Non-Confidential

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DAIKIN'S SECOND RESPONSE TO ECHA PUBLIC CONSULTATION (NON-CONFIDENTIAL)

Introduction

Daikin Industries, Ltd. is a leading multinational air-conditioning and chemical company headquartered in Japan, and with a presence in several EU member states. Its chemicals division is specialized in the production of fluorochemicals, such as fluoropolymers, fluorotelomers, as well as fluorocarbons.

In addition, Daikin is a member of PlasticsEurope's Fluoropolymer Group (FPG), the Performance Fluoropolymer Partnership (PFP), as well as the Alliance for Telomer Chemistry Stewardship (ATCS). Daikin supports the comments on the restriction proposal that these three organisations have submitted to this public consultation.

As expressed in our first contribution in May 2020, Daikin questions the restriction proposal's legal and scientific validity due to deficiencies in the dossier's risk justification. PFHxA is not PBT or vPvB. In addition, a proposal to identify PFHxA as SVHC based on equivalent level of concern to PBT/vPvB did not reach a consensus with ECHA Member State Committee and was withdrawn. Finally, alternatives and socio-economic implications are not sufficiently assessed.

Daikin welcomes the opportunity to reply to this consultation with a second individual contribution and submit further details and input on our recommended changes to the proposal to restrict PFHxA, its salts and related substances under REACH. Confidential information is contained only in the confidential version, separated from this non-confidential version. In this non-confidential version, when we use the term "the substance(s)" without any definition, it is or they are one(s) of PFHxA, its salts and related substances, which fall in the scope within current restriction proposal. As substance(s) name itself is confidential, we use this term.

Our input focuses on the following product groups: fluoropolymers (fluoroelastomers and fluoroplastics), and C6-side chain fluorinated polymers. The definition of product groups used in this second contribution has been updated compared with our first contribution. In our first contribution, we referred to "fluoropolymers" when designating plastics/resins in contrast to fluoroelastomers, and at the same time, when describing the entire group of plastics/resins and fluoroelastomers.

In this contribution, and in line with the terminology agreed upon within FPG, the term "fluoroplastics" is introduced to designate plastics/resins products, while the term "fluoropolymers" refers to the wider group that includes both fluoroelastomers as well as fluoroplastics. Please find FPG's submission and definitions for these different product groups.

Daikin has also identified significant gaps in the currently proposed exemptions. These gaps demonstrate that the restriction proposal lacks an appropriate assessment of the dossier's socio-economic consequences and available alternatives.

1. Fluoroelastomers

ECHA QUESTIONNARIE Section III – Specific concerns

Question 1 - Additional uses: Are you aware of any other present or future intentional uses, or uses where impurities are above the concentration limit proposed?

Overview

As mentioned in our first contribution, Daikin has fluoroelastomer production sites in France and the Netherlands. We also import a certain amount of fluoroelastomers from non-EU regions.

To our understanding of fluoroelastomer market, 8,900 tonnes were produced in the EU. The major usage of fluoroelastomers is in automotive applications, with about 70% of the market due to increasing environmental obligations and higher performance engines. Fluoroelastomers mainly contribute to automotive in three points: Reduction of emission, improvement of thermal efficiency, and safety. 20% of fluoroelastomers are used in the chemical sector, where they are used in seals and O-rings for the safe sealing of hazardous and corrosive chemicals. Fluoroelastomer seals and O-rings are used in machinery (7%) and industries using valves such as oil&gas, pharmaceutical, semiconductors, aerospace (3%) and used at high temperatures (150°C or higher), or where there is direct contact with corrosive fluids. Fluoroelastomers especially contribute safe operation of vehicles/aircrafts/machines etc with preventing over-heat and leakage of oil/fuel which may cause serious accidents, and also minimize emissions to the environment.

PFHxA-related processing aids are critical for European fluoroelastomer market, representing significant volume of the supply.

It is our understanding that Daikin has certain amount of share in the European market. Our plant in France is the largest production site of fluoroelastomers (base polymers) within Daikin. Other portion is imported from non-EU regions.

The major part of base polymers produced in France are further processed at Daikin's facility in the Netherlands. The remaining part is supplied directly to customers (compounders, molders), predominantly in Europe, but also in the US, Japan and China.

Our plant in the Netherlands processes base polymers into pre-compounds. Most of base polymers come from France, the rest comes from Daikin's facilities in non-EU regions.

Most of fluoroelastomers produced by Daikin in the EU are supplied to the European market.

Daikin's fluoroelastomers are intended predominantly for the automotive sector. For certain applications, Daikin is the leading supplier, with high market share for fuel lines and turbo charger applications.

The current proposal as it stands would result in a considerable supply shortage of key fluoroelastomers on the European market. This would result in a cessation of a significant part of production of European users of fluoroelastomers, substantially impairing their competitiveness and jeopardising their overall operations. The short- and long-term competitiveness of the entire value chain is at risk, and this would go against the EU's industrial policy objectives.

Suggestion for amendments to the current exemption wording

Daikin welcomes the exemption 11 for fluoroelastomers in the automotive and aerospace industry, as well as the exemption 7(a) for semiconductors. However, it is worth highlighting that fluoropolymers, which includes fluoroelastomers, are used in critical applications and are highly stable chemicals that do not pose a risk for human health.

We, therefore, advise to <u>completely exclude the production, placing on the market and use of fluoroplastics and fluoroelastomers from the scope of this restriction, including mixtures and articles</u> containing fluoroplastics and fluoroelastomers, without resorting to specific thresholds or limitations to specific sectors of use.

However, in case that it should nevertheless be decided to set and implement a more specific exemption with thresholds and conditions, the current scope and wording of the exemption point 11 for fluoroelastomers requires significant modifications. Otherwise, it will be unusable for industries. Especially, the exemption does not cover articles – means original threshold 25ppb for PFHxA and its salts, and 1000ppb for related substances is applied to the articles. This makes impossible to keep manufacturing automotive, as actual impurity level in the articles is much higher than original threshold. At the same time, the current exemption may cause supply shortage, because it does not allow fluoroelastomer producers to keep using current emulsifiers/processing aids. Furthermore, the current exemption does not allow industries to keep producing/using certain portion of product portfolio.

With regard to fluoroelastomers and exemption 11, Daikin would like to make the following suggestions in detail:

<u>1. Need to include import and use of processing aid for the production of fluoroelastomers</u>

We understand from the ECHA Q&A document on the consultation that emulsifiers are not covered by the current exemption.

A certain amount of fluoroelastomers, which are of crucial importance to the industries, are produced by Daikin within the EU with using the substance that falls in the scope of this restriction proposal.

