and

control are crucial. A combination of passive and active thermal management solutions is investigated through simulations for different thermal loads. This includes the novel utilisation of cork, as a cell holder material, which is also saturated with a Phase Change Material (PCM), which allows for function integration of two safety relevant properties. Mechanical impact can be mitigated through the cellular structure of the cork material, while short time temperature peaks, which can lead to lithium plating and accelerated aging of the battery [7], can be prevented by the inclusion of PCM. Further, the fire retardant properties of cork [8] are investigated in an approximated experiment which replicates the highly abrasive flames which occur in battery fires through spark emission.

The innovations proposed within the presented work are expected to deliver a battery housing that matches with conventional metal solutions in terms of safety, durability, and thermal performance, while dramatically lowering its environmental footprint. Preliminary results suggest that the incorporation of recycled and natural materials can lead to significant reductions in CO₂ emissions generated during the production processes. Additional benefits in end-of-life and potential cost savings through the utilisation of secondary materials are expected. The integration of sustainable materials, triggered disassembly, and thermo-functional optimisation into a battery housing exemplifies circularity in electromobility. In conclusion, the project contributes to the broader transformation of mobility systems by aligning vehicle design with environmental goals and circular resource use, paving the way for a more sustainable and climate-friendly future in transportation.

ACKNOWLEDGEMENTS

This research project receives funding from the, 'Mobilität 2023 - Kreislaufwirtschaft' program, a research, technology and innovation funding program of the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology of the Republic of Austria. The Austrian Research Promotion Agency (FFG) has been authorized for program management.

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