To
ECHA

Place: Oslo, Norway
Date: 25.09.23

Input to ECHA public consultation on the universal PFAS restriction proposal

Norwegian Hydrogen Forum refers to the consultation on the universal PFAS restriction proposal published 22.03.23. NHF appreciates the opportunity to give feedback to ECHA and we hope our input will be considered as useful.

Norwegian Hydrogen Forum (NHF) is a national non-profit member organization, which promotes the advantages of hydrogen and ammonia as energy carriers. Our members span the whole hydrogen value chain, from production to end-use, including industry, public authorities and academia. We are actively promoting our members' interests towards public authorities and decision makers, to contribute to improved regulatory framework conditions and strong financial support schemes. NHF also disseminate key information in Norway on hydrogen and ammonia research and technology commercialization, market trends and international policy making. NHF is a member of Hydrogen Europe and supports their formal position on the topic.

Main take aways

- Hydrogen is essential if we are to reach the climate targets, and a ban of PFAS would jeopardize the highly important work that the EU and Norway are doing to reach the climate goals in the Paris agreement.
- Fluoropolymers are used in electrolysers, fuel cells and other crucial technologies throughout the hydrogen value chain.
- There are no alternatives available on the market today or in the foreseeable future.
- The PFAS types used in the hydrogen industry are by the OECD criteria to be defined as ‘polymers of low concern’ (PLC) and verifiably do not pose a risk to human health or the environment.
- Fuel cells and electrolyser manufacturers and their suppliers should be exempted from the proposed fluoropolymer ban.
- EU and Norway should intensify the research on alternatives for PFAS in hydrogen technology so that PFAS can be replaced as soon as possible.

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Hydrogen is essential to reach the climate goals

Hydrogen produced by using electrolysers and renewable energy is considered a zero-emission energy carrier. Hydrogen is one of the key pillars to decarbonise the global energy system and hard to abate sectors.[1]

The new EU Chemicals Strategy for Sustainability set in 2020 out the plan to bring the European Union's framework on chemical regulation in line with the increased targets of the Green Deal. Since then, geopolitical and climate-related developments have accelerated this ambition further, raising the goals through Fit for 55 and REPowerEU. To achieve the European ambition of 20 million tonnes of hydrogen consumption by the end of the decade, and to meet Green Deal objectives and replace Russian gas as soon as possible, the European hydrogen industry must reach an annual manufacturing capacity of 25 GW of electrolyser by 2025. This target is endorsed by the Electrolyser Partnership to reach 10 million tonnes of hydrogen produced in Europe, corresponding to 100 GW of electrolysis capacity by 2030.

According to a report made by MENON in 2022[2], the hydrogen industry in Norway will by 2030 have 83 billion NOK (roughly €7,2 billion) in revenue with 5 800 people employed. On a European scale, the hydrogen industry, including only electrolysers and fuel cells, is estimated to sustain up to 200 000 direct jobs and 260 000 indirect within 10 years in a market with a potential value of €820 billion, employing 5.4 million jobs by the middle of the century.[3]

Use of PFAS in the hydrogen sector

Fluoropolymers, considered a PFAS subtype, are used in the hydrogen value chain to manufacture proton exchange membranes (PEM) electrolysers, alkaline electrolysers, and fuel cells, as binder materials in the electrodes, both anode and cathode, and as a component of the gas diffusion layers (GDLs). Moreover, fluoropolymers are used for gaskets and sealings in most electrolyser and fuel cell types, and in parts of the transport and distribution system in valves.

<u>Electrolysers:</u>
There are different types of electrolysers on the market, but the two most known types are PEM and Alkaline. For the Alkaline electrolyser, the PFAS ban will have a direct impact on the system level, while the PEM electrolyser will be affected directly on a stack level.

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[1] https://www.iea.org/energy-system/low-emission-fuels/hydrogen
[2] Winje et.al (2022) «*Verdien av den norske hydrogennæringen*» Retrieved on: https://www.menon.no/wp-content/uploads/2022-134-Verdien-av-den-norske-hydrogennaeringen-1.pdf
[3] Hydrogen Europe Position Paper on PFAS (2023), retrieved on: https://hydrogeneurope.eu/wp-content/uploads/2023/02/Hydrogen-Europe-position-paper-on-PFAS-ban_v12_FINAL.pdf

The membrane is an essential component of the membrane electrodes assemblies (MEA) for both the fuel cells and electrolysers. The membrane has three roles, (1) to isolate the electrodes from each other electrically and to prevent a short circuit, (2) to act as electrolyte and conduct protons from anode to cathode, and (3) to provide a mechanical barrier to the MEA, especially to make sure oxygen and hydrogen stays separated. Materials containing ionomers that carry sulfonic acid groups (SO_3H) provides the best association of conductivity, chemical stability and mechanical strength. These are most commonly reinforced by PTFE such as Nafion®, Forblue® S, Aquivion®, 3M Corporation ionomers.[4] According to the global electrolyser company Nel, the most irreplicable PFAS in their PEM cell stacks is the Nafion and there is no viable alternative.

