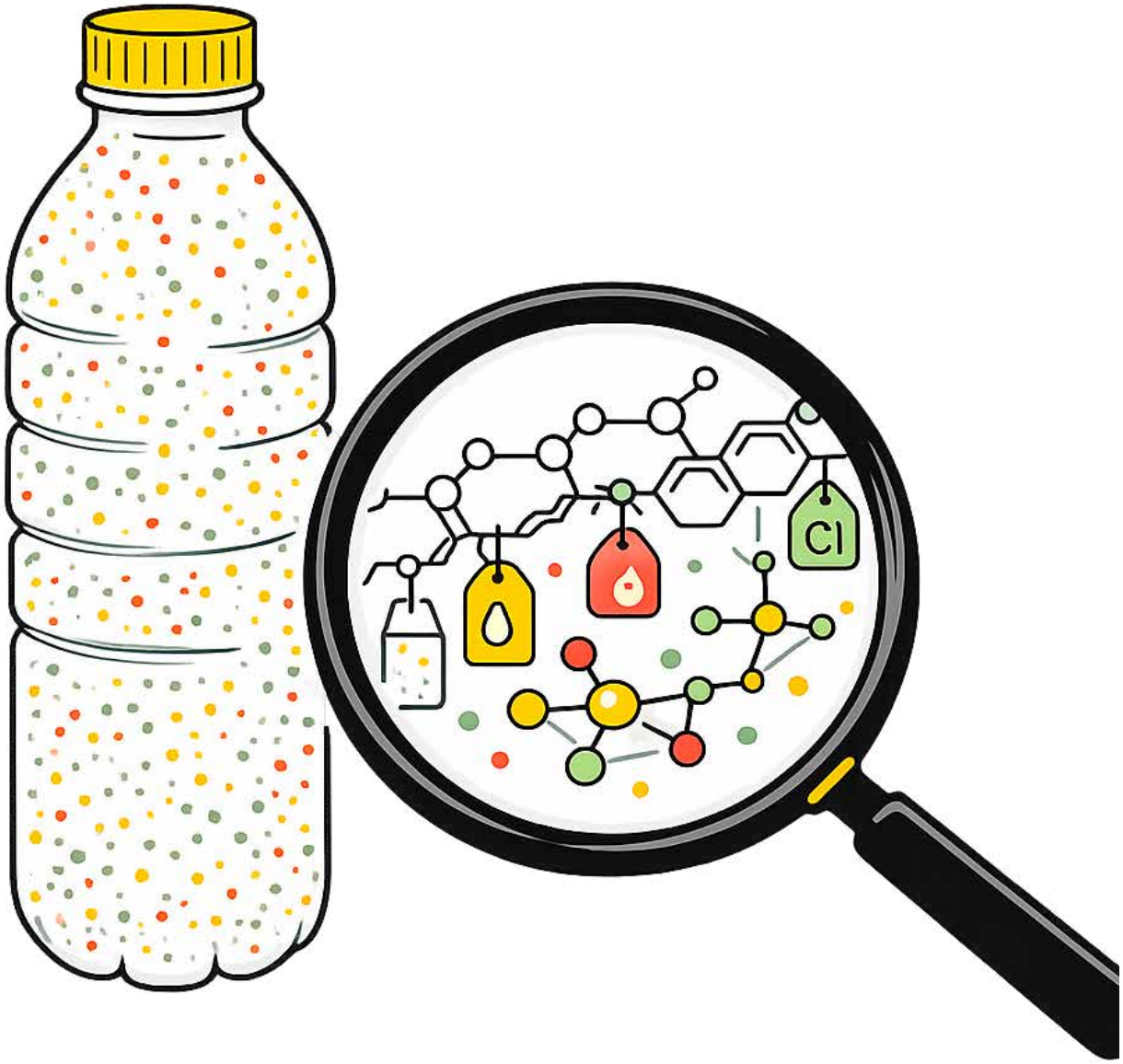
Knowing What Chemicals are in Products

Why transparency and traceability of chemicals are essential for product safety, circularity and the right to know



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Executive Summary

Key message

Chemicals in products remain largely invisible and unknown once they enter materials, components, products, waste streams, reuse systems and recycling markets. This lack of information undermines health protection, circular economy policies, regulatory enforcement and the public right to know. This publication shows how globally harmonized chemical transparency and traceability can close this gap.

