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Factsheet "PFAS in Batteries”


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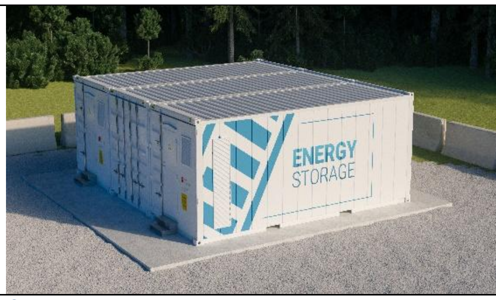

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Product(s):

- Batteries are used to store electric energy and provide it to power electric appliances. They are produced in many different forms and sizes for a wide range of applications. These include general public applications such as smartphones, power tools, hearing aids, energy storage systems (ESS), defibrillators and safety lighting, as well as industrial applications such as back-up power, industrial trucks, wireless automation and asset tracking. Rechargeable lithium batteries in particular have become critical to the transition towards low-emission mobility (used to power electric vehicles and e-bikes) and electrical storage of renewable energy.

Market Information:

- Due to their use in electric vehicles and for energy storage, rechargeable lithium-ion batteries constitute by far the largest group of batteries in the market. The European lithium-ion battery market alone was valued at around 5 billion € in 2020 and is expected to grow by about 25 % per year, reaching between 40 and 50 billion € by 2030. A high number of new production plants for this kind of batteries is currently being built or planned in the EU, to become less dependent on imports, especially from Asia. These new sites alone represent over 56 billion € of investment and are expected to generate more than 100,000 additional jobs.
- Modern Lithium-ion batteries produced in GWh-scale as well as other kinds of batteries currently fully rely on the use of PFAS in certain components to achieve the needed performance and durability.
- The current use of PFAS is therefore a key factor in achieving the goals of the EU Green Deal, which would not work with less efficient and durable batteries, since more batteries and thus more energy and materials for their production would be needed for the same tasks.

Requirements Profile

- Requirements regarding the lifetimes of rechargeable batteries have constantly increased in recent years, which is a key factor for reducing the resources for their production. For example, lifetimes of at least 10 years are achieved for electric vehicle (EV) batteries. In addition, the “second use” of such batteries stationary electric energy storage is intended according to the EU Green Deal and the new EU battery regulation. Thanks to the use of PFAS, some kinds of batteries achieve lifetimes of up to 25 years, such as primary lithium batteries for industrial applications.
- With few exceptions, PFAS used in batteries belong to the group of fluoropolymers, which are non-toxic and much less harmful for the environment compared to other groups of PFAS. Fluoropolymers provide a unique combination of properties that are essential for the high performance, durability and safety of state-of-the-art batteries. Details about these properties are given in the chapter “PFAS uses in batteries”.

PFAS Uses in Batteries

1. Cathode binder

The cathode is connected to the plus pole of the battery. The binder material is used to hold the active material particles together within the electrode and to provide a strong connection between the electrode and the current collector.

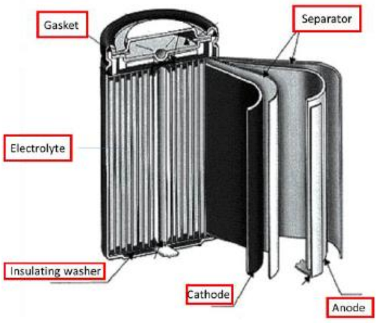
PFAS substance/substance group:

The fluoropolymers PTFE (polytetrafluroethylene) and PVDF (polyvinylidine difluoride) are used as binders in rechargeable and non-rechargeable lithium batteries as well as Ni-based rechargeable batteries and zinc-air batteries. They are also expected to be needed for efficient new-generation batteries such as lithium-based solid-state batteries and Na-ion batteries.

