

Dossier – Mineral oil hydrocarbons

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1 Introduction

Mineral oil hydrocarbons (MOHs) are mixtures of thousands of different molecules, generally derived from crude oil [1]. MOHs are composed of open-chain, cyclic, and aromatic hydrocarbons (Figure 1). MOHs are grouped into mineral oil saturated hydrocarbons (MOSH) and mineral oil aromatic hydrocarbons (MOAH). High concentrations of MOSH were measured in different human tissues where they accumulate depending on their structure and molecular mass [2-4]. MOAH are of concern, since they may include mutagenic and carcinogenic constituents. In technical MOH preparations, the MOAH content is typically 15-35%, but in food grade MOHs (“white oils”) it is minimized by refinement [1].

MOHs are present in numerous food contact materials (FCMs), e.g. food packaging made from recycled paper and board, printing inks, plastics, adhesives as well as jute and sisal bags. FCMs are one important exposure source, because MOHs migrate easily into the food. However, MOHs are also used as direct food and feed additives, processing aids, lubricants, and release agents. Environmental pollution and the use of MOHs in cleaning agents additionally contribute to the contamination of food. MOHs in personal care and medicinal products add to human exposure (e.g. baby oils, creams, lotions, lipsticks, sunscreens, and hair products) [1].

2 Definition and nomenclature

2.1 Mineral oil hydrocarbons

MOHs are complex mixtures of many types of hydrocarbons, mainly obtained from crude oil, but equivalent products are derived from coal, natural gas or biomass. They are available at different compositions, from crude and technical preparations to food and analytical grades. Fairly crude products may also contain compounds with sulfur or nitrogen [1].

The chemical analysis of MOHs is complex. Thus, MOHs are generally classified not based on their chemical identity, but their physico-chemical properties. Such a classification system results in products of considerably different composition, but still having similar technical properties [1].

Table 1. Classification of highly-refined mineral oil hydrocarbons according to JECFA [5, 6].

Name	Class	Ø Mol. mass	Viscosity [mm ² /s]	C-atoms at 5% distillation point
Mineral oil, medium- & low viscosity	I	480-500	8.5-11	≥25
	II	400-480	7.0-8.5	≥22
	III	300-400	3.0-7.0	≥17
Mineral oil, high-viscosity		>500	>11	≥28
Wax, microcryst.		≥500	≥11	≥25

In 1995, the Joint FAO/WHO Expert Committee on Food Additives (JECFA) classified highly-refined MOHs into high-viscosity mineral oil, three classes of medium- and low-viscosity mineral oils and microcrystalline wax (Table 1) [5]. This classification is based on the average relative molecular mass, the viscosity, and the number of carbon atoms in a molecule at the 5% distillation point, i.e. the proportion of low molecular mass constituents.

2.2 MOSH and MOAH

Mineral oils mainly consist of MOSH and MOAH (Figure 1). MOSH comprise open-chain, often branched hydrocarbons (commonly named paraffins) and cyclic saturated hydrocarbons (commonly named naphthenes), which are generally highly alkylated and contain one or more rings. MOAH include mono- or polycyclic aromatic molecules, which are also highly alkylated. Depending on the source of the crude oil and its refining steps, the MOAH content reaches up to 35% [1]. Hydrocarbons of plant origin are also a common component of food, but they have a different composition: they are largely linear alkanes or of terpenic structure.

2.3 POSH

Polyolefin oligomeric saturated hydrocarbons (POSH) are of synthetic origin and include for example oligomers in polyethylene (PE) and polypropylene (PP). POSH also occur in polymeric additives, adhesives, synthetic lubricants, oils, and waxes [7]. POSH are characterized by short- and long-chain branching and chain end cyclization. POSH originating from PE may mainly consist of even-numbered *n*-alkanes [7]. Other synthetic hydrocarbons may also contain double bonds or aromatic constituents.

3 Production and analysis

MOHs are derived from crude oils by many processing steps including distillation, extraction, crystallization, acid treatment and/or hydrotreatment [6]. The production process, but also the type of crude oil influence the final composition of MOHs [1]. In alternative processes, coal, natural gas or biomass are converted to hydrogen and carbon monoxide that are further transformed to equivalent products by Fischer-Tropsch synthesis [1].