PFAS is also used in the electrodes (anode and cathode). These are attached to the membrane, and depending on the type of membrane, contain a certain type and amount ionomers. It enables an ionic connection between membrane and active catalyst sites, which is necessary for the overall function of the electrolyser or fuel cell. Another essential characteristic of perfluoropolymers that is essential for a high performance, is the property of high oxygen permeability to keep the catalyst particles accessible for reactant gases.

In several applications within the hydrogen industry, PTFE is also used as a coating material to protect surfaces and structures from harsh processing conditions. Fluoropolymers are for instance used in Alkaline Electrolysis technologies where warm caustic solutions require extensive surface protection.

PEM fuel cell and Gas Diffusion Layers (GDL):

The proton-exchange membrane fuel cell (PEMFC) is the most suited fuel cell technology for transportation applications, whose role is to produce electrical energy directly from its hydrogen fuel. This is due to its compactness, high power density, and quick start-up/shut-down ability. The PEMFC electrolyte is the perfluorosulfonic acid (PFSA) polymer membrane, more commonly known under its most famous trademark Nafion. This membrane conducts protons from the anode to the cathode during operation, being the source of the name of this fuel cell technology. No other material currently exists that can match this material's overall properties i.e. performance and stability. The same material is also used in the electrocatalyst layers on the anode and cathode side to utilize a larger degree of the catalyst material. PTFE is used in the porous carbon-based gas diffusion layers (GDLs) to increase their hydrophobicity, thereby preventing flooding of their pores, which would otherwise block the gas flow to the electrocatalyst layers. PFAS can also exist in different sealings in the PEMFC.

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[4] Sood et.al (2016) "*Electrospun Nanofibre Composite Polymer Electrolyte Fuel Cell and Electrolysis Membranes".* Retrieved on: https://hal.science/hal-01342720/document

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Hydrogen refueling stations (HRS):

Due to their characteristics, PTFE (nylon bands) is used in a variety of applications in HRS. Including in valves, flow meters and dispensers in addition to being key in hydrogen compressors.

Transport and storage:

Fluoropolymers are also used in infrastructure and storage applications. In aboveground storage applications, PTFE, PFA and ETFE are used in lining materials, packing rings and valve internal seal. In gas grids, PFSA ionomers and PTFE are used as key materials in mechanical compression, electrochemical compression (proton exchange membranes), cryogenic impression and in volumetric compression. Fluoropolymers are also being used as gas separating membranes. To achieve low friction and wear, and good seal and fitting in valves and joints, PTFE (including Teflon-types), PEEK and Viton are used. In cryogenic liquid hydrogen carrier solutions, PTFE and FKM are utilized for compact heat exchange technologies and PTFE are used in cooling systems for catalysis, and as equipment insulation and cryogenic vessels. Fluoropolymers are similarly used in sealing materials in valves and compressors in liquid organic hydrogen carrier (LOHC) technologies. Even for the transport of gaseous and liquid hydrogen by road and water transport, and for onshore storage of bulk liquid hydrogen, fluoropolymers, such as ETFE and PFA in compounds in addition to PTFE are used. PTFE is used in compressors in such transfer systems to achieve sufficiently low friction and long lifetime. PFAS emissions from the hydrogen industry

PFAS are increasingly detected as environmental pollutants, and some are linked to negative effects on human health. Some types of PFAS are known to persist in the environment longer than any other synthetic substance and are difficult to remediate. PFAS is often found in the groundwater and drinking water.[5] It has been demonstrated that most fluoropolymers used in the hydrogen value chain meet the OECD criteria to be defined as 'polymers of low concern' (PLC). They verifiably do not pose a risk to human health or the environment as they do not dissolve or contaminate water, are not found in drinking water, and cannot enter or accumulate in a person's bloodstream.[6, 7] As well as being categorized as polymers of low concern, electrolysers and fuel cell applications are produced and used in highly controlled industrial environments where their emissions are easier to control.

[5] https://echa.europa.eu/hot-topics/perfluoroalkyl-chemicals-pfas

[6] Henry et.al (2018), "*A critical review of the application of polymer of low concern regulatory criteria to fluoropolymers»*. Retrieved on: https://setac.onlinelibrary.wiley.com/doi/10.1002/ieam.4035

[7] Korzeniowski et.al (2022), "*A critical review of the application of polymer of low concern regulatory criteria to fluoropolymers II: Fluoroplastics and fluoroelastomers* "Retrieved on: https://setac.onlinelibrary.wiley.com/doi/10.1002/ieam.4646

There is still work being done regarding the end of life for the different applications, but as they contain highly valuable materials, there is an economic incentive to recycling and reusing the materials.

