ZERO WASTE EUROPE

"Bye Bye" to PVC in food packaging – once and for all

Briefing

July 2024

zerowasteeurope.eu

Introduction

Food packaging is a large product group of consumer products that can contain many hazardous substances, as a result of both their intentional use and not intentional presence. The material that the food packaging is made from is important. Plastic materials are particularly of high concern due to the potential presence of thousands of chemicals and their level of migration, and polyvinyl chloride (PVC) has the potential to contain a high volume of additives and the largest number of substances of concern out of all the plastic types.

Therefore, when it comes to plastics that should be avoided in contact-sensitive applications such as food packaging, PVC is a prime example.

Good to know

- On its own, PVC is not particularly useful as it rapidly degrades at temperatures required for processing, that are typically above 160°C. Hence, PVC resin is mixed with other chemicals (additives) to achieve plastic that is tough and rigid, or soft and flexible.
- PVC requires by far the most chemical additives of all plastics types, alone accounting for 73% of the world production of additives by volume.
- Over 85% of all plasticizers (mainly phthalates) are used in PVC plastics.
- Assuming additives represent about 20% of PVC resin overall, the EU output of PVC additives likely amounts to approximately 1 million tonnes per year.

PVC in food packaging

Over **400,000 tonnes per year of PVC** (3.7% of total production) is used in packaging across Europe in rigid film (about 80%), flexible film such as cling film (15%) and closures (3%). Around **185,000 tons of PVC resin is used for food contact applications**, and 215,000 tons for pharmaceutical packaging.

The different types of PVC packaging material — containers (cups, trays, lids), foil, cling film and cap sealing — are used within the range of food packaging applications (e.g. for packaging delicacies, sweets, refrigerated goods, baked items and meat, blister packaging for gum, seals on metal lids, bottle sleeving). Plasticised PVC can be found in food wraps, for both commercial and consumer use, in components of certain food processing equipment such as conveyor belts and tubing, as well as in the gaskets found in metal cap closures used on glass jars and bottles.

Whilst in general the volume of PVC use in packaging has significantly decreased, Ellen MacArthur Foundation noticed its global growth by 3% (% change by weight vs 2020).

Exposure to chemicals present in PVC food contact articles

Good to know

- Ca. 470 additives have been identified as currently in use in PVC products. ECHA has recently confirmed that a regulatory action is necessary for a number of chemicals which belong to three main classes of additives (heat stabilisers, plasticisers and flame retardants).
- Products made from PVC have a long history of replacing hazardous additives (such BPA and DEHP) with other chemicals.
- European Commission and ECHA reports on the use of PVC in the context of a non-toxic environment and PVC and its additives, have flagged considerable data gaps on additives in this material.
- While there is evidence for migration of phthalates which are under scrutiny for their reprotoxic and endocrine-disrupting effects, there is little information publicly available on the release potential, migration and bioavailability of other plasticisers and additives, making it impossible to assess their risk properly.
- Overall, manufacturers in the EU are switching away from phthalates and their primary plasticiser to alternate compounds such as ESBO, ATBC, DEHT, DEHTP, DINCH, DEHA and DINA.
- DINCH and DEHTP are not considered to be hazardous, however, the structural similarity between the substances is striking and in humans both DEHTP and DINCH are metabolised through the same pathways as DEHP. Research indicates political action might be needed due to the strong increases of the DINCH and DEHTP measured in humans across Europe. The new substitutes are less intensively investigated toxicologically.

PVC used for food packaging has potential to leach harmful substances into food ingested by the population:

- **229 migrating and extractable chemicals** identified in finished PVC food contact articles (number of database entries for polyvinyl chloride = 736; FCCmigex[1])
- Among these chemicals, there are substances that are **considered harmful** according to the EU's Chemicals Strategy for Sustainability, meaning they are **carcinogenic, mutagenic, or toxic to reproduction, or persistent and bioaccumulative, or endocrine disrupting chemicals, or are toxic to specific target organs**.