The paper includes 5 headline findings:

1. Product-related chemical information must follow materials and products across their full life cycle.
2. Transparency and traceability must work together: disclosure alone is not enough if information cannot be linked to individual products.
3. A global approach to chemical information disclosure is needed to prevent double standards and fragmented national or industry systems.
4. Digital tools, databases and product identifiers can make enforcement and safe circularity more practical.
5. Digital product information governance is a long-standing global product strategy

1. Background: why chemical transparency and traceability matter

Many manufactured materials and products contain intentionally added chemicals, including plastics, textiles, electronics, building materials, paper and packaging materials – also in their recycled forms. However, information about their chemical composition is often unavailable to product designers and architects, retailers, consumers, public procurers, repair technicians and craftspeople involved in product maintenance, recyclers, waste handlers, regulators, and other downstream users.

This information gap hinders informed decision-making on substitution, the design of non-toxic products compatible with circularity, and the development of resource-efficient material cycles that reduce dependence on virgin raw materials and associated climate, water, and chemical footprints. It also limits the implementation of risk-reduction measures for materials and products containing hazardous chemicals that cannot be immediately phased out, potentially exposing consumers, waste handlers, recyclers and the environment. Moreover, it may enable double standards and greenwashing, challenges that are particularly difficult for low- and middle-income countries to address.

A circular economy cannot be built on unknown material flows. If products containing hazardous chemicals are repaired, reused, repurposed, recycled, or traded without reliable information on their chemical composition, the circular economy risks becoming a mechanism for perpetuating the circulation of legacy contamination.

Therefore, the disclosure of hazardous chemicals in products is essential for protecting human health and the environment, enabling safe circular economy systems, facilitating international trade, and supporting effective enforcement.

This concept was introduced in a 2022 White Paper[1] that describes "Globally Minimum Transparency Standard" (GMTS) as a practical approach for chemical information transparency in manufactured materials and products.

2. The GMTS concept

GMTS is proposed as a global benchmark for disclosing the identities of chemicals in materials and products and for harmonizing the sharing of that information throughout product life cycles. In non-binding contexts, it can operate as a system; in legally binding contexts, as a standard.

It establishes a minimum level of chemical identity information accessible to all stakeholders, enabling informed decision-making that supports toxics-free circularity and ensures a uniformly high level of protection for human health and the environment.

It builds on hazard-based definitions of "chemicals of concern," including substances that are persistent, bioaccumulative and toxic (PBT); very persistent and very bioaccumulative (vPvB); carcinogenic, mutagenic or reprotoxic (CMR); neurotoxic; endocrine disruptors (EDs); and substances of equivalent concern.