The quantitative and qualitative chemical analysis of MOHs in foods and FCMs is a complex task [1]. Liquid chromatography (LC) coupled to gas chromatography (GC) and flame ionization detection (FID) is the most recommended method, because of its separation efficiency and the possibility to quantify substances in the absence of pure standards [8, 9]. An alternative and modified method needs less advanced equipment [10]. A combination of LC with two-dimensional GC (GC x GC) may provide more detailed information about the subgroups and the ring structures of MOAH [11]. Mass spectrometry (MS) may enable further characterization of MOHs [12]. Notwithstanding the advances in separation and detection of MOHs, quantification of single compounds is almost impossible and may only be achieved when additional information, e.g. about the source and chemical preparation of the MOH mixture, further supports the results of the analysis [12].

To be able to classify the substances present in a typical MOH mixture, MOSH are grouped on the basis of their molecular masses. Such groups are defined by using *n*-alkanes, typically between *n*-C₁₁ and *n*-C₅₀, as standards [8, 13]. During chemical analysis, MOSH with the same number of carbon atoms behave similarly to the respective standards defining the group. Accordingly, the majority of MOSH characterized by this method have the same number of carbons atoms as the *n*-alkane standards. However, these groups also contain some cyclic and *iso*- alkanes of slightly smaller and higher masses, respectively.

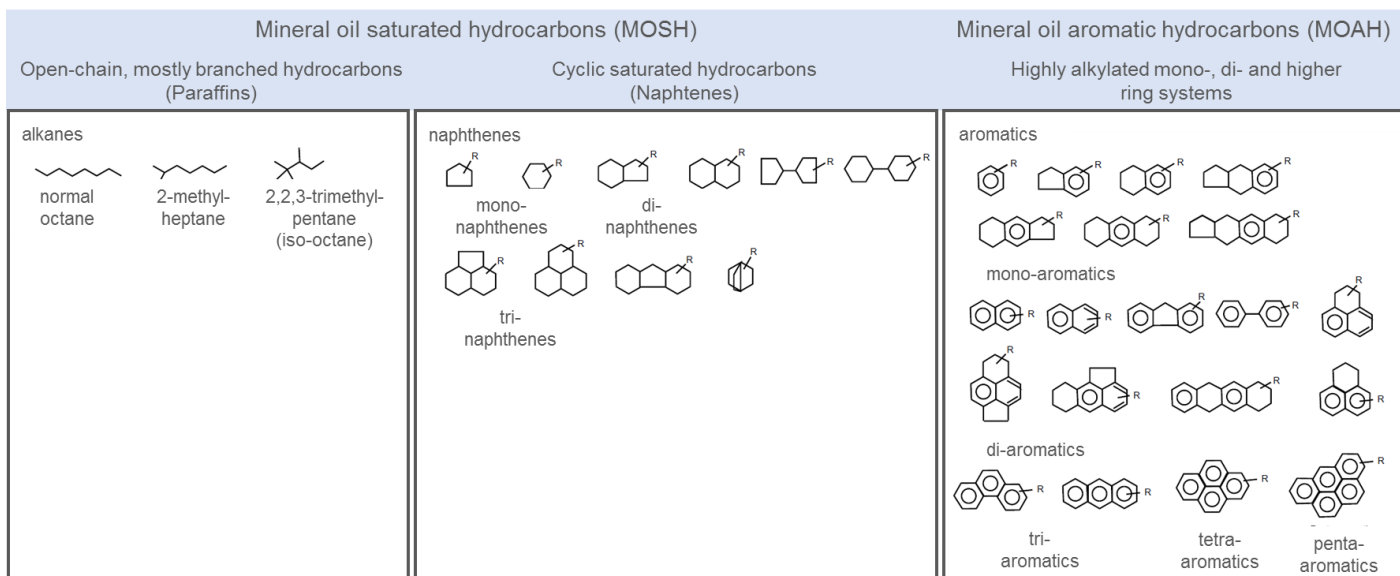


Figure 1. Examples of mineral oil hydrocarbons (MOHs). R and R' are branched or unbranched alkyl groups with up to 20 carbon atoms. Chemical structures were obtained from [1].

