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I have reviewed the March 2019 narrative draft titled “Product – Chemical Profile for Carpets and Rugs Containing Perfluoroalkyl or Polyfluoroalkyl Substances”, which DTSC based on the literature and in consultation with stakeholders for external scientific peer review (ESPR) supporting their proposed adoption of carpets and rugs containing perfluoroalkyl or polyfluoroalkyl substances (PFAS) as a Priority Product. I understand that the CA Safer Consumer Products Regulatory Program requires DTSC to identify product-chemical combinations that pose risks to people or the environment and to adopt them as Priority Products. For the latter designation, this product chemical combination must meet the following two general regulatory criteria: (1) potential sources of exposure to humans and other environmental biota; and (2) these exposures have potential to cause significant or widespread adverse impacts.

In the case of PFAS and PFAS-containing carpets and rugs, DTSC’s review determined that there is overwhelming evidence to support the required regulatory criteria, specifically: (1) PFAS or their degradation products are extremely persistent and ubiquitous in the environment, leading to ubiquitous human and ecological exposures; and (2) Humans, including sensitive subpopulations such as infants, children and carpet sector workers, as well as other living organisms may be exposed to PFAS throughout the life cycle of carpets and rugs.

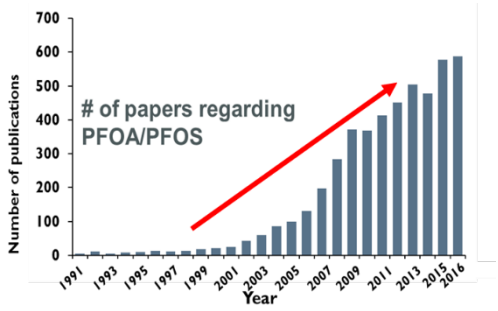
Consistent with the evidence in support of the required regulator criteria, DTSC’s over overarching conclusions are:

Conclusion 1. Humans and biota may be exposed to members of the class of PFAS, including PFAAs, through the manufacturing, normal use, handling, recycling or disposal of carpets and rugs that contain these chemicals.

Conclusion 2. Exposure to any PFAS used in carpets and rugs or their degradation products, during product use or at its end-of-life, may contribute to or cause significant or widespread adverse impacts to humans or biota.

My review of the ESPR draft is based on the directive to determine whether the scientific portion of the proposed regulation is based on sound scientific knowledge, methods and practices. I was already familiar with much of the literature cited in the ESPR draft. For some of the key citations for which I had no familiarity, I accessed them for a quick review as part of my assessment of the ESPR draft. I am most qualified to address Conclusion 1 based on my training and the majority
of my research over the past 30+ years; however, I have also been directly involved in research associated with Conclusion 2 for the past 5 years. I found all major claims made to be consistent with sound scientific knowledge or a reasonable extrapolation of what is known in cases where clear data gaps exist, which were acknowledged. A few other claims I found less supported by science, but also found that these claims do not weigh heavily on the decision to propose adoption of PFAS-containing carpets and rugs as Priority Products or other literature not cited better supports the claims.

There is no doubt to DTSC's statements in support of Conclusion 1 regarding the extreme persistence and presence of PFAS and their degradation products in all environmental compartments including indoor air and dust (particulary indoor from consumer products and particulary carpets), soil, water, plants, animals and humans. There discharges into the environment are not limited to industrial discharges and landfill leachate, but also from discharges of wastewater treatment plant (WWTP) effluent and release to soil and water from land-applied as nutrient-rich biosolids derived from WWTP sludge. Likewise, PFAS entering WWTPs are not just from industrial sources and landfill leachate, but from consumer use of PFAS-containing products. It is well-established from multiple studies that PFAS only degrade in the environment to just another PFAS subclass, e.g., perfluoroalkyl acids (PFAAs), which tend to be more mobile than their precursors. Even chemical means to trap or degrade PFAS are limited and expensive. In addition, to achieve long-term sustainable treatment will require a treatment train at best and will be expensive. Their persistence coupled to their ability to transport large distances through air and water are what has led to ubiquitous presence and multiple exposure pathways to humans and environmental biota. Their extreme persistence means that even if we stopped using PFAS for all uses, PFAS presence from previous and current direct discharges as well as long-term use and disposal of existing consumer products will remain indefinitely in the environment although presumably become increasingly dilute over time with various dissipation mechanisms (not natural degradation processes)



