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Perfluoro- and Polyfluoroalkanes (PFAS) in Cosmetics—A Short Review

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Abstract

PFAS remain ingredients in certain cosmetic products. Often referred to as "forever chemicals," many PFAS degrade only extremely slowly once released into the environment, often leading to other PFAS compounds. At the same time, a number of PFAS substances have been associated with adverse human health effects, and some have been identified as carcinogens. Consequently, increasingly stringent legislative measures are being developed that will further limit their use in cosmetics. This review summarizes the current use of PFAS in cosmetics, their effects on human health, and both existing and proposed regulatory restrictions governing their application in cosmetic products.

Keywords

Cosmetics, Personal Care Products, Perfluoroalkanes, Polyfluoroalkanes, Environmental Health, Regulatory PFAS Framework

1. Introduction

Perfluoro- and polyfluoroalkanes (PFAS) are alkanes in which all substituents on at least one carbon atom have been replaced by fluorine atoms [1]. PFAS comprise thousands of individual compounds and have become environmentally significant because they degrade extremely slowly under natural conditions, which has led to their designation as "forever chemicals" [2]. None of the PFAS compounds occur naturally. All are either produced through industrial synthesis or arise as degradation products [3] of these manufactured substances. PFAS have many uses. Typically, PFAS are utilized in industrial processes such as in metal plating [4], surface treatment and in electronics manufacturing, specifically in the manufacture of semiconductors [5] [6]. They are often found as processing aids in chemical production [7]. They are used in aqueous film-forming foams (AFFF) [8]-[10]

for combating fuel fires, for instance at airports and industrial sites. In addition, PFAS can be found in many consumer products such as in water- and stain-resistant textiles [11], and food packaging [12], especially in grease-resistant paper and in fast-food wrappers. Other uses of PFAS are as coatings for wires, cables, and hoses [13]. Moreover, they are found in a number of medical devices [14]. Although ever more legislative restrictions on the use of PFAS are on the horizon, the annual production volumes of certain types of perfluoroalkanes are still on the rise. Accordingly, global production of polytetrafluoroethene (PTFE) exceeded 240,000 metric tons in 2023, representing a 6.1% increase compared to 2022 [15]. Demand for PTFE is driven by its outstanding chemical resistance, high thermal stability up to 260˚C, and exceptionally low coefficient of friction of approximately 0.05. Numerous techniques have been investigated for removing PFAS from waste streams, particularly within the water cycle. However, advanced oxidation and reduction processes frequently fail to achieve complete defluorination because the carbon-fluorine (C-F) bond, with a bond dissociation energy of approximately 485 kJ/mol, is stronger than the reactive species generated by most oxidants [16] [17]. As a result, PFAS are often only partially transformed into shorter-chain fluorinated acids that remain highly persistent. Similarly, many microbial degradation systems convert PFAS into shorter-chain intermediates rather than fully defluorinating them. These transformation products may exhibit greater environmental mobility and, in some cases, increased toxicity. Comparable processes occur in natural environments, where PFAS degradation often produces shorter-chain, partially defluorinated compounds that persist and require further breakdown to achieve complete mineralization.

Poly- and perfluoroorganic compounds have also found entry to cosmetic and personal care products. Similar to a larger variety of highly volatile siloxanes [18] and of microplastics [19], which all share characteristics such as widespread environmental dispersion, slow degradation, and potential biomagnification, many PFAS used in cosmetics are currently regarded as problematic substances. The following review gives a short overview of the different PFAS that have been added to cosmetics/personal care products, potential health effects of such PFAS and the present legislative framework governing PFAS in cosmetics/personal care products.

2. Methodology

Data base searches were carried out in Scopus®, Web of Science® and SciFinder®, utilizing the following keyword combinations "PFAS AND cosmetics", "PFAS AND health", "PFAS AND degradation", "PFAS AND legislation", and combinations thereof. Legislative regulations in regard to PFAS were also sought for, utilizing google search®. The literature searches were performed in the first half of 2026. No restrictions were placed on the publication year of the papers included in the search. As an example, 94 entries covered the search combination "PFAS and cosmetics" in Scopus®. The first entry is for a paper published in 2016, while

2024 and 2025 each accounted for 19 entries, and 2026 had already matched that total by 18 June, 2026. Of the identified entries, 16 focused specifically on PFAS in cosmetics, including the development of analytical methods for PFAS quantification in cosmetic products and their associated health implications. 15 entries examined human exposure to PFAS from various sources, including cosmetics. 20 entries addressed the health effects of PFAS more broadly, while 12 investigated environmental contamination by PFAS, including contributions from cosmetic products. 6 entries focused on the remediation of PFAS-contaminated matrices, and three explored alternatives to PFAS in cosmetic formulations.

In general, for exclusion/inclusion of the articles, first the titles and then the abstracts of the respective papers were evaluated. All pertinent references in the given papers were analyzed for any missed publications. The "forward" citations given in the databases for the entries found in the databases were also examined for any missed publications. The relevant manuscripts were acquired utilizing the resources of the library of the United Arab Emirates University, where not directly available online.

In addition, ingredient databases provided by INCI Beauty® [20] and by Kemiluppen® [21] were used, the latter in combination with a survey of chemical substances in consumer products, distributed by the Danish Environmental Protection Agency [22].

Patents were searched through SciFinder® and Google Patents®. Patents were viewed through PatentPak® as embedded in SciFinder® or through Google Patents® directly. In the review, the collection of patents on PFAS in cosmetic formulations is intended to be illustrative and is not exhaustive. The search engine Google Patents® provides over 100.000 entries for the keyword combination "cosmetics AND perfluoro", alone. Therefore, while some of the selected patents are seminal in the field, other patents were chosen to be representative of a larger body of similar patents. In many patents, the inclusion of PFAS in the cosmetic is facultative and is listed among a choice of hydrophobic oil components, and the inclusion of PFAS does not represent the main claim of the patent or is an essential part of it.