4 Uses in FCMs

MOHs are used as additives in many different types of FCMs, e.g. plastics, adhesives, rubber articles, wax paper and board, and printing inks [1]. They are applied as batching oils for the processing and softening of jute and sisal fibers and as defoaming agents during paper production [14-16]. Furthermore, MOHs serve as lubricants in the manufacture of e.g. plastic packaging and cans [17]. Food processing equipment (e.g. harvesters, mills, stirrers) is often maintained and cleaned with MOHs. In food factories, MOHs are used as non-stick and release agents on surfaces and machinery [1]. Especially FCMs made from recycled paper and board often contain high levels of MOHs which mainly originate from previously applied printing inks [16].

5 Toxicity

The overall toxicity of MOHs depends on their chemical composition, because MOAH are the most toxic fraction [18]. Highly-refined MOHs mainly consisting of MOSH are less toxic than MOHs obtained from non-refined products with high levels of MOAH. MOH mixtures containing MOAH generally tested positive for mutagenicity [1]. In 2012, untreated or mildly treated mineral oils were classified as carcinogenic for humans [19]. Long chain MOSH and some highly alkylated MOAH are tumor promoters at high doses, but they are not carcinogenic themselves [1]. MOSH between *n*-C₁₆ and *n*-C₃₅ were considered as the toxicologically most relevant range [13].

Acute toxicity of MOH mixtures is low to moderate: Oral LD₅₀ data were in the range of several gram per kg body weight [1]. In rats and humans, exposure to MOSH led to formation of microgranulomas in certain organs including the liver [20-22]. Exposure to some MOSH mixtures resulted in increased weights of liver and spleen [1]. In the last few years, several studies reported the accumulation of various MOSH fractions in different tissues of humans and rats [2, 3, 20-22]. In 2015, the estrogenicity of 15 mineral oils was investigated [23]. Ten out of 15 mineral oils, containing at least 16% MOAH, triggered estrogenic responses in three different *in vitro* assays. The authors concluded that mineral oils are potential endocrine disruptors and may contribute to the burden of xenoestrogens in humans.

Autoimmune responses, including systemic autoimmunity, the induction or exacerbation of rare human autoimmune disease, were

associated with parenteral administration of MOHs as well as non-dietary exposure routes [24]. However, the authors stated that dietary exposure to MOHs did not correlate with the development of autoimmune disease and the initiation or enhancement of autoimmune responses.

6 Exposure and biomonitoring

In 2012, the dietary exposure of the European population to MOSH was estimated to be in the range of 0.03 to 0.3 mg/kg body weight per day [1], i.e. a 60 kg person consumes 1.8 to 18 mg of MOSH with food per day. Exposure data for MOAH may indirectly be estimated based on the typical composition of the mineral oil products found in food, e.g. lubricating oils (20-30% MOAH), migrates from paperboard boxes (15% MOAH) and white mineral oils (virtually no MOAH) [1].

Biomonitoring data revealed that MOSH levels in humans are higher than the concentrations of any other contaminant [2-4]. In a series of human samples, MOSH were always detected in fat tissue, liver, spleen, mesenteric lymph nodes, lung and breast milk as well as in some samples of kidney, heart and brain [2, 4]. Mean MOSH concentrations in, e.g. mesenteric lymph nodes and spleen were 233 and 93 mg/kg, respectively, and maximum levels in both organs reached up to 1.4 g/kg [2]. Depending on the tissue and the individual subject, the composition of the accumulated MOSH differed. Unexpectedly, MOSH up to and beyond 45 carbon atoms were measured in spleen and liver (Figure 2) [2]. In abdominal tissue fat, MOSH mainly consisted of *iso*-alkanes and cyclic alkanes in the range of *n*-C₁₆ to *n*-C₃₆ [4].