Processing aid is a wider definition which includes emulsifiers and other aids i.e. stabilizers etc. To secure the continued production and supply of these key fluoroelastomers within Europe, the exemption should cover the import and use of this substance.

Daikin's production sites in Europe operate under strict conditions, with effective emissions reduction and worker protection measures in place. Emissions are well controlled by means of Best Available Techniques (BAT) in Daikin's sites. Detailed information on these risk control measures are disclosed only as confidential basis.

In May 2019, Daikin submitted series of information related to this restriction proposal to German authorities during the drafting phase.

Daikin produces fluoroelastomers in the EU in two steps.

Daikin Chemical France (DCF)

In the first step, Daikin imports processing aid for the production of high-performance fluoroelastomers. This substance is mainly used for polymerization. Certain amount is also used as stabilizer. If we use stabilizer other than this substance i.e. hydrocarbon, which is non-fluorinated, it lowers performance of the resulting fluoroelastomers. Namely, chemical/fuel/heat resistance which are required properties for automotive application are decreased.

Processing aid arrives at DCF in sealed containers. Once emptied, the containers are stored in the waste zone without being rinsed. Empty containers are sent to a specialized company to be incinerated. Water is used for the polymerization step, after coagulation and for the cleaning of equipment. All wastewater is conveyed to Daikin's on-site wastewater treatment plant (WWTP). Daikin has made substantial investments to keep emissions to the environment to a minimum level. With the use of BAT technology, usually Daikin achieves very high capture ratios. This technology is recognised as an effective treatment for removing the substance from waste water.

Yearly total emissions to water from DCF have been reduced every year. In consequence, the capture ratio of the substance from waste water, has been improved every year. Detailed information can be found only in our confidential version.

Daikin even aims to reuse the captured processing aid for subsequent production cycles in the future.

Daikin Chemical Netherlands (DCN)

In a second step, the base polymer sheets are sent for pre-compounding to DCN. Most of the base polymers come from DCF are pre-compounded in DCN. The process consists of incorporating additives (cross linking / curing agents, accelerators) to the base polymers to make pre-compounds. No water is used for the production, nor the cleaning of equipment at DCN.

A detailed description of the production process and emissions to air in DCF, as well as DCN, can be found in our confidential version.

2, Higher threshold needed

The 150ppm threshold proposed in exemption 11 is too low. A higher threshold is required to cover the products used by various industries.

Daikin's products are mainly intended for use in the automotive industry. Fluoroelastomers are especially critical for the safe functioning and high-performance of combustion engines in vehicles, from small passenger cars to large trucks. More precisely, fluoroelastomers ensure that key applications and components are able to withstand extremely high temperatures, as well as resist exposure to chemicals, prevent permeation of fuel/oils, and are tear resistant.

Daikin would like to propose to set the higher threshold at for fluoroelastomers. Actual value is mentioned in our confidential version. The proposal is based on Daikin's measurements by CEN/TS15968. This is a standardised analytical method originally developed to detect PFOS, but is now also used more widely by a number of research institutes/laboratories as a common and recognised method for measuring PFOA/PFHxA. The method is also reasonable in terms of cost, time and yields consistent results and measurements.

However, it has to be stressed that there are currently no fully harmonised analytical methods specifically for measuring PFHxA impurities in products, in particular in articles.

Different analytical methods yield different results, and mentioned and evidenced above, results can even vary within one single method. As another case in point: the dossier itself is not based on analytical methods that would be applicable to the vast scope of products to be covered by the restriction. In the absence of a standard analytical method, the setting of - and compliance with – impurity level thresholds is an extremely complex and challenging process. That is also one of the reasons why Daikin is proposing higher threshold in order to allow for a safety margin. For further explanations and points on analytical methods, please see *Question 13 – Analytical methods* section. On confidential basis, the test results for Daikin's fluoroelastomers (in a state called base polymer and pre-compounded) and resulting articles made by our customers, which are available on the market, can be found.

3. Need for exemption to cover articles

Fluoroelastomers are mainly used in the automotive industry, because of three reasons.

1. Reduction of emission: CO_2, particle matters, evaporation of fuel/oil etc
2. Improvement of thermal efficiency: contribute to further CO_2 emission
3. Safety: protect automotive from over-heat, leakage of fuel/oil etc

For example, the main applications inside an automotive engine are:

- Turbo charger hoses: improve thermal efficiency

- Particle filter hoses/Differential pressure hoses: reduce emission
- Fuel hoses: transport fuel without evaporation to the environment
- Seals and gaskets: prevent fuel/oil leakages - safety

Some articles such as O-rings might be entirely or mainly constituted of fluoroelastomers.

The exemption therefore needs to be extended to articles, and threshold for articles should be the same with the one proposed by Daikin for fluroelastomers – higher than current 150ppm.

Furthermore, the impurities in the articles is not decreased to below 25ppb for PFHxA and its salts / 1000ppb for related substances but still remain higher even after the compounding/molding process.

4. Wider range of industry sectors need to be covered

The exemption should be extended to sectors other than the automotive and aerospace industries. The table below shows examples of the industries which need fluoropolymers – not only fluoroelastomers but also fluoroplastics.

Fluoroelastomers are widely used for sealings - O-rings, gaskets and so on - in many applications. For other key applications in a range of sectors, please see the table below.

Table 1: Non-exhaustive list of industries/applications for which fluoropolymers are essential

Industries	Application	Used product group
Automotive	Internal combustion engine (Filler neck hose)	Fluoroplastics
	Internal combustion engine Turbo charger hose)	Fluoroelastomers
	Internal combustion engine ((Particle filter hose)	Fluoroelastomers
	Internal combustion engine (Fuel hose)	Fluoroelastomers
	Electric powertrain	Fluoroelastomers
Aerospace	High Temperature Release Film for Composite	Fluoroplastics
	Fuel Systems (-60°F and above)	Fluoroelastomers
	Filtration	Fluoroplastics
Semiconductor	Pipes for plant equipment	Fluoroplastics
	Exhaust Duct & Heat exchanger	Fluoroplastics
	Chemical Tank and containers	Fluoroplastics
	Tank and container external coating	Fluoroplastics
	Tubing / Fitting / Valve / Filter	Fluoroplastics
	Sealing materials	Fluoroelastomers
Oil & Gas, Petrochemical	V rings and O rings for downhole application	Fluoroelastomers
	Back up rings, Valves, Cable, Pumps, Diaphragms	Fluoroplastics
	Packers	Fluoroelastomers
	Umbilicals/flexible pipes/flow lines	Fluoroplastics
Electronics	Printed board	Fluoroplastics
	Communication Wire insulation (LAN, POE)	Fluoroplastics
	Consumer electronics and appliances	Fluoroplastics
	Copy machine/printers	Fluoroplastics
Pharmacy & Healthcare	Catheter/ Guidewire	Fluoroelastomers
	Pharmaceutical packaging	Fluoroplastics
	Surgical equipment	Fluoroplastics
Home and living	Solar cell	Fluoroplastics
	Packaging	Fluoroplastics/elastomers
Energy solutions	Lithium-ion battery	Fluoroplastics
	Wind-power generation	Fluoroplastics
	Photovoltaic Solar cell	Fluoroplastics
Building and Construction	Roofing	Fluoroplastics
	Coatings	Fluoroplastics
	Photovoltaic Solar cell	Fluoroplastics
	Weather resistant film (roof membrane)	Fluoroplastics