Reason for PFAS Use/ Requirements Profile:

PFAS binder materials provide a unique combination of properties that are essential for the manufacturing process as well as the performance, durability and safety of the batteries:

- Chemical and electrochemical stability (for high durability)
- For most Li-Ion chemistries a chemical stability is required above 4V vs. Li/Li+
- Good dispersion properties (for production process)
- Good adhesive properties on common current collector materials
- Suitable mechanical properties (high toughness + certain flexibility)
- Thermal stability (for production process + for save use)
- Unique fibrillation properties (small amounts needed)



Typical design of a high-power cell (Figure 1(c) of Arora, P., Zhang, Z. (John), Chem. Rev. 2004, 104(10), 4419–4462)

2. Electrolyte salts and additives

Lithium-ion batteries and some lithium primary batteries employ lithium salts dissolved in organic solvents as electrolytes. Electrolytes need to be stable and provide good lithium-ion transport.

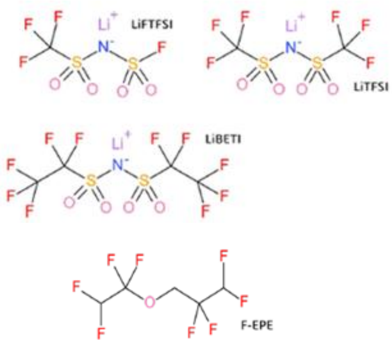
PFAS substance/substance group:

- Lithium salts with PFAS anions such as Li-triflate, LiTFSI and LiBETI
- PFAS additives in the electrolyte such as F-EPE

Reason for PFAS Use/ Requirements Profile:

Especially Li-triflate is used as lithium salt in the Li-MnO_2 electrochemical system, which is widely used in coin cells and cylindrical consumer cells such as CR2 and CR123A as well as for industrial applications. It has replaced lithium perchlorate, which acts as endocrine disruptor in the environment and can be explosive in its dry state.

In rechargeable lithium-ion batteries, while $LiPF_6$ is still commonly used as lithium salt, PFAS salts and additives have the potential to increase the performance, durability and safety.



Examples for PFAS lithium salts and electrolyte additives

3. Valves, gaskets, washers, membranes, separator coatings

These components are important for the tightness of the cells and the insulation between polarities inside the cells. While non-PFAS materials are common, certain batteries and applications require the use of PFAS.

PFAS substance/substance group:

- PTFE, FEP (fluorinated ethylene propylene), FKM (fluorine rubber materials) and others for valves, gasket, washers and membranes
- PVDF as binders in ceramic separator coatings

Reason for PFAS Use/ Requirements Profile:

- Chemical stability against chemically aggressive electrochemical systems, such as lithium thionyl chloride (most common primary lithium system for industrial applications with very long lifetimes)
- Increased safety due to the higher stability and durability of PFAS for critical applications such as aviation and explosive atmospheres
- Unique hydrophobic and permeability properties of PTFE for membranes of zinc-air batteries (used in hearing aids)
- Unique properties as very thin high performance gaskets needed for high performance rechargeable lithium batteries

Substitution

- Contrary to what is stated in the UPFAS dossier, solid-state lithium batteries and lead based batteries are not potential non-PFAS alternatives to current lithium-ion batteries. It is expected that solid-state lithium batteries will still require the use of PVDF or PTFE as binder in the active material layers and possibly also in the solid or gel polymer electrolytes. Although lead based batteries do not require PFAS as binders, they use PFAS containing valves and membranes. The performance and durability characteristics of lead based batteries are specific for their current applications, which are different from those of lithium-based batteries.
- Although there are numerous scientific publications on replacing PFAS materials as cathode binders, all the data obtained so far show that there are currently no alternatives that come even close to PFAS regarding the resulting performance and durability of the batteries. First PFAS-free lithium-ion batteries are available in the market, but there are no reports about their use in relevant demanding high-volume applications or their durability compared to PFAS containing lithium-ion batteries in general. In particular, the ability to process PVDF and PTFE based cathode formulations in scaled mass production is a significant achievement that has not yet been demonstrated for alternative materials.
- In principle, feasible alternative materials may exist for use in valves, gaskets, washers, membranes, separator coatings, however, they may not be applicable in all kinds of batteries and applications.
- Even after suitable alternatives for PFAS are identified, development times for batteries can be very long (up to 5 years depending on the application). This is often due to long times needed for qualification and certification, especially for safety-sensitive applications such as electric vehicles, explosion protection, and aviation. In addition, safety issues are also relevant for consumer products such as power tools.