In subchronic studies with rats, MOSH mainly accumulated in the liver and to a lower extent in the spleen and adipose tissue (Figure 2) [20]. However, the composition of the MOSH mixtures influenced the distribution of hydrocarbons to certain tissues. The liver mainly contained highly branched and cyclic MOHs, while MOHs with linear moieties were mostly found in the adipose tissue of the rats.

Based on these studies, it was concluded that human tissue concentrations cannot be easily extrapolated from animal experiments using high doses, possibly leading to an underestimation of human exposure [20].

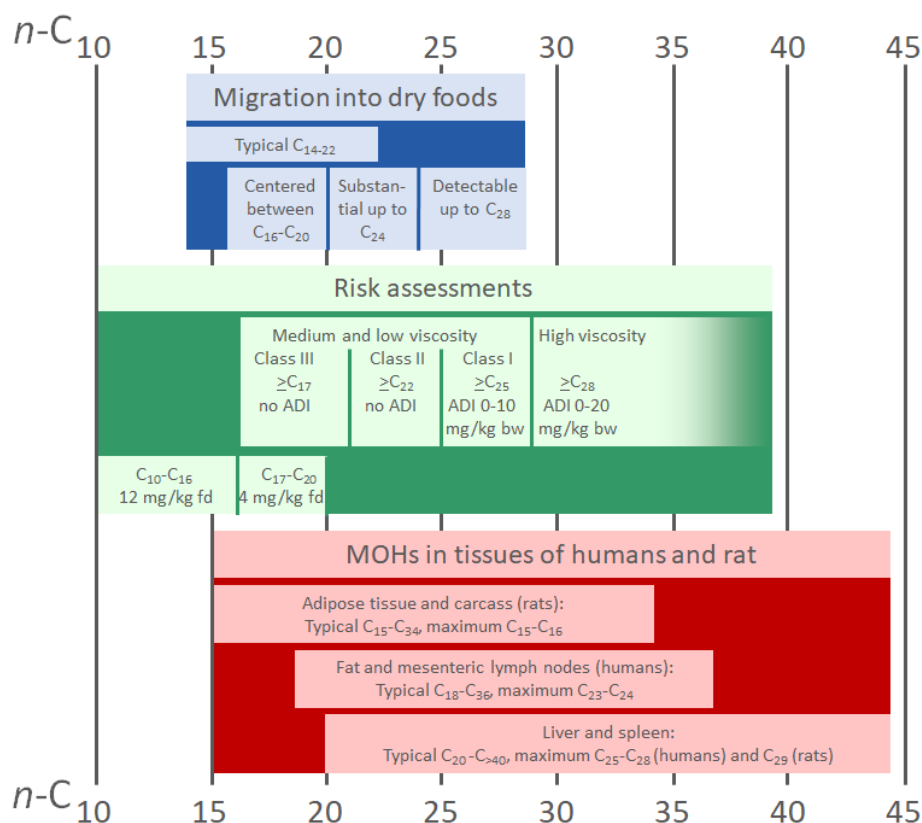


Figure 2. Molecular mass fractions of MOSH migrating into dry foods (blue), subject to risk assessments (green) and measured in tissues of humans and rats (red). Migration: MOSH fractions migrating through the gas phase into food [8, 13, 25-27]. Other exposure sources of MOH are not covered in the illustration. Risk assessment: Acceptable daily intakes (ADIs) [5, 6, 28] and limits in food (fd) [29, 30] for highly-refined MOHs. Biomonitoring: Distributions of MOHs measured in different tissues of humans and rats [2, 4, 20, 21].

7 Migration

First studies on the migration of MOHs from FCMs were published in the early 1990s [14, 15]. Although MOHs have many technical applications, they were mainly measured in food samples packaged in recycled paper and board which is commonly contaminated with MOHs. Secondary packaging, e.g. transport boxes of corrugated board, also contributed to MOH migration if the primary packaging did not provide sufficient barrier properties [31]. Migration of MOHs occurs almost exclusively through the gas phase: Substances evaporate into the gas phase and condense in the food [32]. Thus, direct contact between the food and the packaging as driver for MOH migration is not necessary [25].

