FEC PFAS Questions & Answers

Definition	
1.	What are PFAS ?
	There are several definitions of PFAS. The most suitable has been given by the OECD. (https://www.oecd.org/chemicalsafety/portal-perfluorinated-chemicals/aboutpfass/) *<< Per- and polyfluoralkyl substances (PFASs) are a large group of chemicals widely used in industrial and consumer applications since the 1950s, most usually where extremely low surface energy or surface tension and/or durable water- and oil-repellency is needed, e.g., chromium plating, various fire-fighting foams, or for surface treatment of textiles, carpets and papers.* *PFASs consist of a fully (per) or partly (poly) fluorinated carbon chain connected to different functional groups. Based on the length of the fluorinated carbon chain, short and long chain PFASs can be distinguished.* *The length of the fluorinated carbon chain can result in different physicochemical properties that influence the substance behaviour in the environment and in organisms, and its bioaccumulation and (eco) toxicity. >>* Polymers are characterized by high molecular weight. The OECD defines a polymer of low concern, when the molecular weight exceeds 1,000 Dalton. For non-stick coatings PTFEs with a molecular weight exceeding 100,000 Daltons are typically used.
2.	Are fluoropolymers PFAS or not?
	Chemically Fluoropolymers belong to the larger group of PFAS, but they should not be mixed up with lower molecular weight PFAS. Due to their very different chemical, physical, environmental and toxicological properties, it is scientifically incorrect and misleading to confuse fluoropolymers with the environmental and toxicological concerns associated to other PFAS: **Concerned PFAS** / **Fluoropolymers** molecular weight: low (< 900 Dalton) / extremely high (> 100.000 Dalton) watersoluble: yes / no emulsifing: yes / no toxic: yes / no bioavailable: yes / no bioaccumulative: yes / no persistant: yes / yes (not mobile) environmental prevalence: yes / low It is important to differentiate between lower molecular weight PFAS and the fluoropolymers with their normal polymer properties. (see also: Integrated Environmental Assessment and Management — Volume 14, Number 3—2017, A Critical Review of the Application of Polymer of Low Concern and Regulatory Criteria to Fluoropolymers Barbara J Henry, Joseph P Carlin, Jon A Hammerschmidt, Robert C Buck, L William Buxton, Heidelore Fiedler, Jennifer Seed, and Oscar Hernandez)

	The so called short-chain PFAS (carbon chain length ≤ 7 or < 360 Dalton) and especially the long-chain PFAS (carbon chain length ≥7 or > 900 Dalton) are not considered fluoropolymers.
3.	What is PFOA ?
	PFOA (Perfluorooctanoic Acid, C8) belongs to the group of non-polymeric PFAS and was used until several years ago as a dispersion aid in the manufacture of conventional non-stick dispersions (small particles of fluoropolymer in aqueous suspension) for cooking articles like cookware, bakeware and small domestic appliances. Concerns about its persistency in the environment and bioaccumulation caused the major manufacturers of PTFE non-stick coatings to seek alternative dispersion aids. A voluntary program was launched in 2006 by the US EPA, requiring phase out of PFOA by 2015. In practice, most non-stick coating companies and certainly all those in the USA and in the EU went PFOA-free before this deadline.
4.	What is PTFE ?
	PTFE (Polytetrafluoroethylene) is a fluoropolymer comprising repeat units of tetrafluoroethylene (TFE), forming the structure $–[CF_2–CF_2]_n–$ where n is the number of repeat units that are joined together in a chain. PTFE has many engineering and medical uses. It is widely used to impart non-stick properties to conventional cookware coatings because of its low coefficient of friction, inertness and good thermal stability compared to food and cooking oils.
Applications	
5.	What are other uses of non-polymer PFAS ?
	There are several applications in which PFAS can be found, e.g. firefighting foams, repellent coatings on papers used for popcorn packaging, pizza boxes, coatings on textiles, ski-waxes, agents in special concrete formulations, cosmetics, coolant in air-conditioning, wetting agents in wall paints, agents for electro plating, aviation hydraulic fluids, polish, waxes. For more information see the table on the OECD page. (https://www.oecd.org/chemicalsafety/portal-perfluorinated-chemicals/aboutpfass/)
6.	What are other uses of Fluoropolymers ?
	The historical use of PTFE consisted in treating of parachutes to ensure that they opened reliably, due to its very low coefficient of friction. Today PTFE is used in many applications where its engineering properties are desirable, such as the already mentioned low coefficient of friction, hydrophobicity, thermal stability and chemical inertness. PTFE is widely used as a coating, in medical implants and in plumbing and piping as a tape. Other applications include membranes for textiles, fuel tanks as inner coating to avoid the evaporation of fuel, and non-fretting component in lubricants.  For more information see the table on the OECD page. (https://www.oecd.org/chemicalsafety/portal-perfluorinated-chemicals/aboutpfass/)