Reference: https://www.daikinchemicals.com/

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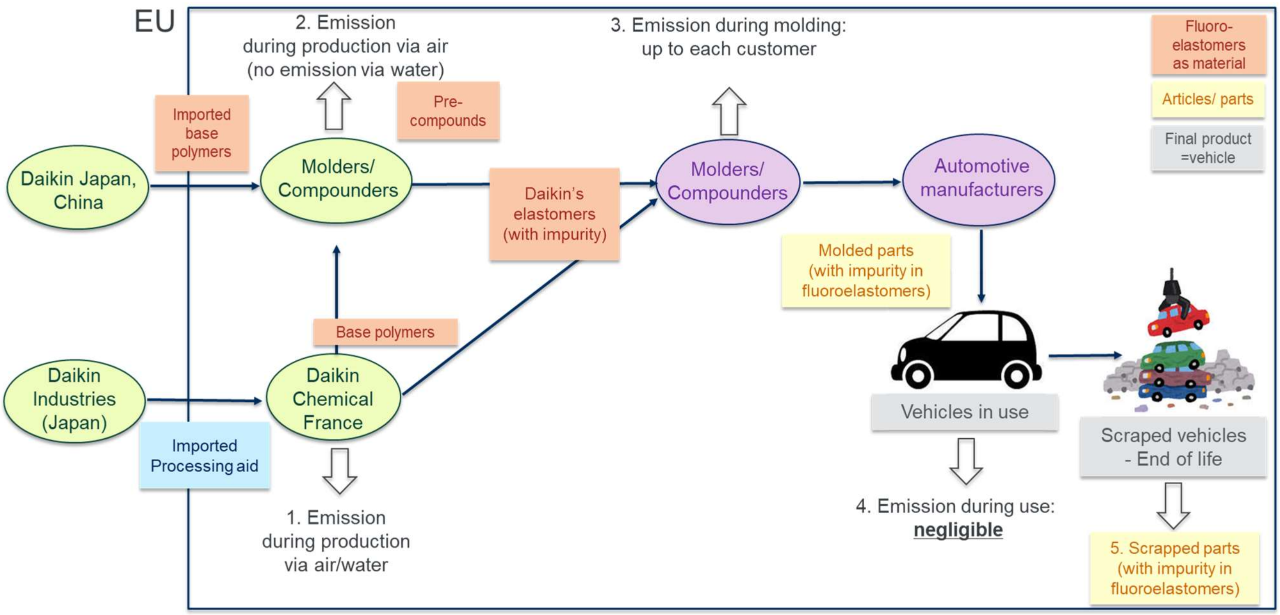
To conclude, without the abovementioned changes, the restriction proposal in its current form will have significant negative socio-economic impacts on European industries which produce and use fluoroelastomers. Fluoroelastomers, are the only materials available that combine all the necessary properties and performance criteria – such as heat and chemical resistance as well as low-permeability – that the downstream industries require in their applications. In the absence of available alternatives, the current exemption wording puts the international competitiveness and the entire European supply and value chain at risk.

Daikin would also like to emphasise that emissions from Daikin fluoroelastomer production facilities in the EU are assumed to be low. Daikin is not in position to calculate/have information on emissions at our customers' sites. Most of Daikin's fluoroelastomers sales is for automotive industry.

Figure 1: Emissions and impurities related to Daikin's fluoroelastomers for automotive (estimated)



1. and 2. Emission during production

Daikin - as fluoroelastomer supplier – take measures to prevent emissions. At the same time, workers are well protected with masks/goggles/gloves and local ventilations. In our best case, maximum yearly emission to water is low in DCF. In addition, emission to air is negligible in DCN, during pre-compounding process, and no water is used for production. Therefore, there is no emission to water in DCN. Detailed calculation, off-air gas, and estimated impurities of the substances which fall in the scope can be found in our confidential version.

3. Emission during molding at customers' sites

When our fluoroelastomers are compounded/molded at customers' sites, usually they take measures in their way. As no water is used during production, we believe there is no emission via waste water. Daikin does not have information from our customers on total emissions via air.

4. Impurity in the automotive parts when vehicles in use and emissions from them

The total impurity in the molded parts, submitted as confidential information, is calculated by multiplying yearly total amount used for automotive industry: 3000 tonnes (Eurostat[1]), our market share, and average impurity level in article - turbo charger hoses.
Impurity in the automotive parts (=articles) can be extracted during use of vehicles. However, air and fuel inside of vehicles are heated up to 800°C or even more. Eventually the substance is decomposed in this high temperature. We believe there is no emission of in the exhausted gas.

5. Impurity in scrapped vehicles and its parts – waste

The average amount of fluoroelastomer use per one internal combustion engine vehicle for the EU market is 330g. About 8 to 9 million tonnes (Eurostat[2]) of end-of life vehicles are generated every year in the EU, representing about 3,000 tonnes of fluoroelastomers. Specific obligations for the treatment of end-of-life vehicles are set out in the EU Directive on End-of-life Vehicles ("the ELV Directive").

In our confidential version, the yearly total of impurity in the scrapped automotive parts is estimated by multiplying our market share, annual volume of fluoroelastomers scrapped as automotive parts, and analysed impurity in articles (turbo charger hoses). These scrapped automotive parts can be either recycled, incinerated, or landfilled.

Question 10 – Alternatives

For uses where substitution would be possible but is expected to lead to a lower quality of products or lower performance.

Fluoropolymers, including both fluoroelastomers and fluroplastics, are the only materials available that combine all the necessary properties and performance criteria – such as heat, chemical, oil resistance as well as low-permeability – that the downstream industries require in their applications.

Non-fluorinated materials are often referred as alternatives to PFHxA grades. However, they result in significantly lower-performing products that do not meet users' safety and quality standards.

Even fluorinated, Daikin currently has no alternative substance to manufacture fluoroelastomers which would provide a better hazard profile as well as an equivalent performance.

Moreover, fluoroelastomers have a diverse and highly complex product portfolio. Automotive parts/units especially require the current PFHxA grades to perform better against fuel, heat, oil etc.