Since the mixture of all migrating chemicals – known as overall migrate – usually contains many different MOHs, single compounds cannot easily be identified and quantified. In dry foods, 98% of the substances representing a typical MOH migrate had a branched or cyclic structure and the MOHs typically contained 14 to 22 carbon atoms (Figure 2) [27]. Migration via the gas phase and at ambient temperature was very high for MOHs up to 20 carbon atoms, substantial up to 24 carbon atoms and detectable up to 28 carbon atoms [16, 25, 32]. Based on their decreased vapor pressure, MOHs with more than 24 carbon atoms mainly migrated in the case of wetting contact between the food and the FCM [7]. A selection of scientific migration studies, as well as testing campaigns, illustrates potential sources of MOHs and typical concentrations measured in FCMs and/or food.

7.1 Scientific studies

- In 1991, contaminations of hazel nuts, coffee, cocoa beans, and rice with a high boiling mineral oil fraction were reported [14, 15]. MOHs, including aromatic compounds, migrated at levels up to several 100 mg/kg from jute bags into the food. The bags had been treated with mineral-oil based batching oils to make the material flexible.
- In 1997, powdered baby milk and cereals were contaminated with MOSH at levels between 10 and 150 mg/kg. Printed cardboard boxes were identified as source of contamination; internal plastic layers did not stop the migration process [27].
- In 2010, MOSH and MOAH were detected in newspapers, journals and cardboard food packaging as well as in a sample of rice packed in a box made of recycled board [16]. Unprinted recycled cardboard contained 300-1000 mg/kg mineral oils of chain lengths up to 28 carbon atoms. The mean concentrations of MOSH and MOAH were 433 and 132 mg/kg paper, respectively. In the rice sample, MOSH and MOAH levels were 15 and 4 mg/kg food, respectively. It was further illustrated that MOHs in rice mainly originated from the recycled board and not from printing inks, varnishes or adhesives.
- 119 dry foods packed in paperboard boxes were purchased from the German market and their MOH content was analyzed immediately after collection, 4 months later and either at the expiry date or after 16 months [26, 32]. Over this time, average MOSH concentrations increased from 8.9 to 14.3 mg/kg, whereas average concentrations of MOAH reached 2.2 mg/kg at the last measurement. Maximum migration levels of MOSH and MOAH

were 101 and 13.2 mg/kg, respectively. In the same study, it was shown that internal bags, which are, amongst other reasons, used to prevent MOH migration, were a source of POSH migration [32].

- In 2012, migration of POSH into dry foods, powdered baby formula, and foods containing wetting liquids was investigated [7]. POSH originated from the polyolefin-based food contact layers of the food packaging. Typically, POSH and MOSH migration levels were in the range of several mg per kg food. In many cases, the migration of C₂₄-C₃₅ compounds was higher than for C₁₆-C₂₄.
- Primary packaging made of recycled paperboard, but also secondary packaging and hot melts used to close the packaging were responsible for MOH contamination of different types of pasta [31]. It was concluded that the nature of the food strongly determined the final MOH levels. Furthermore, steadily increasing concentrations of MOSH and MOAH, reaching up to 14.5 and 2.0 mg/kg food, respectively, indicated a continuous contribution from the environment over the whole shelf life.
- In 2016, hot melt adhesives consisting of waxes, polyolefins and hydrocarbon resins were analyzed for their potential to release hydrocarbons into food [33]. Especially the hydrocarbon resins were a source of migration: It was estimated that hot melts contributed to food contamination with hydrocarbons in the order of 1 mg/kg food.

7.2 Testing campaigns

Several testing campaigns were initiated by enforcement laboratories, non-governmental organizations (NGOs) and consumer magazines. MOHs were measured in flour, oat flakes, semolina, cornflakes, chocolate, rice, pasta, and many more dry foods as well as in their packaging.

