Response to call for evidence

on the polyvinyl chloride (PVC) and its additives

Consultation response

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Zero Waste Europe (ZWE) strongly supports a restriction on polyvinyl chloride (PVC) and PVC additives, and welcomes the opportunity to provide feedback to ECHA Call for evidence.

While considering the advantages and disadvantages of restricting the production and use of PVC in the EU, it is extremely important to look at this polymer within the broader policy framework and to acknowledge that changes in the way we manage our resources in the future are inevitable - for example in relation to the goals of a truly non-toxic environment. The failure to address some chemical pollution sources are the key reasons for the limited progress towards the EU's zero pollution targets. Learning from the past, we must show extra firmness in tackling pollutants of concern.

PVC is a mass-market plastic that continues to pose many health and environmental hazards during production, use, and final disposal. While widely used across Europe in construction, flooring, medical applications, electronics cables and much more, in the context of this consultation, Zero Waste Europe would like to focus its feedback on packaging, especially food packaging.
Food contact materials (FCM), including food packaging, is a large product group of consumer products which can contain many hazardous substances due to poor regulations on their content. Plastic materials are of higher concern due to the large presence of chemicals and their level of migration. The type of plastic that the packaging is made from is important, since the different plastic types have the potential to contain quite few (e.g. PET) or a large number (e.g. PVC) of hazardous substances.

PVC and its additives in food contact

On its own, PVC is not particularly useful; it has very low thermal stability and rapidly degrades at temperatures required for processing, that are typically above 160°C. Hence, PVC resin is mixed with other chemicals and processed under heat and pressure; this process yields an intermediate product known as "PVC compound." By using various additives, PVC can be made tough and rigid, or soft and flexible; it can be transparent, opaque, or, by incorporating pigments and colourants, white, black or coloured. PVC requires by far the most additives of all plastics types, alone accounting for 73% of the world production of additives by volume, followed by polyolefins (polyethylene and polypropylene) (10% by volume), and styrenics (5% by volume).

There are numerous plastic materials used to produce packaging, but PVC and polyethylene terephthalate (PET) have become exceptionally popular for packaging solutions in recent years. In total, more than 400,000 tons of PVC is used in packaging across Europe each year. Its major packaging applications are rigid film (about 80 %), flexible film such as cling film (15 %) and closures (3 %). 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).

Knowing that in 2019, PVC use by converters was more than 5 million tonnes and assuming additives represent about 20% of resin overall, the EU output of PVC additives likely amounts to approximately 1 million tonnes per year. According to one study, of the 10,000-plus different chemicals that have been used in various forms of plastics — like PVC or polystyrene — a quarter are substances of concern. PVC has the potential to contain a high number of hazardous substances that can also migrate from the products. Around 80% of all plasticizers are used in PVC plastics and include short, medium, and long-chain chlorinated paraffins (SCCP/MCCP/LCCP), Diisoheptyl phthalate (DIHP), 1,2-Benzenedicarboxylic acid, di-C7-11 -branched and linear alkyl esters (DHNUP), Benzyl butyl phthalate (BBP), Bis(2-ethylhexyl) phthalate (DEHP), Bis(2-methoxyethyl) phthalate (DMEP), Dibutyl phthalate (DBP), dipentyl phthalate (DPP), di-(2-ethylhexyl) adipate (DEHA), di-octyladipate (DOA), diethyl phthalates (DEP), diisobutyl phthalate (DiBP), Tris(2 chloroethyl) phosphate (TCEP), dicyclohexyl phthalate (DCHP), butyl benzyl phthalate (BBP), diheptyl adipate (DHA), heptyl adipate (HAD), and heptyl octyl adipate (HOA), while the remaining 20% are used in cellulose plastic.[1]

PVC used for food or beverage packaging has potential to leach harmful substances into food and drink ingested by the population. Systematic review on chemicals migrating and extractable from food contact materials and articles identified 229 chemicals in finished PVC food contact articles (number of database entries for polyvinyl chloride = 736; "database on migrating and extractable food contact chemicals" FCCmigex).[2] Among chemicals migrating from PVC FCMs, 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 (CMRs), or persistent and bioaccumulative, or endocrine disrupting chemicals (EDCs), or are toxic to specific target organs (STOT).[3]
In fact, the number of hazardous substances / substance groups that can potentially be present in PVC is the largest out of all the plastic types. Enforcement reports performed for the Swedish EPA (2016), with the focus on substances that are restricted through REACH and the Candidate list, found for example hazardous substances as nonylphenol and perfluorinated alkylated substances (e.g. PFOS and PFOA) in food packaging, and plasticisers such as short-chained chlorinated paraffins in kitchen appliances made from PVC.

