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TNO-rapport

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Potentie van mitigatiemaatregelen in de oud papier-en-kartonketen (OPK) ter reductie van minerale-oliemigratie naar voeding

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Goedgekeurd door	M.A.J. Rennen
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Summary

Motivation

Exposure to mineral oils occurs via food. From a food safety perspective, the presence of saturated hydrocarbons (mineral oil saturated hydrocarbons (MOSH)) and aromatic hydrocarbons (mineral oil aromatic hydrocarbons (MOAH)) in food is considered alarming. It has been shown that there is a lack of information on the sources of MOSH and MOAH and their contribution to the total exposure to mineral oils. However, the following information provides sufficient reason for exploring methods to reduce the exposure to MOSH and MOAH:

- the current information available on exposure to MOSH and MOAH via food;
- the current knowledge about the potential presence of MOSH and MOAH in food packaging and their migration to food;
- the fact that MOAH are compounds that are possibly genotoxic. For genotoxic compounds it is required to keep the concentration in food as low as possible (the so-called ALARA-principle[3]), and,
- the fact that the sources of MOAH concern mineral oils that are less purified[4] and mostly end up as a contaminant in food, for example by the recycling of paper and board.

As is known that migration from recycled paper and board is a relevant source of MOSH and MOAH, this research aimed to explore the potential of several measures to reduce MOSH and MOAH in the used paper-and-board chain (OPB chain).

Assignment and approach

The Netherlands Institute for Sustainable Packaging (KIDV) and the Top Institute Food and Nutrition (TiFN) commissioned TNO to perform an exploratory investigation into the potential of several technologies to eliminate mineral oil from the (Dutch) OPB chain, with respect to food safety (people), sustainability (planet) and costs/implementability (profit).

The assessment was performed using a framework developed for the purpose of this project. Applying the framework, the effect of the application of the technology on (mineral oils in) the recycled product/process was compared to a baseline situation without any measures in the OPB chain. The three aspects have been evaluated as follows:

1. food safety: product safety and chain safety
2. sustainability: material retention, (energy) sources and waste
3. costs and implementability: costs, production efficiency, implementability, Technology Readiness Level (TRL-level) and the quality of the final product

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[3] ALARA = as low as reasonably achievable: as low as reasonably possible; a principle used in risk assessment purposes for compounds that may be hazardous at very low amounts, such as genotoxic compounds

[4] Examples of less purified oils are printing inks (for newspapers/magazines), lubricating oil for food production machinery and cleaning products

The focus of this assessment was food safety. In the first place, the effect of the technology on the reduction of (the migration of) MOSH and MOAH was assessed. In the second place, it was assessed whether the application of the technology could introduce other compounds in the recycled product and thereby influence food safety. In general, food safety encompasses many more aspects than those mentioned here; in this report the term "food safety" is used in the restricted sense within the framework of the mineral oil problem as described above. With respect to the food safety assessment, it was also investigated whether the Complex Mixture Safety Assessment Strategy (CoMSAS), developed by TNO, could be applied. CoMSAS is a science based method for the safety assessment of mixtures in which it is not necessary to separately identify and assess compounds when the exposure to these compounds is low (below the safety limit) provided the compounds concerned also meet certain criteria.

For an integrated assessment of the technologies on all evaluated aspects (food safety, sustainability and costs/implementability) it is necessary to weigh their performance on these different aspects. The result of this weighing depends, amongst others, on the importance that is attributed to each of them. TNO has attributed most weight to food safety and has strived to attribute equal weight to the other two aspects: sustainability and costs/implementability. In this process, the large differences in the availability of (reliable) information as well as in the precision of the assessments of the evaluated aspects of the various technologies, has been a complicating factor. Therefore, only a qualitative integrated assessment is given in this report.

The potential of the technologies to eliminate or fixate mineral oil from the OPB chain was compared with the potential of the use of cleaner (mineral-oil-free) inks, as printing inks used for newspapers and magazines are considered the major sources of contamination of the OPB chain with mineral oil. Based on this research recommendations for follow-up steps have been formulated.

Additionally, KIDV/TiFN asked TNO to complement, from the perspective of toxicological risk assessment, a literature review performed by Wageningen University regarding the issues surrounding mineral oils in packaging. The report of this literature research has been published separately: Thoden van Velzen et al. (2018).

Technologies for elimination or fixation of mineral oils

During the research it was found that in The Netherlands, in practice only one technology to reduce the migration of mineral oils from packaging is currently applied. This technology is the **MB12** technology, which aims to fixate the mineral oil in the packaging. In addition, the packaging industry applies **flotation** to deink paper. As the mineral oil partly originates from the ink, this technology may contribute to the elimination of mineral oils from recycled paper and board, and has therefore been selected for assessment using the framework.

