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Alternative substances replacing microplastics in cosmetic products

An analysis of substitutes for microbeads

RIVM letter report 2026-0081
H.A.A. Proquin | W. Brand

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Colophon

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H.A.A. Proquin (author), RIVM
W. Brand (author), RIVM

Contact:
Héloïse Proquin
Centre for Safety of Substances and Products
heloise.proquin@rivm.nl

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Synopsis

Alternative substances replacing microplastics in cosmetic products

An analysis of substitutes for microbeads

Manufacturers sometimes add microplastics to personal care products, for example in a skin scrub or to give a cream a firmer texture. Microplastics can be harmful to people and the environment. The European Commission has introduced new rules to limit their use in personal care products. As a result, microplastics will gradually be banned in an increasing number of products over the coming years. As a first step, they may no longer be used as exfoliating particles in personal care products. These particles are also known as microbeads.

As a result of this ban, manufacturers are replacing microplastics with other ingredients. These substances are often made from minerals, plant-based materials, or synthetic materials. It is important that these alternatives are safe for human health and the environment.

RIVM therefore investigated which alternatives to microbeads are present in personal care products sold in the Netherlands. From these, RIVM selected the ten most frequently occurring alternatives, described them and assessed their potential adverse effects. These are titanium dioxide, (hydrated) silica, hydroxyapatite, charcoal powder, kaolin, pumice, microcrystalline cellulose, apricot kernel powder, walnut shell powder, and tin oxide.

The analysis shows that most substances can be used safely. However, certain plant-based alternatives, such as apricot kernel powder or walnut shell powder, can trigger allergic reactions.

Some alternatives, such as certain forms of titanium dioxide or silica, contain nanoparticles. It is not yet known precisely whether these nanoparticles may have harmful effects when the substances are used as alternatives to microplastics. In addition, obtaining alternatives through mining or agriculture can harm the environment.

RIVM recommends monitoring over the coming years whether alternatives other than those examined in this study are used during the next stages of the restrictions.

RIVM carried out this analysis for the Netherlands Food and Consumer Product Safety Authority (NVWA).

Keywords: cosmetics, microplastics, microbeads, alternatives, health risks, environmental risks

Publiekssamenvatting

Vervangende stoffen voor microplastics in persoonlijke verzorgingsproducten

Een analyse van alternatieven voor microbeads

Fabrikanten voegen soms microplastics toe aan persoonlijke verzorgingsproducten, bijvoorbeeld in een scrub voor de huid of om een crème steviger te maken. Microplastics kunnen schadelijk zijn voor mens en milieu. De Europese Commissie heeft nieuwe regels gemaakt om het gebruik van microplastics in persoonlijke verzorgingsproducten te beperken. Hierdoor wordt het gebruik ervan de komende jaren in steeds meer producten verboden. Als eerste stap mogen microplastics niet meer als scrubdeeltjes worden gebruikt in verzorgingsproducten. Dit worden ook wel microbeads genoemd.

Door dit verbod vervangen fabrikanten microplastics door andere ingrediënten. Deze stoffen zijn vaak gemaakt uit mineralen, materialen van planten, of synthetische materialen. Het is belangrijk dat deze vervangende stoffen veilig zijn voor de gezondheid en het milieu.

Het RIVM onderzocht daarom welke alternatieven voor microbeads in persoonlijke verzorgingsproducten zitten die in Nederland worden verkocht. Het RIVM selecteerde daaruit tien alternatieven die het vaakst voorkomen, en heeft deze beschreven en geanalyseerd op ongewenste effecten. Het gaat om titaniumdioxide, (gehydrateerde) silica, hydroxyapatiet, houtskoolpoeder, kaolien, puimsteen, microkristallijne cellulose, abrikozenpitpoeder, walnootschilpoeder en tinoxide.

Uit de analyse blijkt dat de meeste stoffen veilig kunnen worden gebruikt. Wel kunnen bepaalde plantaardige alternatieven, zoals poeders van abrikozenpitten of walnootschillen, een allergische reactie veroorzaken.

Sommige alternatieven bevatten nanodeeltjes, zoals bepaalde vormen van titaniumdioxide of silica. Hiervan is nog niet precies bekend of ze als alternatief voor microplastics schadelijke effecten kunnen hebben. Verder kan de winning van alternatieven in mijn- of landbouw schadelijk zijn voor het milieu.

Het RIVM beveelt aan de komende jaren te volgen of in de volgende stappen andere alternatieven gebruikt gaan worden dan nu zijn onderzocht.

Het RIVM deed deze analyse voor de Nederlandse Voedsel- en Warenautoriteit (NVWA).

Kernwoorden: cosmetica, microplastics, microbeads, alternatieven, gezondheidsrisico’s, milieurisico’s,

Contents

Summary — 6

1 Introduction — 8

2 Definition of microplastics — 10

3 Regulatory framework — 11
3.1 Restriction of synthetic polymer microparticles according to the Regulation (EU) 2023/2055 — 11
3.2 Products covered by the restriction from 17 October 2023 — 11

4 Methodology — 12
4.1 Mintel Global New Products Database — 12
4.1.1 Selection of the category and sub-categories — 12
4.1.2 AI-assisted ingredient screening — 13
4.1.3 Ingredient compilation and frequency analysis — 13
4.1.4 Verification using regulatory databases and literature search — 14
4.2 Additional information sources — 14

5 Results — 15
5.1 Mintel GNPD search — 15
5.2 Additional information sources — 15
5.3 Selection of alternative substances — 16
5.3.1 Identification of microplastic alternatives — 16

6 Toxicity profile of the selected alternatives — 20
6.1 Titanium Dioxide — 20
6.2 Hydrated Silica / Silica — 22
6.3 Hydroxyapatite — 24
6.4 Charcoal Powder — 25
6.5 Kaolin — 26
6.6 Volcanic rock: Pumice — 27
6.7 Microcrystalline Cellulose — 28
6.8 *Prunus Armeniaca* (Apricot) Seed Powder — 29
6.9 *Juglans Regia* (walnut) Shell Powder — 30
6.10 Tin(IV) Oxide — 32

7 Discussion — 34

8 Conclusion — 36

Acknowledgements — 38

References — 39

Appendix 1 Tables of the 20 most common ingredients per product category — 48

Appendix 2 CosIng database functions of potential microplastic alternatives — 50

Summary

Microplastics are increasingly recognized as a widespread environmental and public health concern, found in both aquatic and terrestrial ecosystems. They originate from the breakdown of larger plastics (as secondary microplastics) or result from intentionally added microplastics in consumer products like cosmetics (primary microplastics).
Different definitions for microplastics exist, however, this report focuses on substances covered by the EU restriction on synthetic polymer microparticles (SPM), which are solid, organic, not readily degradable, and insoluble.

The restriction on SPMs was introduced by the European Commission in response to the risks related to microplastic pollution. They prohibit the use of microplastics in certain products, especially cosmetics, with phased deadlines for compliance from 2023 up to 2035. This regulation started with immediate restrictions on specific product types or applications, namely loose glitter and microbeads in cosmetics.

As a result of the microplastic ban, the cosmetics industry is using alternative ingredients to replace microplastics. These alternatives, often sourced from minerals, plants, or chemically synthesized, must be carefully assessed to ensure they do not pose health and environmental risks, thereby contributing to undesired substitution.
This report aims to identify alternative substances for microbeads in cosmetics, by focussing on selected cosmetic products presently concerned by the ban on microplastics. To identify the most common alternatives to microbeads in cosmetics, a systematic approach was used combining regulatory databases, literature search, AI (Perplexity), and expert judgment. The Mintel Global New Products Database was used as the main information source to find products and their ingredients present in the Netherlands.

Ingredients were screened for their frequency of occurrence, especially in products labelled “scrub”, “polish”, or “exfoliate”. The following ten ingredients were selected for further investigation of their toxicity profiles: titanium dioxide, hydrated silica/silica, hydroxyapatite, charcoal powder, kaolin, pumice, microcrystalline cellulose, apricot seed powder, walnut shell powder, and tin oxide.

While the identified (potential) substitutes do not pose immediate health risks to humans, two categories warrant closer scrutiny.
The first category contains substances that consist at least partly of nanomaterials (i.e. titanium dioxide, silica/hydrated silica and hydroxyapatite). Due to their small size, nanoparticles may penetrate biological barriers more easily than larger particles, potentially leading to unknown health effects or toxicity. Although for their use as alternatives for microbeads likely larger, non-nanosized particles have to be applied, they can still partly consist of nanoparticles. There is ongoing scientific debate about the long-term safety of specific nanoparticles, particularly regarding inhalation or skin absorption when used as scrubs, and their behaviour in the environment.

The second category concerns plant-derived ingredients (like apricot seed powder or walnut shell powder) which are generally considered safe and biodegradable but may cause allergic reactions in sensitized individuals.
Additionally, overharvesting or unsustainable agricultural practices of plant-derived alternative substances could lead to negative environmental impacts or resource depletion. An (additional) environmental concern lies in the impact of the alternative substances regarding their extraction and mining practices required for mineral-based ingredients. Responsible sourcing and production methods of alternative substances for microplastics are essential to minimize ecological harm.

The current report focused on the analysis of alternative substances based on the cosmetic products in which the use of microplastics has been banned from 17 October 2023, i.e. products containing microbeads. Future deadlines of the restriction concern rinse-off products from 17 October 2027, leave-on products from 17 October 2029, and make-up, lip, and nail products from 17 October 2035.

1 Introduction

Microplastics have emerged as a pervasive pollutant in aquatic and terrestrial environments, and are considered a global concern due to their categorization as an ecological pollutant and public health hazard (SAPEA, 2019; Anagnosti et al., 2021; Villarrubia-Gómez et al., 2018). These particles often evade waste-water treatment processes and enter natural ecosystems, where they can accumulate and pose risks to aquatic organisms (EC, 2019; ECHA, 2020; Kukkola et al., 2024). Their small size allows for ingestion by plankton and invertebrates, facilitating transfer through food webs and potentially impacting higher trophic levels, including humans (Cole et al., 2011; Wright et al., 2013).

Microplastics are typically classified as primary or secondary (Giustra et al., 2024). Primary microplastics are intentionally manufactured and incorporated into products for specific functions, such as exfoliants in detergents, personal care items like lotions and soaps, construction materials, and agricultural fertilizers or pesticides.
Secondary microplastics, by contrast, result from the degradation and abrasion of larger plastic items, including tires, rubber granules on sports fields, paints, plastic pellets, synthetic clothing, and single-use products like plates and straws. They also include particles released from textile production and laundering.