- Between 2012 and 2017, especially chocolate has been the focus of several campaigns testing for MOHs food contamination. MOSH and MOAH were commonly measured in different types of chocolates including seasonal Christmas and Easter products [34-40].
- In 2013 and 2015, the German consumer magazine *Ökotest* analyzed oat flakes and found MOHs in 75 and 80% of the tested samples, respectively [41, 42].
- In 2015, the NGO *foodwatch* analyzed MOSH and MOAH concentrations in 120 dry foods and their packaging. The food was purchased in Germany, France and the Netherlands [43]. 83% of the samples contained more than 2 mg MOSH per kg food. MOAH was detected in 43% of the samples (levels of detection: 0.2 mg/kg for dry foods, 0.5 mg/kg for fatty foods).
- In 2016, *foodwatch* summarized results on MOH contaminations in dry foods previously measured by German official food control authorities [44]. 375 and 128 of 446 tested foods contained MOSH and MOAH, respectively. All foods were packaged in paper or board and analyzed between 2011-2015.
- In 2016, the Danish Consumer Council *THINK Chemicals* measured MOHs in 16 different types of cardboard and paper packaging. Seven food samples exceeded MOSH and MOAH concentrations of 24 and 6 mg/kg, respectively [45].
- In 2017, Dutch cheese biscuits were recalled from the market due to the presence of up to 190 mg MOAH per kg. Furthermore, MOSH concentrations exceeded 1000 mg per kg [46]. It was not mentioned whether FCMs were a possible source of this contamination.

8 Safer packaging solutions

8.1 Recycled paper and board

The frequent detection of high MOH levels in packaging materials made of recycled paper and board initiated a broad discussion about

the development of safer packaging solutions [47]. Most materials recycled into paper and carton-based food packaging are not intended for food contact. Newspapers printed with mineral-oil based inks were identified as major source of MOHs in recycled paper and board [16], but adhesives, coatings, additives, and contaminations from previous uses also introduced unwanted chemicals into the recycle [48].

Substitution

The replacement of mineral-oil based printing inks by e.g. vegetable-based printing inks in all food-grade and non-food grade products will eventually lead to lower concentrations of MOHs in recycled paper and board. This suggestion does not quickly solve the migration issue, but it will help to decrease the load of MOHs in the long-term view of a circular economy.

Functional barriers

Internal bags or barrier layers on the inner surface of the packaging can minimize migration. It was recommended that such functional barriers shall reduce migration by at least 99% to ensure that no unknown substance reaches a concentration possibly endangering human health [49].

In 2014, the quality of 87 internal bags for packaging of dry foods was investigated and the bags were classified based on their barrier efficiency against five test substances, namely dipropyl phthalate, 4-methyl benzophenone, triethyl citrate, *n*-heptadecane and *n*-octadecane [50]. 17 bags consisting of paper, PE and/or polyethylene vinyl acetate (EVA) were assigned to class 1. These bags hardly slowed down migration of the test substances. Class 2 comprised 28 bags made of oriented polypropylene (OPP) as monolayer or in combination with PE. Internal OPP bags reduced migration during the first six month of storage at room temperature, but migration became significant afterwards. 15 bags were assigned to class 3 and typically consisted of different multilayer materials with intermediate barrier efficiency. Class 4 comprised polymeric multi-layer materials with high barrier efficiency composed of e.g. polyethylene terephthalate (PET), polyamide (PA), PE, PP, EVA, and polyethylene vinyl alcohol copolymer (EVOH). Bags with an aluminum foil were qualified as tight without testing and assigned to class 5. All 27 bags of classes 4 and 5 were judged as appropriate to guarantee the safety of food packaged in recycled paperboard

Further studies recommended PA, PET, polylactide (PLA), polystyrene (PS), and cellophane as good barriers protecting against mineral oil migration [47, 49, 51, 52].

Integrated Adsorbents

Adsorbents such as activated charcoal integrated into the recycled paper and board can trap contaminants and prevent their migration into the food [53].

Deinking

Deinking is commonly used during recycling of paper and board to detach printing inks from the fibers and subsequently remove them from the pulp. A comparison between flotation and adsorption deinking investigated the efficiencies of both methods regarding the reduction of MOHs [54]. Depending on the pulp sample, adsorption and flotation deinking reduced the concentration of MOHs by 61-83 and 51-75%, respectively.