7.	What is a PTFE coating ? / What are PTFE coatings used for ?
	A PTFE coating is a mixture that comprises PTFE and other ingredients such as functional fillers and pigments. It forms a film on a cooking surface that has a low coefficient of friction as well as hydrophobic and to some extent oleophobic properties. A PTFE coating is commonly applied to cooking surfaces such as cookware, ovenware and small electrical appliances, to ease the release of food and allow easier cleaning. PTFE can also act as barrier to substances that may be transferred to food from the substrates (during cooking). In technical applications such as automotive many grades of PTFE coatings are used to support fuel savings, engine life time, comfort and security for the consumer. In medical devices the inertness, stain- and water-repellency and the low friction coefficient are important reasons to use PTFE coatings.
8.	What are the advantages of PTFE coatings on cookware and bakeware ?
	Advantages of the use of PTFE include non-stick properties and easier release of food during cooking and baking, strongly decreasing possible burning, which impair food taste and may potentially lead to formation of dangerous decomposition substances. Non-stick properties allows easier cooking of food with less fat content. In addition, easier cleaning implies use of fewer detergents, less water and less energy, and consequently lowering the environmental impact of the cleaning process. Applied as a continuous film PTFE can also act as barrier to substances that may be transferred to food from the substrates.
Production	
9.	How are PTFE coatings applied onto cookware or bakeware ?
	In general PTFE coatings are sprayed or rolled as a suspension on a surface and then cured in a high temperature furnace, above normal cooking and frying conditions. This process can be done on sheet material, which is then cut into pieces and formed into products – mainly for bakeware forms, or directly on the final product, e.g. on fry pans.
10.	What happens during the curing process of coatings ?
	The coating is produced through a sintering process. This process ensures that the coating is tightly bound to the surface of the substrate and covers the surface entirely and homogeneously. As a first step, the volatile substances (including water) are evaporated from the wet formulation of the PTFE coating. Inside the oven, the temperature progressively increases and has to exceed 327 °C, which is the starting temperature for the sintering process. During the curing process, PTFE particles sinter, i.e. coalesce to form a continuous film. In addition any residual amounts of processing aids, which might have been present in the coating, are completely broken down and the by-products stripped out.
11.	Do coatings contain PFOA, PFOS and other low molecular PFAS ?
	PFOA and PFOS are no longer used in Europe and in the USA during the manufacture of PTFE dispersions, as they have been replaced by shorter chain PFAS. Even when they were used, they were stripped out of the coating during curing and any residual traces of short chain PFAS were then totally destroyed during the curing process. Today EU compliant fluoropolymers fulfill the PFOA limit of 25 ppb (0.025 ppm). Nowadays low molecular PFAS might be used as emulsifiers in the production process of fluoropolymers. Used in the range 0.1 to 1.0 % w/w these emulsifiers are removed with a cleaning process step and then recycled. The residue traces in the finished coating lies far below 1 ppm.