In cosmetic formulations, primary microplastics such as polyethylene or polypropylene microbeads have been widely used and intentionally incorporated as exfoliating agents, fillers, and viscosity modifiers (GESAMP, 2015; Bikiaris et al., 2024). Other (consumer) products such as glitter can even completely consist of microplastics. The European Commission adopted Commission Regulation (EU) 2023/2055 — commonly referred to as the "microplastics restriction" — which has applied since 17 October 2023 and establishes restrictions on synthetic polymer microparticles used on their own or intentionally added to mixtures, with transitional implementation periods for specific product categories extending up to 2035 (EU, 2023). Synthetic polymer particles cover only primary microplastics, are heterogeneous in material and shape, with dimensions below 5 mm, and are organic, insoluble and resist degradation (EC, 2026).
For cosmetics, the deadlines to comply with the restriction are 17 October 2023 for products containing microplastics for use as an abrasive, i.e. namely to exfoliate, polish or clean ("microbeads"), followed by deadlines for different cosmetic categories: 16 October 2027 for rinse-off products, and 16 October 2029 for leave-on products in general. The date of application for the restriction in make-up, lip, and nail cosmetics is 16 October 2035, with a declaration obligation starting at 17 October 2031 until 16 October 2035. The latter means that in that period, these products must carry a label stating that they contain microplastics.

As a result of the microplastics restriction, microplastics in personal care products likely have been, or will be replaced by alternative substances. It is important to note that the specific definition of synthetic polymer

microparticles (SPMs) applied within the context of the restriction is more narrow than often used for microplastics in general. As an illustration, NGOs, such as the Plastic Soup Foundation for instance, handle a broader definition of microplastics in cosmetics (Plastic Soup Foundation, 2026). The alternative substances dealt with in the present report are alternatives for primary microplastics covered by the SPM restriction applicable to cosmetics.

The alternative substances to microplastics in personal care products can be separated into different categories including minerals, plant products and animal products (Hunt et al., 2021). It is crucial to carefully evaluate alternatives to microplastics in cosmetics to avoid regrettable substitution. Therefore, potential substitutes should be assessed for their chemical composition, persistence, their physico-chemical properties, their dermal permeation as well as dermal toxicity, as well as their toxicity in the environment in order to make a evaluation of the health and enviroment risks. Within the scope of this report, this assessment is limited to cosmetic products that are subject to the first deadline in the microplastics restriction i.e. limited to microbeads. This delineation was applied to ensure that the evaluated products are expected to be free of intentionally added SPMs, thereby providing a consistent basis for assessing alternative substances.

In the current report, first the definition of the microplastics covered has been further clarified (Chapter 2), together with the related regulatory framework (Chapter 3). Chapter 4 describes the methodology of the search for alternative substances for replacing microplastics in cosmetic products. Chapter 5 describes the resulting outcome of the search, also listing the alternative substances identified. From these, ten alternative substances have been selected for further analysis, i.e. by describing their properties and creating a (limited) toxicity profile in order to identify any potential health and environmental risks associated with these substances (Chapter 6). The discussion and conclusions from this study are described in Chapter 7 and 8, respectively.

2 Definition of microplastics

According to the Commission Delegated Decision (EU) 2024/1441, the definition of microplastics corresponds to "solid plastic particles composed of mixtures of polymers and functional additives. They may also contain residual impurities. Microplastics can be unintentionally formed when larger pieces of plastic, like car tyres or synthetic textiles, wear and tear. But they are also deliberately manufactured and added to products for specific purposes, such as exfoliating beads in facial or body scrubs."

In the restriction of the use of intended microplastics in cosmetics, however, only synthetic polymer microparticles (SPM) are concerned (EU, 2023). Therefore, the EU definition of SPM is used in this report as a working definition of microplastics, as the scope of the report is on the same primary microplastics as covered by the restriction.

According to the Regulation (EU) 2023/2055, polymers that are solid and which fulfil both of the following conditions are considered SPMs (EU, 2023):

- are contained in particles and constitute at least 1% by weight of those particles; or build a continuous surface coating on particles;
- at least 1% of the weight of the particles referred to in point (a) fulfil either of the following conditions:
  - all dimensions of the particles are equal to or less than 5 mm; and
  - the length of the particles is equal to or less than 15 mm and their length to diameter ratio is greater than 3.

The following polymers are excluded from this designation:

- polymers that are the result of a polymerisation process that has taken place in nature, independently of the process through which they have been extracted, which are not chemically modified substances;
- polymers that are degradable as proved in accordance with Appendix 15 [to REACH, Regulation (EC) No 1907/2006];
- polymers that have a solubility greater than 2 g/L as proved in accordance with Appendix 16 [to REACH, Regulation (EC) No 1907/2006]; and
- polymers that do not contain carbon atoms in their chemical structure.

The analysis performed in this report is focused exclusively on products that are presently the subject of the restriction (a detailed description of the products included is provided in Chapter 3.2). Throughout this report, the term microplastics is preferred over SPM, as it is the terminology more commonly used in scientific community and the general public, except while discussing the regulatory framework.

3 Regulatory framework

3.1 Restriction of synthetic polymer microparticles according to the Regulation (EU) 2023/2055

On 25 September 2023 Commission Regulation (EU) 2023/2055 amending Annex XVII to the REACH Regulation (EC) No 1907/2006 as regards SPM was adopted. It resulted from a call by the Council upon the Commission to propose measures to reduce the discharge of macro- and micro-sized plastic debris in the marine environment, including a proposal for a ban on polymers in cosmetics, personal care products and detergents. The call was a reaction on the earlier conclusions from the EU action plan for the circular economy and on international ocean governance. In September 2018, the European Parliament called on the Commission to introduce a ban on microplastics in cosmetics, personal care products, detergents and cleaning products, by 2020 (EC, 2023).

3.2 Products covered by the restriction from 17 October 2023

The EU is phasing out intentionally added SPM in cosmetics and other products through Regulation (EU) 2023/2055, which entered into force on 17 October 2023. The phase-out is gradual, with immediate restrictions applying to products such as loose glitter in crafts and toys and microbeads in cosmetic products from that date, followed by deadlines for different cosmetic categories: rinse-off products from 17 October 2027, leave-on products from 17 October 2029, and make-up, lip, and nail products from 17 October 2035. For certain make-up, lip, and nail products, a labelling requirement applies from 17 October 2031 until the final deadline in 2035.

Regarding the products concerned by the ban from 17 October 2023, recital 21 explains that "Concerning the ban on the placing on the market of 'microbeads', i.e. synthetic polymer microparticles for use as an abrasive, i.e. namely to exfoliate, polish or clean, mainly used in rinse-off cosmetic products or detergents, no transitional period was proposed, as industry was expected to have voluntarily phased out their use by 2020" (EU, 2023).

The concerned cosmetic products are (KVK, 2026):

- All rinse-off cosmetic products containing microplastics for use as an abrasive (e.g. shower gels, shampoos, foams, exfoliating gels),
  - Exfoliating shower gels containing abrasive plastic microbeads
  - Body and facial scrubs containing microplastics
  - Rinse-off facial cleansers containing microplastics
  - Shampoos containing microplastics used as exfoliating agents
  - Shaving foams containing plastic microbeads
  - Other rinse-off cosmetic products used for exfoliation, polishing or cleansing
- Products for lips, nails and make-up (microbeads and glitter)
  - loose glitter, not embedded in a matrix

4 Methodology

Based on the definition of the products covered by the ban from 17 October 2023 (Chapter 3.2), specific product categories were selected as a source for identifying potential alternative substances for microplastics in cosmetics, namely those personal care products that are presently the subject of the restriction, and therefore do not contain microplastics as defined by the microplastic restriction.

The Mintel Global New Products Database was chosen as a primary source to identify alternative substances in such products. The use of additional information sources (such as literature) was also foreseen.

4.1 Mintel Global New Products Database

As primary source, the Mintel Global New Products Database (GNPD)[1] was used for product information. It is important to note that products are added to this database by Mintel upon their entry into the market. Therefore, the search was initiated from the date the regulation on microplastics for this category of products came into effect until the day of search (17 October 2023- 13 Nov 2025). The personal care cosmetic product categories Soap & Bath products, Oral Hygiene, and Skin Care as defined by Mintel (Mintel database, 2025) were selected as they fit the products defined to be presently the subject of the restriction.

4.1.1 Selection of the category and sub-categories

The selection of database search categories was based on the description of prohibited products by the Netherlands Chamber of Commerce (KvK). Loose glitter was excluded from the scope as this is not a cosmetic product, and glitter incorporated in cosmetic products falls under the deadlines for rinse-off and leave-on cosmetics in 2027 and 2029, respectively.

Within the Mintel database category Soap & Bath products the sub-categories
shower product and bar soap were selected. The sub-categories bath additives, intimate hygiene, liquid soap, and wipes were not selected as they are out of scope of this report. Within the scope of this report, the assessment is limited to products that were already subject to the microplastics restriction i.e. limited to (rinse-off) products with microbeads such as scrubs and shower gels. This delineation was applied to ensure that the evaluated products are expected to be free of intentionally added microplastics, thereby providing a consistent basis for assessing alternative substances.
The resulting products were filtered on the keyword's "scrub", "polish", and "exfoliate" in product descriptions. This approach ensured the inclusion of products likely to contain particulate materials relevant to microplastic substitution.

Within the Mintel database category Oral Hygiene, the sub-category toothpaste was selected. Products could not be filtered on the same

[1] https://www.mintel.com

keywords as for the categories Soap & Bath product and Skin care as these are not standard descriptions of toothpastes. Therefore, all products in this sub-category were included in the analysis.

In the Mintel database category Skin Care, the sub-categories face/neck care, body care, face-cleansers, lip care, hand/nail care, eye care, sets, foot care, nail enamel removers, and eye-cleansers were selected. Products were filtered on the keyword's "scrub", "polish", "exfoliate".

4.1.2 AI-assisted ingredient screening

Artificial intelligence, specifically the Perplexity platform, was used to support targeted screening and classification of ingredients.
This AI-powered answer engine integrates real-time web search with multiple advanced large language models (LLMs). The platform leverages a multi-model architecture, dynamically routing queries to the most suitable model based on task requirements. For this research, targeted questions were addressed using used the default option, whereby Perplexity selects the model best suited to the task such as GPT (OpenAI), Claude Sonnet (Anthropic), and Perplexity's proprietary Sonar models, which are optimized for fast, grounded web search and summarization.
The platform operates via retrieval-augmented generation (RAG), where real-time search results from authoritative sources (scientific literature, regulatory databases, industry reports) are retrieved and passed to the LLM as context alongside the original query. This ensures answers are grounded in current, factual information rather than pre-trained knowledge alone. Each response includes numbered inline citations linking to original sources, enabling traceability and verification of all retrieved data.