3. PFAS as Constituents in Cosmetics

PFAS are incorporated into cosmetics because of their properties such as their hydrophobicity and film-forming ability, which can enhance product wear, durability, and spreadability. They are also claimed to promote greater skin absorption and to improve the skin's appearance and texture. Some of the PFAS ingredients are classified as anti-caking agents. Typical PFAS compounds in personal care products (**Figure 1** and **Figure 2**) include polytetrafluoroethene (PTFE, **1**), perfluorodecaline (**2**), perfluorohexane (**3**), perfluoro-1,3-dimethylcyclohexane (**4**), perfluorohexylethyl triethoxysilane (**5**), perfluorononyl dimethicones such as **6**, and the fluorinated ethers methyl perfluorobutyl ether (**7**), ethyl perfluorobutyl ether (**8**), ethyl perfluoroisobutyl ether (**9**), and methyl perfluoroisobutyl ether (**10**).

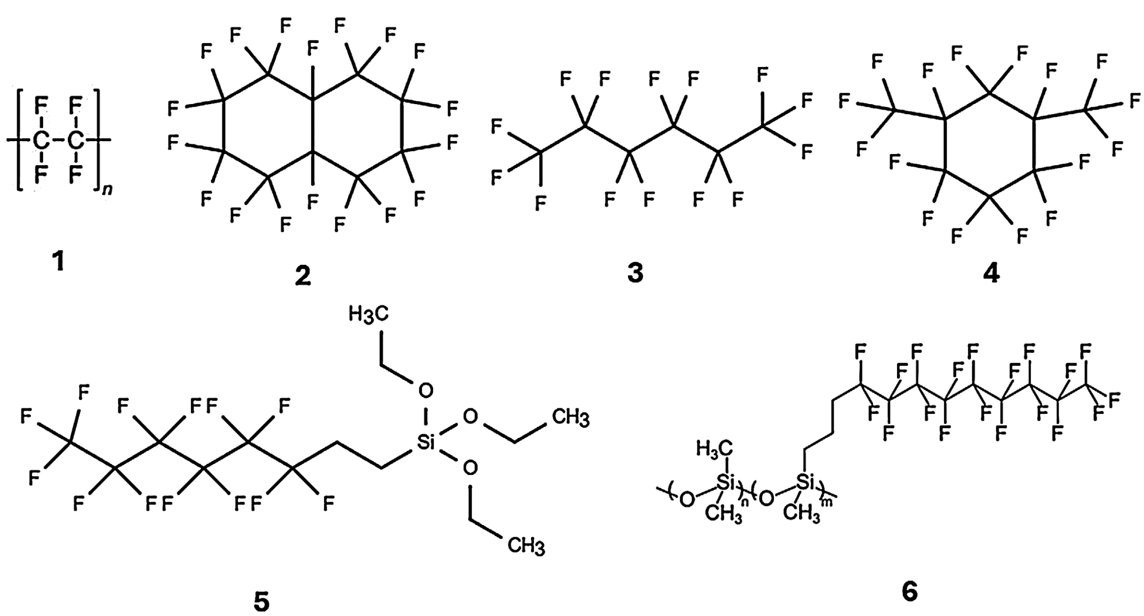


Figure 1. Polyfluorinated substances that can be found in cosmetics/personal care products.

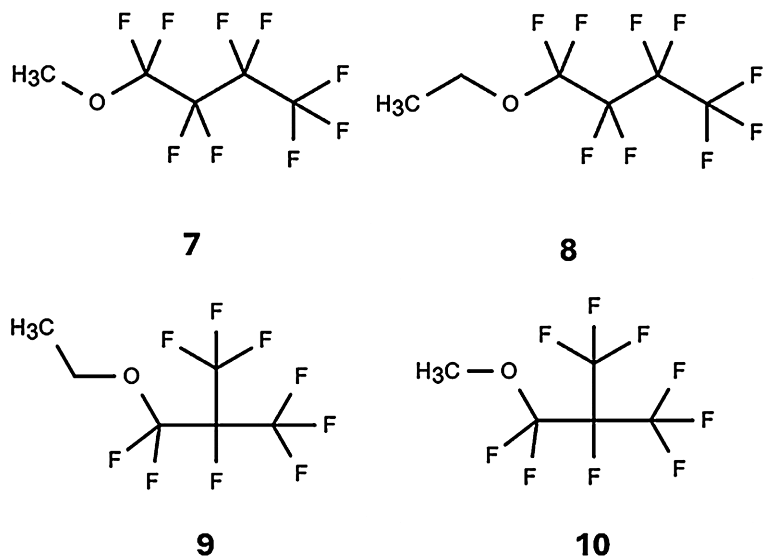
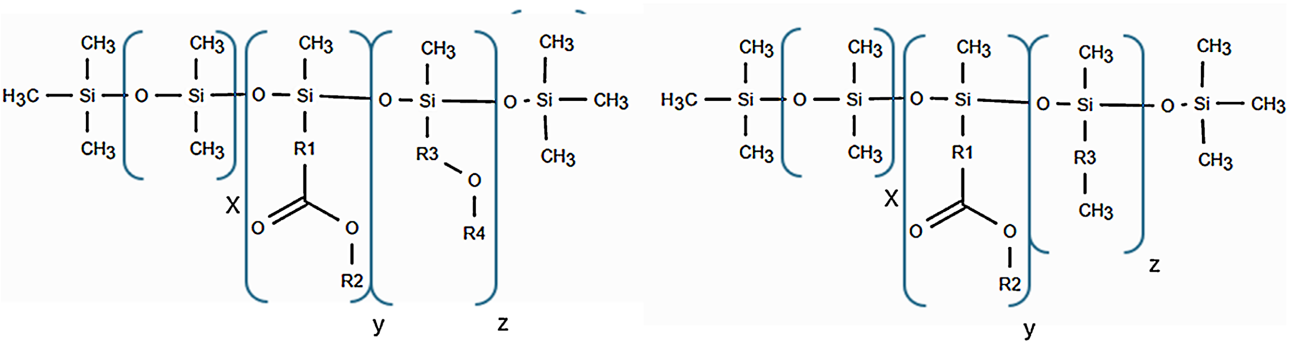


Figure 2. Structure of fluorinated ethers **7**-**10** that can be found in cosmetics/personal care products. Often, they are used as "solvents" in the products.