[1] Eurostat, End of life vehicles (ELV) https://ec.europa.eu/eurostat/web/waste/key-waste-streams/elvs

In the absence of viable alternatives, the current wording of exemption 11 puts international competitiveness and operations of the entire European supply and value chain at risk.

Without the changes to the exemption mentioned under Question 1, the restriction proposal would result in a closure of Daikin’s production sites in France and the Netherlands. It would furthermore result in shortage of fluoroelastomer supply in the EU, leading to higher prices and requalification costs which will affect the competitiveness of car parts manufacturers located in Europe compared to importers. For detail, please see Table 2, and note that the analysis below is applicable to fluoroplastics as well, means whole fluoropolymers.

In our confidential version, a more detailed explanation can be found as to why there are no viable alternatives, as well as detailed assessment of the socio-economic impact on the production and supply of fluorelastomers for critical applications in the EU.

Table 2: Comparison of impacts

Impact	Continued use	Non-use scenario
Human Health (workers)	Low emissions Safe use with protective worker equipment	Limited health benefits for workers
Environment	Total releases to the environment estimated to be low in the best case. Reduction in exhaust gas emissions from vehicles	Limited benefits given emissions under current conditions. Increasing use of other fluorinated processing aids with more hazardous profile than the current one. Transfer of production to other regions outside of the EU with potentially less effective emission control measures Increased exhaust gas emissions from vehicles
Economic (Daikin)	Continued operation of facilities where important investments and upgrades were made in recent years Continued sales	Cost of plant closures Loss of market Extra capital costs in new investment capacities outside of Europe Loss of competitiveness
Social (Daikin)	Several jobs kept in Europe	Several job losses
Wider socio-economic	Supply of qualified fluoroelastomers at a competitive price to the automotive industry Major EU supplier of fluoroelastomers located in Europe	Supply shortage for downstream users, putting at risk supply of materials with similar efficiency, environmental performance and safety Fluoroelastomer price increase Requalification costs Lower competitiveness for the EU automotive sector Potential capital relocation outside of the EU Higher production volumes for other producers of fluoroelastomers

Question 13 – Analytical methods

Are you aware of a method for chemical analysis of PFHxA present in a matrix relevant for the restriction proposal? Do you develop or intend to develop such a method?

Publicly available methods

As fluorochemical industry, former FluoroCouncil (now FPG with respect to European fluoropolymers) submitted each company's methods during discussions on PFOA restriction. In addition, we would like to mention about 2 other methods as below:

CEN/TS15968 (2010)

Determination of extractable perfluorooctanesulphonate (PFOS) in coated and impregnated solid articles, liquids and fire-fighting foams - methods for sampling, extraction and analysis by LC-qMS or LC-tandem/MS. Please also see Question 1 for this analytical method.

US FDA method C-010.01(Version 2019)

Determination of 16 per- and poly-fluoroalkyl substances in foods by using Liquid Chromatography-Tandem Mass Spectrometry (LC-MS/MS)

Daikin would like to reiterate that there is currently no harmonised/established analytical method to measure PFOA/PFHxA impurities. In the absence of a standard analytical method, the setting of impurity level thresholds is very challenging. Moreover, lack of harmonised analytical method causes serious implementation / enforceability challenges on both industries and regulators, in case the restriction proposal is adopted in its current form.

Discussion of effectiveness of milling for elastomer analysis

Moreover, Daikin would like to highlight that using the process of milling of base polymers and pre-compounds gives unstable change of extraction efficiency. As seen in table 3 below, some grades show higher detection when milled, however others showed lower. After polymers are frozen and milled, fragments melt immediately and can easily stick together. If authorities decide to apply the milling in their analytical method, a very detailed instruction/management will be required i.e. particle size of milled polymers and lead time between milling and extraction. The results heavily rely on the individuals who do analysis. Therefore, consistency is often doubted. In addition, milling causes higher costs and longer lead time for the conduct of the tests.

Table 3: Range of extraction efficiency

Product	Extraction efficiency
A	60-84%
B	114-140%
C	49-130%
D	187-384%

$$\text{Extraction efficiency (\%)} = \frac{\text{Max/Min milling value}}{\text{Non-milling value}} *100$$

In our confidential version, actual values on this analysis are disclosed.

2. Fluoroplastics

Question 1 - Additional uses: Are you aware of any other present or future intentional uses, or uses where impurities are above the concentration limit proposed?

Import/Production

Our processing aid, which is the substance may fall in the scope of the PFHxA restriction proposal, is used to produce some fluoroplastics. Daikin has no production site of fluoroplastics in the EU. Daikin imported certain volume of fluoroplastics and resulting products (i.e. coatings, micropowders, greases etc) made with this substance into the EU from non-EU regions.

Suggestion to exempt all fluoropolymers, including fluoroplastics

The exemption 11 should be extended to fluoropolymers, which not only are fluoroelastomers but also fluoroplastics such as resins and resulting products.

Authorities may wish to consider applying one single threshold for fluoroelastomers and fluoroplastics to facilitate implementation as well as surveillance and enforcement.

However, should authorities decide to set a specific threshold for fluoroplastics, then Daikin would like to propose another threshold. In our confidential version, we share actual value and the test results with authorities to that effect.

Uses of fluoroplastics

Fluoropolymers, including fluoroplastics, are critical for a number of industry sectors and are used in extreme temperature conditions. In the automotive and machinery industry they are needed for seals, tubes, and linings. For the aerospace industry, they are essential for wire and cables, and films. Fluoroplastics contribute safe operation of vehicles/aircrafts with preventing over-heat and leakage of oil/fuel which may cause serious accidents, and also minimize emissions to the environment. The semiconductor industry also relies on fluoropolymers for key parts: tubes, tanks, lining, and seals.

Furthermore, fluoroplastics, such as PTFE micropowders, are added to other materials or greases to reduce surface friction and wear e.g. in the automotive, aerospace, machinery, and semiconductor industries. This reduction of friction is important for the proper functionality of manifold and equipment parts in these sectors. When added to other materials, fluoroplastics themselves work as lubricants during molding - no other lubricants needed. In sliding materials, they are used as additives to inks, paintings, thermoplastics, elastomers, synthetic oils, and greases.

In addition, fluoropolymers, including fluoroplastics, are also of critical importance for the safe and efficient functioning of appliance in a number of growth and future industries where the EU is seeking to solidify its international competitiveness.

Detailed applications/industries are shown in Table 1 of the fluoroelastomers section of this reply.

For Question 10 on alternatives and Question 13 on analytical methods, please refer to the fluoroelastomers section.

3. C6 Side-chain Fluorinated Polymers (Repellents)

Question 1 - Additional uses: Are you aware of any other present or future intentional uses, or uses where impurities are above the concentration limit proposed?