AI assistance was applied to address the following research questions:

- Identification of ingredients used as alternatives to microplastics in cosmetic formulations.
- Detection of ingredients with identical INCI names (detailed below), shared CAS numbers, or missing/ambiguous nomenclature.

This step enabled efficient pre-screening of large ingredient datasets and facilitated the identification of candidate substances for further evaluation.

4.1.3 Ingredient compilation and frequency analysis

As some ingredients can have similar names or fall under the same International Nomenclature of Cosmetic Ingredients (INCI), a check was performed with the help of an AI model named Perplexity (see 4.1.2.) followed by expert judgement. For each selected product, ingredient lists were extracted and compiled into category-specific datasets. Ingredients were standardized where possible (e.g., harmonizing naming conventions) to enable aggregation and comparison.
A frequency analysis was performed within each category to identify the most commonly used ingredients. This step allowed prioritization of substances with higher market relevance and potential consumer exposure.

4.1.4 *Verification using regulatory databases and literature search*

To ensure accuracy and regulatory relevance, identified ingredients were cross-checked using the CosIng database (European Commission database for cosmetic substances and ingredients).
A detailed comparison was performed including key parameters such as:

- INCI name and CAS number
- Functional role (e.g., abrasive, exfoliating, skin conditioning)
- Regulatory status and restrictions

This verification step ensured consistency with EU cosmetic regulatory frameworks and improved the reliability of ingredient classification.

Additionally, with the information retrieved from CosIng, a literature search was conducted to identify potential alternatives to microplastics in cosmetic formulations. Scientific databases, including Google Scholar and Web of Science, were queried using the keywords "microplastics", "cosmetics", "alternatives", and "replacement". Relevant peer-reviewed articles were selected, and data on the physicochemical properties and functional performance of identified alternatives were extracted and analysed (see Appendix 2).

4.2 Additional information sources

Several governmental institutes, universities as well as NGOs were consulted with the question whether they have reports on alternatives for microplastics in cosmetics.

The following institutes were contacted and/or their websites visited: the German Federal Institute for Risk Assessment (BfR), the French Agency for Food, Environmental and Occupational Health & Safety (ANSES), the Danish Environmental Protection Agency (Danish-EPA), and the Swedish Chemicals Agency (KEMI).

In addition, the following NGOs were consulted: the European Consumer Organisation (BEUC), the Swedish Consumers' Association (Sveriges Konsumenter), the Portuguese Association for Consumer Protection (DECO), the French Union Fédérale des Consommateurs - Que choisir (UFC-Que choisir), and the Hungarian Association of Conscious Consumers (TVE).

Other sources consisted of contacting the National (NL) project on microplastic MOMENTUM (Momentum | Universiteit Utrecht | Homepage), and LinkedIn. Via LinkedIn, some contacts were made with the university of Le Mans in France where research on microplastics is being performed.

5 Results

5.1 Mintel GNPD search

Initially, the database search was performed in all EU countries/markets, which resulted in around 30,000 products. As this number was considered too high to be analysed in detail, the search was limited to the Netherlands only. In total, 1569 products were selected and their specifications downloaded for further research.

Table 1 below describes the number of products obtained with the Mintel GNPD search and after filtration on keywords and with the help of AI. In the appendix the 20 most frequently occurring ingredients are presented in Table A1 for the Soap & Bath, in Table A2 for Oral Hygiene, and in Table A3 for Skin Care.

Table 1. Number of products identified through Mintel GNPD search and filtered using keywords and AI. The search was initiated from the date the regulation on microplastics for this category of products came into effect until the day of search (17 October 2023- 13 Nov 2025)

Category	**Sub categories**	**Products including variants**	**Unique products**	**After filtration on keywords**		**After AI check**
				Number of products	**Number of ingredients**	
Soap & Bath	Shower product	387	379	10	138	138
	Bar soap					
Oral Hygiene	Toothpaste	107	107	107	276	271
Skin Care	Face/neck care	1083	1083	113	812	807
	Body care					
	Face-cleansers					
	Lip care					
	Hand/nail care					
	Eye care, sets					
	Foot care					
	Nail enamel removers					
	Eye-cleansers					

5.2 Additional information sources

The consultation of governmental institutes overall yielded only limited information, as in general no projects were performed or reports on this matter, apart from a publication by KEMI (KEMI, 2016). In that publication from the 'Swedish Chemicals Agency's 2015 store study' a listing of substitutes for plastic microbeads in cosmetic products was provided including: Microcrystalline cellulose, Rice grains, Olive stones, Minerals, Walnut shell powder, Sugar, Salt, Pineapple peel, Bentonite (clay), Pumice, Jojoba microspheres, Silica, Corn cob powder, Bitter orange, Citric acid, Mica, Montmorillonite (silicate mineral), and Almond shell, which were contained by scrub products (KEMI, 2016).

Regarding the NGO's contacted, no tests or reports could be provided. TVE subsequently asked their contacts in Czech Republic, Slovakia, Slovenia and Austria; but no complementary report was found.
The University of Le Mans in France where research on microplastics is being performed indicated not to have performed a review on alternative substances.

5.3 Selection of alternative substances

5.3.1 Identification of microplastic alternatives

Following the described methodology, a total of 14 potential microplastics alternatives were found in the Soap and Bath category, 15 in the Toothpaste category, and 52 in the Skin Care category. The occurrence of all potential alternatives as well as their frequency of occurrence is shown in the Table 2,
Table 3Table 4 below.

Table 2. Occurrence of selected potential alternative ingredients for microplastics in the Mintel Soap and Bath products selected subcategories

Ingredient	**Number of products**	**Occurence (%)**
Plant-derived powders and fibers		
Cellulose	3	30%
Coffea Arabica/Robusta Seed Powder	3	30%
Microcrystalline Cellulose	2	20%
Juglans Regia Shell Powder	2	20%
Oryza Sativa Germ Powder	2	20%
Argania Spinosa Shell Powder	1	10%
Butyrospermum Parkii Nut Shell Powder	1	10%
Olea Europaea Seed Powder	1	10%
Simmondsia Chinensis Seed Powder	1	10%
Cellulose Gum	1	10%
Cellulose Acetate	1	10%
Mineral or inorganic texturizers		
Silicium oxide minerals		
- Hydrated Silica	2	20%
Volcanic minerals		
- Pumice	1	10%
Other substances		
- Xanthan Gum	1	10%

Table 3. Occurrence of selected potential alternative ingredients for microplastics in the Mintel Oral care (Toothpaste) (sub)category.

Ingredient	**Number of products**	**Occurence (%)**
Mineral or inorganic texturizers		
Silicium oxide minerals		
- Hydrated Silica	84	79%
- Silica	12	11%
- Solum Diatomeae	1	1%

Ingredient	Number of products	Occurence (%)
Hydroxyapatite	6	6%
Alumina	4	4%
Clay materials		
- Kaolin	3	3%
- Bentonite	2	2%
- Illite	1	1%
Volcanic minerals		
- Perlite	1	1%
Tin oxide	1	1%
Other particulate abrasive alternatives		
- Charcoal Powder	3	3%
Plant-derived powders and fibers		
- Microcrystalline Cellulose	7	7%
- *Malva Sylvestris* Leaf Powder	1	1%
- *Thymus vulgaris* leaf/stem powder	1	1%
- *Zanthoxylum Americanum* Bark Extract	1	1%

Table 4. Occurrence of selected potential alternative ingredients for microplastics in the Mintel Skin Care products selected subcategories

Ingredient	Number of products	Occurence (%)
Mineral or inorganic texturizers		
Titanium dioxide	16	14%
Silicium oxide minerals		
- Silica	12	11%
- Hydrated Silica	5	4%
- Magnesium Aluminium Silicate	4	4%
- Solum Diatomeae	1	1%
Tin oxide	8	7%
Clay materials		
- Kaolin	7	6%
- Bentonite	5	4%
Volcanic minerals		
- Pumice	6	5%
- Perlite	4	4%
- Volcanic Ash	1	1%
- Volcanic Sand	1	1%
Mica	5	4%
Zinc Oxide	1	1%
Calcium carbonate	1	1%
Other particulate abrasive alternatives		
Charcoal Powder	2	2%
Plant-derived powders and fibers		
Prunus Armeniaca (Apricot) Seed Powder	10	9%

Ingredient	Number of products	Occurence (%)
Zea Mays Starch	8	7%
Hydroxyethylcellulose	7	6%
Aloe Barbadensis Leaf Juice Powder	4	4%
Carrageenan	3	3%
Cellulose	3	3%
Ceratonia Siliqua (Carob) Gum	3	3%
Microcrystalline Cellulose	3	3%
Acacia Senegal Gum	2	2%
Bambusa Arundinacea Stem Extract	2	2%
Camellia Sinensis Leaf Powder	2	2%
Juglans Regia Shell Powder	2	2%
Prunus Amygdalus Dulcis Shell Powder	2	2%
Cellulose Gum	2	2%
Zea Mays Cob Powder	1	1%
Oryza Sativa Starch	1	1%
Aloe Barbadensis Leaf Powder	1	1%
Prunus Persica Seed Powder	1	1%
Salvia Hispanica Seed Powder	1	1%
Theobroma Cacao Seed Powder	1	1%
Avena Sativa Kernel Extract	1	1%
Avena Sativa Kernel Flour	1	1%
Houttuynia Cordata Powder	1	1%
Luffa Cylindrica Fruit Powder	1	1%
Ribes Nigrum Fruit Powder	1	1%
Sclerotium Gum	1	1%
Vaccinium Macrocarpon Fruit Powder	1	1%
Chondrus Crispus Powder	1	1%
Cellulose Acetate	1	1%
Salts and sugars		
Sucrose	16	14%
Maris Sal / Ancient Sea Salt (Sodium Chloride)	6	5%
Other substances		
Xanthan Gum	44	39%
Gellan Gum	2	2%
Sodium Hyaluronate Crosspolymer	2	2%
Acrylates Crosspolymer-4	1	1%
Adipic Acid/Neopentyl Glycol/Trimellitic Anhydride Copolymer	1	1%
Amber powder	1	1%
Biosaccharide Gum-1	1	1%

A multi-criteria evaluation was applied to identify potential alternatives to microplastics. The selection criteria included:

- Functional relevance: Ingredients associated with “scrub”, “polish”, or “exfoliate” claims.
- Frequency of occurrence: Presence in and across multiple products categories.
- Market relevance: Preference for widely used and commercially established ingredients.