A website operated by INCI Beauty [20] shows the main ingredients of more than 1 million beauty products. In this regard, it should be noted that in most cases, INCI Beauty compiles its data by examining ingredient lists disclosed on product labels and through voluntary cooperation of cosmetic manufacturers. According to the website, as of April 2026, PTFE (**1**) is the most common PFAS in cosmetics, present in 0.13% of all listed products, in 3.95% of all eyeshadow products listed, 2.11% of all compact powders, 0.98% of all blushers, and 0.37% of all lipsticks. As a swelling agent, it reduces the bulk density of cosmetic products. Perfluorononyl dimethicones are listed as an ingredient in 0.05% of all cosmetic products, 7.47% of eye and Kohl pencils, 5.1% of lip pencils, and 1.28% of eyeliners and kajals. They are used to keep the skin in good condition. Typical trademark names for perfluorononyl dimethicones are Biosil Basics® Fluorosil 14 [23], Biosil Basics® Fluorosil LF [24], a product for hair care applications, where it provides shine, conditioning and frizz control benefits, Pecosil® FSH-150 [25], Pecosil® FSH-300 [26], and Fluorosil® J15 [27], among others. Many of the products are marketed as wetting agents and dispersants, especially used in foundations, where the substances posesses non occlusive, moisture retentive, moisturizing and protecting properties. A similar purpose is attributed to specifically perfluorononylethyl carboxydecyl lauryl dimethicones such as **11** and **12** (**Figure 3**), which are ingredients in 3 products catalogued by INCI Beauty database.



R^1= $(CH_2)_{10}$; R^2=$(CH_2)_2CF_2)_8CF_3$; R^3=$(CH_2)_3$; R^4=$(CH_2CH_2O)_nH$, where n has an average value of 10.

11

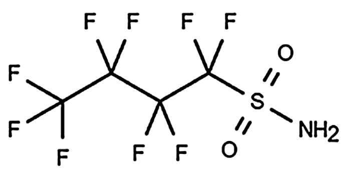
R^1= $(CH_2)_{10}$; R^2=$(CH_2)_2CF_2)_8CF_3$; R^3=$(CH_2)_{25}$

12

Figure 3. Perfluorononylethyl carboxydecyl lauryl dimethicones **11** and **12** that can be found in cosmetics/personal care products.

The ethers methyl perfluorobutyl ether (**7**) [28], ethyl perfluorobutyl ether (**8**) [29], ethyl perfluoroisobutyl ether (**9**) [30] and methyl perfluoroisobutyl ether (**10**) [31] are used as solvents, and have been listed by Incicoder in 154, 24, 16 and 156 personal care products, respectively. Incicoder lists 4 cosmetics [32] that include perfluorohexylethyl triethoxysilane (**5**), 23 cosmetics [33] with perfluorodimethylcyclohexane (**4** and its positional isomers) and 222 cosmetics [34] with perfluorodecaline (**2**) as well as 71 cosmetics [35] including perfluorohexane (**3**), both used as solvents in their formulations.

On the other hand, perfluorobutanesulfonamide (FBSA, **13**) is not used as an ingredient in cosmetics. Neither is perfluorobutanoic acid (PFBA, **14**) (**Figure 4**) commonly employed as an intentional cosmetic ingredient. However, it may be present in cosmetic products as an impurity, a residual manufacturing by-product, or a degradation product of other PFAS-containing substances. The same is true for other perfluoroalkanoic acids, including perfluorooctanoic acid (PFOA, **15**) (**Figure 4**). Thus, in 2013, Fujii *et al.* [36] found PFOA and its homologues in personal care products. Thirteen of 15 cosmetic samples, and 8 of 9 sunscreen samples contained perfluoroalkylcarboxylic acids (PFCAs) at concentrations of up to 5.9 μg/g for cosmetics and 19 μg/g for sunscreens. Most of these products also contained polyfluoroalkyl phosphate esters (PAPs) such as **17** (**Figure 5**) as



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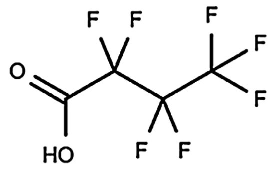

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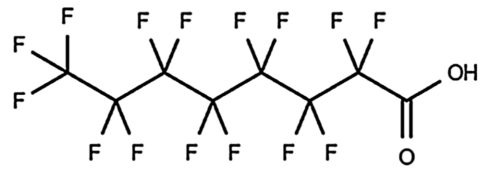

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Figure 4. Perfluorobutanesulfonamide (FBSA, **13**), perfluorobutanoic acid (PFBA, **14**) and perfluorooctanoic acid (PFOA, **15**) are not used as ingedients in cosmetics, however, **14** and **15** can be present in trace amounts as an impurity.