General

C6 side-chain fluorinated polymers (hereafter C6) provide highly durable water and oil repellency. These properties are obtained due to the polymers' very low surface free energy. Applications are shown in Figure 1 below.

Figure 1: Applications of Water and Oil Repellents

Functional polymers, which account certain amount of gross weight, have a chemical formula corresponding to PFHxA related substances. This is due to the fact that the C6 monomer is incorporated as side-chain to the polymers during the polymerization. In addition, some of PFHxA related substances, is contained as unbound impurities. During shelf life, further decomposition can happen, and maximum impurities can be increased up to certain concentration.

To perform properly, functional polymers should be applied to fabrics beyond proposed threshold 25ppb of PFHxA and its salts, and 1000ppb of PFHxA related substances. Otherwise repellency cannot be obtained.

Therefore, appropriate exemptions are needed for high-performance textiles.

Imported volumes

Daikin shows its presence in the European repellents market, importing certain amount of C6 fluorinated side-chain polymers into the EU regions. More than half of them are used to produce high-performance textiles including medical application. Another half is for papers, stones and so on. Daikin has no production site of this product group in the EU. We have developed and are still making efforts to develop more non-per/polyofluorocarbon repellents (non-PFC) grades for the applications where non-PFC are sufficient. The term “non-PFC” is widely used in textile industry than “non-fluorinated”, which is used in the Restriction Proposal. Both terms mean the same area of chemistry.

Recommendations for additional exemptions

Daikin welcomes the current exemptions for non-woven medical textiles (9c) and PPE: personal protective equipment (9b). However, to protect workers properly, wider exemptions for technical/professional textiles are needed.

Therefore, Daikin would like to propose 5 additional exemptions of textiles.

1) Medical woven textiles

Woven-based textiles are currently not covered by 9(c), although these can be used in similar contexts for similar purposes to non-woven textiles. This includes doctors’/researchers’ gowns, nurses’ wear, surgical gowns, etc.

For example, during surgery, body fluids can splatter toward medical staff. When textiles are treated with C6, they have good aqueous liquid repellency. This means that, even during surgery, alcohol like medical sanitizers are repelled well. At the same time, other liquids, like body fluids, are blocked as well.

Textiles treated with non-PFC can allow body fluids penetrated into textile. In that case, medical staff have contact with body fluids and they are posed at significant risk to get infected. Textiles treated with non-PFC has poor aqueous liquid repellency, and alcohol is absorbed. This means that other liquids, such as body fluid, can easily penetrate into textiles, putting the surgeons and other medical staff at risk.

2) Wider exemption for PPE

These are numbers of fields which are not covered by 9(b) PPE exemption.

To protect workers properly from harsh environment where they come into contact with substances outlined below, non-PFC is not sufficient.

i) Oil/fuel – Gas station, oil&gas drilling/production site, chemical/fire fighters, kitchen, etc

When work wears for this application are not treated with C6, it can easily absorb oils/fuels and catch fire – which put workers’ lives in danger in case of accidents. As explained in Table 2 below, C6 has greater oil repellency on woven textiles than non-PFC. On non-woven textiles, non-PFC has no oil repellency but C6 shows same level as woven-textiles. When you see index against Xylene, which is flammable substance contained in petroleum, non-PFC is very poor against Xylene absorption – this means textiles treated with non-PFC can easily catch fire.

ii) Body fluids, chemicals – Emergency service (Fire fighters, ambulance crews, police etc),

Non-PFC can allow dangerous substances entering into workers' bodies. C6 has greater aqueous liquid repellency as well as hydrostatic pressure than non-PFC on non-woven textiles, as explained in 1) Medical woven textile section and in Table 2 below.

The wording of the exemptions should be clarified. It has to be clear that not only ready-for-use garments but also repellents for production of PPE textile/non-woven and treated fabrics should be exempted. If they are not covered by the exemptions, there is the risk that the EU would have to rely on imports for medical / PPE garments. Under global pandemic circumstances, like now with COVID-19, where there is competing global demand, supplies to EU would not be guaranteed. This means EU citizens are posed at risk.

iii) Outdoor/extreme conditions (cold/snow/heavy rain) – Professional athletes, rescue staff

C6 protects human lives under extreme weather conditions by preventing the loss of body temperature which could cause threats to life. Lifeboat crews and mountain rescue teams, for instance, often have to operate under extreme weather conditions and require adequate protection. As non-PFC has lower durability, they are not sufficient to protect the lives of these rescue teams.

3) Automotive

C6 is needed to avoid the penetration of oil/gasoline into the woven/non-woven, and also to maintain noise reduction, heat-, flame retardancy, and even such lighter weight material contributes to reduce CO_2 emissions. Non-PFC is not sufficient in oil/fuel repellency because they cause penetration as explained in Table 2 below. As a result, non-PFC cannot meet stringent environmental standards, or ensure the safety of the automotive vehicle and its users. C6 has much greater repellency against Xylene penetration than non-PFC.

4) Filtration – industrial filters against fuel, chemicals, coal, nuclear, water, automotive paint etc

Industrial filters especially require oil repellency. As outlined in Table 2 bewlo, C6 shows greater repellency, on the contrary non-PFC has no oil repellency.

5) Military textile – Soldiers and police uniforms etc

Military and police uniforms are not covered by EU Regulation 2016/425, which is referred in the proposed exemption 9(b).

Military and law enforcement personnel may be exposed the outdoor elements for long time, and come into contact with biological weapons/arms, fuels etc.

Non-PFC has lower durability and they do not offer the necessary protection.

Performance standards for C6 water and oil repellent

Table 1 below shows the applications which especially require strong oil repellency as follows;

Automobile, Filter, Textile for professional use, non-woven for medical, chemical protective clothing.

To have the repellency, repellents need to have a lower surface tension than the liquid to be repelled. As seen in Table 1, surface free energy of most liquids is below 30.