Next to the two technologies already applied in The Netherlands, scientific literature was surveyed to identify whether there are other innovative technologies potentially suitable for the purpose of elimination of mineral oils. **Supercritical CO_2** and **heat treatment** are technologies that are currently being developed to eliminate mineral oil from the OPB chain. Additionally, brainstorms with experts were held to create new ideas based on the production process of paper and board and on

chemical/analytical knowledge regarding the behavior of compounds in paper. From those brainstorms, the application of **anionic trash catchers** (ATCs) and the use of **functionalized clay** were identified as potential technologies to fixate mineral oils in packaging.

Evaluation of the potential of the technologies

Based on the experimental results and the literature survey, it can be concluded that flotation, MB12, sCO2 and heat treatment are effective in reducing migration of MOSH and MOAH from packaging to food. The level of effectiveness differs between the technologies, where sCO2 seems to be most effective (90-99%) followed by flotation, MB12 and heat treatment (approximately 70-80%). For ATCs and functionalized clay insufficient information is available to assess their effectivity. The ideal situation would be a technology that has a maximal positive effect on food safety without having a negative influence on sustainability. In addition, it is important that the technology is feasible in terms of costs and implementability.

Based on this exploratory research, it can be concluded that none of the evaluated technologies has a maximal score. From a food safety point of view, it seems that, on the basis of this research, sCO2 is the most desired technology. However, this technology scores low in terms of investment costs and the use of energy sources. Also flotation, heat treatment and MB12 are suitable technologies from a food safety point of view, but they perform less well compared to sCO2. Flotation, however, is not desirable in terms of sustainability and costs. The number of uncertainties surrounding heat treatment, ATCs and functionalized clay impede drawing conclusions on their relative potential. Additional research could contribute to solve or reduce these uncertainties.

Despite the possible negative effect on chain safety and the absence of information on costs (for which reason costs were assumed to fall in the highest category), MB12 seems to be the preferred technology on the basis of an integral, qualitative weighing of all aspects assessed in this report. However, the technology is patented, and at the time cannot be applied yet by third parties. Therefore, from the perspective of reduction of mineral oils in the OPB chain, MB12 can only be recommended if the technology were allowed to be used by other parties.

Adjustment of technologies may positively influence the result of their assessment, e.g. by introducing reuse of energy, water and compounds (sustainability), a topic the recycling industry in The Netherlands is already putting a lot of effort in. Additionally, further technology development may positively influence the results of the assessment, for example in terms of efficiency.

Relative potential of the use of reducing/fixating technologies in the OPB chain vs. the use of cleaner inks

It is generally assumed that it is best to tackle problems at the source. However, from the perspective of the issues surrounding mineral oils, this is complex, as mineral oils in food can originate from many different sources. Printing inks from newspapers are probably the largest source of mineral oils in recycled packaging. Therefore, the use of cleaner inks was selected for investigation in this exploratory research. In the table below, advantages and disadvantages of the application of the reducing/fixating technologies in the OPB chain are set against the use of cleaner inks.

	Reduction/fixation of mineral oils in packaging	*Cleaner inks*
Advantage	Reduction/elimination of mineral oil migration from packaging independent of the sources	Approach starts at the source of the problem
	Direct effect on product safety	
		Solves the problem for the major source of contamination in the packaging chain
Disadvantage	The problem remains as the sources of mineral oils are not dealt with	Addresses only one out of multiple sources of mineral oils in packaging
		Requires the contribution of multiple parties worldwide
		These parties (printing industry) are not primarily responsible for food safety as the final product (news-papers/magazines) is not meant for food contact
		Reaching the intended effect is expected to take decades

Primarily based on their low short-term implementability, cleaner inks do not seem capable of having sufficient impact on the reduction of exposure to MOSH and MOAH via food packaging material from recycled OPB in the short term. However, the fact remains that it is desirable to apply cleaner inks instead of traditional inks, although their impact is only felt in the long term. Based on this exploratory research, it can be concluded that the technologies to reduce migration of mineral oils have more potential to solve the mineral oil problems (for the use of recycled OPB in food packaging materials) in the short term than cleaner inks.

CoMSAS: applicability and added value

During this research, the applicability and added value of CoMSAS for the purpose of this research was investigated. For this purpose, two paper and board producers provided samples to TNO for experimental research on MB12 and flotation. By comparing samples taken before and after the application of the technology, the effect of the technology on food safety can be assessed. Based on the results it can be concluded that CoMSAS:

- provided a clear view on the compounds introduced or increased by application of the technology;
- was able to estimate the exposure via food to these compounds and relate it to a safe exposure limit;
- evaluated the estimated exposure of all additionally detected compounds as being safe.