8.2 Jute

The substitution of MOH-based batching oils with vegetable oil during the conditioning process of jute fibers was reported in different studies [55, 56].

9 Risk assessment

9.1 MOSH and MOAH

JECFA assigned acceptable daily intakes (ADIs) of 0-10, 0-20 and 0-20 mg/kg body weight per day to medium- and low-viscosity mineral oils (class I), high-viscosity mineral oils and microcrystalline wax, respectively (Table 1; Figure 2) [5, 6]. In 1995, a temporary group ADI of 0.01 mg/kg body weight per day was established for medium- and low-viscosity mineral oils (classes II and III) which was withdrawn in 2012 due to absence of data on internal exposure and the relative accumulation potential of these compounds in humans [28].

In 2012, the European Food Safety Authority (EFSA) concluded in its scientific opinion on mineral oils that the absence of toxicological studies on MOSH mixtures does not allow to establish a health based guidance value for MOSH [1]. Furthermore, safe doses of intake cannot be defined for MOAH based on its genotoxicity [18]. EFSA's recommendations included the establishment of health based guidance values based on whole mixture studies of MOHs and characterization of the chemical composition of MOH mixtures including the molecular mass range and subclass composition [1].

In 2017, the French Agency for Food, Environmental and Occupational Health & Safety (ANSES) published an opinion on the migration of mineral oil compounds from recycled paper and board [57]. ANSES recommended limiting consumer exposure to MOHs, and to MOAHs in particular, by using MOAH-free printing inks, glues, additives and processing aids during manufacture of paper and board packaging.

9.2 POSH

In 2016, the trade association PlasticsEurope published a summary of a research project on the risk assessment of polyolefin oligomers [58]. Accordingly, the results demonstrated "that consumer exposures to the oligomers from the polyolefin plastics food packaging under typical conditions of use are not a safety concern to human health." In the same year, a study by the Official Food Control Authority Zurich revealed that polyolefin manufacturers did not supply sufficient data on the identification and potential migration of oligomers, including POSH, from polyolefin granulates [59]. After semiquantitative analysis of the granulates' low molecular mass constituents, it was concluded that "there is a broad gap between the legal requirements and reality that ought to be eliminated."

10 Current regulations

10.1 Europe

The use of mineral oils in different types of FCMs is not specifically regulated, but falls under the general provisions defined in the European Framework Regulation [EC 1935/2004](#) on FCMs. The Plastics Regulation [EU 10/2011](#) lists three authorized MOHs (FCM #93-95) in its positive list of additives and monomers and further includes a hydrocarbon resin (FCM #97) (Table 2).

Microcrystalline waxes are additionally approved as food additive E905 for use in the surface treatment of confectionery, excluding chocolate, chewing gum, melons, papaya, mango and avocado. Their purity requirements are similar to FCM substance No. 94 (Table 2).

In 2017, the European Commission (EC) adopted Recommendation [EU 2017/84](#) on the monitoring of MOHs in food and in FCMs. In the years 2017 and 2018, Member States are asked to monitor MOHs in several types of food and FCMs.

In Germany, two ordinances are currently under discussion aiming at the prevention of mineral oil migration from recycled paper and board into foods: The [21st draft ordinance amending the Consumer Goods Ordinance](#) ("printing ink ordinance", version of June 24, 2016) includes a positive list of substances to be used in printing inks. This list includes the same three MOHs that are also authorized under the Plastics Regulation (Table 2). The [22nd draft ordinance amending the Consumer Goods Ordinance](#) ("mineral oil ordinance", version of March 7, 2017) recommends a specific migration limit of 0.5 mg/kg food for MOAH and the introduction of functional barriers. However, in comparison to previous versions of this draft, no specific migration limit for MOSH was provided.

In Switzerland, mineral oils and waxes are included on the list of permitted substances for the manufacture of packaging inks, e.g. light white mineral oil (CAS 92062-35-6) and white mineral oil (CAS 8042-47-5) are listed as non-evaluated substances [60]. When searching this list for related terms, such as "naphtha", "petroleum", "paraffin" and "wax," a few dozen substances appear that may have similar properties and applications. Additionally, the Swiss Ordinance [817.023.21](#) on Materials and Articles prohibits the use of recycled paper and board in direct contact with food.