Table 1: Standard test method for each application

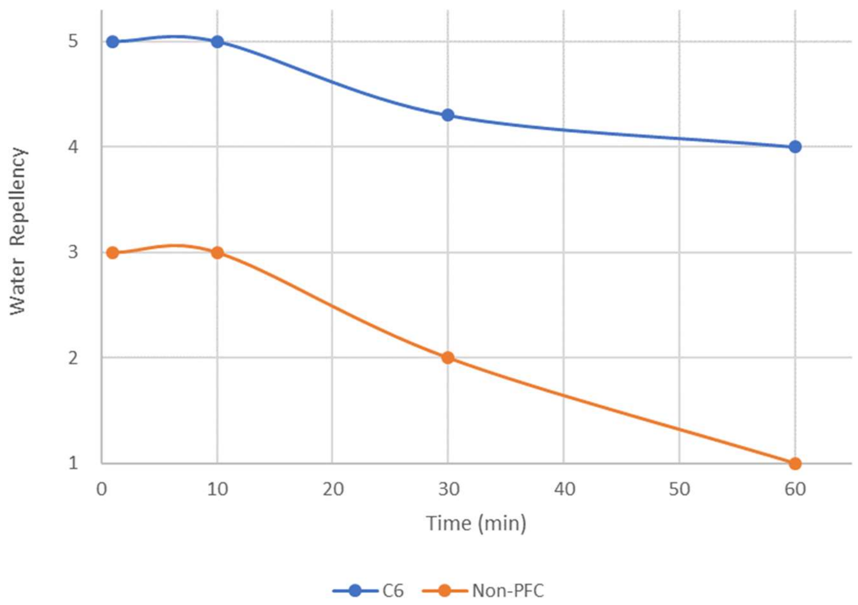
Need of C6

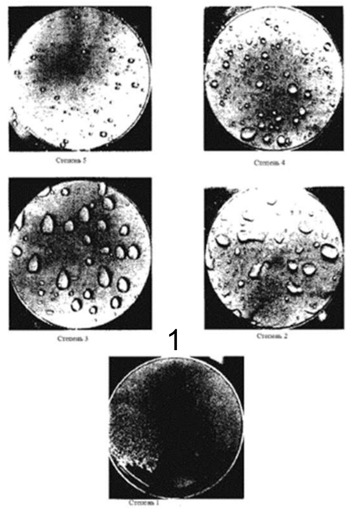
Application	Details application	Test Liquid	Surface free energy of test liqud (mN/m)	Standard test method
Automobile	textile	gasolline	25.0	FIA-Standard 8856
		diesel oil	28.0	
Filiter		Oil	See Table 8	ISO 14419:2010
Textile for professional use	outdoor Sports	Water	72	EN 14058
	Coating application	DMF	36.4	N/A
		toluene	27.9	
		MEK	24.0	
Non-woven for medical		ethanol	22.0	
		IPA	20.9	
Chemical protective clothing		xylene	29.8	ISO 6530:2005
		butan-1-ol	24.9	ISO 6530:2005

Comparison results C6/non-PFC

The following figure 2 is about durability of water repellency with ISO 9865. This shows difference of performance of C6 and non-PFC when the fabrics get wet by rain continuously. As indicated, water repellency of non-PFC has decreased drastically after 10 minutes and it has completely gone in 60minutes - in other word, expanding wet area on the fabric takes heat away easily from human body. On contrary, C6 maintains its water repellency even after 60 minutes.

Figure 2: Durability of water repellency (ISO 9865, Bundesmann rain-shower test)





Water repellency rating:
Top left 5 - bottom 1

In addition, it has to be stressed that textiles treated with non-PFC does not reach the required hydrostatic pressure, which is the index to see how much tolerable the repellents against pressure of liquids. Repellency is affected how much pressure the liquids have when spattered, or textiles contacted with liquids are pressed. Table 2 below shows C6 has better hydrostatic pressure property.

Table 2 below also shows that C6 has greater aqueous liquid repellency than non-PFC on woven textiles. Aqueous liquid repellency, or for instance alcohol repellency, is an index against mixture of water and alcohol. When number is larger, stronger alcohol can be repelled. Especially now under circumstance with COVID-19, medical sanitizers are essential, and they are often mixture of water and alcohol. WHO, the World Health Organization recommends in their guideline to use sanitizers which contain alcohol more than 60-80v/v% of for proper disinfection effect. It is obvious that medical textiles are required to have better aqueous liquid repellency, which cannot be performed by non-PFC.

Table 2: Potential Performance Difference and Application between C6 and non-PFC

Fabric	Function	Test Standard		Performance		Required propertries				
				C6	Non-PFC	1. Medical	2. PPE	3. Automotive	4. Filter	5. Military
Woven	Water Repellency	ISO 4920		Excellent	Good		x			x
	Oil Repellency	ISO 14419		Excellent	Very bad		x	x	x	x
	Aqueous Liqid Repellency	Modified ISO 23232		Excellent	Very bad	x	x		x	
	Deisel Oil Repellency	FIA-Standard 8856		Excellent	Very bad		x	x	x	
	Xylene Repellency	ISO 6530	Absorption	Excellent	Very bad		x	x		
			Penetration	Excellent	Very bad		x	x		
			Repellency	Excellent	Very bad		x	x		
	Hydrostatic Pressure	ISO 811		Good	So so	x	x			x
	Solvent Repellency	Daikin Original	DMF	Good	So so		x	x		x
			Toluene	Good	Very bad		x	x		x
			MEK	Good	Very bad		x	x		x
Non-Woven	Aqueous Liqid Repellency	Modified ISO 23232		Excellent	Very bad	x	x		x	-
	Oil Repellency	ISO 14419		Excellent	Very bad		x	x	x	-
	Hydrostatic Pressure	ISO 811		Excellent	Very bad	x	x			-

Table 3: Aqueous liquid grade

Aqueous Liquid Grade(IPA%)	Test Solution IPA/water(vol/vol)	Surface Free Enargy (mN/m)
0	0/100	59
10	10/90	50
20	20/80	42
30	30/70	33
40	40/60	27.5
50	50/50	25.4
60	60/40	24.5
70	70/30	24
80	80/20	22.6
90	90/10	21.7
100	100/0	21

Table 4: FIA-Standard 8856 Assessment

EX	Excellent (nice shiny drop)
G	Good (no penetration, dark drop
So	So so (dark drop, no round shape)
B	Bad (partly penetration)
VB	Very bad (complete penetration)

Table 3/4 are used as index of aqueous liquid repellency and diesel oil repellency shown in table 2.

For further comparison of C6 and non-PFC, please refer next section.

Efforts to be more eco-friendly industry

Recently, the textile industry is becoming more and more eco-friendly. Thanks to the instruction by bluesign and ZDHC (Zero Discharge of Hazardous Chemical), and textile industry's voluntary action, most of the textile mills reuse liquids which contain fluorinated substances, or send it to a specialised external company after use for appropriate waste treatment. The fluorochemical industry and its association, formerly known as Fluorocouncil, has published guidance for textile mills on how to treat the chemicals and waste water/used liquids.

Reference: Guidance for Best Environmental Practices (BEP) for the Global Apparel Industry Including Focus on Fluorinated Repellent Products, April 2014, FluoroCouncil

https://fluorocouncil.com/wp-content/uploads/2017/06/FluoroCouncil-Textile-BEP-Guidance-English.pdf

Question 10 – Alternatives

For uses where substitution would be possible but is expected to lead to a lower quality of products or lower performance.