Expert judgment was combined with AI-assisted searches and CosIng database verification to refine the list of candidate substances. This integrative approach ensured both scientific robustness and practical applicability.

Based on the selection methodology described above, ten ingredients were shortlisted for a further (limited) evaluation of their potential human health and environmental toxicity. Due to time constraints, the selection of ingredients is limited. This selection was made to support a risk-based prioritisation approach, focusing on ingredients with the highest frequency of occurrence and therefore the greatest potential for consumer exposure, while keeping the assessment manageable within the available timeframe:

- Titanium Dioxide
- Hydrated Silica / Silica
- Hydroxyapatite
- Charcoal Powder
- Kaolin
- Volcanic rock: Pumice
- Microcrystalline Cellulose
- *Prunus Armeniaca* (Apricot) Seed Powder
- *Juglans Regia* (Walnut) Shell Powder
- Tin oxide

6 Toxicity profile of the selected alternatives

The selection of alternative ingredients was based on an initial inventory of the functions of various cosmetic ingredients. Functional information was obtained from both CosIng and the scientific literature; however, discrepancies between sources were occasionally observed. Consequently, the final selection also considered the frequency of occurrence of the ingredients and their occurrence across different product categories. The ten ingredients selected for toxicity profiling are representative of these criteria.

These ingredients have been screened for their general properties, toxicity for humans and concerns for the environment. It should be noted that this evaluation is limited to a high-level screening exercise, that is not specifically tailored to the use as exfoliating ingredient. Where possible, existing hazard or risk assessments were used as primary information sources, with added information from literature, and where appropriate from industry or NGO websites.
Although the general toxicological profile is compiled, it should be noted that not all endpoints are equally relevant for the use of these ingredients as alternative to microbeads (e.g. inhalation of loose nanoparticles is likely to be minimal from this application), and therefore several opinions (e.g. by SCCS) are not targeted for this application.

6.1 Titanium Dioxide

Introduction
Titanium dioxide (TiO_2) (CAS No: 13463-67-7) represents the most widely employed white pigment across various applications, including coatings, food products (outside EU), and personal care formulations (Proquin et al., 2017). TiO_2 may be used in cosmetics either as a white pigment, opacifier, thickener or as inorganic ultraviolet (UV) filter. Its properties like opacifier, and its textural properties may allow it to replace certain functions of microplastics. According to Hunt et al., it is also used as a mild abrasive in scrub formulations, although this function is not currently listed in CosIng (Hunt et al., 2021, Appendix 2).

Physico-chemical properties
TiO_2 occurs naturally in three crystalline forms: rutile, anatase and brookite, with particles in different size ranging from micro (µm) to nano (nm).
TiO_2 is used for its distinct physicochemical properties. It exhibits exceptional chemical stability, a high refractive index, strong ultraviolet (UV) radiation resistance, whitening, thickener and opacifying effects (Proquin et al., 2017). Rutile TiO_2 is preferred in sunscreens due to its high UV stability as well as the nano form (Slomberg et al., 2021). In sunscreens, TiO_2 is often combined with surface modifiers such as stearic acid, isostearic acid, polyhydroxystearic acid, and dimethicone/methicone copolymer to enhance performance and stability (SCCS, 2014). For many other cosmetic applications, TiO_2 is usually used in the micro sized form and surface-coated (Slomberg et al.,

2021), which improves spreadability and reduces the feel thick, dense, or dragging on the skin.

Toxicity in humans
TiO_2 is photoreactive with a resulting increase in reactive oxygen species (ROS) known to be implicated in cellular damage (Dréno et al., 2019). The main concern with using TiO_2 in skin-related products is its ability to generate ROS, which can potentially harm skin cells (Egerton et al., 2007; Racovita, 2022). Although, all forms of TiO_2 nanoparticles can cause this phototoxic effect, the severity of the response may vary depending on the crystalline form. Anatase is generally considered the most photoreactive phase. It absorbs light more efficiently and generates higher levels of ROS compared to rutile and brookite. Rutile produces fewer ROS under the same conditions, which is why rutile is often preferred in sunscreen formulations. Brookite is less commonly used and studied, but its photoreactivity is generally considered to be between that of anatase and rutile.
ROS production by TiO_2 nanoparticles (NPs) has been identified in many different dermal cell lines and observed after 5 min, 6h and 24h of exposure (Shukla et al., 2011; Saquib et al., 2012). Another study demonstrated that the administration of TiO_2 NPs can increase the dermal sensitization potency of other substances, i.e. dinitrochlorobenzene, by augmenting a Th_2 response, showing the immunomodulatory abilities of TiO_2 NPs (Hussain et al., 2012).

According to the Scientific Committee on Consumer Safety (SCCS), titanium dioxide—both in pigmentary and nanoparticulate forms—exhibits negligible dermal absorption through intact human skin (SCCS, 2024a). The overall conclusion of SCCS was that for oral cosmetic products, the available evidence does not allow it to exclude a potential genotoxic effect for almost all titanium dioxide (TiO_2) grades used in cosmetics (both nano and non-nano). *In vitro* studies have demonstrated that TiO_2 particles predominantly localize within the stratum corneum, with minimal penetration into the viable epidermis or dermis (SCCS, 2024a). Furthermore, the International Agency for Research on Cancer (IARC) has reported that dermal contact does not result in an increased incidence of tumours (IARC, 2010).

Regarding oral exposure (relevant for cosmetics in the case of e.g. toothpaste), the food additive titanium dioxide (E 171), is banned since 2022 as a food additive primarily due to concerns over its potential genotoxicity. The European Food Safety Authority (EFSA) reassessed the additive in 2021 and concluded it could no longer be considered safe. Citing new data on nanoparticles in E 171 (up to 50% of particles under 100 nm), EFSA raised concerns that these smaller particles may increase the risk of genotoxic effects, contributing to the decision to ban titanium dioxide as a food additive. These particles showed evidence of DNA strand breaks and chromosomal damage in studies, with low absorption after ingestion but possible accumulation in the body. Genotoxicity risks could not be ruled out, and no safe daily intake threshold was identifiable due to uncertainties in particle size effects and lack of carcinogenicity studies (EFSA Scientific Committee, 2018a).

Toxicity in the environment
Data on the ecotoxicity of TiO_2 in aquatic organisms remain limited and contradictory due to the lack of standardised methods (Baltar et al., 2025). Studies demonstrate that TiO_2 exposure reduces embryo viability in zebrafish (starting at a concentration of 0.1 mg/L) (Yang et al., 2023), inhibits goldfish growth (starting at a concentration of 10 mg/L) (Ates et al., 2013, Shah et al., 2017), and decreases cell viability and chlorophyll in microalgae (starting at a concentration of 5 mg/L) (Li et al., 2015). Anatase TiO_2 NPs (21 nm) are particularly toxic to *Daphnia magna*, affecting survival, growth, and reproduction (Kim et al., 2010). Further research is needed to evaluate the environmental risks of nanomaterials to aquatic species.

Conclusion regarding possible risks
In conclusion, current safety assessments by the SCCS and ECHA indicate that the primary concerns regarding TiO_2 relate to inhalation exposure, particularly from spray and powder formulations. In addition, there is doubt about its safety through oral exposure. In contrast to these exposure routes, risks associated with dermal exposure, which will usually be the most relevant for TiO_2 as an alternative for microplastics, remain negligible. Also risks associated with ecotoxicity are regarded to be negligible. These findings support the continued use of titanium dioxide in topical products, provided that any inhalation risks are appropriately managed.
Regarding the oral exposure of TiO_2, for instance from the use of oral care products, oral mucosa absorption risks prompted manufacturers to reformulate or phase out the additive in specific products voluntarily due to genotoxicity concerns from oral exposure.

6.2 Hydrated Silica / Silica

Introduction
Silica (CAS Nos: 7631-86-9; 112945-52-5; 60676-86-0) and hydrated silica (CAS Nos: 10279-57-9; 1343-98-2; 7631-86-9; 112926-00-8; 63231-67-4) are silicon dioxide (SiO_2) materials. Altogether, these ingredients are commonly employed in many different products for various functions, including as food additive SAS (E 551), and in many other consumer products. In cosmetics it is used in a broad range of formulations including skin care, make-up, and oral care products, where they serve various reported functions including abrasive, absorbent, anticaking, bulking, opacifying, viscosity controlling, skin conditioning, skin emollient, and emulsion stabilising (SCCS, 2015a). These substances can be used as e.g. an abrasive alternative for microplastics in personal care products (Hunt et al., 2021).

Silica and hydrated silica in cosmetics consist of synthetic amorphous silicon dioxide (SAS) particles. Hydrated silica includes water molecules bound to its structure, which makes it a softer, more porous, and less abrasive material. Dependent on different production processes, SAS exists as (hydrophilic and hydrophobic) precipitated silica, pyrogenic silica, and colloidal silica (Brand et al., 2021). Silica can also be found in cosmetic products under different INCI names, including Pyrogenic Silica, Silica Silylate, and Silica Dimethyl Silylate. Apart from amorphous

silica substances, there are also crystalline forms of silica, i.e. quartz, which is also allowed in cosmetics.

Physico-chemical properties
The different SAS materials have been described as white powder or fluffy white powder, or as bluish white dispersion for colloidal particles. SAS usually forms small aggregates and larger agglomerates of constituent particles ranging between 5 and 100 nm in size, and the material should therefore be considered as a nanomaterial according to the EU Definition (Brand et al., 2021). In common applications these particles bind together to form larger agglomerates.
The SCCS concluded that the solubility of both hydrophilic and hydrophobic SAS is low, generally below 1-100 mg/L. As such, these materials met the definition of "insoluble or bio-persistent" according to the Cosmetic Regulation (SCCS, 2022).