[1] Hahladakis et al. (2018) "An overview of chemical additives present in plastics: Migration, release, fate and environmental impact during their use, disposal and recycling". *Journal of Hazardous Materials.*
[2] Geueke et al. (2022) "Systematic evidence on migrating and extractable food contact chemicals: most chemicals detected in food contact materials are not listed for use". *Critical Reviews in Food Science and Nutrition.*
[3] Zimmermann et al. (2022) "Implementing the EU Chemicals Strategy for Sustainability: The case of Food Contact Chemicals of Concern." *Journal of Hazardous Materials..*

Exposure and toxicity

It is very difficult - if possible at all - to quantify exposure to hazardous chemicals from FCM / food packaging made from PVC. A group of chemicals that humans are exposed to through diet (through food contact materials) and which are widely used to soften PVC, are phthalates, including these used in food contact materials. It is well established that certain phthalates can have an impact on reproduction and development. HBM4EU monitored phthalates in children and teenagers from 11 European countries and found that 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 phthalates. The HBM studies across Europe produced robust, coherent evidence on human internal exposure to chemicals commonly used in FCMs / food packaging, including those made from PVC. Very alarming conclusions can be made, notably that many of these chemicals are currently widely found in the bodies of consumers, including children, often at levels that may harm their health.[4] The research produced by HBM4EU emphasised the need to address combined exposure to chemicals (chemical mixtures).

- The most comprehensive scientific study on the toxicity of chemicals present in plastic products to date, "Benchmarking the in Vitro Toxicity and Chemical Composition of Plastic Consumer Products", analysed 34 widely used consumer products made out of plastics, including products coming in contact with food such as refillable water bottles, food wraps and yoghourt cups.
    - Extracts of PVC and polyurethane (PUR) induced the highest toxicity at most endpoints from the eight polymer types investigated (including baseline toxicity, oxidative stress, cytotoxicity, estrogenicity, and antiandrogenicity).
    - Authors did not observe a significant difference for baseline toxicity and estrogenicity between FCMs and non-FCMs.
    - Some individual PVC FCMs were even more toxic than non-FCMs made of PVC.
    - A high baseline toxicity and antiandrogenicity for specific food contact articles was observed, including a food wrap made from PVC.
    - Nontarget chemical screening detected between 0 and 194 features per sample, and PVC had the largest total peak count and area.
    - Regarding their functionality, most of the tentatively identified compounds were classified as food additives and contaminants (13.2%), intermediates (9.9%), solvents (8.6%), process regulators and aids (8.3%), surface-active substances (6.3%), as well as lubricants and lubricant additives (6.3%).
    - 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.

- Another study investigated the toxicological and chemical profiles leaching into water from 24 everyday plastic products available on the German market and covering eight polymer types, including PVC.
    - All plastic products investigated leached chemicals triggering *in vitro* toxicity, and the compounds migrating from PVC and PUR samples were very toxic. In general, the prevalent

[4] HBM4EU-Newspaper.pdf

antiandrogenicity was an indicator for the leaching of endocrine-disrupting chemicals relevant for human health.

- o The results also show that many more chemicals are migrating from plastics than previously known. Interestingly, the organophosphates migrating from PVC products were the only tentatively identified chemicals that are obviously related to plastic additives.
- o The large number of compounds, and the fact that most of these remain unidentified, pinpoint the shortcomings of current scientific and regulatory approaches to the chemicals leaching from PVC plastics. As an example, very few of the chemicals found to migrate from plastic products marketed in the European Union are covered by REACH. Accordingly, these compounds do not undergo formal risk assessment and it, thus, remains unknown whether many chemicals leaching from consumer plastics are safe.

The PVC industry is frequently emphasising that it has moved to replacing hazardous phthalates (such as DEHP) with other safe plasticisers. A European Commission report on the use of PVC in the context of a non-toxic environment has however flagged considerable data gaps on additives in this material. While there is evidence for migration of additives that are not covalently bound in the plastic matrix, and DEHP and other phthalates 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 additives, making it impossible to assess their migration risk. In addition, only limited data could be identified concerning the classification of PVC mixtures containing hazardous additives by manufacturers.