Alternatives to PFAS in hydrogen technology

There are no alternatives to perfluorinated membranes commercially available today or in the foreseen future. An alternative must be able to offer the same durability, gas permeability, thermomechanical performance, and efficiency as today's products. To be economically viable, electrolysers need to run at least 5 000 – 8 000 hours a year for up to 10 years, meaning an operational lifetime of at least 50 000 hours.

There are important R&D efforts going into researching alternatives to fluoropolymers. During the last 5-6 years, the major membrane manufacturers have invested profoundly, and recent improvements have enabled further cost and performance improvements in fluorocarbon membranes. But they are still inferior in terms of duration and stability. Alternative materials that are currently being studied are hydrocarbon sulfonated polymers. In an internal test done by Nel, the hydrocarbon membranes resulted in cell failure around the 10-hour mark due to the hydrogen level in the oxygen rising rapidly. This is typical of hydrocarbon membrane technology that exists today. Comprehensive R&D efforts are still needed to find viable solutions for replacements. Over fifty years of development place fluorocarbon membranes in an outstanding position for building electrolysers and fuel cells. Even after half a decade of development on alternatives, they still do not reach the necessary technical requirements.

In the short term, there is a significant potential for reducing the amounts of PFSA materials used in electrolysers and fuel cells per produced unit, as both the goals of reduced costs and improved performance is related to reducing the membrane thickness. For example, the technology developed by the Norwegian company Hystar will enable a reduction of PFSA use in PEM electrolysers by up to 90 %.

In the longer term, it is possible that fluorine-free membranes will be developed. Using fluoropolymers is expensive which is an incentive to look for a substitute. Finding a good substitute with high performance and no environmental or health related negative effects will be a competitive advantage for the companies.

There are some new research of low technology readiness level (TRL) going on in laboratories, and these efforts should be further supported. To be of commercial value, the product needs to be of the same key performance indicators (KPI) as today's solutions. Hydrocarbon membranes are as mentioned a future possibility but needs to achieve the same KPI as today's technologies first. After achieving this, the technology needs to be commercialised and integrated into original equipment manufacturer (OEM) products and then introduced into the marketplace. This is a process that takes time and is not foreseen to happen within the next 10 years.

Overall, it remains clear that research will not yield the results needed in time to allow the industry to replace today's products containing PFAS for the establishment of a hydrogen economy in Europe, and to achieve the goals of the Hydrogen Strategy and the European Green Deal.

Consequences of a ban of PFAS for the hydrogen industry

A rushed PFAS ban without granting any exemptions for applications in the hydrogen sector would have destructive effects on an industry in growth that is needed if we are to reach the climate goals. It would jeopardise the achievement of the EU's Hydrogen Strategy, REPowerEU targets and of the Green Deal objectives. A ban of PFAS with no exemption for the use of fluoropolymers across the hydrogen value chain, would also have devastating consequences for the hydrogen industry, from the jobs to revenues it provides and will provide, and will be a substantial barrier for the development of the hydrogen economy.

Due to EUs high ambitions for hydrogen, a lot of support has already been given to further develop the hydrogen value chain. If the PFAS ban goes through with no exemption for the fluoropolymers used in these technologies, the framework conditions for the industry will change dramatically. By changing the framework conditions with a short timeframe, 5 + 1,5 years, as suggested in the ban, the support already invested in further development will be of no value.

The same applies in Norway. Through the Norwegian Research Council, the government has invested in hydrogen research and innovation through several FME projects[8] where 2 out of 9 centres have developed solutions that are directly or indirectly depending on PFAS. Furthermore, in the call for new FMEs and research infrastructure there are consortiums that now will apply for a continuation of this innovative research. A banning of PFAS will put these investments from the Research Council with a big question related to foresight.

Furthermore, the European hydrogen industry is competing on a global market with companies from for instance the US and China. A ban on all PFAS will also affect the European companies' competitiveness.

[8] Centres for Environment-friendly Energy Research (forskningsradet.no)

Summary and recommendations

Both electrolysers and fuel cells are considered fundamental technologies in the hydrogen industry and there are no alternative materials to PFAS available in the market today or in the foreseeable future that meets the requirements needed. Electrolysers and fuel cell applications are produced and used in highly controlled industrial environments. Furthermore, the PFAS used meets the OECD criteria to be defined as ‘polymers of low concern’ (PLC). Recycling and reusing of the materials are also actively investigated due to their initial high cost and to elevate their environmental impact.

Instead of banning the use of fluoropolymers in key applications in the hydrogen industry, the restriction should focus on substances that present an unacceptable risk in line with REACH regulation. There should therefore be an exemption for the use of PFAS in the hydrogen industry.

NHF recommends an exemption for use of PFAS in the hydrogen industry, and that EU as soon as possible put in place a framework incentivising:

a) best practices for the manufacturing, use and end-of-life stages of fluoropolymers, implementing circular economy practices across value chains in the short and medium term, and
b) research into finding non-fluoropolymer alternatives that could reach the same KPIs as fluoropolymers offer in the medium to long term.

With kind regards
Norwegian Hydrogen Forum

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