Toxicity in humans
In 2015, the EC Scientific Committee on Consumer Safety (SCCS, 2015a) evaluated the safety of the nanomaterials silica, hydrated silica, silica silylate and silica dimethyl silylate for use in leave-on and rinse-off cosmetic (i.e. hair, skin, lip, face, nail) products. The SCCS concluded that the available data were inadequate and insufficient to allow any firm conclusions either for or against the safety of any of the individual SAS material, or any of the SAS categories that are intended for use in cosmetic products. The SCCS identified several critical data gaps, including insufficient characterisation of the test materials (e.g., size distribution, agglomeration state, surface chemistry), lack of reliable dermal penetration studies, and absence of robust toxicological data including long-term toxicity and genotoxicity studies. A new opinion on these substances is therefore under development (SCCS, 2022). The focus of these opinions is for an important part dedicated to the potential effects of SAS nanoparticles. For silica particles to function as an abrasive alternative to microplastics, they need to larger than nano-sized. The SCCS opinion does not take inhalation exposure into account.

In general, for its uses SAS is regarded as safe, and unable to penetrate the skin. However, for nano-sized silica particles, some concern exists regarding their use in cosmetics as these might be able to penetrate the skin. The SCCS found no proof that nano-silica penetrates the skin but also did not find enough evidence to rule out those possibilities. A study by Bosch et al. (2024) reviewed local and systemic dermal toxicity of SAS and concluded that the risk of dermal application of SAS in cosmetic formulations is negligible. More data are necessary for a better conclusion regarding the safety of silica (nanoparticles) upon dermal exposure (SCCS, 2015a).

Toxicity in the environment
As silica is an inert, ubiquitous naturally occurring substance and unlikely to react chemically with any other substances in the environment. Therefore, silica (non-nano), in the context of use in the personal care products concerned, is posing negligible risk to the environment (US-EPA, 1991).

Conclusion regarding possible risks
The SCCS identified several critical data gaps including lack of reliable dermal penetration studies, and the absence of robust toxicological data including long-term toxicity and genotoxicity studies. A further opinion by SCCS, assessing all possible (nano)grades of Si used in cosmetic products, is currently under construction (SCCS, 2022).
In general, it is considered that silica is practically insoluble, poorly absorbed, and not bioavailable via dermal contact. EFSA does not consider dermal irritation or systemic toxicity from topical exposure to be an area of concern (EFSA ANS Panel, 2018). Also, the American Cosmetic Ingredient Review (CIR) concluded that synthetically manufactured amorphous silica and hydrated silica are safe in the present practices of use and concentration when formulated to be non-irritating, provided that products are formulated to prevent respiratory irritation or sensitization from inhalation.

6.3 Hydroxyapatite

Introduction
Hydroxyapatite (CAS No: 1306-06-5) is a mineral obtained from pearl oyster shells, salmon bones, phosphate rock, or derived synthetically. It conforms generally to the formula $3Ca_3(PO_4)_2*Ca(OH)_2$ (SCCS, 2025). Hydroxyapatite has abrasive and skin conditioning properties. Its application is mainly in oral care products such as toothpaste (Mintel database, 2025; Hiller et al., 2018), but because of its abrasive function, its application in scrubs has been mentioned on several internet sources. For instance, according to the Cosmetics Database of the Environmental Working Group (EWG) Skin Deep, hydroxyapatite may be used as an abrasive, a bulking agent, as an oral care agent or as a stabilising emulsion (EWG's Skin Deep, 2026).

Physico-chemical properties
Hydroxyapatite is a white powder with different sizes and morphologies, including nanosized particles (SCCS, 2025). Hydroxyapatite is slightly soluble in water.

Toxicity in humans
SCCS has published an opinion on nanosized hydroxyapatite (SCCS, 2025). According to this opinion, the application of hydroxyapatite in oral care products is considered safe up to a maximum concentration of 29,5% in toothpaste and up to 10% in mouthwash. Regarding nano-sized hydroxyapatite, although the particle shape is reported to be rod-shaped, it is also known that, depending on the manufacturing process, needle-shaped hydroxyapatite nanoparticles may also be produced (SCCS, 2025).

While bulk hydroxyapatite is inert, the impact of nano-sized hydroxyapatite particles is heavily dependent on their shape. The SCCS has noted that needle-shaped hydroxyapatite nanoparticles may raise concerns regarding toxicity as genotoxicity cannot be excluded. Therefore, needle shaped nano-hydroxyapatite should not be used in cosmetic products.

Toxicity in the environment
Hydroxyapatite is regarded as safe due to its composition and ability to (slowly) dissolve into harmless components, i.e. calcium, phosphate and water.

Conclusion regarding possible risks
Hydroxyapatite is considered safe for consumers as an abrasive in dermal application up to 5% (used in the risk assessment of the SCCS opinion); considering rod-shaped nano-sized particles are not included in the material. Hydroxyapatite is also considered not to pose a risk for the environment. These findings support the safe use of hydroxyapatite in topical products, provided that inhalation risks are appropriately managed.

6.4 Charcoal Powder

Introduction
Charcoal powder (CAS No.: 7440-44-0; 16291-96-6) is an amorphous form of carbon produced by partially burning or oxidizing wood or other organic matter. The resulting powder can be used for its abrasive characteristics as an alternative for microplastics in personal care products (Habib et al., 2022; Sanchez et al., 2020). Charcoal powder can also consist of activated charcoal, which is specially processed with high heat and gases to create a more porous structure. Charcoal is also the source for the production of the colourant food additive vegetable carbon (E 153) (EFSA FAF Panel, 2026), and the cosmetic ingredient carbon black (CI 77266) which can partly consist of nanoparticles (SCCS, 2015b).

Physico-chemical properties
Charcoal powder is a black powder with a relatively low water solubility.

Toxicity in humans
There is no SCCS opinion available on charcoal. For carbon black under Annex IV to the Cosmetic Regulation upper limits have been on impurities, including on PAHs. According to the Cosmetic Ingredient Review, charcoal powder is not considered irritating or sensitizing. It was not predicted to be irritating in reconstructed human epidermis model tests, nor was it irritating in a rabbit primary skin irritation test when tested at a concentration of 100%. In local lymph node assays (LLNAs) in mice, charcoal was not sensitizing when tested at concentrations up to 10% (CIR, 2023). For carbon black, which could be considered a potentially more harmful substance considering the smaller particles contained, the SCCS concluded that the use of carbon black CI 77266 in nano-structured form, with a size of 20 nm or larger at a concentration up to 10% as a colorant in cosmetic products, is considered to not pose any risk of adverse effects in humans after application on healthy, intact skin. This conclusion does not apply to applications that may lead to inhalation exposure (SCCS, 2015b).

Toxicity in the environment
Charcoal is a natural occurring substance, biodegradable, and not considered harmful for the environment.

Conclusion regarding possible risks
The use of charcoal powder, including activated charcoal, is generally regarded as safe as a substance applied to the skin, provided levels of any impurities are acceptable.

6.5 Kaolin

Introduction
Kaolin (CAS No: 1332-58-7; CI 77004), also referred to as China clay or white clay, is a naturally occurring aluminosilicate mineral widely utilized in cosmetics. Its primary component is hydrated aluminium silicate.
As an alternative for microplastics in personal care products, kaolin functions as an absorbent due to its high oil-absorbing capacity, facilitating the removal of excess sebum and impurities from the skin surface. This property contributes to its effectiveness in cleansing products and in the prevention of acneiform conditions. Moreover, kaolin exhibits a mild abrasive action, allowing its use as a gentle exfoliant suitable for sensitive skin types. It also assists in maintaining skin hydration, thereby supporting the management of dry skin (Draelos, 2011).

Physico-chemical properties
Kaolin is a clay mineral composed primarily of about 45% silicon dioxide (SiO_2; silica), 39% aluminium oxide (Al_2O_3), and 14% water, with minor quantities of iron(III) oxide, magnesium oxide, calcium oxide, potassium oxide, sodium oxide, and titanium(IV) oxide. It typically appears as an odourless, white to yellowish-grey powder, and its particles are usually very fine (<2 µm).
Kaolin minerals are classified mainly into four types—kaolinite, dickite, nacrite, and halloysite—which share the same chemical formula [$Al_2(OH)_4Si_2O_5$] but differ in crystal structure and morphology. Kaolinite is the most abundant and industrially useful due to its fine, platy particles, chemical inertness, and high whiteness. Dickite has a monoclinic crystal structure. Nacrite has a layered structure with near-rhombohedral symmetry. Halloysite is distinguished by its higher water content and can form tubular or plate-like particles; heating removes its interlayer water (Buyondo et al., 2022).
Particle size distribution for kaolin typically shows a median diameter (d50) of 0.6–0.8 µm, with 90% of particles (d90) below 2.1 µm (Pagis et al., 2020).

Toxicity is humans
The SCCS opinion on the safety of aluminium in cosmetic products notes that many aluminium-containing formulations utilize insoluble ingredients such as kaolin (Steiling et al., 2018). These insoluble compounds are not expected to release bioavailable aluminium upon dermal exposure (SCCS, 2024b).

However, one *in vitro* study investigated the genotoxic effects of micro- and nano-sized kaolin particles on human epidermal keratinocytes and dermal fibroblasts. Cells were exposed for six hours to kaolin particles with diameters of 4.8 µm and 200 nm at concentrations of 0.2, 2, 20, and 200 µg/mL. The results demonstrated that micronucleus (MN) formation was induced in primary normal human epidermal

keratinocytes neonatal (HEKn) starting at 0.2 µg/mL, with a dose-dependent increase observed. In primary normal human dermal fibroblast FJ cells, MN induction began at 20 µg/mL, also in a dose-dependent manner.
Additionally, the comet assay revealed that exposure to kaolin particles at 200 µg/mL increased the percentage of tail DNA by 8- to 20-fold across all cell types tested, indicating significant DNA damage. Notably, the 200 nm kaolin particles exhibited greater genotoxic potency compared to the 4.8 µm particles, while no significant differences were observed between the three cell types (Kawanishi et al., 2020).

Regarding the oral toxicity (in case of toothpaste), the reported acute oral toxicity in the US-EPA study in rats is low, with an oral LD50 greater than 5000 mg/kg (no size mentioned), and human dietary exposure is considered negligible in the cited regulatory assessment. In practical terms, this means that incidental swallowing is not expected to cause harm (US-EPA, 1998).

Toxicity in the environment
Kaolin is widely regarded as an inert particle, the major impact of kaolin in the environment lies in the extraction/mining of it (Buyondo et al., 2022).