Based on these results, it seems that CoMSAS is more efficient and faster method compared to the traditional approach by which all compounds are separately identified and assessed because all compounds are under the exposure threshold.

General conclusion and recommendations

Based on this exploratory research, the following can be concluded:

- In the short term, technologies for reduction of mineral oils in food packaging of recycled OPB or the migration of mineral oils from this packaging have more impact than the application of cleaner inks;
- However, although their impact is on felt in the long term, it is desirable to apply cleaner inks instead of traditional inks, which form a source of MOSH and MOAH (as the concentrations of MOAH need to be kept as low as possible (ALARA principle) due to their possible genotoxic potency);
- From the investigated technologies, two are already in use (MB12 and flotation), two are in development (sCO2 and heat treatment) and two are available as a conceptual idea (ATCs and functionalized clay);
- All technologies of which the effectivity to eliminate/fixate mineral oils that could be investigated (MB12, flotation, sCO2 and heat treatment) are able to eliminate or fixate >70% (up to 99%) in packaging material. Therefore, these technologies are promising for solving the issue of mineral oils;
- None of the technologies present an optimal score regarding food safety, sustainability and costs/implementability;
- sCO2 seems to be most desirable in terms of food safety as it is able to eliminate >90%-99% of the mineral oils, however, due to negative scores on energy use, investment costs and implementability, the final score in relation to the other technologies decreases;
- In an integrated assessment of all aspects, the patented MB12 technology seems to be the preferred option, provided that this technology will be allowed to be used by other parties;
- There are more sources of mineral oils in food than packaging. Measures for reduction of migration of mineral oils from packaging will therefore never be 100% effective in the elimination of MOSH/MOAH;
- However, the application of mitigation measures in packaging made out of recycled OPB is expected to be a big step in reducing migration of MOAH to food. From a food safety perspective, highest priority needs to be given to the reduction of MOAH in view of its potential genotoxicity, for which the ALARA principle applies. Therefore, mitigation measures are highly desirable;
- The framework assessment yields a clear overview of the advantages and disadvantages of the assessed technologies. Based on this, several technologies may be improved in certain aspects, after which the assessment can be adjusted and the final judgement updated;
- Applying CoMSAS is more efficient compared to the traditional compound specific approach.
- An exploratory investigation using CoMSAS did not demonstrate migration from products treated with MB12 or flotation to levels exceeding the safety limit.

Recommendations

The issue of mineral oils in food products is a result of multiple sources and factors. Therefore, one solution does not rule out the other, and it is recommended, **where possible and relatively easy, to take action**. When feasible, it is recommended to start applying cleaner inks. Additionally, it may be possible to **combine knowledge and technology** to create new ideas to solve the problem. Since the exposure to mineral oils via food is also caused by **other sources**, it is recommended to **investigate mitigation measures** for these sources as well, in which, from a food safety perspective, priority should be given to sources of MOAH.

It is recommended to apply **the developed assessment framework to another mitigation measure as well: the application of coatings**. This may provide solutions in the short term.

Different stakeholders are involved with the different possible solutions. Therefore, the remainder of the recommendations are organized according to the (most important) stakeholders that should implement them.

For the OPB industry

- Set up a **license** model for the application of MB12
- Further develop **deashing** of OPB containing MB12 to decrease the possible effect of the presence M12 bound mineral oil on chain safety
- Investigate and monitor whether MB12 bound mineral oil will **always stay fixated in the packaging matrix**.
- Optimize the **sCO_2 technology** in order to increase its efficiency of production and decrease investment costs

Based on the present knowledge, the disadvantages of flotation and thermal treatment, especially with respect to sustainability and costs, are so big that at this time no recommendations for optimization aimed at the mineral oil problem can be made for these technologies.

For the ink and printing industry

- Apply cleaner inks and develop them further for various printing techniques, where needed, especially for those requiring vegetal oil-based inks

For the food industry

- Investigate **mitigation measures** for **other sources of mineral oil contamination in food** than OPB, giving, from a food safety perspective, priority to sources of MOAH

For the KIDV and other research institutes

- **Combine knowledge and technology** to produce new ides to tackle the mineral oil problem
- Increase the **CoMSAS analyses** of MB12 with more samples to gain insight in the representativeness of the experimental results and evaluate the safety of **all new/increased substances**, including the substances that could be identified
- Explore **whether and to which degree** ATCs and functionalized clay are **effective in fixating mineral oil in the packaging matrix.** Investigate and further develop these options only if they are able to fixate >90% of the mineral oil, since otherwise they probably cannot compete with MB12 or sCO_2.