12.	Are pure fluorinated surfactants added to coating formulations ?
	Various surfactants may be used in formulations, fluorinated and/or non-fluorinated. These substances are also destroyed at the high temperatures used during curing of the coating. And for this reason they will not be present in the coatings on cookware that are purchased by the consumers. FEC members do not use fluorinated surfactants in their formulations.
13.	How much PFAS is released to the environment during production ?
	This depends on the polymer producer. Polymer manufacturers acting responsibly use closed loops in their production in order to keep emissions at insignificant levels. Fluorinated surfactants are not added to the formulation by FEC members and therefore there is no release into the environment during this step. As already mentioned in answer no.10 any remaining traces of fluorinated surfactants are decomposed during the curing of the coating. Thus there is no release into the environment.
Usage	
14.	What are industry recommendations for a safe use of PTFE coatings ?
	PTFE coatings are very stable, and safe to use for long-term up to temperatures as high as 230^{o}C or up to 250^{o}C, for shorter times (e.g. for up to 15 minutes). It is not recommended to heat up the empty articles, in order to avoid overheating. Attention should be paid as to not damaging non-stick cookware of all types, either PTFE or Ceramic, therefore it is recommended not to use metal or other sharp utensils that may cause scratches. Damages in the coating may expose the metal substrate underneath, and potentially lead to leaching of metals into the food, particularly when the food is acidic. Consumers should follow recommendations given in the Use & Care manual of the manufacturers.
15.	Do fluorinated surfactants come out of the coating ?
	Under normal conditions of use fluorinated surfactants do not migrate out of the coating.
16.	Do coatings degrade during use and release dangerous substances ?
	The recommended use temperatures are 230°C for long-term use and, for short periods, up to 250^{o}C (e.g. for 15 minutes). Within these recommended use conditions the degradation is insignificant. However, attention should be paid to avoid overheating of PTFE significantly above its maximum use temperature, as it may break down into short chained PFAS species.
Disposal	
17.	What happens with the coating during waste disposal ?
	Coating are used in combination with Stainless Steel and Aluminum, which are widely recycled at the end of service life of the cooking articles. These articles if properly sorted, are recycled through melting where the melting temperatures completely degrades the coating, and the resulting by-products are transformed into mineral components. As PTFE is not mobile, the coating will not leach any substances and will not cause any harm to the environment if the coated articles end up in a landfill.
Toxicity and Legal Situation	
18.	Are all PFAS dangerous ?
	Concern about PFAS relates mainly to non-polymeric substances. Most of these substances are regarded as dangerous, being highly persistent in the environment, often bio-accumulative, and showing toxic, in some cases potentially carcinogenic properties.

	PFAS however is a large family of chemicals that also includes fluoropolymers, such as PTFE. Fluoropolymers are safe at their recommended and foreseeable conditions of use; for example PTFE is used for manufacture of medical implants owing to its inertness.
19.	What is the regulatory status of these substances ?
	Non-polymer PFAS including PFOA and PFOS are highly regulated in Europe and globally. In a number of countries strict limits are in place on their release into the environment. Here are the major regulations and International Agreements that rule these chemicals: **Stockholm** Convention (adopted by 179 countries) Regulation **EC No 2019/1021** on Persistent Organic Pollutants REACH Regulation **EC No. 1907/2006** Water Frameworks Directive **2000/60/EC** PFOA Voluntary Stewardship Program (**US EPA 2015**) California Proposition 65 and other US state laws Madrid Statement – **seeking to replace PFAS with un-fluorinated alternatives** There are no restrictions for fluoropolymers as PTFE, when used under appropriate conditions.
20.	Is there literature (toxicity, PTFE on cookware) available ?
	There are many toxicological studies that have been carried out on PTFE coatings and the raw materials, including PFAS, that are used to make them. There is a comprehensive article from IARC (IARC Monographs, Volume 19, 1979, IARC Monographs, Supplement 7, 1987) The study has been performed on pure PTFE and states that no toxicity was observed in male and female rats fed PTFE for 90 days, even with a level of 25% in the diet. The polymer has not been found to produce skin irritation or to act as an allergenic agent. They IARC researchers concluded that pure PTFE is not classifiable as a human carcinogen. The German Federal Risk Assessment Institute (BfR) has put together “Selected questions and answers on cookware, ovenware and frying pans with a non-stick coating made of PTFE FAQ of 18 December 2018“The main conclusions reads as follows: The BfR advises against the overheating of coated cooking, baking and frying utensils when empty. Toxic vapours from fluorinated compounds and particles develop at temperatures above 360 °C. To date cases of illness are only known from the industrial manufacture of PTFE and not from its use in private households. Fluorinated substances can be released from coated cookware, especially when it is overheated. The transfer to food cannot be excluded according to the latest available knowledge. The BfR has no data which would indicate that, under normal usage conditions (no overheating), any PTFE-coated cookware, ovenware or frying pans currently available on the market transfer fluorinated chemicals to food in quantities suitable for endangering human health. It is still safe to health if minute particles are released from scratched coatings and swallowed when eating. As PTFE is inert, these particles are not digested and are excreted from the body unchanged. Most of the concern today is related to the impact of non-polymeric PFAS such as PFOA and PFOS released into the environment. The exposure to non-polymeric PFAS is insignificant when using PTFE coated cookware, bakeware and household appliances under recommended conditions. More details are given

