NATIONALER WASSERSTOFFRAT

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Effects of the ban on perfluorinated and polyfluorinated chemicals (PFAS)

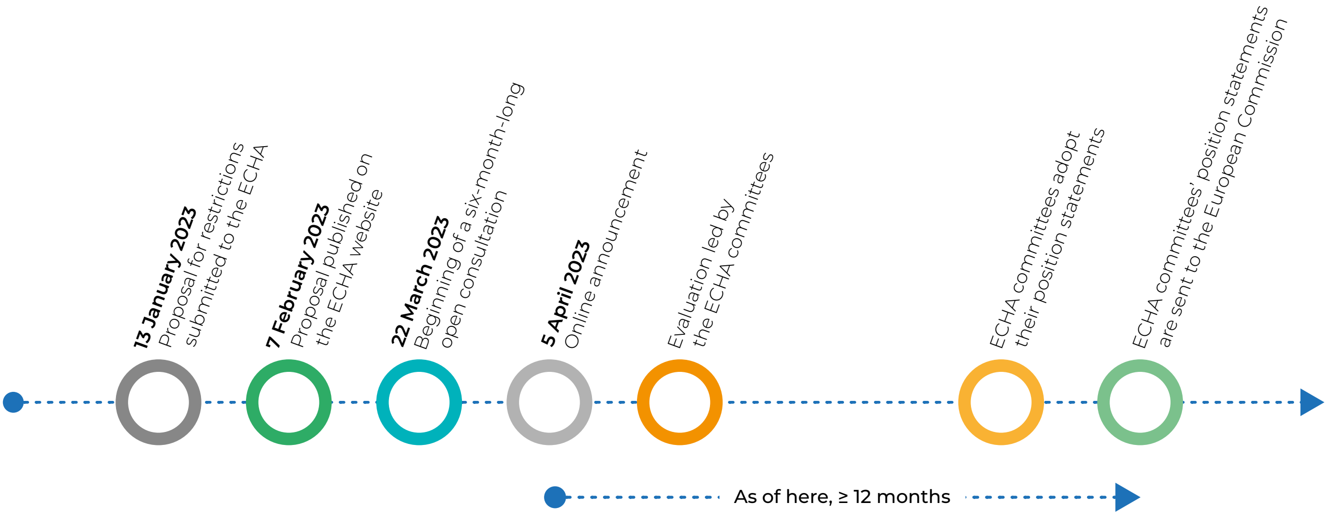
1 INTRODUCTION

Per- and polyfluoroalkyl substances (PFAS) are a large class of thousands of synthetic industrial chemicals that have been produced since the late 1940s and are widely used in society. There are currently about 4,700 known compounds that belong to this group of substances. PFAS are organic compounds which, from a chemical perspective, consist of carbon chains of different lengths in which the hydrogen atoms attached to the carbon are completely (perfluorinated) or partially (polyfluorinated) replaced by fluorine atoms. Carbon-fluorine bonds are among the strongest chemical bonds in organic chemistry. With their unique physicochemical properties, these special plastics are virtually chemically inert, non-wetting, non-adhesive and extremely resistant to temperature, fire and weathering. However, these properties also mean that they are difficult to degrade both as they are being used and in the environment; and if they continue to be released, they accumulate in the environment, drinking water and food.

The European Union is therefore planning a comprehensive REACH (Registration, Evaluation, Authorisation of Chemicals) restriction process, which is intended to ban the production and use of PFAS within the EU as well as ban them from being placed on the European market.

'The national authorities of Denmark, Germany, the Netherlands, Norway and Sweden submitted a proposal to the ECHA (European Chemical Agency) on 13 January 2023 to restrict per- and polyfluoroalkyl substances (PFAS) under REACH, the European Union's (EU) chemicals regulation' [https://echa.europa.eu/de/-/echa-receives-pfass-restriction-proposal-from-five-national-authorities]. In the subsequent process, the ECHA's scientific committees for Risk Assessment (RAC) and for Socio-Economic Analysis (SEAC) will check whether the proposed restriction meets the legal requirements of REACH in their meetings in March 2023. The committees will then perform a scientific evaluation of the proposal, and a six-month consultation period will follow. In the course of this consultation period, it is planned to organise an online briefing session for 5 April 2023 in order to explain the restriction process and help those who wish to participate in the consultation. The RAC and SEAC normally prepare their position statements within 12 months after the scientific evaluation has started and in accordance with the REACH regulation. However, the committees may need more time to finalise their assessments, given the complexity of the proposal and the amount of information expected in the course of the consultation. As soon as the opinions are adopted, they are forwarded to the European Commission, which then makes a decision about a possible restriction together with the EU Member States.

Figure 1: Timeline of the regulation process with professional assessment



These planned restrictions and the associated potential exemptions or bans are, however, essential for some applications and for the substances from the PFAS material class used for them, as they are currently not interchangeable in their areas of application. These applications include future technologies such as electrolysers, fuel cells, lithium-ion batteries and their corresponding components, which play a significant role both for the German climate targets and for the EU's 'Fit for 55' package.