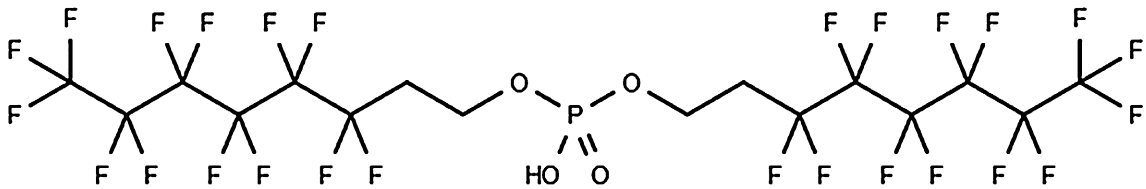

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Figure 5. Structure of a typical polyfluoroalkyl phosphate ester **17** (PAP) as an intentionally added ingredient. Perfluoroalkylcarboxylic acids (PFCAs) can derive from these by hydrolysis and subsequent oxidation.

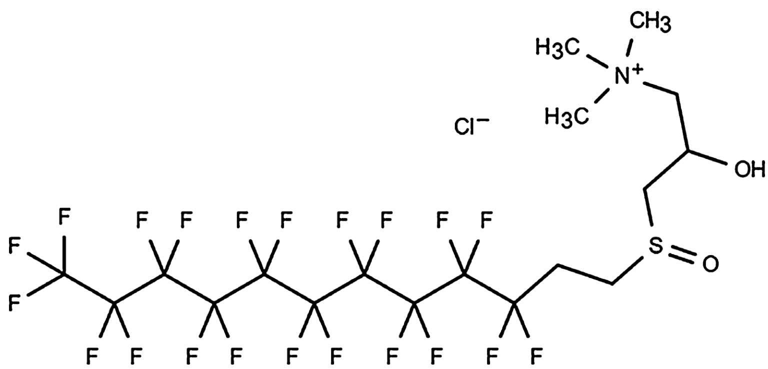

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Figure 6. Structure of ([3-(3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,11,11,12-,12,12-henicosafluorododecylsulfinyl)-2-hydroxypropyl]-trimethylazanium chloride (**16**), an ingredient used in some cleansers.

intentional ingredients. Indeed, PAPs have been reported at sum concentrations of up to 1080 µg/g in cosmetic products from Sweden, the US and Canada [37]. Fujii *et al.* [36] could show that mica and talc, typical compound materials present in cosmetics, when treated with PAPs release PFCAs after some time. Previously, biotransformation of PAPs to PFCA had been observed in rats [38] and in a microbial system in wastewater treatment plants [39]. As in Japan [36], PAPs were also measured in North American cosmetic products [40], in cosmetics available in Scandinavia [22] [41], and in China [42], where again PFCAs were seen to be associated with the presence of perfluoroalkyl phosphates.

There are also other perfluoro compounds that in principle can degrade to PFAS such as C4-18 perfluoroalkylethyl thiohydroxypropyltrimonium chlorides which are used as conditioning and surface-modifying agents in cosmetic and personal care formulations [43]. Importantly, they have antimicrobial activity and are utilized in skin and tooth cleansers. The compounds contain a cationic (quaternary ammonium) head group, which adsorbs strongly to negatively charged surfaces such as hair and skin, and perfluoroalkyl chains, which provide water-, oil-, and soil-repellent properties. 2-hydroxy-N,N,N-trimethyl-3-[(3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,11,11,12,12,12-heneicosafluorododecyl)thio]-1-propanaminium chloride ([3-(3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,11,11,12-,12,12-henicosafluorododecylsulfinyl)-2-hydroxypropyl]-trimethylazanium chloride, **16**) is shown as an example of such a compound in **Figure 6**. The following is a short table of typical examples, where the addition of these types of perfluoroalkylethyl thiohydroxypropyltrimonium chlorides as a surfactant to the formulation is given as a possibility (**Table 1**).

Table 1. Patents in which is given the possibility of adding a perfluoroalkylethyl thiohydroxypropyltrimonium chloride as a surfactant to the formulation.

Inventor	Assignee	Country/region of application	Application date	Publication or Granted date	Patent number	Description in view of perfluoro organics
F. Genrich *et al.* [44]	Symrise AG	Europe	Dec. 3rd, 2018	Sept. 15th, 2021 (P)	EP3877494A1	Antimicrobial surfactant based composition
D. Knoop *et al.* [45]	Symrise AG	Europe	Aug. 20th, 2020	March 18th, 2026 (G)	EP4025675A1	Perfume oil mixture
A. Nakano *et al.* [46]	Symrise AG	USA	Sept. 14th, 2018	April 21st, 2022 (P)	US20220117881A1	Hair care composition

Table 2 gives an overview of some of the studies that have been carried out on the identification of PFAS containing cosmetics in markets around the world. Targeted detection and quantification of PFAS is commonly carried out by LC-MS/MS set-ups with the use of PFAS standards.

As shown in **Table 3**, perfluorinated substances are presented as possible cosmetic ingredients in a number of patents. Thus, F. Lahousse and E. Henin [50] [51] suggest a lipstick composition in emulsion form, which incorporates at least 8% of a non-volatile oil. As non-volatile oils, fluoro oils are considered specifically, where fluorosilicone oils and fluorinated polyethers but also the fluorinated alicycles perfluorodecaline (**2**) and perfluoroperhydrophenanthrene (**18**) are mentioned. Furthermore, the lipstick composition comprises a film-forming agent selected from vinyl polymers, which may contain fluorinated substituents. These substituents can introduce fluoroalkyl and fluoroalkyloxyfluoroalkylene groups into the vinyl monomers from which the polymers are derived.

Hasegawa *et al.* [52] disclose a surface-treated powder coated with a perfluoropolyether-modified aminosilane compound, as well as cosmetic formulations containing this treated powder. The perfluoroether modified aminosilane is of

Table 2. Studies on the targeted identification and quantification of PFAS in cosmetics/personal care products from different regions of the world.