- Overall, it appears that manufacturers are switching away from phthalates as their primary plasticiser to alternate compounds such as ESBO, ATBC, DEHT, DINCH, DEHA and DINA. The industry also emphasizes that these plasticisers are safe as they are not classified as hazardous / as substances of very high concern under REACH. While agreeing that many alternative plasticizers and other types of phthalates are currently widely used, we would dispute with conclusion on PVC '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 combined exposure), is significant, and whether there are adequate control measures in place.
- DEHTP and DINCH are mainly used as substitutes for DEHP and other high molecular phthalates. These compounds 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 and other high molecular phthalates.
- The already mentioned above HBM4EU research indicates political action might be needed due to the strong increases of the substitutes DINCH and DEHTP measured in humans across Europe. The new substitutes are less intensively investigated toxicologically; DINCH, which was put on the market in 2002 as a substitute for some of the most toxic phthalates, is thought not to have similar effects on the reproductive system and is not an endocrine disruptor, but effects on the kidneys have been observed in rat studies at high doses.
- Recent Danish study on metabolites of 15 phthalates and the two substitutes DEHTP and DINCH in infants and their parents showed that the infants were exposed to several phthalates and DEHTP and that a few infants and their parents exceeded the threshold for anti-androgenicity, which is of significant concern. The observed exposure levels were surprising as several of these phthalates have been regulated or even banned in the EU.

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. Authors concluded that such highly toxic materials as the toxic PVC are not suitable as standard reference materials, because of protection of animals from suffering. A local subcutaneous implantation study in mice and rats used PVC material as a positive control material to induce (successfully) a toxic response.

Microplastic

Besides the migration of leachable chemicals from plastic packaging into foods, the potential contamination with microplastics (which can also attract and carry chemical substances), raises serious concerns for human health and the environment, even if knowledge gaps still exist. As shown more recently – human exposure to microplastics is manifold, including via the air, food, tap water or come from the products (including plastic beverage packaging) we use. Scientists showed that babies fed formula milk in plastic bottles were swallowing millions of particles a day, and suggested that people may be ingesting 5 grams of microplastics each week. Recently, microplastics were revealed in the placentas, breastmilk, blood and the lungs of people.

Studies suggest that many particles are released from e.g. disposable drinking cups and consumption from plastic containers can change human gut and oral microbiota composition. The release of microplastics and the migration of additives from plastic containers into food is amplified by heat, fatty or acidic foods, or contact with liquids. Oral administration of micro- and nanoplastics may produce redox imbalance, disruption of energy homeostasis, and neurotoxicity in the gut, intestine, and kidney.

Among different microplastics, PVC should receive extra attention because of its carcinogenic monomer, requirement for the most and often hazardous additives, being high-volume usage plastic 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.
- 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.
- Evaluation of toxic effects of different sizes and concentrations of PVC microplastics showed that when immune cells were exposed to microplastics for 4–5 days, immune activation was observed: PVC induced the production of IL-6 and TNF-α, respectively.
- Investigation whether nanoplastics exposure induces inflammatory processes in primary human monocytes and monocyte-derived dendritic cells concluded that PVC nanoplastics can provoke human immune cells to secrete cytokines as key initiators of inflammation.

- Other study showed that PVC microplastic particles induced cytotoxicity on human blood lymphocytes which was associated with intracellular reactive oxygen species (ROS) formation, lysosomal membrane injury, mitochondrial membrane potential collapse, depletion of glutathione, and lipid peroxidation.
- Toxic interactions *in vitro* were observed between PVC microplastics and Human Serum Albumin – the secondary structure of HSA underwent a decrease in α-helix induced by PVC MPs. 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 blood stream. Once PVC MPs entered 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 organs along with blood, and further causing more serious damage *in vivo* potentially.

A 2022 report from the World Health Organisation (WHO) confirms an overwhelming consensus among all stakeholders: measures should be taken to mitigate exposure to nano- and microplastics. This should include reducing the use of plastics, when possible. Another 2022 report from the Food and Agriculture Organisation (FAO) recommends that we need to recognize the impact of packaging and 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. Where necessary, limits on human exposure to these substances should be introduced by implementing suitable precautionary measures as needed.

Control measures for PVC food contact materials/food packaging

To start with, the recently completed evaluation of the current EU FCM legislation identified a number of shortcomings with the current regulation such as:

- focus on starting substances (rather than materials and final FCM 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 of FCM (EU and national) rules across Europe, due notably to a lack of capacity (technical, human, financial) from the national enforcement authorities.