Conclusion regarding possible risks
These findings suggest that exposure to high concentrations of kaolin particles can induce oxidative DNA damage *in vitro*; however, such results do not provide direct evidence that typical cosmetic use of kaolin on intact human skin leads to carcinogenesis or other adverse clinical outcomes.
Consequently, current evidence indicates that the dermal toxicity of kaolin is low. However, evidence is lacking regarding the presence of nanoparticles in its effects upon repeated dermal and oral exposure. As far as is currently known, the primary concern for consumers remains limited to potential skin irritation and dryness. Kaolin is generally regarded as an inert substance as long as it is not inhaled, and environmental considerations are primarily associated with its extraction and mining processes.

6.6 Volcanic rock: Pumice

Introduction
Pumice (CAS No.: 1332-09-8) is a porous volcanic rock consisting mainly of complex silicates of aluminium and alkali metals. It is utilized as an alternative for microplastics in personal care products as an abrasive in exfoliating scrubs, hand soaps, cleansers, and in polishing products such as pumice stones for foot care (Draelos, 2012).

Physico-chemical properties
Pumice is a highly porous volcanic rock, with porosity ranging from 64% to 90% by volume due to its microvesicular bubble structure. This results in a low bulk density which often enables pumice to float on water. Structurally, pumice is glassy and amorphous.
Chemically, pumice consists primarily of silicon dioxide (SiO_2, ~70–76%) and aluminium oxide (Al_2O_3, ~13%), with minor constituents

including ferric oxide (1–1.5%), sodium oxide (~1.6%), and potassium oxide (~1.8%). It is classified as an acidic, inert volcanic material with a nearly neutral pH (approximately 7.2). Trace minerals present include feldspar, augite, hornblende, and zircon.
The average particle size of pumice sold ranges from 10 to 177 microns (Naturally thinking, 2026).

Oral care formulations may incorporate an abrasive system containing pumice. For example, such systems can include: (a) a first particulate abrasive with at least 20 wt% pumice, based on the total weight of the oral care composition, with an average particle size between 20 and 300 microns; and (b) a second particulate abrasive comprising calcium carbonate with an average particle size between 2 and 13 microns (Joziak et al., 2013).

Toxicity in humans
This product may contain trace amounts of crystalline silica, which is recognized as a hazardous substance. Dust present on the surface of the product (e.g. pumice rock), or generated during processes such as crushing or abrasion, may contain crystalline silica particles of respirable size. These particles are sufficiently small to be inhaled into the lungs, posing a potential health risk, particularly when not bound within a formulation or when used as pure powder in rinse-off products.
Pumice is an odourless material that appears white to greyish-white and is available in forms ranging from pebbles to granular powder. Contact with pumice may cause irritation of the eyes, skin, respiratory system, and gastrointestinal tract. Specifically, exposure of the eyes to pumice can result in ocular irritation, while skin contact may lead to dermal irritation. Inhalation of pumice dust may irritate the respiratory tract (IARC, 2001)

Toxicity in the environment
Considering its origin and constituents, pumice is not suspected to be an environmental toxin (EWG Skin Deep®, 2026).

Conclusion regarding possible risks
Pumice exhibits low dermal toxicity overall, with no significant acute skin corrosion or systemic absorption risks when used topically in cosmetics. Pumice is considered safe for cosmetic use as long as inhalation of the dust is properly controlled. The environmental impact is mostly limited to the extraction of the material.

6.7 Microcrystalline Cellulose

Introduction
Microcrystalline Cellulose (CAS No: 9004-34-6) consists of the isolated, colloidal crystalline portion of cellulose fibres. Microcrystalline cellulose is predominantly derived from plant-based material rich in cellulose, such as wood pulp, by chemical (delamination usually through acid hydrolysis or sometimes alkaline treatment) and/or physical treatment (grinding) processes, although it can also be (bio)chemically synthesized. Apart from microcrystalline cellulose, there are also different smaller types of cellulose, including nanocrystalline celluloses, which can also be part of microcrystalline celluloses (Brand et al., 2022). As an alternative for

microplastics in personal care products, the resulting powder can be used for its abrasive characteristics (Hunt et al., 2021). Apart from its use as a cosmetic ingredient, microcrystalline cellulose is applied in many other product types, including in medication and as food additive (E 460(i)) (CIR, 2009; EFSA Scientific Committee, 2018b).

Physico-chemical properties
Microcrystalline cellulose is a fine, white, odourless, crystalline powder. The particles are insoluble but able to swell in water, in dilute alkali and acids, and in most organic solvents. The substance is soluble in NaOH solution, at concentrations below 1%, microcrystalline cellulose forms colloidal solutions, and above 1% thixotropic gels (EFSA Scientific Committee, 2018b).

Toxicity in humans
Microcrystalline cellulose is widely considered safe, non-toxic, non-irritating, and non-sensitizing for dermal applications (CIR, 2009). Although in very rare cases the occurrence of mild skin irritation or even allergic reactions (probably caused by the abrasive function, and by the potential presence of substances remaining from the production process source) have been reported (Schofield & Afrin, 2019). Potential allergic reactions can typically be avoided by careful selection of source materials during production.

Toxicity in the environment
Microcrystalline is not suspected to be an environmental toxin: cellulose is the most abundant polymer on earth, and is biodegradable (Barbaud & Lafforgue, 2021).

Conclusion regarding possible risks
Overall, microcrystalline cellulose is considered a safe cosmetic ingredient with regard to both human and environmental toxicity.

6.8 *Prunus Armeniaca* (Apricot) Seed Powder

Introduction
Prunus Armeniaca seed powder (CAS No: 68650-44-2; same CAS number for other materials derived from *Prunus Armenica*, e.g. juice, leaf extract, fruit extract, kernel oil, etc.) is derived from ground apricot kernels. The resulting powder can be used for its abrasive characteristics as an alternative for microplastics in personal care products (Hunt et al., 2021).

Physico-chemical properties
Prunus Armeniaca seed powder is a (light) brown powder with a neutral odour. Apricot kernel seeds, and the derived powder, have a relative high protein content: 18-34%, and consist furthermore of lipids (mainly unsaturated fatty acids), fibres and minerals (Zhu et al., 2025). A well-known protein constituent of amygdalin, a cyanogenic glycoside.

Although not limited to apricot (it is also present in the seeds of many more closely related fruits such as plums, cherries, and almonds), the highest concentration of amygdalin has been detected in the kernels of apricot, at up to 5.2% (on a dry weight basis) (Borczak et al., 2025).

During the production of *Prunus Armeniaca* seed powder, amygdalin and cyanide can be removed from edible plant matrices through a range of conventional, natural, physical, and chemical methods, including washing, peeling, drying, fermentation, thermal processing, and chemical treatment. However, the application of these techniques in food processing remains limited due to several drawbacks: chemical methods may introduce toxic residues, while natural and physical approaches often lack consistency, precision, and overall efficiency (Borczak et al., 2025).

Toxicity in humans
The primary obstacles in the applications of apricot kernel seed derived materials and substances in food related products involve the removal of amygdalin, the cyanogenic glycoside. Amygdalin can release toxic hydrogen cyanide upon ingestion, which can cause cellular hypoxia and eventually organ failure. Hydrogen cyanide can be absorbed through the skin as well, although it is less likely to be formed through the dermal route, and therefore it is not expected that standard application of topical products containing *Prunus Armeniaca* seed powder leads to a risk of cyanide poisoning (Borczak et al., 2025).

In rare cases mild skin irritation caused by the abrasive, exfoliating effect may occur; the presence of specific allergens from the plant may be the cause of allergic reactions (Kim et al., 2017; Zhu et al., 2022).

Toxicity in the environment
Prunus Armeniaca seed powder is of plant origin and biodegradable; no environmental risks are to be expected from release from personal care products to the environment. There is no ecotoxicological concern and no (self-classified) notification in the ECHA database for amygdalin.

Conclusion regarding possible risks (if possible)
Altogether, *Prunus Armeniaca* seed powder is widely regarded as a safe cosmetic ingredient with regard to both human and environmental toxicity. It is unlikely that sufficient hydrogen cyanide is formed from dermal application of apricot kernel seed powder in cosmetic products to pose a risk. Although it can be considered rare, allergens from apricot products including kernels could lead to allergic reactions.

6.9 *Juglans Regia* (walnut) Shell Powder

Introduction
Juglans regia shell powder (CAS No: 84012-43-1) is a particulate material obtained by mechanical comminution of the shells of *Juglans regia L.* (walnut) fruits. This natural exfoliant is frequently used as an alternative for microplastics in personal care products and incorporated into cosmetic formulations due to its ability to facilitate the mechanical removal of corneocytes, sebum, and superficial debris from the stratum corneum, thereby contributing to enhanced epidermal smoothness. Owing to its moderate abrasive characteristics, *Juglans regia* shell powder is utilized in various topical preparations, including facial scrubs, body polishes, and exfoliating cleansers.
The processing of walnut shell enables its use as a scrub in the soap and cosmetic industries and as an abrasive suitable for polishing jewellery,

gun casings, and some metal materials constituents inherent to walnut shells.

Physico-chemical properties
The middle part of the walnut fruit surrounding the kernel is called the shell. It is considered a hard organic abrasive that is chemically inert, and biodegradable. The shell portion of the walnut fruit is a lignocellulosic agricultural waste composed of cellulose (17.74%), hemicellulose (36.06%), and lignin (36.90%). Morphologically, the powder presents as a granular, brown substance, with particle size distribution and colour dependent on the degree of grinding.

Toxicity in humans
The CIR classifies *Juglans regia* shell powder as non-irritating to skin under normal use, with no expected corrosivity or sensitization in most users. Its mild abrasiveness can cause micro-tears or irritation if overused or on sensitive skin, so gentle formulations and limited application are recommended (ECHA, 2022).

As a tree nut product, it may contain walnut proteins that trigger allergic reactions in sensitive individuals, even via topical exposure. Patch testing is advised for those with nut allergies or dermatitis history (Costa et al., 2014).

Reputable suppliers of walnuts test for heavy metals, PAHs, mycotoxins, and pesticides to meet regulations (e.g., (EU) 2023/915 or (EG 396/2005), ensuring contaminations and residues are below action levels. As these regulations are not directly applicable to the walnut shells, contaminations and residues could theoretically contribute to the (dermal) exposure to such substances, however, the contribution to risk of exposure to these substances compared to other routes and sources is likely negligibly.