Region	Year of Publication	Number of cosmetics screened	Name of PFAS found/targeted	Detection frequency and conc.	Analytical technique used	Reference
USA/Canada (North America)	2021	29 (17 Canadian, 12 US products)	53 PFAS targeted	Products were pre-selected (147 - 10,500 ng/g for US, 0.23 - 221 ng/g for Canadian products)	Targeted liquid chrom-atography tandem mass spectrometry (LC-MS/MS) and gas chromatography-mass spectrometry (GC-MS)	Whitehead *et al.* [40]
Canada (North America)	2022	38	PAPs PCFAs, FTSAs PFSAs	99.7%, 299 ng/g (for PAP)	Targeted liquid chrom-atography tandem mass spectrometry (LC-MS/MS)	Harris *et al.* [47]
China	2023	45	27 PFAS, incl. PAPs PCFAs, FTSAs PFSAs	PFAS in all samples (100%) 4.05 - 94.9 ng/g	Ultra-high performance liquid chromatography-Orbitrap high resolution mass spectrometry (UHPLC-Orbitrap HRMS)	Lin *et al.* [42]
Japan	2013	24 (15 cosmetics, 9 sunscreens)	PFCAs	13/15 cosmetics (86.7%), 8/9 sunscreens (88.7%) LOD-19 µg/g	PCFAs were analysed as benzyl ester derivatives: gas chromatography-mass spectroscopy with electron-capture negative ionization (GC/ECNI/MS)	Fujii *et al.* [36]
Thailand	2024	21	10 PFAS	PFAS in all samples (100%) 2.0 - 707 ng/g	Targeted liquid chromatography-mass spectrometry (triple quadru-pole mass spectrometer)	Keawmanee *et al.* [48]
Sweden (EC)	2018	31 (24 listing PFAS, 7 without PFAS listed)	39 PFAS, incl. PAPs PCFAs, FTSAs PFSAs	Pre-selected, highest PFAS conc. 470 µg/g, no PFAS conc. for creams, pencil and shaving foams	Targeted liquid chroma-tography tandem mass spectrometry (triple qua-drupole mass spectro-meter)	Schultes *et al.* [41]
Sweden (EC)	2022	15 (for target PFAS)	21 PFAS, incl. PAPs PCFAs, FTSAs PFSAs	7 out of 15 samples (46.7%) LOD - 9560 ng/g	Liquid chromatography-tandem mass spectro-metry (LC-MS/MS)	Pűtz *et al.* [49]

Table 3. Patents disclosing cosmetic formulations with perfluoro/polyfluoro substituted ingredients.

Inventor	Assignee	Country of application	Application date	Publication or Granted date	Patent number	Description in view of perfluoro organics
F. Lahousse and E. Henin [50] [51]	L'Oreal SA.	Japan Europe	May 17th, 2019 March 25th, 2014	Aug. 25th, 2021 (P) June 14th, 2023 (G)	JP6926147B2 EP3593863A1	Cosmetic powder compositions containing a finely divided, high-density polyolefin as a substitute for talc

Continued

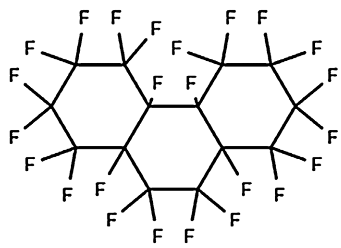
Y. Hasegawa *et al.* [52]	Miyoshi Kasei Inc, Daikin Ind Ltd.	China	Feb. 27th, 2008	Dec. 1st, 2008	TW200846025A	Surface-treated powder coated with perfluoropoly-ether-modified aminosilane, and cosmetic preparations incorporating it
N. Imai *et al.* [53]	Kose Corp.	Japan	Dec. 27th, 2002	July 29th, 2004	JP2004210720A	Fluorine-modified cyclic silicone as a constituent of an oily cosmetic formulation useful in lip cosmetics
S. Tamura *et al.* [54]	Dow Corning Toray Company Limited	S.-Korea USA	Nov. 25th, 2010	Aug. 23rd, 2012 (P, KR) July 7th, 2014 (G, US) Dec. 5th, 2018 (G, KR)	KR20120093979 A US8784787B2	A cosmetic composition comprising a novel organopolysiloxane copolymer which can have trifluoropropyl, pentafluoroethyl and similar perfluoroalkyl groups as substituents.
J. Nakabayashi [55]	Kose Corp..	Japan	July 24th, 2007	Feb. 12th, 2009	JP2009029718A	Cosmetic has a propylene homopolymer in its formulation with oily components that can include silicones such as fluorine-modified polysiloxane, perfluorodecane (**20**), or perfluorooctane (**21**)

the general formula $F(CF_2)_3O[CF(CF_3)CF_2O]_mCF(CF_3)CONR\text{-}R<1>\text{-}Si(X)_n(Y)_{3-n}$, with R<1> representing an alkylene group having 1-6 carbon atoms. The surface treatment is reported to confer excellent flexibility and adhesion properties to the resulting cosmetic product.

Imai *et al.* [53] put forward 1,3,5-trimethyl-1,3,5-tris(3,3,3-trifluoropropyl)cyclotrisiloxane (**19**, **Figure 7**) as a specific fluorine-modified cyclic silicone that together with an acrylic acid-methacrylic alkyl ester copolymer and silicic anhydride would impart excellent usability to oily cosmetic formulations, while providing a glossy film, enhanced slip and anti-adhesion properties, long-lasting moisturization, and good formulation stability.

Tamura *et al.* [54] describe the preparation of novel co-modified organopolysiloxanes to be used in cosmetics. The cyclic siloxanes can have monovalent fluorinated hydrocarbon group substituents that include trifluoropropyl groups, pentafluoroethyl groups, and similar perfluoroalkyl groups.