The human biomonitoring studies across Europe produced robust, coherent evidence on human internal exposure to chemicals commonly used in food contact articles / food packaging, including made from PVC. Many of these chemicals are currently widely found in the bodies of consumers, including children, often at levels that may harm their health.

[1] "database on migrating and extractable food contact chemicals"

A big group of chemicals that Europeans are exposed to through food contact materials, and which are widely used to soften PVC, are **phthalates** which may lead to infertility and impair development, and their **substitutes** for which the impacts on citizens and the environment is not fully known yet.
EU-wide HBM4EU project studied phthalates in children and teenagers from 12 countries and found that for some phthalates (BBzP, DiBP, DEHP, DiDP) and DINCH (substitute), higher levels were found in the more susceptible group of children. 4% of children exceeded the human biomonitoring guidance value for di-n-butyl phthalate (DnBP), while at least 4% of the children and 1% of the teenagers exceeded the guidance value for di-isobutyl phthalate (DiBP).
Phthalates act cumulatively, so currently **17% of European children and adolescents are at risk from combined exposure to mixtures of 5 reprotoxic phthalates** (DEHP, DiBP, DnBP, BBzP, DiNP).

Despite existing regulatory measures, children and teenagers in Europe are still exposed to multiple phthalates and/ or substitutes simultaneously.

Toxicity of chemicals present in PVC food packaging

Good to know

- While the focus of toxicological studies is mainly on additives used in PVC, some earlier studies confirm hazards related to the material itself: for example, when various potential materials were tested for their biocompatibility *in vivo* and *in vitro*, the PVC implant showed the largest thickness of inflammatory tissue capsule and highest cytotoxicity among tested materials.
- Chemicals leaching from PVC-made products often show higher toxicity *in vitro* compared to other polymers.[2]
- The large number of migrating chemicals, and the fact that most of these remain unidentified and do not undergo formal risk assessment, pinpoint the shortcomings of current scientific and regulatory approaches to the chemicals leaching from PVC plastics.

Looking closer into safety of PVC food packaging

"Benchmarking the in Vitro Toxicity and Chemical Composition of Plastic Consumer Products"

- o Extracts of PVC and polyurethane induced the highest toxicity at most endpoints from the eight polymer types investigated (including baseline toxicity, oxidative stress, cytotoxicity, estrogenicity, and antiandrogenicity).
- o Some individual PVC food contact materials were even more toxic than non-food contact made of PVC.
- o A high baseline toxicity and antiandrogenicity (indicator for the leaching of endocrine-disrupting chemicals relevant for human health) was observed for a food wrap made from PVC.
- o Nontarget chemical screening detected between 0 and 194 features per sample, and PVC had the largest total peak count and area.
- o Compounds found in PVC plastic packaging were UV filters, antioxidants and the plasticizers: tributyl acetylcitrate, DEHP and didecyl phthalate, and known NIAS (non-intentionally added substances), including 9-octadecenamide.

"Plastic Food Packaging from Five Countries Contains Endocrine- and Metabolism-Disrupting Chemicals"

- o Testing of extracts from 36 plastic food contact articles (real-world mixtures of chemicals) showed that they contain endocrine- and metabolism-disrupting chemicals.

[2] See for example: Plastic Products Leach Chemicals That Induce In Vitro Toxicity under Realistic Use Conditions

- Chemicals present in packaging made of PVC, PUR and LDPE induced most effects, whereas the extracts of HDPE, PET, and PP were less active.

Substitution of PVC by other materials in manufacturing of the food packaging will have an immediate impact on flow of chemicals (including known and unknown, hazardous and potentially hazardous substances) in the sector.

