Alternatives to the use of per- and polyfluoroalkyl substances (PFAS) in the electrodes and electrolytes of lithium-ion batteries (LIBs)

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Introduction

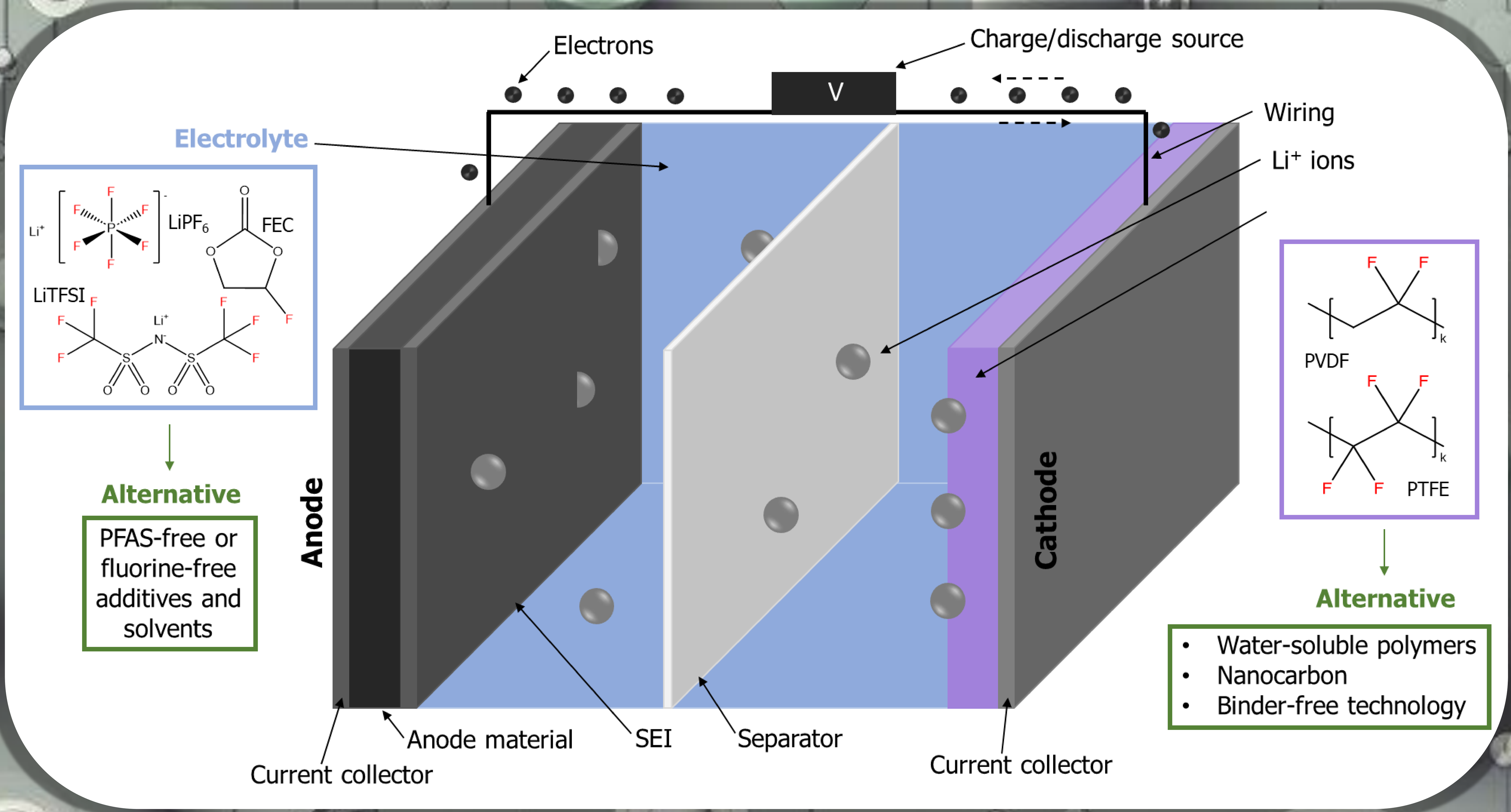
The battery industry is confronted with the task of replacing PFAS prompted by a proposed restriction. Their arguments against the proposal are:[1,2]

1) PFAS are essential for realizing the objectives of the Green Deal.
2) They serve crucial functions in society owing to their diverse applications.
3) The PFAS restriction proposal is an obstacle for innovation and economic growth.

The industry claims that viable alternatives to PFAS in LIBs are currently lacking.[1-4] This study aimed to evaluate this claim by reviewing scientific literature and consulting experts from both industry and academia. The focus was on materials for the electrode (cathode) and electrolyte of LIBs, which account for the crucial uses of PFAS in LIBs.

Conclusion

The battery industry faces regulatory pressure to find alternatives to PFAS. While potential alternatives exist, widespread adoption may impact LIB performance in certain applications. Balancing battery performance with material sustainability is complex and requires input from various experts. While innovation in green energy is crucial, caution is needed to avoid problem shifting. The PFAS restriction presents an opportunity for the European battery industry to lead in sustainable energy storage. Additionally, developing efficient recycling processes is vital to ensure sustainability and minimize environmental impacts in the future.



Electrode

= Cathode: Li^+ ions move from the anode to the cathode during discharge, storing the ions within the cathode material. During charging they return to the anode. The cathode is made of active materials such as lithium metal oxide.

PFAS are used as binder
Function of binder: binds the active material and makes it adhere to the current collector
Commonly used: polymers such as PVDF, PTFE because of their chemical inertness, high thermal stability and strong adhesive properties
Potential alternatives: water-soluble fluorine-free polymeric binders, nanocarbon, binder-free material

Electrolyte

= Medium in which Li^+ ions move between the electrodes, and is composed of a salt and (organic) solvent.

PFAS are used as electrolyte additives
Function of additive: enhances the properties of the electrolyte (i.e. improved cycling performance) and provides a safe application (i.e. they are thermally more stable and non-flammable)
Commonly used: for salts e.g. LiTFSI; for solvents e.g. FEC (not a PFAS)
Potential alternatives: trend towards fluorine-free additives

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References
1 Advanced Rechargeable & Lithium Batteries Association RECHARGE, Application for derogations from PFAS REACH restriction for specific uses in batteries, https://rechargebatteries.org/wp-content/uploads/2023/06/RECHARGE-FIRST-submission_.pdf, (accessed 25 April 2024).
2 Advanced Rechargeable & Lithium Batteries Association RECHARGE, Leaflet on the PFAS restriction proposal, https://rechargebatteries.org/wp-content/uploads/2024/02/DEF_2024_PFAS_Leaflet_630x297_digital_240223.pdf, (accessed 25 April 2024).
3 European Chemicals Agency, *Annex XV Restriction report for the restriction on the manufacture, placing on the market and use of PFASs.*, 2023.
4 ZVEI, FACTSHEET "PFAS IN BATTERIES", https://www.zvei.org/fileadmin/user_upload/Themen/Nachhaltigkeit_Umwelt/PFAS/12-ZVEI-PFAS-Factsheet-Batteries.pdf, (accessed 01 May 2024).