Nakabayashi [55] developed a cosmetic formulation containing a propylene homopolymer in combination with oily components, which may include silicones such as fluorine-modified polysiloxanes, perfluorodecane (**20**), and perfluorooctane (**21**).



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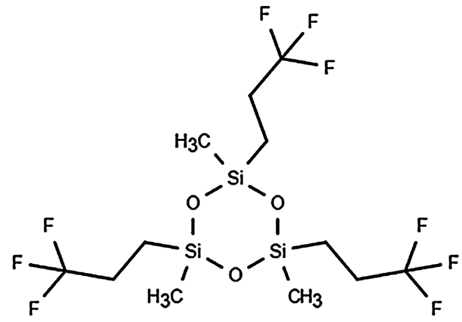

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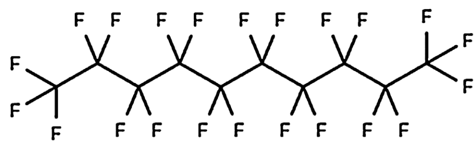

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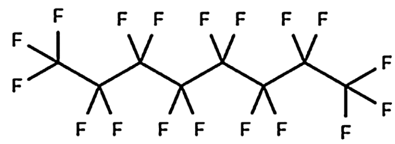

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Figure 7. Structures of fluorinated compounds named in the patents shown in **Table 3**.

4. Dermal Penetration and Potential Effects of PFAS on Human Health

In addition to exposure through PFAS-containing personal care products, PFAS can also enter the human body through contaminated drinking water [56], food [57], air [58], textiles [11] and household dust [59].

In a study with a sample of 61 adults from Oslo, Norway, dietary exposures appeared to be the predominant pathway for PFAS exposure, followed by ingestion of house dust, inhalation of indoor air, and dermal absorption [60]-[63]. Deposition of the compounds on the outermost layers of the skin (epidermis) and their evaporation are a matter of their molecular weight and their polarity. The surface of human skin is coated with a skin surface film liquid (SSFL), which consists of a mixture of sweat and sebum. For chemicals present in materials that come into contact with the skin, e.g., from house dust, dissolution into the SSFL is the initial step required before dermal uptake can occur. Interestingly, commonly used cosmetic products, including foundation, sunscreen, moisturiser, and deodorant, significantly influence the dermal bioaccessibility of PFAS. For example, the application of moisturiser markedly reduced the overall bioaccessibility of both PFCAs and PFSAs [64]. In the case of PFAS containing cosmetics, the distribution of the individual PFAS between SSFL and the cosmetic layer needs to be taken into account.

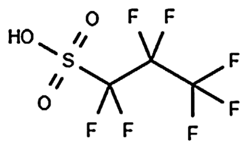
To be absorbed into the skin, the compounds would need to pass the stratum corneum, the outermost layer of the epidermis. The stratum corneum contains a dense lipid matrix composed mainly of ceramides, cholesterol, and fatty acids.

Therefore, non-polar/lipophilic molecules dissolve more readily into these lipid layers and diffuse across them more efficiently than very polar or even ionic compounds. Nevertheless, it must be noted that extremely hydrophobic compounds may also penetrate poorly because they become trapped in the lipid layers and do not partition efficiently into deeper water-rich tissues. Therefore, for efficient absorption, molecules should generally possess a molecular weight of below 200 amu, a partition coefficient (log K_o/w) between 1 and 3, and a certain degree of water solubility. Early research suggested only limited dermal absorption of ionic PFAS compounds [65]-[67]. In a recent study the dermal penetration of 30 PFAS was investigated, both as mixtures and individual compounds, where *in vitro* human skin models were used in a Franz Diffusion Cell system. Here, results showed that in a mixture, short-chain PFAS, including perfluorobutanesulfonamide (FBSA, **13**), perfluorobutanoic acid (PFBA, **14**), perfluoropropanesulfonic acid (PFPrS, **22**), and perfluoropentanoic acid (PFPeA, **23**), demonstrated permeation rates of 4.8% ± 2.5%, 3.7% ± 0.3%, 2.0% ± 0.1%, and 1.1% ± 0.1%, respectively, over 24 h. In contrast, none of the long-chain PFAS penetrated the skin in the same period. When tested individually in water, FBSA exhibited the highest permeation, achieving 7.0% ± 0.9% ($p < 0.05$), underscoring its ability to cross the stratum corneum under simulated environmental conditions. These findings highlight that while permeation of long-chain PFAS could be slowed down by the skin barrier, certain short-chain PFAS, such as FBSA, can penetrate human skin *in vitro*. That chain length has a notable influence on dermal penetration is also shown by studies of Wang *et al.* [68], who investigated the permeation of 14 PFAS using in vitro 3D-human skin equivalents (3D-HSE). Of the PCFAs investigated, perfluorobutanoic acid (PFBA) exhibited the highest cumulative permeation.

Kissel *et al.* (2023) [65] calculated the dermal-to-inhalation (D/I) ratios for 107 neutral PFAS and found 11 of these to have dermal-to-inhalation (D/I) ratios >5, suggesting that direct dermal absorption may be a relevant or important exposure pathway for these substances, which included *N*-methylperfluoroctansulfonamidoethanol (*N*-MeFOSE, **24**), *N*-ethylperfluoroctansulfonamidoethanol, (*N*-EtFOSE, **25**), and the shorter chain compounds *N*-methylperfluorobutanesulfonamidoethanol (*N*-MeFBSE, **26**), *N*-methylperfluorohexanesulfonamidoethanol (*N*-MeFHxSE, **27**), and *N*-ethylperfluorohexanesulfonamidoethanol (N-EtFHxSE, **28**) (**Figure 8**). The above, however, are not typical ingredients found in cosmetics.