Microplastic: barely visible but a huge problem

Good to know

- Presence of microplastics was revealed in people's bodies (among others, in blood, the placentas, breastmilk, the lungs, the testes)
- Scientists showed that plastic particles are released from drinking cups and food containers, and for example babies fed formula milk in plastic bottles were swallowing millions of particles a day.
- The release of microplastics and the migration of additives from plastic food containers into food is amplified by heat, fatty or acidic foods, or contact with liquids.
- Studies suggest that consumption of microplastics can change human gut and oral microbiota composition. Oral administration of nano- and microplastics may produce redox imbalance, disruption of energy homeostasis, and neurotoxicity in the gut, intestine, and kidney.
- A 2022 report from the Food and Agriculture Organisation (FAO) recognises the impact of packaging and emphasises that, despite the poor information currently available on the toxicity of microplastics, it is vital that authorities, stakeholders and legislative bodies find a way to tackle the issue.
- The World Health Organisation (WHO) confirms that measures should be taken to mitigate human exposure to nano- and microplastics.

The European Chemicals Agency (ECHA) identified the regulatory need for reduction of PVC microparticles releases to minimise PVC-specific risks such as: 1) higher anticipated additive releases from PVC, and 2) higher co-exposure from additives through PVC microplastics.

Without a doubt, additionally to the migration of leachable chemicals from PVC plastic packaging into foods, the potential **contamination of food with PVC microplastics** (which can also attract and carry chemical substances), **raises serious concerns for human health**, even if knowledge gaps still exist.

Among different microplastics, PVC should receive extra attention because of its carcinogenic monomer, requirement for the most (and often hazardous) additives, as well as being more easily fragmented than other thermoplastics. Multiple factors may cause **effects of PVC on human cells**, including particle-specific morphology and surface chemistry, or leachates from the polymer matrix, or both.

- Endocytic mechanisms allow PVC particles (150 nm) to penetrate the gut wall and end up in lymph nodes and the blood vascular system.
- PVC nano- and microplastic can provoke human immune cells to secrete cytokines as key initiators of inflammation.
- PVC microplastic particles can induce cytotoxicity on human blood lymphocytes (associated with intracellular reactive oxygen species (ROS) formation, lysosomal membrane injury, mitochondrial membrane potential collapse, depletion of glutathione, and lipid peroxidation).
- PVC microplastics can change the secondary structure of Human Serum Albumin, when tested *in vitro*. This provides significant information for elucidating the potential biological toxicity of PVC microplastic at a molecular level, and should receive particular attention knowing there is proof of microplastics presence in the bloodstream. Once PVC microparticles enter into the digestion organs and the blood circulation system, they might adsorb and bind with

serum albumin, destroying the structure and physiological function of proteins firstly, then transferring to each organ along with blood, and potentially causing more serious damage *in vivo*.
- PVC micro- and nano-particles can induce carcinogenesis in humans.
- PVC particles produce moderate *in vitro* toxicity for human pulmonary cells and cardiometabolic toxicity.

Looking closer into PVC microplastics in humans

- Systematic analysis of the presence of microplastics >20 µm in size in **digestive and respiratory human tissues** revealed that small-sized microplastics (20-100 µm) were predominant, and PVC was the dominant polymer in all tissues tested.
- Microplastics were found in all 62 of the **human placenta** samples tested, with concentrations ranging from 6.5 to 790 micrograms per gram of tissue. PVC and nylon each represented about 10% of the total microplastics found.
- PVC was one of the two dominant polymer types found in **human testes** and a negative correlation between PVC and PET and the normalised weight of the testis was observed.
- A study conducted in Germany analysed a total of 17 human tissue samples (11 liver, 3 kidney and 3 spleen samples) of 6 patients with liver cirrhosis and 5 individuals without underlying liver disease. All samples from patients without underlying liver disease tested negative for MPs; in contrast, microplastic concentrations (including PVC particles) in **cirrhotic liver tissues** tested positive and showed significantly higher concentrations compared to liver samples of individuals without underlying liver disease. The results of this study confirm 1) internal exposure to PVC microplastic and equally important 2) vulnerability of certain groups to such exposure.
- Patients with carotid artery plaque in which microplastics were detected had a higher risk of myocardial infarction, stroke, or death from any cause at 34 months of follow-up than those in whom microplastics were not detected. PVC was detected in **carotid artery plaques** of 31 patients (12.1%), respectively.
- Worker studies suggest **unique liver carcinogenicity potential** of polyvinyl chloride microplastics (while the evidence of liver toxicity from occupational exposure to microplastics other than PVC is lacking).