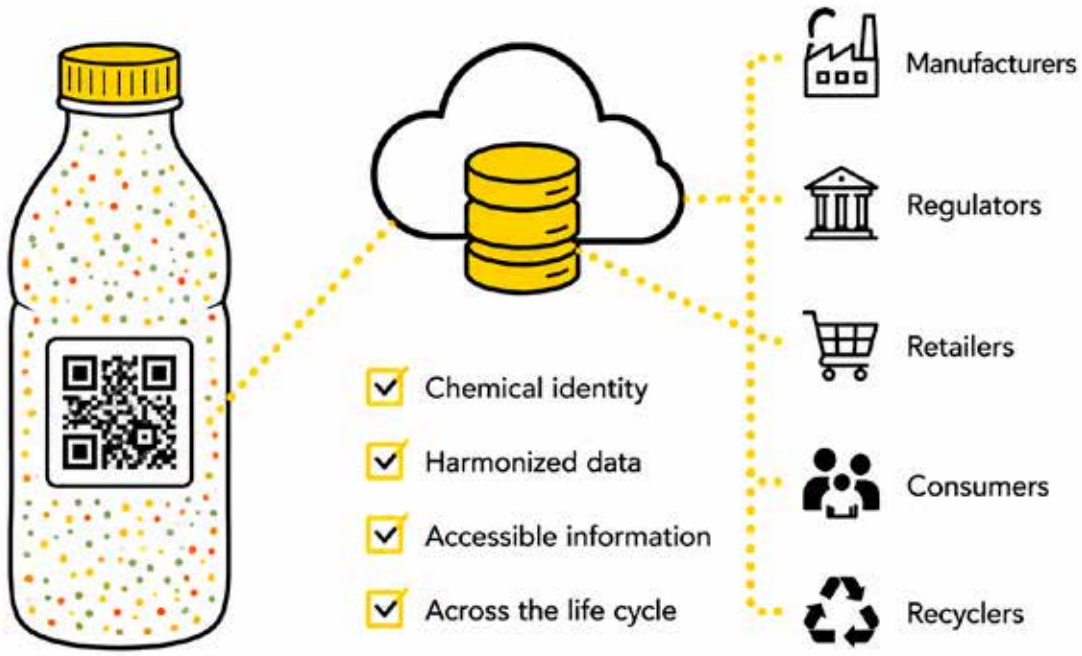
For the scope of chemicals considered, it draws on criteria from existing policy frameworks such as the United Nations Environment Programme's Chemicals in Products Programme (UNEP CiP)[2], the EU's REACH regulation[3] (specifically Substances of Very High Concern, SVHCs), the EU's RoHS directive[4] on hazardous substances in electrical and electronic equipment, and the EU Ecodesign for Sustainable Products Regulation (ESPR)[5].

Chemicals regulated under multilateral chemicals and waste conventions, the Candidate List of SVHCs[6] under the EU REACH Regulation, national regulations that apply hazard-based criteria to identify chemicals of concern, and non-regulatory reference lists – such as the Substitute-It-Now List (SIN List)[7] developed by International Chemical Secretariat – may inform the initial negative list of chemicals to be disclosed under the GMTS approach. This helps avoid unnecessary duplication of existing efforts.

To reliably track GMTS-disclosed chemical information across material and product life cycles, a supporting digital architecture is required. Developments in this area are progressing rapidly. Emerging frameworks include the United Nations Transparency Protocol (UNECE TP)[8], United Nations Economic Commission for Europe and the International Organization for Standardization initiative for standardized digital product passports (UNECE/ISO DPP standard)[9], UNEP's concept of Digital Product Information Systems (DPIS)[10], the Digitalization for Circular Economy Initiative (D4CE Initiative)[11], which introduces digital product passports (DPPs) as a regulatory requirement. Together, these initiatives represent complementary layers – ranging from regulation and standardization to system design and coordination – that are shaping how interoperable product and chemical data sharing can be implemented at scale. This discussion is further developed in Section 6.

An illustrative example of an emerging industry-led approach is Chem-X – a European initiative aimed at enabling harmonized digital exchange of chemical and material information across supply chains. The initiative incorporates concepts closely related to DPPs, DPIS, OECD Chemicals in Products activities, and broader efforts to improve traceability and transparency across value chains. Chem-X demonstrates how interoperable digital information systems can support the collection, exchange, and reuse of chemical information among supply-chain actors. While its current focus appears to be business-to-business communication and supply chain management rather than public right-to-know access, it provides a practical example of how digital infrastructures could contribute to the implementation of transparency and traceability objectives under the Global Framework on Chemicals.

The existence of initiatives such as Chem-X suggests that the principal challenge is increasingly not technical feasibility, but rather governance questions concerning data access, disclosure requirements, interoperability, verification, and the balance between commercial confidentiality and the public interest.