Non-PFC is often named as alternatives of C6. However, there is no non-PFC available that offer the same properties with C6. In this section, gap of performance between C6 and non-PFC is discussed.

Basic properties of fluorochemistry – why C6 is needed for repellents?

Formation of atoms - Specific properties derived from carbon-fluorine bond

It is well known that the surface coated with fluoroalkyl compounds shows a significant water and oil repellency, therefore they are widely used in many applications. This comes from the specific property of the carbon-fluorine bond, which is the origin of the atom.

Table 5 shows a comparison of physical properties of hydrogen (H), fluorine (F) and chlorine (Cl) atoms. Fluorine atoms have a smaller atomic radius and polarizability than other halogen atoms, and have the highest electronegativity among all atoms. Due to these physical properties, carbon and fluorine form a strong bond. Thus, the polymer materials with a carbon and fluorine bond have high heat resistance, chemical resistance, and weather resistance, because the bond is thermally and chemically stable and strong.

Table 5: Physical properties of hydrogen (H), fluorine (F), and chlorine (Cl) atoms

	H	F	Cl
Electron configuration	$1s^1$	$2s^2 2p^5$	$3s^2 3p^5 3d^0$
Van der Waalls radius (nm)	0.120	0.135	0.180
Electronegativity (Pauling)	2.1	4.0	3.0
Ionization energy (kJ/mol)	1319	1688	1256
Electron affinity (kJ/mol)	75	350	365
Polarizability (χ^2) (10^{-24}ml)	0.79	1.27	4.61

In addition, the carbon-fluorine bond has a small polarizability because it is electrically neutral, the compounds having C-F bonds, which is perfluoroalkyl (Rf) group-containing compound, have a small intermolecular cohesive force and a low surface free energy. As a result, due to these physical and chemical properties, they have non-adhesiveness[1], low abrasion, and water and oil repellency[2-5].

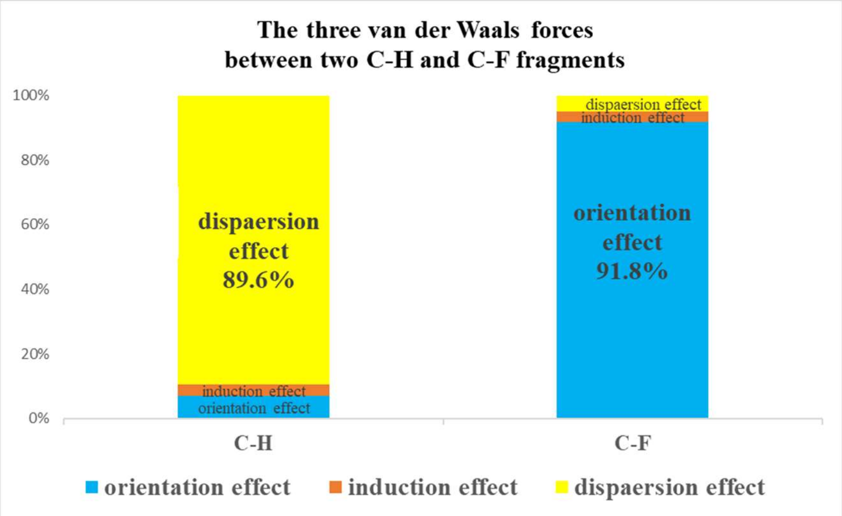
Table 6 shows relative intensities of the orientation, induction, and dispersion effects between the C–H or C–F fragments[6]. The interactive force between two C-H fragments is found to be mostly governed by the dispersion force (89.6%) as expected for the hydrocarbon compounds. This explains the reason why van der Waals force is often solely attributed to the dispersion force. On the other hand, for two C-F fragments, the dominant force is changed to be the dipole-dipole interaction (orientation force; 91.8 %). Although this is a very rough estimation, the comparison is good enough to reveal the intrinsic difference between the hydrocarbon and Rf groups. In short, Rf compounds cannot be discussed in an extended or corrected way of hydrocarbons using a concept of the dispersion force[6].

Table 6. The three van der Waals forces between two C-H or C-F fragments.

	μ / D	α / $\times 10^{-30}$ m^3	IE/ eV	orientation/ $\times 10^{-79}$ Jm^3	induction/ $\times 10^{-79}$ Jm^3	dispersion/ $\times 10^{-79}$ Jm^3
C-H	0.4	0.652	10.64	0.422 (6.96%)	0.209 (3.44%)	5.43 (89.6%)
C-F	1.39	0.555	9.11	61.5 (91.8%)	2.14 (3.20%)	3.37 (5.03%)

μ ; dipole moment, α; molecular (or atomic) polarizability, IE : first ionization energy

Figure 3. The three van der Waals forces between two C-H or C-F fragments in graph



Mechanism why chemicals can repel liquids

Textiles can repel liquids (water, oil, alcohol etc) only when surface free energy of textile is smaller than that of contacting liquids. As seen in figure 4 further below, surface free energy of water is 72. In this case, both non-PFC, which has surface energy around 30, and C6, which has surface free energy around 10, can repel water. Applications which require water repellency only can be substituted by non-PFC.

On the other hand, many oils, i.e. diesel, gasoline, and also alcohols have surface free energy around 30 – lower than it of water. This is same level with surface free energy of non-PFC. As a consequence, textiles treated with non-PFC cannot repel oils and alcohols. C6 still has much lower surface free energy and can repel oils and alcohols.

Figure 4 below shows the relationship between surface free energy of materials and test liquids.

When the number of surface free energy of material is smaller than its of test liquids, the surface of material can repel the test liquid[11]. On contrary, if surface free energy of repellents is larger than or equal to test liquids, it means these repellents cannot repel these liquids – liquids can be penetrated.

