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Halbzeuge und Konsumprodukte
aus Kunststoff e.V.

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January 16, 2022

Subject: Fluoropolymers – Sustainability & Circularity

Dear Sir or Madam,

pro-K Industrieverband Halbzeuge und Konsumprodukte aus Kunststoff e. V. (pro-K) represents manufacturers of semi-finished and finished industrial products as well as consumer products made of plastic. pro-K demonstrates the application opportunities and performance properties of plastics and actively promotes the image of plastics and its products. The members of pro-K Fluoropolymergroup mainly focus on processing of Fluoropolymers, part manufacturing and its applications. Their contributions can be used as the involvement of downstream users into the PFAS regulation process.

Fluoropolymers – Sustainability & Circularity

- Fluoropolymers ensure safety, reliability, durability, and unmatched performance in everyday products, technologies and industrial processes that are critical for human health, safety and the environment. With a unique set of properties unobtainable by any other materials, fluoropolymers are irreplaceable across many key sectors and applications and play a vital and critical role in serving our society.
- Fluoropolymers play an important role in achieving EU Green Deal objectives and UN Sustainable Development Goals because of their vital use in Lithium-ion batteries, Green hydrogen, Fuel Cell, Solar and Wind energy. Restriction on use of fluoropolymers would adversely impact implementation of these technologies crucial for planet's future as well as in all existing applications vital for the society.
- The Fluoropolymer manufacturing & processing industry fully realizes the necessity of environmentally sustainable production, safer products and

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their processing as well as safe disposal at the end of application life of fluoropolymers. The industry has been constructively working on substantially reducing emissions by developing and investing in cutting edge technologies.

Responsible Manufacturing & Processing of Fluoropolymers

- For regulators, the main concern during manufacturing phase is the use of fluorinated polymerization aids for a limited type of fluoropolymers. Here it is important to note that 50-60% of fluoropolymers do not require fluorinated polymerization aids. For remaining, serious efforts are being made to develop the use of non-fluorinated polymerizations aids to substitute fluorinated polymerization aids. Many patent filings in the last years prove a significant progress in this direction. We expect that the use of fluorinated polymerization aids will become less and less over the next years although it is difficult to predict if industry would be able to completely abolish the use of fluorinated polymerization aids.
- Industry has been focusing on optimizing the use of fluorinated polymerization aids by minimizing their amount used per ton production of fluoropolymers as well as maximizing recovery & recycle to reduce the overall requirement and, hence, the environmental footprint to bring it down to sustainable use levels.
- Parallelly, fluoropolymer manufacturers have been investing in emission control technologies to reduce the environmental footprint of fluorinated polymerization aids. Fluoropolymer manufacturers who are members of "Fluoropolymers Products Group" (a sector group under Plastics Europe) made a collective "Responsible Manufacturing" commitment in 2021 through commissioning of "Regulatory Management Option Analysis" developed by the independent consulting firm Chemservice. All FPG members have voluntarily committed to responsible manufacturing principles in terms of continuously improving and/or developing the best available techniques in the manufacturing process, management of environmental emissions, development of R&D programs for the advancement of technologies allowing for the replacement of PFAS based polymerization aids, and/or the increase of recyclability and reuse of its products in line with the objectives of circular economy.
- As part of their new stewardship initiatives, fluoropolymer producer companies have taken proactive steps to target and achieve very significant reduction in emissions committing large sums of capital

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investments. By all means, these are significant efforts towards remediating risks associated to fluoropolymers manufacturing. For example, data from one major fluoropolymer manufacturer shows that its wastewater treatment achieves over 99% removal of the fluorinated processing aids it uses prior to discharge, and its gaseous emissions from the manufacturing processes where fluorinated processing aids are used are fully captured and routed to a thermal oxidizer where they meet a 99.99% destruction and removal efficiency.

- With reference to Report summary of PFAS and PFAS polymer production published by BauA in July 2021, emission from fluoropolymers is only 2,69% of the total PFAS emissions in EEA whereas F-gases contribute 94,2%. We believe most of the 2,69% emissions related to fluoropolymers may be contributed by side-chain fluorinated polymers mostly used in consumer applications like textiles, leather products and paper surfaces and they can potentially degrade and release fluorochemical residual compounds that are expected to persist in the environment, may bioaccumulate, and may be highly toxic. Fluoropolymers do not degrade and are almost entirely going in industrial processing. Hence, the risk from fluoropolymers is negligible.
- pro-K is taking industry leadership role to help the fluoropolymer processing industry control its emissions and waste by propagating following steps:
    - to inform and exchange
    - to explain the science
    - to develop and deploy good manufacturing practices

  Individual fluoropolymer manufacturers are also taking up the task of educating their customers for controlling their respective emissions and wastes to the extent possible.

  The downstream user industry is optimistic and is poised to work in a constructive way towards achieving emissions and waste control.