“Transparency and traceability matter

Why does a “minimum transparency” approach matter?

A globally harmonized disclosure benchmark helps address a fragmented information ecosystem shaped by multiple systems or standards with varying disclosure criteria and thresholds. It allows more ambitious approaches to go further, while ensuring a global minimum level of information is available to all stakeholders.

In combination with digital product information systems, such as DPPs, the GMTS approach supports countries with limited regulatory and testing capacity by providing predictable, verifiable, and machine-readable data. It can significantly simplify the work of customs services and testing units within national regulatory authorities. Substantial cost savings can be achieved by reducing the need for time-consuming, costly, and fragmented spot checks, followed by chemical analyses requiring advanced equipment and accredited laboratory protocols. At present, regulatory oversight to meet national and international legal obligations often represents a bottleneck in low- and middle-income countries.

A global minimum transparency benchmark helps prevent double standards in international trade by ensuring that a consistent baseline of information is available regardless of where a product is manufactured, used, recycled, or disposed of. DPPs and other digital information systems can support implementation of such a standard by enabling structured data exchange, traceability, data integrity, and, where appropriate, independent verification.

3. Transparency and traceability: the distinction

For the purposes of this paper and policy actions related to product safety and the circular economy, "transparency" refers to the disclosure of information about the identities of chemicals present in manufactured materials and products, as well as their associated chemical hazards.

"Traceability" in this context refers to the ability to track disclosed chemical identities linked to a specific material, component, or product throughout its life cycle.

The two are distinct practices, yet should go hand in hand.

To ensure that information flows uninterruptedly among all stakeholders in value chains and is not lost throughout the life cycles of manufactured materials and products, four basic conditions must be met:

- An agreed and harmonized approach to disclosing the presence, identity, and hazard characteristics of intentionally added chemicals in materials and products;
- Linking disclosed chemical composition information to individual manufactured materials, components, and products through identifiers such as QR codes, watermarks, or other labelling methods, to enable traceability;
- Supporting digital infrastructure, such DPPs, that meet interoperable standards to ensure smooth data exchange between systems.
- Clearly defined stakeholder responsibilities for data collection, digital data entry, and the tagging of materials, products, and their packaging with identifiers.

TRANSPARENCY

(What is in the product?)

Disclosure of chemical identity information

TRACEABILITY

(How to track chemicals in products?)

Ability to follow information throughout the value chain

4. Chemical transparency and traceability in the Global Plastics Treaty

The practices of chemical transparency and traceability are relevant to all major multilateral chemicals and waste agreements, including the Basel, Rotterdam, Minamata and Stockholm Conventions, as Parties continue to face challenges in ensuring effective implementation due to the lack of binding disclosure and labelling provisions. The 2024 Stockholm Convention report on POPs in products and articles (UNEP/POPS/COP.12/INF/26) identified the absence of globally harmonized systems for chemical identification, labelling, information exchange and traceability as a significant barrier to the environmentally sound management of persistent organic pollutants. The report further highlighted that limited information on chemical content throughout product life cycles contributes to the continued circulation of POPs in products made of recycled materials, and in waste streams including through international trade. To address these challenges, the report points to enhanced transparency and traceability mechanisms, including digital information systems, databases, Digital Product Passports, and harmonized labelling approaches, as important tools for improving information exchange across value chains and for supporting the effective implementation of the Stockholm Convention. These findings demonstrate the broader relevance of chemical transparency and traceability systems for achieving the objectives of international chemicals and waste agreements.

The Global Plastics Treaty is still under negotiation, providing an opportunity to avoid the information gaps that affect other multilateral agreements.

The analyses in this chapter, therefore, place emphasis on the Global Plastics Treaty, although many of the arguments presented are more broadly applicable.