Moreover, the fundamental problem is that conclusion on plastic 'safety' for human health is based on compliance with a principal rule (Article 3) of the FCM Regulation 1935/2004, which does not sufficiently define the level of safety or quality expected for FCMs, and which does not state how safety should be achieved nor how it can be demonstrated. Therefore, currently it is easy to bend the significance of "unsafe" and "endanger human health": products are "unsafe" only if there is evidence for potential damage to human health. In the frequently encountered reality this implies that the enforcement authorities have to provide the evidence, despite the fact that the legal texts express a different view: the business operator has to prove that the amount of migrating substances is safe.

Whenever compliance checks are performed - the alarming gap between legal requirements and reality is frequently revealed. Often, differences in the number and concentration of additives are observed between suppliers, indicating that the chemical signature is product dependent.

Unsuccessful enforcement is even counterproductive: if non-compliant business operators learn that legal requirements are not enforceable, many will no longer care. The plasticisers migrating from the PVC gaskets into oily foods are a good example, as 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, even though it is unrealistic that a packer performs tests lasting years before he uses the lids (in fact none of them did).
- In the most recent (2022) Swiss national campaign on the compliance of migration of plasticisers from the gaskets for lids into oily food in glass jars, 20 local food safety enforcement authorities as well as the authority of Liechtenstein took a total of 109 food samples containing free edible oil packaged in glass jars. The results 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 with Regulation (EU) No 10/2011 since migration was exceeded for ESBO (11 samples), PA (3 samples), acetyltributylcitrate (ATBC, 3 samples), DEHP (2 samples), and/or the sum of approved plasticizers (25 samples). Three samples had unauthorized plasticizers migrating into the food which also resulted in their non-compliance. Overall, samples from smaller food producers more often exceeded regulatory SML than those from larger supermarket chains or brands (food producers do not always check the compatibility of their packaging material with the food they pack). The proportion of non-compliant samples with a PVC based sealant in this study and a decade ago was comparable. Accordingly, hardly an of the oily products in glass jars controlled in this campaign (gaskets with plasticized PVC) should have been on the market.
- The proportion of non-compliances over all samples was lower, however, 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.

PVC will always leach chemicals, and we need to reconsider how we define 'safety'. 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 consumer products. While there is no acute danger in ingesting chemicals migrating from PVC FCMs, 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 in lifetime 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 This is why PVC should be identified as a polymer that requires strong regulation.

End of life options and their impacts

Restrictions on use of PVC rather than individual additives should be prioritised. This will not only speed up effective protection of consumers, but also represents a practical and efficient solution to achieve toxic-free material cycles. In all the years since the plastics industry mounted a recycling push, it's estimated that no more than 10 percent of all plastics produced has ever actually been recycled. Approximately 6 million (m) tonnes of primary PVC were manufactured in 2019 in the EU27. Approximately 70% of PVC produced annually in Europe goes into durable pipes, windows, flooring, roofing, and cables.

- A European Commission report on the use of PVC in the context of a non-toxic environment has 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.
- The Swedish Chemicals Agency has drawn the conclusion that a lot of articles on the Swedish market, mostly articles made of PVC, contain substances with hazardous properties, and that the total amount of hazardous substances in use and in the waste flow may be of large impact even though the levels in a single article may be low.

The amount of recycled PVC has been increasing steadily over the past 20 years, but the amount of produced virgin PVC and amount of generated waste increased significantly as well**:**

- According to industry, close to 7.3 million tonnes of PVC have been recycled into new products since 2000, thus in more than 20 years.
- At the same time, the EU output of new PVC products is approximately around 6 – 6.5 million tonnes per year.
- Importantly, only very few PVC waste streams are, to some extent, recycled today.
- In 2021, 63.6% of recycled waste was pre-consumer waste (thus material diverted during a manufacturing process that the holder discards).
- Industry committed to recycling at least 900,000 tonnes of PVC waste into new products by 2025 and one million tonnes by 2030. With an estimated 2.5 million - 2.9 million tonnes of PVC waste generated annually in Europe, this means that still millions tonnes of PVC waste will need to be landfilled or incinerated every year.