How safe is PVC in food contact materials?

Good to know

- The evaluation of the current EU FCM regulation[3] concluded on a number of deficiencies such as: focus on starting substances rather than materials and final food contact articles; poor quality, availability and transparency of information in the supply chain; the lack of prioritisation of substances including the most hazardous; a serious lack of enforcement rules across Europe.
- The current regulatory framework defines food contact materials as "safe" if they comply with the regulations setting "safe levels" for a small set of well-studied chemicals. But legislation, so far, fails to ensure the real safety of products, namely ensuring the absence of hazardous and untested chemicals in food packaging.
- Accordingly, **it simply remains unknown whether use of PVC in food contact applications is safe.**

PVC will always leach chemicals. While there is no acute danger in ingesting chemicals migrating from PVC food contact articles, it is relevant to consider the risk from chronic (repeated) exposure from multiple chemicals, in particular to certain demographic groups that are more vulnerable to the toxic effects of chemicals, including children and pregnant women. The sooner exposure takes place and the higher the frequency of exposure, the more harmful the cocktail effect of the chemicals is to health. Assuming that those vulnerable groups will be avoiding usage of certain (less safe) packaging through individual decisions and choices is not feasible.

[3] FCM Regulation 1935/2004

A gap between legal requirements and reality

In general, products made from PVC often show a lack of compliance with risk management measures.
The case of plasticisers migrating from the food contact application (PVC gaskets) into oily foods are a good example of how the majority of the lid manufacturers are failing in complying with legal requirements for more than 10 years.

- Studies have shown that a large number of PVC gaskets of commercial lids exceed the existing migration limits for epoxidised soybean oil (ESBO). The first joint European enforcement campaign on the migration of plasticisers from the PVC gaskets of lids into oily foods in 2011 revealed exceeded legal limits in 24% of the samples.
- As a follow-up, a second campaign was performed with the focus on systematic compliance work that ensures the abidance by the legal limits for the plasticisers. Authorities of 12 European countries participated with 48 samples. Legal limits were exceeded in 10 packed foods, which corresponded to 29% of those with free oil in contact with the gasket. Most lid producers abdicated from their responsibility by delegating migration testing to the food packer.
- In the most recent (2022) Swiss national campaign with a total of 109 food samples containing free edible oil packaged in glass jars showed the migration of plasticisers from PVC-gaskets on lids of glass jars is high and exceeds regulatory limits in many cases where the packed food contains much oil: of the 109 foods, 27 were not compliant. The proportion of non-compliant samples with a PVC based sealant in this study and a decade ago was comparable. Accordingly, **hardly any of the oily products in glass jars controlled in this campaign (gaskets with plasticized PVC) should have been on the market**. Importantly, the proportion of non-compliances over all samples was lower, due to the use of non-PVC sealing plastics (26% of the samples were found not to be made of PVC) – another proof that shifting to alternative materials can really make a difference.

All above points out to the fact that **restrictions on use of PVC in food contact articles – rather than individual additives – should be prioritised**.