<u>In Use Phase of Fluoropolymer (applications)</u>:

- *Polymers of low concern (PLC)* - In 1993, the Organisation for Economic Co-operation and Development (OECD) Expert Group on Polymers found that sufficient data existed to create a consensus document identifying the essential data elements to qualify a polymer as a Polymer

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of low concern to human health and the environment (OECD 1993). By 2007, the OECD Expert Group on Polymers agreed that, "Polymers of low concern are those deemed to have insignificant environmental and human health impacts" (OECD 2009).

- The 2018 Henry et al article reported on four major fluoropolymers that the authors assessed against the PLC eligibility criteria. They found all four fluoropolymers to qualify as PLCs. The four fluoropolymers are polytetrafluoroethylene (PTFE), fluorinated ethylene propylene (FEP), ethylene tetrafluoroethylene (ETFE), and tetrafluoroethylene copolymers with perfluoroalkyl vinyl ethers (e.g., perfluoroalkoxy polymer, PFA). Together, these four fluoropolymers (FP) accounted for approximately 70% to 75% of the world fluoropolymer consumption in 2015 (HIS 2016).
- Few of the world's largest manufacturers of fluoropolymers have come together to evaluate whether 14 additional FPs that they manufacture, over and above the major four FPs assessed in the 2018 Henry et al article, also meet to PLC eligibility criteria. They have concluded that all 14 fluoropolymers meet the PLC criteria. Together with the four previously studied fluoropolymers, these 18 polymers constituting most of the fluoropolymers in commerce meet the eligibility criteria. Importantly, none of the remaining minor percentage of fluoropolymers are known, not to meet the eligibility criteria. Indeed, the entirety of the fluoropolymer universe would all be expected to meet the PLC eligibility criteria given the common structure and high molecular weight of any and all fluoropolymers.
- Fluoropolymers have high thermal, chemical, photochemical, oxidative, hydrolytic, and biological stability; have low flammability, neutral electrical charge, and resistance to degradation; have negligible residual monomers and low molecular weight oligomer content; have limited low molecular weight leachables; and have no reactive functional groups of concern (Gangal and Brothers 2015)."
- Fluoropolymers are high molecular weight polymers with unique properties attributable to the strong C–F bonds, the strongest bond between C and another atom, making them highly stable (Olabisi and Adewale 2015). Carbon atoms alone form the fluoropolymer backbone, each surrounded by an envelope of F atoms. Fluoropolymers are generally very high molecular weight (>100 000 Da). Because these large molecular weight polymers cannot enter the cell, or react with or

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adversely impact "target organs," such as the reproductive system, and they are not bioavailable.

- In terms of end-use function, PTFE's inertness, physical properties (Ebnesajjad 2011), and the low level of residual monomer, oligomers, and low molecular weight leachables meet the requirements for low levels of contaminants and particulates in manufacturing environments essential for the food and beverage, pharmaceutical, medical, and semiconductor industries (Olabisi and Adewale 2015).

Degradation products of fluoropolymers –

- Another aspect that has come into focus is the degradation products of fluoropolymers. Before we address this, we need to distinguish & divide *Fluorinated polymers* into sub-categories based on their degradation potential. The Danish Environmental Protection Agency (2013) considered that fluorinated polymers could be considered in the following three main groups:
  Fluoropolymers - These have a carbon polymer backbone with the fluorine atoms attached directly to the carbon backbone. These polymers are not known to lead to the formation of long-chain perfluoroalkyl sulfonates or perfluoroalkyl carboxylates as a result of degradation;
  Perfluoropolyethers - These have a polyether polymer backbone with the fluorine atoms directly attached to the carbon in the polymer backbone. These polymers are not known to lead to formation of long-chain perfluoroalkyl sulfonates or perfluoroalkyl carboxylates as a result of degradation; and
  Side-chain-fluorinated polymers - These have a non-fluorinated polymer backbone with fluorinated side chains. Depending on the side chain, these types of polymers have been shown to potentially lead to the formation of perfluoroalkyl sulfonates substances as a result of degradation.
- In 2020, the European Commission contracted a study to propose criteria for the identification of polymers requiring registration (PRR) under REACH ("the Wood report"). The Wood Report notes that side chain fluorinated polymers "can potentially lead to the formation of PFAS substances as a result of degradation," but considers fluoropolymers as PLCs, following the recommendations of Henry et al." Id. at 12821,

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emphasis added. Because fluoropolymers are essential ingredients in so many products and applications that contribute so importantly to the health and welfare of society, it is especially important that fluoropolymers not be indiscriminately lumped together with all other PFAS & side-chain fluorinated polymers and subjected to bans or additional regulation that is not justified by sound science.