Safe Use: Emissions and Exposure

- No unintended or uncontrolled emissions of PFAS during the battery manufacturing process. PFAS-containing waste generated during manufacturing is 100 % collected and disposed of according to applicable regulations.
- No PFAS emissions during normal use of the battery, since PFAS are only used in sealed battery types.
- Pyrometallurgical recycling processes for collected waste batteries convert all the fluorine contained in PFAS into hydrofluoric acid, which is removed from the flue gas by scrubbers and can be further converted into fluoride salts.
- The recycling of waste batteries by hydrometallurgical processes, which enable a somewhat higher overall recycling efficiency, has reportedly led to some PFAS emissions. This is probably due to the fact that these processes sometimes include a thermal pre-treatment step carried out at around 600 °C, which leads to the decomposition of fluoropolymers, but may partly convert them into monomolecular PFAS instead of fully mineralizing them. Such processes need to be optimized, either by extracting the fluoropolymers before heat treatment without decomposing them for their further use, or by performing the pre-treatment at a higher temperature.
- It has been demonstrated in a study at Karlsruhe Institute of Technology (KIT) that it is possible to fully mineralize fluoropolymers at 860 °C, which is a temperature that is typically achieved in municipal waste incinerators (Gehrmann et al., Chemosphere 365 (2024) 143403). Thereby, even batteries that are not separately collected and end up in municipal waste would not be considered to cause PFAS emissions at their end of life. It should be noted that this is an ongoing study and further results and publications on this important topic are expected.
- Regarding the fluoropolymers that are supplied to the battery industry, production processes that use non-PFAS polymerization aids have been developed and are already used by some suppliers (https://www.kunststoffindustrie-online.de/produktion/fluorpolymere-polymerisation-mit-fluorfreien-emulgatoren-jetzt-moeglich). Thereby, it will be possible in the future to fully avoid any PFAS emissions already during production of the fluoropolymers.

Socio-economic Impact

Consequences of the Proposed Restriction

- A complete PFAS restriction without derogations and transition periods for batteries, and without review clauses, will limit the Green Deal and prevent Europe from achieving a net zero economy by 2050.
- The competitiveness of cell production sites operating in Europe will be reduced, therefore investments in new sites will be stopped.

- Sales of second-hand electric vehicles and new electric vehicles from outside Europe will be stopped.
- Growth of renewable energies will be inhibited due to lack of efficient batteries for storage.
- Some safety and even live-saving equipment powered by primary and rechargeable lithium batteries will not be available any more or become less reliable.
- Lack of efficient portable batteries will stop Europe from achieving objectives of digitalization.

Required Transition Period and/or Derogations

- Due to the importance of batteries for society, the importance of PFAS for the performance, durability and safety, and the lack of alternative materials, ZVEI suggests a general derogation period of at least 13.5 years for PFAS in batteries.
- On top of that, downstream industries such as manufacturers of equipment powered by batteries will need further 2-3 years for testing and adapting of PFAS-free batteries in their products.
- Finally, we would like to stress the need for a review of the derogation periods and the possibility of extending them in case that potential alternatives still have not been found after a certain time.

Our sector offers:

- The battery industry is stepping up research and development towards PFAS-free batteries. The industry has been investigating and assessing alternative, VOC-free processes and PFAS-free binders for many years, accumulating a wealth of experience that can be leveraged. If suitable alternatives to PFAS with comparable properties are available, the battery industry is dedicated to adopting them.

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