10.2 U.S.

In the U.S., MOHs are used as direct and indirect food additives [61]. Specifications for white and technical white mineral oils are given in [21 CFR 172.878](#) and [21 CFR 178.3620](#), respectively. White mineral oil is permitted for direct addition to food for human consumption ([21 CFR 172.878](#)) and as component of non-food articles intended for use in contact with food when compliant with any limitations provided in 21 CFR 170-189 [61].

Technical white mineral oil is permitted as indirect food additive in a wide variety of FCMs, e.g. in adhesives ([21 CFR 175.105](#)), as component and defoaming agent in paper and paperboard ([21 CFR 176.200](#) and [21 CFR 176.210](#)), in resin-bonded filters ([21 CFR 177.2260](#)), in rubber articles intended for repeated use ([21 CFR 177.2600](#)), in textiles and textile fibers ([21 CFR 177.2800](#)), and as lubricant ([21 CFR 178.3570](#) and [178.3910](#)). Further permitted applications of (technical) white mineral oil include its use in resinous and polymeric coatings ([21 CFR 175.300](#)), cellophane ([21 CFR 177.1200](#)) as well as in packaging materials intended for radiation ([21 CFR 179.45](#)). It may further be used as antioxidant, stabilizer and/or plasticizer in polymers ([21 CFR 178.2010](#) and [178.3740](#)). Additionally, mineral oil is permitted as feed additive ([21 CFR 573.680](#)).

10.3 Self-regulation

In November 2016, six French retailers restricted the presence of mineral oil residues in their own-brand foods: MOSH shall not exceed a limit value of 2 mg/kg food and MOAH are completely prohibited [62]. Three German retailers requested specific limit values for mineral oil residues in food [63].

Table 2. MOHs authorized as additives under the Plastics Regulation EU 10/2011.

FCM substance	Substance No.	SML [mg/kg]	Average MW	Viscosity at 100°C [mm ² /s]	Hydrocarbons with C<25	Comments
Waxes, paraffinic, refined, derived from petroleum based or synthetic hydrocarbon feedstocks, low-viscosity	93	0.05	>350	>2.5	<40%	Restriction: Not to be used for articles in contact with fatty foods.
Waxes, refined, derived from petroleum based or synthetic hydrocarbon feedstocks, high-viscosity	94	n.d.	>500	>11	<5%	JECFA classification: Wax, microcrystalline
White mineral oils, paraffinic, derived from petroleum based hydrocarbon feedstocks	95	n.d.	>480	>8.5	<5%	JECFA classification: Mineral oil, medium- & low-viscosity, class I
Petroleum hydrocarbon resins, hydrogenated, produced by polymerization of dienes and olefins	97					Restriction: Residual aromatic monomer ≤ 50 mg/kg

n.d. – not defined

Abbreviations

ADI	Acceptable daily intake	LD ₅₀	Lethal dose, 50%
ANSES	French Agency for Food, Environmental and Occupational Health & Safety	MOAH	Mineral oil aromatic hydrocarbons
CFR	Code of Federal Regulation	MOH	Mineral oil hydrocarbons
EC	European Commission	MOSH	Mineral oil saturated hydrocarbons
EFSA	European Food Safety Authority	MS	Mass spectrometry
EVA	Polyethylene vinyl acetate	NGO	Non-governmental organization
EVOH	Polyethylene vinyl alcohol co-polymer	OPP	Oriented polypropylene
FCMs	Food contact materials	PA	Polyamide
FAO	Food and Agriculture Organization of the United Nations	PE	Polyethylene
FDA	U.S. Food and Drug Administration	PET	Polyethylene terephthalate
FID	Flame ionization detection	PLA	Poly lactide
GC	Gas chromatography	POSH	Polymer oligomeric saturated hydrocarbons
JECFA	Joint FAO/WHO Expert Committee on Food Additives	PP	Polypropylene
LC	Liquid chromatography	PS	Polystyrene
		SML	Specific migration limit
		WHO	World Health Organization

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