PVC food packaging in circular economy: another failure

Good to know

- Only very few PVC waste streams are, to some extent, recycled today, with a big part of recycled PVC waste being pre-consumer waste (thus material diverted during a manufacturing process). This means that still millions tonnes of PVC post-consumer waste is landfilled or incinerated every year.
- Ca. 20% of the PVC post-consumer waste each year comes from packaging,, characterised by a short lifetime so a timeline of waste production is closely coupled with consumption.
- Incineration of PVC waste is associated with risks to both the equipment in the facilities and hazardous emissions to the environment, and is a source of hazardous waste (such as incineration fly ash containing dioxins).
- Recycling is considered one of the main microplastic emission sources in the PVC lifecycle, but growing evidence shows that unburned plastics still exist in the bottom ash (a solid residue from incinerators).
- Many recycling technologies require the removal of PVC as PVC causes serious problems for the recycling of other plastics. In practice, this separation can be very difficult and expensive to carry out as plastics may arrive at the recycling facility in pieces, making identification even more challenging.
- When attempting to recycle PVC back into PVC by mechanical means, the problem is that PVC has many different formulations beyond simply rigid and flexible characteristics requiring varying levels of chlorine and additives. Mixing these together results in a poor quality of recyclate which is unlikely to meet the specific input needs of PVC manufacturers.
- Chemical recycling of PVC also suffers from difficulties associated with chlorine and phthalate additives. Back in 1999, Dutch Organisation for Applied Scientific Research (TNO) concluded that "it is simply unlikely that a rather expensive technique like chemical recycling will be used voluntarily. Separated collection, cleaning and subsequent treatment by chemical recycling is simply too expensive, and will only play a role in exceptional situations". To date, not a single plant exists that can chemically recycle relevant quantities of PVC waste.
- The reports by the European Commission and European Chemicals Agency have flagged that restricted or unwanted additives are an issue when recycling PVC, because no technology on industrial scale currently exists to remove such substances from PVC waste.

For **short-lived products such as plastic food packaging** it is fair to assume that a product is manufactured and becomes waste within a very short lifespan – a weeks' / months' time. A substantial portion of food packaging cannot be recycled in a cost-effective manner. As mixed waste streams with a low content (below 10%) do not economically justify separation, the amount of PVC occurring in packaging waste is too low for economically feasible separation. Therefore, when it comes to PVC packaging end-of-life management in the EU, this waste is landfilled or incinerated. The recyclability of food packaging is essential for the food packaging industry to meet the ambitions of the European Union's circular economy and revised Packaging and Packaging Waste Regulation requirements. There are significant opportunities for food packaging organisations to replace problematic polymers, like PVC, by other – more circular – materials.

How to fix the problem

- According to industry, the ECHA's proposal to replace prioritised additives (acting as substitutes already) would result in major issues of technical and economic feasibility, as well as availability with major implications for the entire PVC value chain. The development of new additives can involve major investment over several decades.
- The future substitution is likely to fuel regrettable substitution anyway, taking into account the history of such substitution for chemicals used in PVC, and the wide number of substances used as additives in PVC (over 400).
- Substitution of a number of harmful chemicals used in PVC by a number of less studied chemicals will not help address the identified risks from microplastics.
- While agreeing that many alternative additives are currently widely used, we would dispute with conclusion on PVC-made food contact applications 'safety' – simply because more information is needed to better understand whether the risk, stemming from all PVC additives, non-intentionally added substances (NIAS) and PVC itself (due to need of addressing microplastic and combined exposure) is significant, and whether there are adequate control measures in place.
- Also obvious is the lack (and prospects) of scaled recycling of PVC food packaging and food contact articles..
- **So why not stop using PVC in food packaging and solve the problem right away and for good?**

Restrictions on use of PVC in food contact articles / food packaging sector will not only speed up effective protection of consumers, but also represent a practical and efficient solution to achieve toxic-free materials cycles in this sector.

A global consensus is emerging on the need to phase out PVC from packaging. The Ellen MacArthur The New Plastics Economy initiative, represented by the world's largest plastic makers and users, along with and a broad group of participant companies, cities and governments across the value chain. They reached in 2017 the conclusion that PVC is an "uncommon" plastic that is unlikely to be recycled and should be avoided in favour of other more recyclable packaging materials. "Uncommon" in the diplomatic parlance of international multistakeholder initiatives means 'unrecyclable'.