Figure 4: Comparison of surface free energy between materials and test liquid

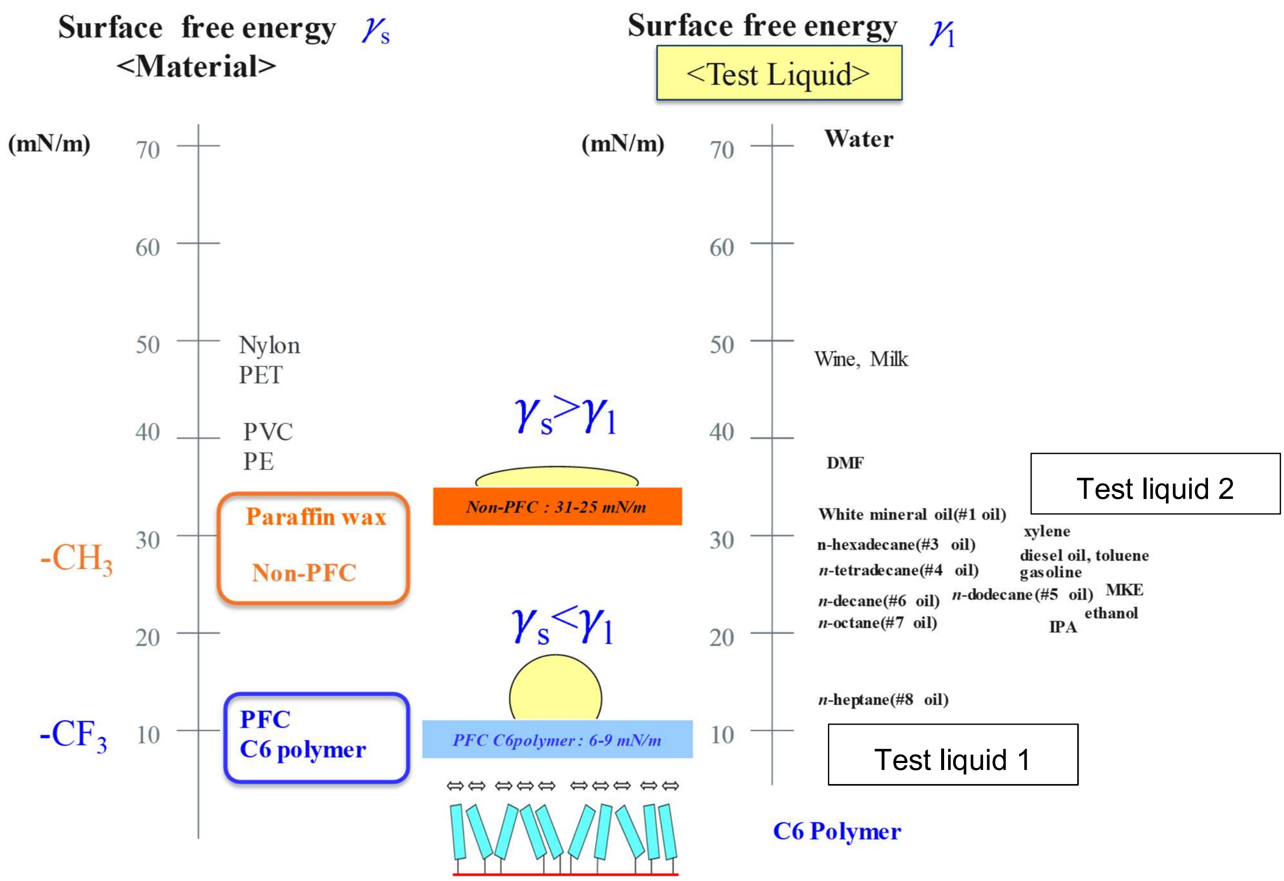
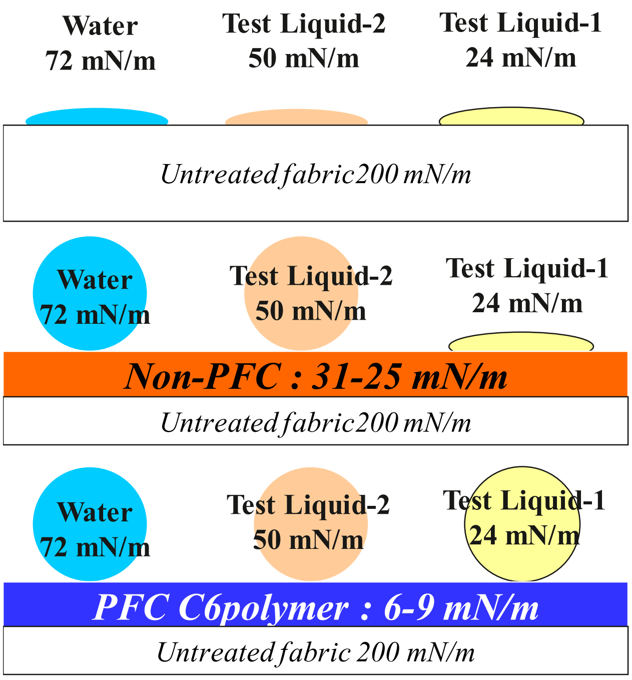


Figure 5 below shows schematic illustration of relationship of surface free energy between materials and test liquids. When fabric is not treated with repellents, liquids can be easily absorbed – in other words, contacting area between fabric and liquids is expanded.

Figure 5: Foam of drop of liquid varied on surface free energy between materials and test liquid



Detailed values of surface free energy of C6/non-PFC and test liquids used in figure 4/5 above are show in Table 7/8 below.

Table 7: Surface free energy of PFC and non-PFC

Material	Structure	Name	Surface free energy of materials (mN/m)	Notes	Refference number
PFC	Trifluometyl group	C20F42	**6.7**	n-perfuluoroeicosane	7
PFC	C6F13-	*p*-C6FA	**7.6**	C6SFA homopolymer	8
PFC	C6F13-	*p*-C6FMA	**9.12**	C6SFMA homopolymer	8
Non-PFC	C18 alkylgroup	*p*-C18A	**24.9**	Stearylacrylate homopolymer	9
Non-PFC	Silicorn	*p*-DMS	**21.0-21.5**	Dimethyl poly siloxane	10
Non-PFC	-(CH2)-	WAX	**31**	Palafine wax	11

Table 8: Surface free energy of Test liquid

Test liquid	Surface free energy of materials (mN/m)	Standard test method	Reference number
gasoline	**21.2**	FIA-Standard 8856	12
diesel oil	**28.8**		12
white mineral oil	**31.5**	ISO 14419:2010	13
n-hexadecane	**27.3**		13
n-tetradecane	**26.4**		13
n-dodecane	**24.7**		13
n-decane	**23.5**		13
n-octane	**21.4**		13
n-heptane	**14.8**		13
DMF	**35.8**	N/A	14
toluene	**27.9**		15
MEK	**24.0**		15
ethanol	**22.0**		15
IPA	**20.9**		15
xylene	**29.8**	ISO 6530:2005	15
butane-1-ol	**24.9**	ISO 6530:2005	15

Question 13 – Analytical methods

Are you aware of a method for chemical analysis of PFHxA present in a matrix relevant for the restriction proposal? Do you develop or intend to develop such a method?

CEN/TS15968, which is mentioned in fluoroelastomers and fluoroplastics sections to this reply, can be used even for C6 side-chain fluorinated polymers. This standard is widely used by laboratories worldwide. Analysis on our products is also based on CEN/TS15968.

Please refer 1. Fluoroelastomers section for more information.

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