2 PFASS IN ELECTROLYSERS, FUEL CELLS AND LITHIUM-ION BATTERIES

PFASs are used in various key components of fuel cells and electrolytic cells. These include things such as the proton exchange membrane, which is made of the polymer perfluorosulfonic acid these days (perfluorosulfonic acid is ONE representative of the PFAS group of substances). PFSA is the proton-conducting material in the fuel cell membrane and the electrolyte membrane and enables the transport of protons with simultaneous spatial separation of hydrogen and oxygen or their partial reactions. The proton-conducting polymer membrane is an essential core component and therefore absolutely necessary for polymer electrolyte membrane fuel cells and for electrolytic cells. There are currently no technically mature alternatives for these key components, as only PFSA ionomers have reached the level of technological maturity (for example, in proton exchange membranes) needed for these functions in the demanding environments in which fuel cells or electrolysers are found. Alternative materials based on non-fluorinated hydrocarbon polymers are at an early stage of development and cannot be qualified for commercial use because various technical parameters do not reach those of PFSA materials.

Fuel cells play an important role in emission-free driving. It is estimated that with a successful market launch, about 200,000 fuel cell vehicles (with 200 kW) would be on the global market by 2030. Assuming a membrane area of roughly 16 m^2 per vehicle, about 128 t of PFSA materials would be needed to produce the proton exchange membranes. For an extreme scenario with one million vehicles, the figure would be 640 t. This value represents only the membrane, but does not yet include the proportions of additional PFAS materials in necessary components such as seals.

In terms of membrane area, an annual expansion of electrolysis capacities up to 2030 totalling ten GW per year would require about 40 tonnes per year of PFSA materials. In an extreme scenario in which these capacities total 40 GW per year, the requirement would be 160 tonnes per year.

PFASs are used to do things such as seal the chambers within a fuel cell stack. Chemical and thermal stability are particularly important in this context. In gas diffusion layers, fluorinated polymers that can withstand the acidic conditions near the catalyst or membrane of a fuel or electrolytic cell are needed as electrochemically stable bonding agents and for surface functionalisation (hydrophobic/hydrophilic). The superior chemical and electrochemical stability of fluorinated polymers under various conditions in a fuel or electrolytic cell is of particular importance here and cannot be replaced in the foreseeable future. It should be noted that membrane electrode assemblies are refurbished at the end of their service life in order to recover rare precious metals, especially iridium. That being said, in the future, it will also be possible to recover the membrane polymer, which will relieve the new material balance. Dumping waste in landfills will almost never occur in these applications. It must be added that the special properties of fluorinated polymers are not only limited to application in fuel and electrolysis, but rather are used in an extremely wide variety of areas today, such as in high-performance seals (FKM, PTFE), as container linings in the chemical equipment manufacturing sector, in functional textiles and also as functional membranes in chlor-alkali electrolysis, to name just a few.

There are currently two main applications for PFAS materials in modern rechargeable lithium-ion batteries. For one, they are used as binders for coating the cathode with active materials such as metal oxides, for which mainly polyvinylidene fluoride (PVdF) is used. The second significant application is fluorinated organic additives in the electrolyte, or the electrolyte (salt and solution) itself. The lithium salt LiPF6 is used almost exclusively due to its high ionic conductivity and its property of being able to prevent aluminium current collectors from corroding. Other salts such as lithium bis(trifluoromethylsulfonyl)amide (LiTFSI) or lithium bis(fluorosulfonyl)imide (LiFSI) are either used as the main component of the electrolyte or can also be used as additives. While the electrolyte accounts for five to ten per cent of the weight of a Li-ion battery, additives are only added to the electrolyte in the low single-digit percentage range. Figures from the manufacturer Hunan Fluopont New Materials Co. (China) show production capacities of 1,200 tonnes per year (as of 2022) for LiFSI alone. In order to meet the increasing market demand, the production capacity for 2025 should reach 12,000 tonnes per year.

3 RECOMMENDATION

PFAS are still indispensable in many applications in our modern world, such as in energy and hydrogen-related applications, and therefore belong to the ‘essential uses’ category. For a number of applications, especially electrolysers, fuel cells and lithium-ion batteries, the hopes are high that they will contribute to a more sustainable, green energy supply. Exemptions in accordance with the Montreal Protocol must therefore be made for the components needed to build these technologies until corresponding affordable, environmentally friendly alternatives are available.

In addition, research in general, especially in the area of alternative materials for PFSA ionomers, as well as materials research into necessary components for fuel cells and electrolysers, must be significantly intensified.

At the same time, intensive research on water-based, fluorine-free binders for Li-ion batteries should continue.

If you are interested in finding out more or have any questions, please contact:
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NATIONALER WASSERSTOFFRAT

THE GERMAN NATIONAL HYDROGEN COUNCIL

On 10 June 2020, the German Federal Government adopted the National Hydrogen Strategy and appointed the German National Hydrogen Council. The Council consists of 26 high-ranking experts in the fields of economy, science and civil society. These experts are not part of public administration. The members of the National Hydrogen Council are experts in the fields of production, research and innovation, industrial decarbonisation, transportation and buildings/heating, infrastructure, international partnerships as well as climate and sustainability. The National Hydrogen Council is chaired by former Parliamentary State Secretary Katherina Reiche.

The task of the National Hydrogen Council is to advise and support the State Secretary's Committee for Hydrogen with proposals and recommendations for action in the implementation and further development of Germany's National Hydrogen Strategy.

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