Many initiatives tackle PVC in packaging already:

✔ Ellen MacArthur Foundation's Global Commitment initiative accelerated voluntary business action. The signatory group has significantly reduced the use of some materials commonly identified as problematic such as PVC. The top quartile brands and retailers group, for example, has eliminated on average 92% of PVC packaging it was using in 2020. Major companies in this category include Colgate-Palmolive, Jeronimo Martins, and Starbucks Coffee Company.

✔ Different Plastic Pacts (for example the UK Plastics Pact, the French Pact, the U.S. Plastics Pact) include measures to eliminate PVC in plastic packaging.

✔ Given the clear drawbacks and available alternatives, companies like Unilever and Marks & Spencer have already phased out PVC from their packaging.

✔ Nestlé included PVC in their Negative List, to remove PVC from all food contact applications (trays, sleeves, labels & films; liners for metal twist-off closures & printing inks; liners for metal press-twist closures & coffee capsule sealing layer)

✔ Advanced Recycling Pilot Project by HPRC (Healthcare Plastics Recycling Council), states that in case of plastics packaging, "*Use of PVC should be limited when possible, as it contaminates materials outputs and most advanced recycling technologies can only tolerate it at low levels in mixed waste streams due to its corrosive properties*".

✔ In general, Nordic Ecolabelling prohibits or restricts PVC in products because of its health and environmental issues, where there are better environmental alternatives fulfilling the same function. It specifically prohibits PVC in products with short lifespan like packaging because today's waste handling systems for these products do not sort the PVC for material recycling. It also sets requirements for recycled content and / or restricts PVC production methods.

As outlined in the European Commission and ECHA reports, there are several technically feasible alternatives to PVC food packaging, including in rigid food packs and shrink foils. All of them are commercially available and used already. Several have been used for many years, including before the use of PVC, with others relatively recent. The joint report by the World Economic Forum and the Ellen MacArthur Foundation on The New Plastics Economy (2017) also recommends alternatives for PVC.

Alternatives do exist, and PVC is already being replaced in more and more packaging applications: (to give some examples) PVC bottles are in decline; solutions based on extruded polyethylene foam or more advanced cone-liner types made from LDPE can replace PVC cap liners; and for labels PE and PP solutions are available. PVC could also be phased out in non-PET-bottle-related packaging applications: PVC is replaced by LDPE in pallet stretch-wrap; PET has found use as blister packaging. Cling film can be made from LDPE material.

Performance criteria for packaging include durability, transparency, barrier protection, temperature resistance and in some cases flexibility. No solid evidence exists to affirm that PVC is superior to alternatives, with regard to these criteria when applied to food packaging. ECHA concluded that there are various alternative materials to PVC in packaging, including both plastics and other types of materials[4], and there appear to be no critical differences between the lifetime or performance of PVC and the alternative materials in packaging.

To summarise, for all reasons listed in this factsheet, **we argue that the combination of certainties around negative impact of PVC on human health and environment during its whole life cycle, and uncertainties surrounding data on chemicals, safety and recycling, calls for precautions restriction of PVC in the food contact applications and food packaging.**

This is the most effective and future-proof risk management measure which also will prevent imports of packaging and food contact applications made from PVC to the EU.

[4] PET, HDPE/LDPE/LLDPE, PP, BOPP, PS, PA, BOPA, PCTFE, EVOH (only in combination with PVC/other materials), PVDC (only in combination with PVC/ other materials), bioplastics, aluminium, paper, ceramics, glass

Zero Waste Europe gratefully acknowledges financial assistance from the European Union. The sole responsibility for the content of this event/material lies with Zero Waste Europe. It does not necessarily reflect the opinion of the funder mentioned above. The funder cannot be held responsible for any use that may be made of the information contained therein.

ZERO WASTE EUROPE

Author: Dorota Napierska
Editor: Seán Flynn
Date: July 2024

General information: hello@zerowasteeurope.eu
Media: news@zerowasteeurope.eu
Cities-related topics: cities@zerowasteeurope.eu

zerowasteeurope.eu
www.zerowastecities.eu
www.missionzeroacademy.eu