4.1 Why plastic requires chemical disclosure

Plastics are complex chemical products composed of polymer backbones, additives, unreacted monomers and processing chemicals, and non-intentionally added impurities. According to the authors of the 2024 Plastchem Project report[12], findings later confirmed in a peer-reviewed study published in Nature in 2025[13], more than 16,000 chemicals are associated with plastics, over 4,200 are of concern, many lack safety data, and less than 1% are regulated under multilateral agreements. The 2025 study further identified 15 priority groups of chemicals, within which more than 40% of members were classified as being of concern. These groups are: aceto- and benzophenones; aromatic amines; aralkyl aldehydes; alkylphenols; aromatic ethers; azodyes; benzothiazoles; benzotriazoles; bisphenols; chlorinated paraffins; ortho-phthalates; organometallics; parabens; PFAS; and salicylate esters (see Tab. S9 in the Supplementary Information to[14] the Nature article.)

Many chemicals used in plastics are not permanently bound to the material and can migrate over the plastic's lifespan, leading to potential exposure for humans and the environment. End-of-life management practices – such as recycling, disposal, or incineration – can further intensify chemical releases and contribute to pollution. A growing body of epidemiological evidence links chemicals associated with plastics to a range of serious health effects, including reproductive, neurodevelopmental, immune, and metabolic disorders. References supporting these claims are provided in the cited Nature article[15].

Recycling is highlighted as a key strategy to reduce dependence on virgin plastics and manage plastic waste in the Intergovernmental Negotiating Committee (INC) negotiations for a Global Plastics Treaty. However, there remains insufficient recognition among some delegations that disclosure and traceability of chemicals in individual plastic materials and products are a fundamental precondition for safe circularity. For more details, see Section 5.4 below.

4.2 What is the price of inaction?

Chemical pollution entails high hidden costs. We have grouped them below into three broad categories.

Toxic chemical impacts on human health: This includes direct medical costs associated with diseases caused or exacerbated by chemical exposure, as well as indirect costs such as lost productivity at work or school due to illness, reduced cognitive function (e.g., IQ loss), and decreased life expectancy. It also encompasses intangible costs, including diminished quality of life, suffering, and even the loss of loved ones.

Environmental contamination costs: Environmental contamination contributes to the human health impacts noted above and imposes additional costs, including loss of income and food security for those directly dependent on arable land, wild harvesting, or fishing, reduced property values, and remediation expenses. Less quantifiable impacts include damage to wildlife and ecosystems, which are vital for the long-term provision of ecosystem services.

Environmental injustice: The health impacts and associated costs across the life cycle of materials and products – including end-of-life handling and recycling – disproportionately fall on already vulnerable, often low-income communities. While these impacts may not be readily quantifiable in monetary terms, their societal costs are no less significant.

The 2013 report Costs of Inaction on the Sound Management of Chemicals[16] presented early research on the health and environmental impacts of unsound chemical management. Although the examples are not specific to plastics, the under-

lying reasoning is directly applicable to plastics. However, estimates of the disease burden associated with certain groups of chemicals relevant to plastics are available. These include endocrine-disrupting chemicals (EDCs), for which data exist from the EU[17] and USA[18], and phthalates, for which US[19] data are available.

Many plastic-associated chemicals are known or suspected EDCs, including phthalates, which are widely used as plasticisers. Estimates of the disease burden attributable to EDC exposure suggest a median annual healthcare cost of €163 billion in the EU (2016), corresponding to 1.28% of GDP, and $250 billion in the USA (2018), corresponding to 1.22% of GDP. In a nationally representative US sample, phthalate exposure has also been associated with increased all-cause and cardiovascular mortality, with estimated societal costs of approximately $39 billion per year or more.

Regarding the cost of inaction and environmental impacts, peer-reviewed literature indicates that chemical-specific valuation remains an important methodological gap in current economic assessments. For example, Zoller (2024)[20] stated that "Existing economic estimates dramatically underestimate total costs because they exclude ecosystem services, non-human endpoints, and long-term chemical persistence."

We have growing evidence of impacts of plastic-related chemicals on wildlife, as illustrated by Ullah et al. (2023)[21], but monetary valuation of these effects remains largely absent.