- While fluoropolymers may meet the REACH definition to be considered persistent, fluoropolymers are high molecular weight polymers and have unique physicochemical properties that constitute a distinct class within PFAS and meet the OECD polymer of low concern criteria are non-toxic, bio-compatible, non-soluble and immobile molecules and they are deemed as such to have insignificant environmental and human health impacts.
- Therefore, as shown here in above, fluoropolymers do not pose a significant health or environmental threat while they are in use in commerce.

End of Life (EOL) safe disposal & Circularity

Pilot studies of the most common form of end-of-life destruction, which is municipal incineration, of the most common fluoropolymer, which is PTFE, found that the combustion converted the fluorine into controllable hydrogen fluoride gas and that of the 31 PFAS species studied, no fluorine containing products of incomplete combustion were produced above background levels. *[Cite to Alexandrov et al study.]*

Landfills that receive fluoropolymer containing wastes also effectively contain any fluorinated compounds that might leach from the fluoropolymer wastes through their leachate collection systems. The EU landfill directive defines the different categories of waste (municipal waste, hazardous waste, non-hazardous waste and inert waste) and applies to all landfills, defined as waste disposal sites for the deposit of waste onto or into land. Typically, fluoropolymer waste is chemically inert. Therefore, fluoropolymers disposed in landfills do not pose any threat to human health and environment.

Incineration – in 2021, RIVM carried out a literature study to investigate presence of PFAS in waste incinerator flue gases. It was investigated whether and, if so, to what extent and under what conditions PFASs, including fluoropolymers, are thermally degraded and what kind of incineration by-

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products are formed. To assess this, an overview of available key literature data on the thermal degradation of PFASs and fluoropolymers and the formation of by-products is presented. PTFE is the most stable fluorine-containing polymer. For PTFE, it was concluded that complete thermal decomposition is achieved at a temperature of about 800°C. It was therefore assumed that other fluorine-containing polymers also thermally decompose completely at a temperature of 800°C. Temperatures at the pyrolysis front and the combustion front in the waste-burning bed range from 900 to 1100°C (Ménard et al., 2006; Asthana et al., 2006), which is well above the temperature of 800°C at which the complete thermal decomposition of PTFE is achieved.

Performance Fluoropolymers Partnership (administered by American Chemistry Council) – a global organization representing world's largest companies that manufacture, formulate and process fluoropolymers is conducting a scientific study on incineration of EOL fluoropolymers. Study project includes literature study, bench scale & commercial scale testing & analysis. It aims to identify optimum combustion conditions of fluoropolymers to achieve 'controlled emissions state' and ensure fluoropolymers get mineralized. Project will be completed in the 2nd half of 2022.

Circularity – Melt FPs like PFA, FEP & PVDF may be reprocessed / reused in certain applications where requirement in terms of purity of polymer is not very high. It is an industry practice to collect PTFE waste from downstream users and, after further processing, use in various applications such as PTFE micropowder additives going into inks, paints, coatings, thermoplastics, rubbers and lubricants or as pre-sintered powders for ram extrusion to make rods, tubes, profiles for the valve and other industries.

In another circularity initiative, in 2015, Dyneon started chemical recycling of fluoropolymers, the so-called ***UpCycling technology of PTFE, PFA and FEP.*** With a capacity of 1000 tons per annum, PTFE, PFA and FEP waste is converted back to its monomer TFE.

Fluoropolymers are expensive and their waste fetches pricing more than that of most virgin polyolefins. Therefore, owing to its high value, fluoropolymer waste generated during processing and at the end of application life is collected / recovered to the fullest extent possible.

Additional quantities for fluoropolymer recycling could be realized if all stakeholders including the fluoropolymer manufactures and end-consumer industries work together to elaborate circular economy approaches. It is not an unsurmountable task and pro-K is propagating the campaign across the

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entire value-chain to recognize, reduce, recover, refine and re-use fluoropolymer waste.

Conclusions

- Fluoropolymers are very important for societal needs and new age technologies to achieve EU Green deal objectives.
- Fluoropolymer manufacturers are constructively working on reducing the use of fluorinated polymerization aids.
- Work on development of non-fluorinated polymerization aid technology is progressing.
- Many fluoropolymers manufacturers have made large investments to reduce fluorinated polymerization aid emissions by 99%.
- Almost all of the fluoropolymers qualify for OECD Polymers of Low Concern criteria.
- Fluoropolymers do not degrade to form dispersible PFAS compounds and are used in industrial processes. Fluoropolymers are different from side-chain fluorinated polymers which may be the main reason of emissions.
- Fluoropolymers get fully thermally decomposed at 800°C and presence of PFAS as a result of incomplete combustion is ruled out during incineration at waste-to-energy treatment.
- Fluoropolymers waste is inert and does not present any harm to humans and environment when disposed of in the landfills.
- Overall, fluoropolymers pose an insignificant risk during the entire life cycle and are very important for the societal needs including achieving of EU Green deal objectives.

With kind regards

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