For about the first decade starting just before 2000, PFAS publications focused on PFOA and PFOS and primarily occurrence. However, in the past decade, numerous other PFAS have been identified routinely in various environmental compartments especially water. In addition, numerous more PFAS have been identified with most being either PFAS degradation products (e.g., the suite of PFAAs and microbial intermediates on the way to PFAAs of PFAS precursors) and major components in PFAS-containing aqueous film forming foams (AFFFs). However, much is still unknown about the PFAS that have entered the environment and are used and released from consumer products.

In relation to persistence but also potential toxicities, PFAS alternatives (typically referring to alternatives to PFOS and PFOA) are just other PFAS with shorter-chains or slight variations in their structure, e.g., a different terminal functional group, addition of oxygen atom(s) in the perfluoroalkyl chain or replacing a F atom with a Cl atom. These 'alternative' are just as persistent as the PFAS they are replacing, may be equally bioaccumulative in some cases, and may have similar toxicities, albeit data are limited in this regard. For example a PFOS replacement used in China does not degrade biologically or chemically and sorbs to soils as well as bioaccumulate similar to PFOS (Chen et al., 2018, ES&T, 52(17):9827-9834; Shi et a., 2015, 49:14156−14165).

Although currently EPA has only initiated the regulatory development process for listing PFOA and PFOS as CERCLA "hazardous substances", it is wise to treat the overall PFAS class of compounds as a whole because of the pervasive persistence of all PFAS. In addition, although long-chain PFAS are currently considered to invoke greater toxicity in humans than shorterchain PFAS, studies on the toxicities of short-chain PFAS to both humans and other environmental biota is still limited. In addition, with shorter-chain PFAS being the most common PFAS alternative right now, their production and use is increasing globally, thus there will be concomitant increases in their presence in the environment, thus exposure to humans and biota. They are also more mobile in soil and water, which also makes them harder to remove from drinking water with common adsorptive processes and increases their plant uptake relative to PFOS and PFOA. Therefore, even if limited science currently available suggests that much higher levels are needed of the shorter-chain PFAS to cause adverse effects compared to PFOS and PFOA, they may end up in being present in greater concentrations in water and plants, thus posing similar net risks especially when added to sources other than carpets and rugs. Currently, the C6 perfluorocarboxylic acid (PFHxA) concentrations are increasing in land-applied biosolids while PFOS and PFOA are generally decreasing and PFHxA is the dominant PFAA in compostable food packaging (Choi et al., 2019, ES&T Letters. doi:10.1021/acs.estlett.9b00280). Therefore, overall, these PFAS alternatives are equally problematic as the longer-chain PFAS they replaced.

In evaluating the DTSC's summary of the literature, there were some points of emphasis that while correct, may be less applicable in evaluating carpets produced in the last few years. For example, PFAS contributions from volatile fluorotelomer alcohols to high levels in homes due their presence as residuals in consumer carpets and rugs is biased