	in the literature, for example: Risk to human health related to the presence of perfluorooctane sulfonic acid and perfluorooctanoic acid in food, EFSA Journal 2018, 16(12):5194 *<< Polytetrafluoroethene (PTFE) cookware was found to contain only residual PFOA in the low µg/kg range >>,<< Analysis of PFOA in (…) in cookware that had been coated with PTFE, together with migration experiments conducted using PTFE film, suggested that fluoropolymer food contact materials were not likely to be a major source of PFASs. >>* Consensus exists among toxicologists that cookware not containing or releasing non-polymeric PFAS creates no toxicological concern.
21.	Are PFAS persistent?
	PFAS are considered persistent in the environment, i.e. they are not biodegradable. Persistency as such does not necessarily pose a risk. (Persistent materials also include rocks and ceramics) For example, PTFE as a high molecular Fluoropolymer is stable, inert and immobile. Therefore it will not diffuse into the environment. Moreover the persistency and durability are highly desirable properties in food contact materials.
22.	Is it safe to use PTFE coatings ?
	PTFE coatings are generally considered safe for use on cookware, bakeware and household appliances provided they are used according to the relevant recommendations given by the manufacturer and overheating is avoided.
Exposure (human and environmental)	
23.	Which other sources of PFAS are there ?
	According to the Nordic Council "many sources of PFAS exposure exist, linked to specialists applications (e.g. AFFFs for firefighting at airports and some industrial locations) and non-specialists uses (e.g. use in consumer goods such as pizza boxes, clothing and cosmetics)". (The cost of inaction, Nordic Council of Ministers, ISBN 978-92-893-6065-4 pdf) In that report also figures are given for deeper reading. The "EFSA draft Public consultation on the draft scientific opinion on the risks to human health related to the presence of perfluoroalkyl substances in food, 2020" states, that PFASs can be released to the environment during production, use and disposal (Ahrens and Bundschuh, 2014). Municipal wastewater treatment plants and landfill waste sites represent important direct sources of PFASs in aquatic ecosystems, while atmospheric deposition is also a major contributor (Ahrens and Bundschuh, 2014). Citation: EFSA Draft Opinion "Risk to human health related to the presence of perfluoroalkyl substances in food,", https://www.efsa.europa.eu/en/consultations/call/public-consultation-draft-scientific-opinion-risks-human-health
24.	What are the main routes of exposure for humans ?
	Diet is the major source of exposure to PFAS (EFSA, 2018), and two main processes are thought to lead to contamination of food with PFASs, namely bioaccumulation in aquatic and terrestrial food chains including drinking water, and transfer from contact materials used in food processing and packaging. Concerning the latter source of exposure, this is almost entirely originated by fat-proof fluorinated paper. Also, municipal wastewater treatment plants and landfill waste sites represent important direct sources of PFAS in aquatic ecosystems, while atmospheric deposition is also a major contributor.

	Similar assessments have been done recently by EPA.
25.	How much do PFAS from cookware contribute to human exposure ?
	Published studies by Korean researchers (Choi at al. 2018) show that only a very small fraction of the total exposure to PFAS is originated by cookware This quantity corresponds to 0.027 % of the maximum quantity that may be ingested without posing threat to health. In Europe it is believed that such fraction would not be very different, however activities are ongoing to reconfirm those findings.
Measures	
26.	How long has PTFE been used for cookware ?
	Safe use of non-stick coatings has a long history: the first non-stick cookware was launched in France in 1956 and by Tefal in the US market in 1958. Since then a number of companies started their own products and the application spread from fry pans to bakeware and electrical household appliances.
27.	What has industry already done to reduce the exposure to non-polymeric PFAS ?
	Regarding the usage of fluorinated processing aids for the polymerization of fluoropolymers the Stewardship Program started 2010 to phase out PFOA, which has been accomplished by 2015. The POP regulation 2019/1021/EU, banning PFOS, has been successfully implemented. Individual actions have been taken to develop closed circuit production processes to further reduce the environmental impact.
28.	Are there alternatives to PTFE coated household articles?
	Yes, there is a number of alternatives ranging from uncoated to enameled products to seasoned cast iron/carbon steel to cooking articles that have a ceramic non-stick coating. Each has its specific properties, thus the intended use of the cookware should be the main driver for the choice of the article. PTFE is versatile and covers a wide range of use conditions, especially regarding the non-stick properties.