Problematic combustion

In fact, almost half of the PVC waste ends up in incineration plants; the formation of neutralisation residues during incineration of PVC waste is an issue as these residues must be disposed of as hazardous waste and are therefore associated with risks. When incinerated, 1 kg of PVC may generate up to 1-1.4 kg of flue gas cleaning residues. Not all the Nordic countries allow incineration of used PVC due to the amount of neutralisation waste generated by the purification of the flue gases; Denmark has waste legislation which states that all PVC must be sorted for material recycling, and if not - then sent to landfill. In landfills, phthalates migrate from PVC at high concentrations into the leachate and eventually into groundwater.

Another significant problem with incineration of PVC is the formation of dioxins. Some municipal waste incinerators may have a clause in the operating license that excludes PVC as a permitted waste to try and avoid additional dioxin generation. It should be mentioned that the PVC industry frequently emphasises that currently used modern technologies in Europe solve the problem of dioxins and other hazardous emissions from incineration, so they "*do not see zero-incineration as a desirable objective*". But the fact is that the way emissions are currently measured only represents a tiny snapshot of the incinerator's output – meaning, not all incineration emissions are evaluated. Recent reports from a biomonitoring research on emissions from incinerators across Europe showed the contamination with substances of very high concern (dioxins (PCDD/F), dioxin-like PCBs, PAHs and PFAS) in eggs of backyard chicken, pine needles, and mosses, in the vicinity of the waste incinerators.

Problematic recycling

PVC's complex composition (high chlorine and additive content) together with low thermal stability complicates the sorting process and makes this polymer difficult to recycle.

- Many recycling technologies require the removal of PVC, as PVC causes serious problems for the recycling of other plastics. When PVC enters the recycling system, it is imperative that it is separated from other polymers to prevent contamination of the plastic recycling output. 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, and cause loss of structural integrity in the final product made from the recyclates.
- When PVC is mixed with other types of polymers in a mechanical recycling process, there are similar issues and the PVC effectively 'contaminates' other polymers, degrading their structural properties and inhibiting production processes such as extrusion. When processing mixed polymers, the recycler is forced to heat the mixed polymers to the highest polymer melting point of the mixture. It can lead to overheating and degradation of lower melting point polymers in the mix. This is the case when PET and PVC are heated together to the higher melting point of PET, causing accelerated dehydrochlorination of the PVC.
- One of the contaminants in recycled PET (rPET) that is well known to produce acids is PVC, and it originates from sorting mistakes and packaging components. Examples of PVC and polyvinylidene chlorid (PVdC) objects found in sorted PET are PET bottles with PVC labels, PVC blisters, PVC nonpackaging objects, PVC stretch wrap on a PET tray, PVdC-coated PET film for cured meats and PVC-based printing inks. PVC dehydrochlorinates at elevated temperatures to form hydrochloric acid. This acid formed from PVC contaminants is the most likely catalyst that converts PET into benzene when exposed to elevated temperatures.

- Chemical recycling of PVC also suffers from difficulties associated with chlorine and phthalate additives. The presence of even small amounts of PVC in the input plastic stream of a pyrolysis unit leads to contamination of the output polymers by hydrochloric acid (HCl), which must be removed. Hydrochloric acid is highly corrosive and imposes severe metallurgical constraints on the process equipment of the pyrolysis unit. If the pyrolysis output is an oil or wax, even very small amounts of halogens prevent its use as fuel or feedstock.
- Phthalate additives challenge solvent processing. An example of how additives can make recycling unviable is the closure of the VinyLoop plant in Italy which operated since 2002 but shut down in 2018 because it could not economically separate the substantial amounts of phthalate plasticizers used in soft PVC to meet EU regulatory requirements.

Germany and the UK are responsible for about half of the European recycling, while PVC profiles present almost half of recycled PVC, followed by rigid pipes, fittings, and films, and electrical cables. Corresponding to this increase, there has been a rise in discussion of possible toxicity implications of such recycling.

Regarding the Scandinavian countries, PVC is treated a bit differently in the Nordics and Denmark has the strictest legislation. As the rules are now, PVC waste has to be segregated in two fractions in Denmark, hard and soft PVC, and while much of the hard PVC can be recycled, it is agreed between the authorities and the industry that soft PVC is disposed of directly to landfills without treatment. In Finland, Norway and Sweden PVC waste is generally sent to energy recovery, and is not separated at source from other types of plastics. Chemical recycling is performed to a very limited extent compared to mechanical recycling. Alternatively, PVC materials can be exported as mixed plastics separated mechanically at facilities in the neighbouring countries.