by data prior to reduction in residuals and production of more strongly bound treatments. Even though some of the research cited was published in the last few years, the data reflected carpets from production prior to the effort to reduce FTOH residuals in carpets. However, while I am skeptical that data prior to reduction in FTOH residuals is applicable to new carpets that are available to consumers, the side-chain fluorinated polymers, which are most likely what is used to treat most carpets currently, will degrade at different rates depending on the side chain and use conditions with FTOH being the intermediate on the way to PFAAs. For example, Dasu and Lee (ES&T, 2015, Chemosphere, 144:2482-2488) report estimated aerobic biodegradation half-lives for two fluorotelomer urethanes half-lives of 3–5 months and 16 to 22 months, respectively, FTOH being generated first followed by a suite of PFAAs. While side-chains bound to polymers will likely degrade relatively slowly, one cleaved the estimated half-lives of the cleave chains will be rapid as exemplified for acrylate and methacrylate by Royer et al. (2015, Chemosphere, 129:54-61) with half-lives of < 1 week and ~ 2 weeks, respectively. With carpets/rugs having a long use time, FTOHs may still be continually released over time, thus continue to contribute significantly to exposure. Also there are new PFAS hitting the market on a regular basis and other residuals, manufacturing impurities or degradation products may be present and released relatively easily during product use, etc. even if less volatile than the FTOHs. This and considering a large percentage of carpet's end-of-life destination being landfills, thus with high potential to create legacy problems, any action that will remove PFAS use in carpets/rugs and foster exploration of safer alternatives, should be taken, which the current proposal does. We cannot afford to wait until the toxicological science is developed for each new PFAS subclass before making decisions especially since we know that even 10+ years after they are phased out, there will still be a significant presence (e.g., PFOS), thus the proposal to address the overall class in carpet/rug is germane.

Another point of emphasis, but to a lesser degree, that in my opinion lacks credibility in the context of carpets and rugs is that the candidate chemicals may be detrimental to the microbial activity necessary to digest biodegradable materials. The reference cited, which (HardingMarjanovic et al. 2016) uses data from another reference not cited in the review (Weathers, et al., ES&T, 2016, 50(1):240−48), showed these effects occurring at high mg/L PFAA concentrations and specific to one bacteria type that can dechlorinate chlorinated solvents. At best, this applies to scenarios where aqueous film-forming foams (AFFFs) have been used and possibly even more limited to sites where AFFFs have been used to put out fires specifically involving chlorinated solvents or near chlorinated solvent contamination.

On last point of emphasis within the review that was not well supported with the references cited is the conclusion that "incineration of carpets treated with fluorinated polymers, including shorter-chain-based side-chain fluorinated polymers, can result in emissions of PFCAs, ozone depleting substances such as chlorofluorocarbons (CFCs), and potent greenhouse gases such as fluorocarbons (Feng et al. 2015; Huber et al. 2009; Schlummer et al. 2015)." The cited references do not include actual incineration

(typically done at ≥ 850 C), but rather heating a PFOS-containing membrane that may be similar to carpets at varying temperatures but not higher than 600 C (Feng et al., 2015) and production of PFAAs from heating at ~< 300 C) food contact materials and consumer products (Schlummer et al. 2015). This was also shown by Ellis et al., (Nature. 2001, 412(6844):321-4) for conditions up to 500 C for Teflon-associated pans, etc. While the science in these references is sound, the application to incineration is a stretch. However, in further searching of other literature in support of concerns during incineration, I found a paper by *Wang, F et al. (ES&T,* 2015, 499:5672-5680) that while also not perfect, does indicate that at even much higher temperatures typical of incineration, complete decomposition of PFAS in PFAS-containing products will not occur, thus contributing to PFAS- emissions during incineration.

Overall, the well-documented science in the peer-reviewed literature of the inherent persistency of PFAS of the original PFAS or the subsequent terminal metabolites (PFAAs) is sufficient to warrant PFAS-containing carpets and rugs be adopted as Priority Product. In addition, this is further supported by the multiple exposure pathways to humans and the environment that are also well-known and the growing body of evidence indicating that PFAS alternatives will likely have similar toxicity profiles.

A note about the acronym PFAS. PFAS is the preferred acronym because of how it is defined. By definition (per & poly fluoroalkyl substances), it refers to two broad classes of compounds (per & poly) thus is plural without adding a small ‘s’, e.g., PFASs, thus PFAS is now considered the preferred acronym as defined.