Input to the Public Consultation regarding the proposed REACH restriction on PFAS substances and its impact on sodium-ion battery cells

Substance: Per- and polyfluoroalkyl substances (PFAS)

From: [redacted]

Use: In Sodium (Na)-ion rechargeable battery cells

Contents

Abbreviations

ESS	Energy Storage System
EV	Electric vehicle
LMO	Layered metal oxide
Na-ion	Sodium-ion
NMC	Cobalt Lithium Manganese Nickel Oxide
PBA	Prussian Blue Analogue
PFAS	Per- and Polyfluoroalkyl Substances
PTFE	Polytetrafluoroethylene
PVDF	Polyvinylidene Fluoride

1. Executive summary

Sodium-ion is an emerging sustainable battery technology for some applications. The Prussian Blue Analogue (PBA) chemistry can be produced without PFAS substances (as a prototype, unclear if it is possible in industrial scale), whereas sodium layered metal oxide (LMO) is dependent on PFAS substances in the same way as Lithium-ion batteries because LMO uses the same manufacturing technology as Lithium-ion.

[redacted] has requested [redacted] years of derogation time for Li-ion rechargeable batteries to enable substitution of PFAS.[1] However, Sodium-ion rechargeable batteries are still in the development phase and only have small scale production facilities. Therefore, it is expected that the substitution of PFAS would be faster. However, for mechanical parts such as gasket and production material where PFAS based materials are required, a longer derogation time of [redacted] years will be needed. For sodium-ion rechargeable batteries of the layered metal oxide type [redacted] years of derogation will be needed.

2. Overview of Sodium-ion battery products and their value chain

2.1. General overview of the Sodium-ion battery market

PBA type sodium- ion rechargeable batteries are currently a more sustainable alternative for energy storage system applied batteries compared to the state of the lithium-ion rechargeable batteries and partly also lead acid batteries[2]. This type of sodium ion batteries can replace lithium-ion batteries in this segment.

Layered Metal oxide (LMO) sodium ion rechargeable batteries are mainly planned to be used in electric cars and micro mobility applications as a more economical and less resource intense alternative at the cost of lower energy density and performance.

Currently the exact chemistry of the sodium ion technology is not set. For this reason recycling processes are just under development.

Sodium-ion cells have recently emerged as an early stage sustainable battery technology showing promise for specific applications due to sodium-ion cells offering significantly lower

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[1] Reference to [redacted] earlier submission on Li-ion, [redacted]

[2] Peters, Jens, et al. "Life cycle assessment of sodium-ion batteries." *Energy & Environmental Science* 9.5 (2016): 1744-1751; Tapia-Ruiz, Nuria, et al. "2021 Roadmap for sodium-ion batteries." *Journal of Physics: Energy* 3.3 (2021): 031503

energy densities than NMC-based Lithium-ion batteries[3i]. The sodium-ion characteristics of low energy density combined with low cost, makes them suitable for ESS and short-range mobility applications (where the lower cost is more important than energy density), but they are not able to meet the high driving range demands of most Western EVs in the same way as NMC-based cells can and are thus not able to substitute the latter.

Sodium ion rechargeable batteries are not industrialized yet but aim to complement Lithium-ion rechargeable batteries by offering significantly lower cost for less energy density. Sodium ion shows a first product market fit for stationary energy storage and light-weight or short-range mobility where the lower cost is more important than energy density.

Sodium-ion rechargeable batteries are grouped into two different cathode types, namely Prussian Blue analogues (PBA) and sodium layered metal oxide (LMO). Other cathode using sodium such as polyanionic cathodes exist but did not yet create commercial traction. All cathode types have in common that they use sodium as the ion transporting charge between cathode and anode.

Batteries using LMO cathodes share a lot of similarities with conventional Lithium-ion batteries and stand out with their compatibility with existing cathode and cell manufacturing setups, allowing for a faster market introduction. The benefit of using a similar product design and production process also means that LMO-based sodium ion batteries rely on PFAS-based components as much as Lithium-ion batteries, meaning switching to **LMO-based sodium-ion batteries does not suppress the need of PVDF and other PFAS-based components**.

The electrode of batteries using PBA cathodes on the other hand can be designed without PFAS-based components, since the electrode can be produced using water, carboxymethyl cellulose, styrene-butadiene rubber and carbon. However, PBA-based batteries are very hygroscopic and can't be produced without adjusting the commonly known battery production process. PBA-based batteries are currently in product development and are expected to come to market shortly after LMO-based sodium-ion batteries due to said manufacturing difficulties. Once commercialized several years from now, **PBA based sodium-ion batteries are expected not to use PFAS-based components in their electrode**.

2.2. [redacted] role in Sodium-ion battery market

[redacted][4] is a European company with a vision to facilitate the shift towards a sustainable, low-carbon future. [redacted]

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[3] Delmas, Claude. "Sodium and sodium-ion batteries: 50 years of research." Advanced Energy Materials 8.17 (2018): 1703137; Yabuuchi, Naoaki, et al. "Research development on sodium-ion batteries." Chemical reviews 114.23 (2014): 11636-11682; Hwang, Jang-Yeon, Seung-Taek Myung, and Yang-Kook Sun. "Sodium-ion batteries: present and future." Chemical Society Reviews 46.12 (2017): 3529-3614; Sawicki, Monica, and Leon L. Shaw. "Advances and challenges of sodium ion batteries as post lithium ion batteries." RSC Advances 5.65 (2015): 53129-53154

[4] Section 2.2. in [redacted] input to the PFAS public consultation, see submission [redacted]

3. Use of PFAS in Sodium-ion rechargeable batteries

3.1. Market trends and developments

Reference to [redacted] submission, number [redacted].

3.2. Policy trends

Reference to [redacted] submission, number [redacted].

4. Analysis of alternatives

4.1. Aim, scope and methodology

This section provides a closer look at the **use, function, and requirements** of PFAS-based sodium-ion battery cells and systems. It outlines the **available alternatives** and the technical obstacles that prevent substitution, before exploring the challenges related to the development process of **new substances**. The analysis of alternatives concludes that today **there are no appropriate chemical alternatives** that could substitute PFAS applications in sodium-ion battery cells (LMO) and systems.

4.2. Function and technical performance of PFAS vs non-PFAS alternatives in Sodium-ion batteries and systems

Reference to [redacted] submission, number [redacted].

4.2.1. PVDF in the cathode electrode

Reference to [redacted] submission, number [redacted].

4.2.2. PFAS in cell applications – gaskets, seal gaskets, and other parts

Reference to [redacted] submission, number [redacted].

4.2.3. PTFE in the battery manufacturing and recycling equipment and in spare parts

Reference to [redacted] submission, number [redacted].

4.3. Assessment of potential alternative battery technologies

Reference to [redacted] submission, number [redacted].

4.4. Redesign process and timing

Reference to [redacted] submission, number [redacted].

4.5. Safety considerations

Reference to [redacted] submission, number [redacted].

4.6. Overall conclusion on suitability and availability of alternatives

Reference to [redacted] submission, number [redacted].