Toxicity in the environment
Juglans regia shell powder (walnut shell powder) is not classified as environmentally toxic per safety data sheet (SDS) data, showing no expected harm to aquatic vertebrates, invertebrates, or terrestrial organisms. Thus, products containing it are not labelled as causing acute or chronic ecological risks, though large or repeated releases could physically smother substrates or raise turbidity in water systems.
This natural lignocellulosic material biodegrades based on available data, albeit slowly in dry or low-moisture settings. It doesn't bioaccumulate and isn't deemed persistent, bioaccumulative, and toxic (PBT) or very persistent and very bioaccumulative (vPvB) under SDS evaluations.

Conclusion regarding possible risks
Juglans regia shell powder is considered safe for human dermal use and presents minimal environmental risk under normal cosmetic application, provided it is properly sourced and formulated. However, caution is advised for individuals with nut allergies and to avoid excessive environmental release due to potential physical effects.

6.10 Tin(IV) Oxide

Introduction
Tin(IV) oxide (CAS No: 18282-10-5; SnO_2) is utilized as an alternative for microplastics in personal care products as an abrasive, bulking agent, opacifier, and viscosity-controlling substance (CosIng, 2026). In addition, tin oxide is included in certain toothpaste and mouth-rinse formulations, primarily serving as a mild abrasive or as an opacifying and whitening-support agent. Its presence in these oral care products contributes to tooth polishing and enhances the visual whiteness of the product.

Physico-chemical properties
Tin(IV) oxide is a white to very light grey crystalline powder. It is a water-insoluble inorganic metal compound and often utilised in a micronized or nano-sized form in cosmetics.
It is also used in electronics because of its high stability and resistance to many acids and bases. It behaves as a robust, inert inorganic oxide in formulations.

Toxicity in humans
The American Cosmetic Ingredient Review (CIR), has concluded that Tin(IV) oxide is safe for use in cosmetic products at concentrations consistent with current industry practices (CIR, 2013).
Both tin monoxide (SnO) and tin dioxide (SnO_2) demonstrate minimal dermal toxicity. According to Cima (2011), these compounds are chemically stable and display limited dermal absorption, therefore, systemics exposure is unlikely. Therefore, Tin(IV) oxide is considered safe in current cosmetic use, at up to 0.4% in rinse-off products and 1.3% in leave-on products.

Data from experimental studies and occupational exposure indicate that tin oxides do not act as primary skin irritants and do not trigger sensitization reactions in humans under normal conditions of use. Reports of adverse effects on the skin are extremely uncommon, with any observed irritation generally attributed to prolonged or repeated exposure to dust, rather than the compounds themselves. The primary health concern associated with tin oxide relates to inhalation of particulate matter rather than dermal exposure (Mannie, 2013).
With the advancement of nanotechnology, the use of tin oxide in nanoscale forms has increased, prompting attention regarding its potential health and environmental effects. However, current evidence continues to support the low toxicity of tin compounds, including as nanomaterials.
Transmission electron microscopy analyses have shown that both nano-sized and bulk tin oxide particles are predominantly localized within the cytoplasmic vacuoles and nuclei of exposed cells, whereas such particles are absent in control cells. Additionally, both forms of tin oxide tend to aggregate in the cytoplasm and nucleus after incubation, with notable alterations in nuclear morphology observed in treated cells (Şeker, 2018).

Regarding oral toxicity (in case of toothpaste), the ATDSR profile notes that inorganic tin compounds are not readily absorbed after oral

exposure, therefore they tend to have relatively low oral toxicity overall. In humans, oral effects from inorganic tin are mainly after eating food contaminated with tin. For tin oxide specifically, the evidence base is limited, and the profile does not present strong human oral toxicity data for it as a standalone substance (ATDSR, 2005).

Toxicity in the environment
No significant environmental impacts have been reported, possibly due to the low solubility, which, in turn, presents a significant challenge for the good experimental design in the determination of the ecotoxicity (Granjeiro et al., 2020).

Furthermore, tin oxides are considered to be inert and exhibit low toxicity towards biota. Due to their low solubility in water and limited bioavailability, tin oxides do not readily enter aquatic food webs and are not associated with bioaccumulation or biomagnification (Cima, 2011). Tin oxide particles may deposit in sediments; however, their environmental persistence does not translate into ecological toxicity. Laboratory studies and environmental monitoring have not demonstrated adverse effects on aquatic or terrestrial organisms at environmentally relevant concentrations. Consequently, tin oxides present a negligible risk to environmental health compared to organotin compounds (Mannie, 2013).

Conclusion regarding possible risks
Based on the available toxicological and environmental evidence, tin oxide presents a low risk to human health and the environment. Dermal exposure is not associated with significant irritation or sensitization, and systemic absorption through the skin is negligible. However, evidence is lacking regarding the presence of nanoparticles in its effects upon repeated dermal and oral exposure.

In environmental context, tin oxides are chemically inert, poorly soluble, and exhibit minimal bioavailability, resulting in negligible toxicity to aquatic and terrestrial organisms. Therefore, under normal conditions of use and exposure, tin oxide does not seem to constitute a significant health or environmental hazard. However, evidence is lacking regarding the presence of nanoparticles in its effects upon repeated environmental exposure.

7 Discussion

Microplastics have been widely used in cosmetic formulations, however, their contribution to microplastic pollution have raised significant environmental and public health concerns. Therefore, the EU decided to phase out intentionally added SPMs (as defined in Chapter 3) in cosmetics through Regulation (EU) 2023/2055, which entered into force on 17 October 2023. The phase-out is gradual, with immediate restrictions applying to products containing microbeads from that date, followed by deadlines for different cosmetic categories and/or uses (see Chapter 3.2).
The current report focusses on the analysis of alternative substances based on the cosmetics products in which the use of microplastics is already banned, i.e. products containing microbeads (e.g. shower gels, shampoos, foams, exfoliating gels). Loose glitter was excluded from the scope as it is not a cosmetic product, but a 'regular' consumer product. Glitter incorporated in cosmetic products falls under the deadlines for rinse-off and leave-on cosmetics in 2027 and 2029, respectively.

Alternatives and their selection

A broad range of alternative materials has been found to replace microplastics in personal care products. The alternative substances identified and selected in this work can be broadly categorized into plant-derived powders and fibres (e.g. cellulose derivatives, starch-based materials, grinded plant shells or seeds), mineral or inorganic texturizers (e.g. titanium dioxide, silica, hydroxyapatite, volcanic materials, clay), and other particulate abrasive alternatives (charcoal). It is important to note that this categorization is based on a literature search and a non-comprehensive screening, and the alternatives included in these categories reflect only the alternatives identified within the scope of the data used. These included at present only personal care products and ingredient functions in which microplastics (i.e. microbeads) have been replaced already. The identification of alternative substances is therefore constrained by the availability of information, and it is likely that additional substitutes exist beyond those captured in this work, or will appear in other types of cosmetic products (e.g. leave-on cosmetics), although it is likely that the replacement of microbeads already covers an important share of the alternative substances for microplastics.

The risk of regrettable substitution

While these substitutes are often promoted as more sustainable or biodegradable (and "green" or "natural"), their human and environmental safety profiles are not always fully characterized. This raises the possibility of "regrettable substitution", where a replacement material may later prove to have unintended adverse effects similar to or different from those of the substances they replace. Evaluating these alternatives therefore requires a cautious and comprehensive approach, considering not only their intended function but also their full life-cycle impacts and potential hazards. The Cosmetics Regulation does not address environmental safety - this is covered by REACH restrictions

(such as those concerning microplastics). It cannot be determined from the (limited) analysis in this report whether regrettable substation concerns the selected substances, however, there are no significant indications suggesting that this is the case.

The wide diversity of substitute materials underscores the challenge for safety assessment, as each alternative may present distinct hazard profiles requiring separate and often limited evaluation. In the present study only a limited number of alternative substances have been reviewed in more detail, resulting in an uneven evidence base to draw conclusions in general. Furthermore, with the (often limited) knowledge acquired from the alternative substances selected for further analysis, one can assume that for many other (newly) introduced materials, toxicological, environmental fate, and biodegradability data are scarce or incomplete as well.

Emerging risks with new applications

Most of the identified alternatives are far from new and are being used in cosmetic products for a long time already. However, their use as an alternative substance for microbeads may implicate that they are used is applications (functions) for which they were not originally intended. In general, this can raise questions about potential emerging risks of the new application or increased uses of these ingredients.
In some cases, the identified alternatives may be used on the skin more extensively than originally intended. For example, *Juglans regia* (walnut) seed powder was previously present in only a limited number of products, but its use has expanded to a larger range of products. This raises concerns regarding potential skin irritation and sensitization. This may be especially relevant in the context of leave-on products where prolonged direct skin contact may occur, or which could therefore result in higher absorption and systemic exposure. The lack of long-term safety data for these novel uses underscores the need for continued monitoring and assessment of potential endpoints such as skin irritation and allergic sensitization. As the market evolves, it will be essential to ensure that substitutions do not introduce new environmental or human health concerns, and that regulatory frameworks keep pace with innovation.

8 Conclusion

The market research as performed in the present study identified several substances that can function as alternatives to microbeads in personal care products. These substances were identified mainly by using the Mintel database, focusing on oral care, soap and bath, and skincare products with scrub particles for which the microplastic ban in cosmetic products already applies. Based on their frequency of occurrence as an ingredient, and/or use in different types of products, ten substances were selected for a further description and screening of their potential human and environmental risk properties. These substances included: titanium dioxide, silica / hydrated silica, hydroxyapatite, charcoal powder, kaolin, pumice, microcrystalline cellulose, *Prunus armeniaca* seed powder, *Juglans regia* shell powder, and tin oxide (all INCI names).

Based on the present knowledge of these substances, no immediate health risks from the use as alternative to microbeads are to be expected. In general, the mineral substances are regarded as safe, in some cases provided that no inhalation of these substances (or their nanoparticles, if present) will take place as a result of their use (i.e. titanium dioxide, silica, hydroxyapatite, pumice). Also, the alternative substances should not contain unacceptable levels of potential present contaminants (such as heavy metals, PAHs, pesticide residues or asbestos).
The plant derived materials could in principle contain proteins that might result in potential allergic skin reactions including skin sensitisation and allergies. While allergies to *Prunus armeniaca* seed powder (apricot) and microcrystalline cellulose are rare, and, in the case of microcrystalline cellulose, they can typically be avoided by careful selection of source materials during production. In contrast, it is well known that some individuals can be highly allergic to walnut proteins. People having a (severe or even life-threatening) walnut allergy might not be aware of personal care products containing these allergens, as there is no (obliged) warning on the labelling, and the INCI name (*Juglans regia* shell powder) may not provide clear information.