Several studies have provided evidence that PFAS absorbed through the skin can contribute to internal body burdens. Thus, Abraham and Monien [69] found that a portion of PFOA in sunscreen can be absorbed transdermally into the bloodstream. In addition, some biomonitoring studies have reported a positive association between cosmetic use and PFAS concentrations in human serum [70] [71].

The effects of PFAS on human health have increasingly become the subject of careful scientific investigation. Here, a range of potential effects of PFAS on human health has been reported [72]-[76], although many of these findings remain tentative rather than conclusive. These include a potentially reduced immune



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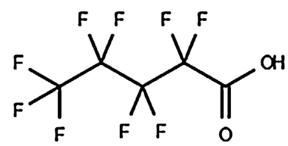

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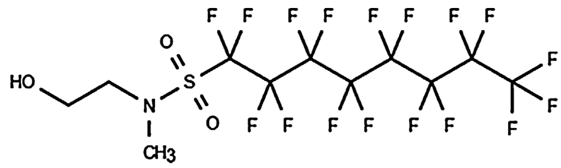

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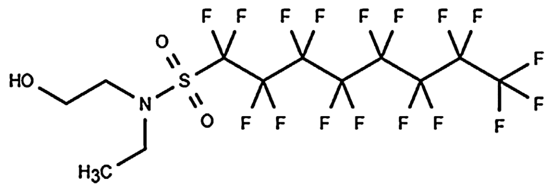

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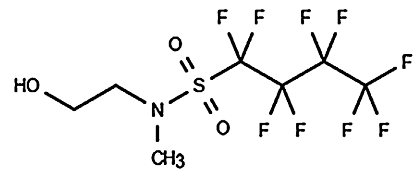

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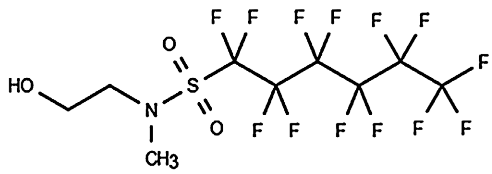

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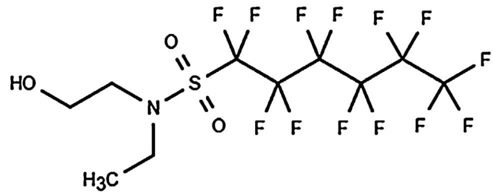

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Figure 8. A plethora of PFAS the skin penetration of which have been studied.

system [77], hormonal and endocrine disruptions [78], developmental and reproductive effects [79], as well as effects on the kidneys [80] as well as on the metabolic system. Furthermore, some PFAS such as PFOA (**15**) and perfluorooctane sulfonate (PFOS), have been linked to increased cancer risk [81]. Also, PFAS-induced neurological effects are known [82].

PFAS have been investigated for possible carcinogenic effects for many years. PFOA (**15**) exposure has been consistently linked to increased risk of renal cell carcinoma in highly exposed populations. Elevated incidence of testicular cancer has also been reported in workers and communities exposed to high PFOA levels. There is mixed and/or inconclusive evidence on links between PFAS and prostate cancer [83] [84], breast cancer [85], thyroid cancer [86], pancreatic cancer [87], liver cancer [88], and non-Hodgkin lymphoma [89]. Animal studies have shown liver [90], pancreatic [91], and testicular tumors [92] after high PFAS exposure. PFAS are generally not considered strong direct DNA-mutating agents like classic genotoxic carcinogens. Rather, proposed modes of action include the induction of oxidative stress, where PFAS increase the creation of reactive oxygen species, which can lead to persistent low-level inflammation, endocrine disruption where PFAS can interfere with hormone signaling pathways involved in cell growth and metabolism, and the activation of nuclear receptors, for instance of peroxisome proliferator-activated receptor alpha (PPAR-α), which affects lipid metabolism, cell proliferation, and liver growth in animal studies. In 2023, the International

Agency for Research on Cancer classified PFOS as a possible carcinogen to humans (Group 2B) and PFOA as carcinogenic to humans, based on sufficient evidence in regard to kidney and testicular cancer (Group 1).

5. Regulatory Framework for PFAS Use in Cosmetics

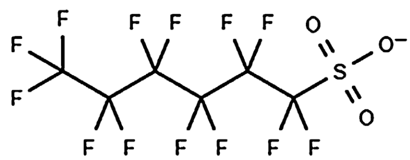
Many of the PFAS will no longer be permitted in cosmetics in Europe, as they are classified as persistent organic pollutants (POPs) and/or as (very) persistent, (very) bioaccumulative, and toxic substances (PBTs/vPvBs). Their use is prohibited under the Stockholm Convention on POPs or restricted under the REACH Regulation. In France, many of these substances will be banned in accordance with Decree 2025-1376. Indeed, Europe is pursuing a precautionary ban on around 14,000 PFAS substances across virtually all uses by 2030, with possible exemptions in printing, sealing, and machinery applications, for medical uses (e.g. in medicinal products and packaging), in military applications, explosives, technical textiles, and for general industrial uses such as for solvents and catalysts [93]. As of 2026, seven U.S. states (California [94], Colorado [95], Maine [96], Maryland [97], Minnesota [98], Vermont [99], and Washington [100]) have already prohibited the intentional use of PFAS in cosmetics [101], and seven more (Connecticut [102], Illinois [103], New Hampshire [104], New Jersey [105], New Mexico [106], Oregon [107], Rhode Island [108]) will introduce comparable restrictions in the time period 2026-2033. In the State of New York [109] and in Massachusetts [110] comparable laws will be voted upon in 2026, with an implementation date of 2029, if approved. As shown in **Table 4**, in other parts of the world, the use of some PFAS has been severely restricted, but a specific ban of PFAS in cosmetics has not yet been issued. In Asia, Japan, China and Thailand have issued restrictions of the use of PFAS [111] [112]. China added PFOA (perfluorooctanoic acid) to the list of Class I Specified Chemical Substances under the Chemical Substance Control Act (CSCA) in April 2021 [111] [112]. Japan has classified multiple PFAS compounds as Class I Specified Chemical Substances and established a phased timeline for restrictions. As of July 2024, 164 PFAS compounds are regulated under the Chemical Substances Control Law, with manufacturers required to report their use [112]. 138 mainly PFOA-related PFAS substances were banned in 2025. In 2023, the Thai FDA moved to ban 13 specific PFAS and their derivatives, including PFOA, PFOS, and perfluorononanoic acid (PFNA), by adding them to the list of prohibited cosmetic ingredients. Since July 1, 2025, Australia has prohibited the use of the PFAS compounds PFOS, PFOA, and perfluorohexane sulfonate (**29**, PFHxS) and has implemented stringent drinking water standards with ultra-low concentration limits. As a result, these persistent "forever chemicals" are now subject to strict regulation across multiple industries. The ban also covers their intentional addition to cosmetics [113]. New Zealand has adopted one of the most comprehensive regulatory frameworks worldwide for restricting PFAS in cosmetic products [114]. Beginning in 2026, the phased implementation of these measures will substantially affect cosmetics manufacturers.