Problematic exports

Trade data (e.g. UN Comtrade database) does not usually contain the detailed descriptions of plastic waste necessary to determine whether they are Basel-listed wastes (A3210 or Y48). However, as PVC plastic waste has its own HS code (39153) and because PVC is a halogenated polymer, it can be considered at a minimum to be covered by the Y48 listing. Data exists showing PVC waste moving from the EU to non-OECD countries; it is clearly illegal because Y48 exports to non-OECD countries are prohibited in the EU. From the available data, it can be can seen that the EU is in violation of their Basel obligations with respect to PVC exports.
Information on PVC waste exports in 2021 from the EU (a download from the UN Comtrade database) can be found here.

A BRS draft report on "Global governance of plastics and associated chemicals" suggests that Parties to the Montreal Protocol should consider narrowing existing exemptions, and possibly start to control vinyl chloride along with its principal feedstock, ethylene dichloride as "associated feedstocks" to help curb production of PVC.

A case of food packaging

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. At the same time, packaging waste has increased over the last 10 years by 19%. Substitution of PVC by other materials in the food packaging manufacturing will therefore have a more immediate impact on flow of chemicals (including hazardous and potentially hazardous substances), and on the waste stage.

A substantial portion of food packaging cannot be recycled in a cost-effective manner, meaning recycling will not be viable when the European Union's plastic strategy is realised in 2030. Developing the recyclability of food packaging is essential if the food packaging industry is going to meet the European Union's circular economy and revised Packaging and Packaging Waste Regulation requirements. There are opportunities for innovation in both packaging designs that are more recyclable and improvements in recycling technologies. There are also significant opportunities for food packaging organisations to phase out most problematic polymers, like PVC, that cannot be recycled at the end of its life.

Due to the wide use of PVC in several products (e.g. toys, packaging), PVC might occur in mixed municipal waste as well. For recycling to be successful it is imperative that all materials can be sufficiently separated, for example a load of PET could be ruined if contaminated by PVC as small as 50 ppm. However, post-separation is not common for mixed municipal waste as the current technical processes cannot adequately remove odours that PVC recyclate would gain from mixed municipal waste. In particular, the presence of organic substances (food leftovers) in the co-mingled collection system and related rotting processes can lead to intensive odour. And as mixed waste streams with a low PVC content (below 10%) do economically not 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, the waste is landfilled or incinerated. However, with a view to enforce legal requirements to protect the environment, the European Commission aims to restrict incineration and landfilling of plastics in Europe. Therefore, a possible and feasible measure for achieving a systems change would be a ban on PVC in food packaging, as a problematic polymer.

A global consensus is emerging on the need to phase out PVC from packaging. The Ellen MacArthur New Plastics Economy Project consists of representatives from the world's largest plastic makers and users, along with governments, academics, and NGOs. In 2017, it reached 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.

Some initiatives tackle PVC in packaging already:

- ✔ Many guidelines specifically exclude PVC from recycling. For example, a recent 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*". PVC is notably problematic for hydrogen chloride formed in the process, which is very corrosive with negative impacts on different chemical recycling technologies.
- ✔ The U.S. Plastics Pact include measures to eliminate 11 problematic and unnecessary resins, components, and formats by 2025 in order to accelerate progress toward a circular economy for plastic packaging in the United States. PVC – Polyvinyl Chloride, including PVDC (Polyvinylidene Chloride), is included in this list.
- ✔ 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 EC report, there are several technically feasible alternatives to PVC packaging, in blister packs, rigid food packs and shrink foils. All of them are commercially available. Several have been used for many years, including before the use of PVC, with others relatively recent. The World Economic Forum report from the Ellen MacArthur Foundation on The New Plastics Economy published in 2017 also recommends alternatives for PVC, existing for most of its packaging applications. Alternatives do exist, and PVC is already being replaced in more and more packaging applications: 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 LLDPE in pallet stretch-wrap; PET has found use as blister packaging. Given the clear drawbacks and available alternatives, companies like Unilever and Marks & Spencer have already phased out PVC from their packaging.

To summarise, for all reasons listed in this document, ZWE strongly supports a restriction on use of PVC in food contact materials / packaging. **We argue that the complex web of certainties around the negative impact of PVC on human health and environment during its whole life cycle, and uncertainties surrounding data on chemicals and the recycling, calls for precautions restriction of PVC in the food contact and packaging.**

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