Another concern relates to the (potential) presence of nanoparticles in some of the alternatives (titanium dioxide, silica, hydroxy apatite), such as certain forms of titanium dioxide or silica. Due to their extremely small size, these nanoparticles may more easily penetrate biological barriers than larger particles. Although in general dermal absorption of these nanoparticles is considered to be low or absent, this assumption is often based on limited experimental evidence. For example, in the case of silica, the lack of dermal penetration studies has (among other data gaps) triggered a re-evaluation by regulatory bodies. Moreover, scenarios involving vigorous mechanical scrubbing and/or compromised skin barrier function (e.g. damaged or inflamed skin) may potentially increase the likelihood of nanoparticle penetration, underscoring the need for more detailed investigations under such conditions. Combined with the increasing number of products containing these substances and potentially higher exposure, this may raise concern of potentially leading

to unknown health effects or toxicity. In general, however, the mineral substances are regarded as safe, in some cases provided that no inhalation of these substances takes place.

Altogether, the selected alternative substances are often well-known ingredients in cosmetic products, however, their use as a replacement of microplastics may lead to increased application with a different function in personal care products, potentially causing new or emerging health or environmental issues. In addition to the substance's intrinsic properties, its use in products like scrubs for their abrasive function may lead to irritation due to the products' physical characteristics. However, it is assumed that manufacturers assess such effects prior to placing their products on the market.

Based on this limited study, no increase in ecotoxicological risk is expected from the use of the alternative substances as ingredients substituting microbeads. In a broader sense, however, certain specific substances may pose environmental concerns related to their production, for instance due to extraction and mining activities, including associated sustainability issues. Replacing microplastics in personal care products is therefore an appropriate case for Safe and Sustainable by Design (SSbD) practices, in order to prevent regrettable substitution (Bhat et al., 2025; Mota et al., 2026).

In summary, this study highlights that a variety of mineral, plant-derived, and synthetic biodegradable materials are currently being used as alternatives to microplastic particles in personal care products. While these substitutes are generally considered safe for human health and the environment based on current knowledge, some important considerations remain. Potential risks include allergic reactions to plant-derived ingredients, unknown effects from nanoparticle exposure, and irritation from abrasive functions. Additionally, environmental concerns may arise from the sourcing and production of certain substances, particularly minerals. As the use of these alternatives may increase in the future, ongoing monitoring of their safety and sustainability is advised to ensure they do not introduce new health or environmental challenges.

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Appendix 1 Tables of the 20 most common ingredients per product category

Table A1 Top 20 most common ingredients in bath and soap products featuring "Scrub", "Polish", or "Exfoliate" (Mintel GNPD Research).

Ingredients names on the package	Number of products	% of products
Aqua	10	100
Glycerin	10	100
Parfum	10	100
Sodium Chloride	8	80
Cocamidopropyl Betaine	6	60
Sodium Benzoate	6	60
Citric Acid	5	50
L-limonene	5	50
Potassium Sorbate	5	50
Linalool	4	40
Cellulose	3	30
Coco-glucoside	3	30
Lactic Acid	3	30
Sodium Coco-Sulfate	3	30
Sodium Cocoyl Isethionate	3	30
Sodium Hydroxide	3	30
Alpha-isomethyl Ionone	2	20
Camellia Sinensis Leaf Extract	2	20
CI 19140	2	20
Coconut Acid	2	20

Table A2 Top 20 most common ingredients in oral hygiene products featuring "Scrub", "Polish", or "Exfoliate" (Mintel GNPD Research).

Ingredients names on the package	Number of products	% of products
Aqua	90	84
Aroma	89	83
Hydrated Silica	84	78
Glycerin	81	76
Sodium Saccharin	78	73
Sodium Fluoride	76	71
L-limonene	70	65
Xanthan Gum	63	59
Sorbitol	52	49
Cocamidopropyl Betaine	49	46

Ingredients names on the package	Number of products	% of products
Sodium Lauryl Sulfate	44	41
Sodium Hydroxide	31	29
(Cellulose Gum	30	28
Sodium Benzoate	26	24
Citric Acid	25	23
Carrageenan	22	21
CI 74160	22	21
Sodium Bicarbonate	21	20
Potassium Sorbate	20	19
Menthol	19	18

Table A3 Top 20 most common ingredients in skin care products featuring "Scrub", "Polish", or "Exfoliate" (Mintel GNPD Research).

Ingredients names on the package	Number of products	% of products
Aqua	97	86
Glycerin	80	71
Parfum	63	56
Xanthan Gum	44	39
Citric Acid	41	36
Phenoxyethanol	37	33
Linalool	35	31
Ethylhexylglycerin	34	30
L-limonene	33	29
Sodium Hydroxide	32	28
Salicylic Acid	30	27
Caprylyl Glycol	29	26
Tocopherol	29	26
1,2-hexanediol/2-hexanediol	29	26
Sodium Benzoate	28	25
Sodium Chloride	28	25
Butylene Glycol	27	24
Lactic Acid	24	21
Potassium Sorbate	24	21
Caprylic/Capric Triglyceride	22	19

Appendix 2 CosIng database functions of potential microplastic alternatives

Overview of the CosIng database functions of cosmetic ingredients selected as potential microplastic alternatives in different Personal Care Products.

	Abrasive	Absorbent	Anticacking	Antimicrobial	Antioxidant	Binding	Buffering	Bulking	Colorant	Deodorant	Emulsion Stabilising	Exfoliating	Film Forming	Fragrance	Gel Forming	Humectant	Light Stabilizer	Opacifying	Oral Care	Skin Conditioning	Skin Protecting	Soothing	Surfactant -	Surfactant -	UV Absorber	UV Filter	Viscosity Controlling
***Acacia Senegal* Gum**													X	X													
Acrylates Crosspolymer-4											X		X										X				X
Adipic Acid/Neopentyl Glycol/Trimellitic Anhydride Copolymer													X														
***Aloe Barbadensis* Leaf Juice Powder**																				X							
***Aloe Barbadensis* Leaf Powder**																				X							
Alumina	X	X	X					X										X									X
Amber Powder										X																	
***Argania Spinosa* Shell Powder**	X																										
***Avena Sativa* Kernel Extract**	X				X															X							
***Avena Sativa* Kernel Flour**	X	X						X																			X
***Bambusa Arundinacea* Stem Extract**																				X							
Bentonite		X						X			X																X
Biosaccharide Gum-1																				X							

	Abrasive	Absorbent	Anticacking	Antimicrobial	Antioxidant	Binding	Buffering	Bulking	Colorant	Deodorant	Emulsion Stabilising	Exfoliating	Film Forming	Fragrance	Gel Forming	Humectant	Light Stabilizer	Opacifying	Oral Care	Skin Conditioning	Skin Protecting	Soothing	Surfactant -	Surfactant -	UV Absorber	UV Filter	Viscosity Controlling
Butyrospermum Parkii Nut Shell Powder	X																										
Calcium Carbonate	X						X	X										X	X								
***Camellia Sinensis* Leaf Powder**												X															
Carrageenan																											
Cellulose		X						X										X									X
Cellulose Acetate													X														
Cellulose Gum						X					X		X	X													X
***Ceratonia Siliqua* (Carob) Gum**						X					X		X	X						X							X
Charcoal Powder	X	X																X									
***Chondrus Crispus* Powder**	X																										
Coffea Arabica Seed Powder												X															
Coffea Robusta Seed Powder												X															
Gellan Gum													X														X
***Houttuynia Cordata* Powder**																				X							
Hydrated silica	X	X	X					X										X									X
Hydroxyapatite	X							X											X	X							
Hydroxyethylcellulose						X					X		X				X										X
Illite	X	X	X					X																			
***Juglans Regia* Shell Powder**	X																										
Kaolin	X	X	X					X	X									X									
***Luffa Cylindrica* Fruit Powder**	X																										

	Abrasive	Absorbent	Anticacking	Antimicrobial	Antioxidant	Binding	Buffering	Bulking	Colorant	Deodorant	Emulsion Stabilising	Exfoliating	Film Forming	Fragrance	Gel Forming	Humectant	Light Stabilizer	Opacifying	Oral Care	Skin Conditioning	Skin Protecting	Soothing	Surfactant -	Surfactant -	UV Absorber	UV Filter	Viscosity Controlling
Magnesium Aluminum Silicate		X	X															X									X
***Malva Sylvestris* Leaf Powder**												X															
Maris Sal																				X							
Mica			X					X	X									X									
Microcrystalline Cellulose	X	X	X					X			X						X	X									X
Olea Europaea Seed Powder	X																										
***Oryza Sativa* Germ Powder**	X							X																			
***Oryza Sativa* Starch**		X				X		X																			X
Perlite	X							X																			
***Prunus Armeniaca* (Apricot) Seed Powder**	X																										
***Prunus Amygdalus* Dulcis Shell Powder**	X																										
***Prunus Persica* Seed Powder**	X							X																			
Pumice	X							X																			X
***Ribes Nigrum* Fruit Powder**												X															
***Salvia Hispanica* Seed Powder**	X																										
Sclerotium Gum											X									X							X
Silica	X	X	X					X										X									X
***Simmondsia Chinensis* Seed Powder**																				X							
Sodium Hyaluronate Crosspolymer																X				X							
Solum Diatomeae	X	X	X															X									

	Abrasive	Absorbent	Anticacking	Antimicrobial	Antioxidant	Binding	Buffering	Bulking	Colorant	Deodorant	Emulsion Stabilising	Exfoliating	Film Forming	Fragrance	Gel Forming	Humectant	Light Stabilizer	Opacifying	Oral Care	Skin Conditioning	Skin Protecting	Soothing	Surfactant -	Surfactant -	UV Absorber	UV Filter	Viscosity Controlling
***Stevia Rebaudiana* Leaf/Stem Powder**																				X							
Sucrose																X				X		X					
***Theobroma Cacao* Seed Powder**	X																										
***Thymus Vulgaris* Leaf/Stem Powder**																				X							
Tin Oxide	X							X										X									X
Titanium Dioxide									X									X							X	X	
***Vaccinium Macrocarpon* Fruit Powder**					X																						
Volcanic Ash	X	X						X																			
Volcanic Sand																				X							
Xanthan Gum						X					X				X					X			X	X			X
***Zanthoxylum Americanum* Bark Extract**														X						X							
Zea Mays Cob Powder	X					X																					
Zea Mays Starch	X	X	X																		X						X
Zinc Oxide				X				X	X								X		X		X				X	X	

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