Table 4. Restrictions of PFAS due to legislation in different parts of the world.

Country	Legislation	Comments
Denmark	EU framework plus national initiative s	Active advocate for a broad PFAS restriction in Europe; cosmetics currently governed mainly through EU legislation. A ban of PFAS in clothing, footwear, and impregnation sprays officially entered into force on July 1, 2025, to be enforced on July 1, 2026 [116]
France	According to Law No. 2025-188 of February 27, 2025, a comprehensive ban in cosmetics from 2026	Manufacture, import, export, and sale of cosmetics containing intentionally added PFAS prohibited from 1 January 2026 [117] [118]
Norway	Follows EU/EEA restrictions	Implements EU REACH and POPs restrictions; supports the proposed EU-wide PFAS phase-out [119].
European Community	No cosmetics-specific PFAS ban yet	Several individual PFAS (PFOS, PFOA, PFHxS, some long-chain PFCAs) are already restricted. A broad PFAS restriction proposal under REACH is under evaluation [120].
United Kingdom	No cosmetics-specific ban	Restrictions primarily target specific PFAS compounds inherited from EU legislation.
Australia	No cosmetics-specific ban	Focus remains on environmental contamination and selected PFAS substances [113].
New Zealand	National phase-out ending in 2026	PFAS are being phased out of cosmetic products, with regulatory implementation from 2026 [114].
USA	State-level regulations (see text)	No federal PFAS cosmetics ban. Several states prohibit intentionally added PFAS in cosmetics (see text).
Canada	No cosmetics-specific ban yet	Some PFAS are regulated through broader chemical management programs; broader PFAS restrictions are under development [121].
Japan	Limited restrictions	Controls focus on specific PFAS compounds rather than cosmetics as a product category (see text) [112].
S.-Korea	Limited restrictions	Primarily regulates individual PFAS substances under chemical legislation [112]
China	Emerging regulation	Restrictions focus on PFOS, PFOA, and Stockholm Convention obligations [111]

Perfluorooctylethyl triethoxysilane (**30**), an anti-caking agent is no longer authorised in cosmetics within the European Community. Also, its analog perfluorooctylethyl trimethoxysilane (**31**), a much less used ingredient for the same purpose, will be banned for use in cosmetics in the EC-region from 2027, onwards. Nevertheless, the ingredient database at INCI Decoder currently lists dozens of cosmetic products containing perfluorooctylethyl triethoxysilane (**30**) [115], spanning powders, foundations, concealers, BB creams, and sunscreens, which will continue to be available in most regions of the world, even after 2027 (**Figure 9**).

Thus, the cosmetic industry feels the pressure to find substitutes for PFAS in their formulations. The most common substitutes for PFAS, given their roles in providing water resistance, smooth texture, and spreadability, include silicones [122] [123], which offer smooth application, shine, and water resistance; hydrocarbons such as paraffins, mineral oils, and synthetic waxes [124], which form a smooth, protective layer on the skin; and fatty acids and other lipid-based ingredients [125], which enhance emolliency, spreadability, and conditioning, and are often used in "natural" or "organic" PFAS-free cosmetics.



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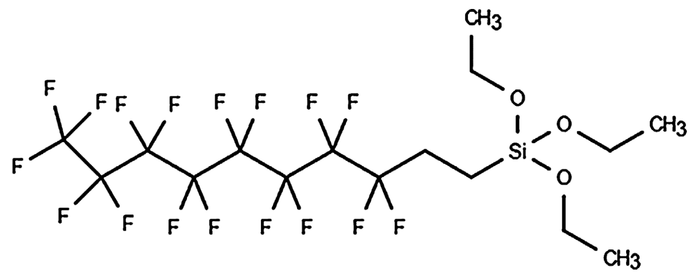

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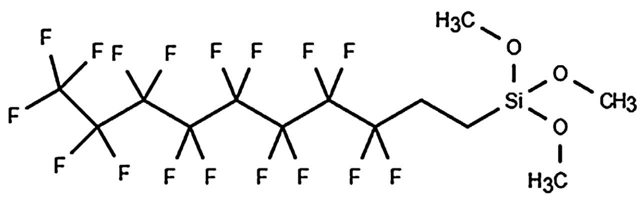

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Figure 9. PFAS that will be/have been banned in cosmetics in certain regions of the world.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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