One of the few peer-reviewed attempts to quantify the global costs of inaction on plastic pollution is a 2024 publication by Cordier et al[22]. The study acknowledges chemical toxicity pathways as part of ecosystem damage, although these are not explicitly modelled in a chemically disaggregated way. The authors estimate costs of inaction for the period 2016–2040 in the range of US$13.7–281.8 trillion, while noting incomplete representation of chemical-specific impacts, suggesting the estimates are conservative.

Estimates of remediation costs for plastic pollution usually pertain to plastic litter rather than plastic-associated chemicals. However, Nikieda and Asiedu (2022)[23] showed that advanced treatment required to remove EDCs and PFAS – chemicals also associated with plastic materials – can cost orders of magnitude more than conventional treatment. This highlights the costs of inaction upstream on chemicals policy.

Although estimates of the cost of inaction in the context of environmental injustice remain limited, peer-reviewed evidence consistently shows that low-income and marginalized communities face disproportionate exposure to chemicals, including plastic-associated compounds. For example, Kassotis et al. (2020)[24] described how disease burdens from EDC exposure can reinforce a poverty trap in already marginalized communities; Dunphy-Daly et al. (2023)[25] argued that the economic benefits of plastics are concentrated upstream among producers and exporters, while health burdens are shifted downstream, often to low-income com-

munities, informal settlements, and populations living near waste-processing sites, and Weiss et al. (2023)[26] estimated that approximately one-third of annual EDC-related health costs in the USA are borne by people of color and low-income groups. Decision-makers should carefully consider whether the annual disease burden, lost ecosystem services, and clean-up costs – along with their potential to undermine economic productivity and hinder poverty reduction – may in fact exceed the costs of regulating problematic chemicals and establishing systems for their transparency and traceability.

4.3 Why article-by-article treaty implementation depends on chemical information

Key articles and associated provisions envisaged in the Plastic Treaty ultimately depend on access to information on the presence and identity of chemicals in plastic materials and products.

This can be illustrated by the INC-5.2 Chair's draft, which served as the starting point for discussions and negotiations at the most recent INC meeting. The INC-5.2 draft treaty text includes provisions on "problematic plastic products" (Article 3). Plastic products may be classified as problematic due to their propensity to generate micro- and nanoplastics, challenges in separating constituent components, or other barriers to recycling, including those arising from chemical composition. To support effective governance, regulatory agencies, academic institutions, and the proposed scientific subsidiary body or committee should have access to full chemical composition data for individual plastic products. Such access would enable more proactive regulatory interventions and strengthen research to address gaps in hazard identification and risk assessment. In addition, chemical transparency and traceability would facilitate tracking of regulated substances across plastic value chains. This includes identifying materials and products that may become "legacy materials" requiring special monitoring or handling following future chemical restrictions. Lessons should be drawn from the Stockholm Convention, which does not include mandatory transparency and traceability provisions for regulated chemicals, thereby complicating compliance efforts for "legacy materials".

"Exemptions" (Article 4) to "problematic plastics" are also sought by several prospective Parties to the Treaty. However, unless information on the presence and identity of chemicals of concern is available at the level of individual exempted plastic items, retailers, consumers, waste sorters, dismantlers, and recyclers face a significant risk of making incorrect decisions. Such errors could lead to unintended exposure to hazardous chemicals, including through contamination of reuse and circular plastic streams, as well as the wider environment.

"Product design" provisions (Article 5) are expected to form part of the Treaty. The integration of chemical-related requirements into design provisions, rather than addressing chemicals in a standalone article, has previously been discussed in the INC process. Manufacturers of products made entirely of plastics, as well as those containing plastic components, should therefore have access to information on the presence and identity of chemicals in plastics. Such information is essential for informed decision-making, including the voluntary substitution of chemicals of concern not yet regulated under the Treaty and the phasing out of plastic components that contain them.

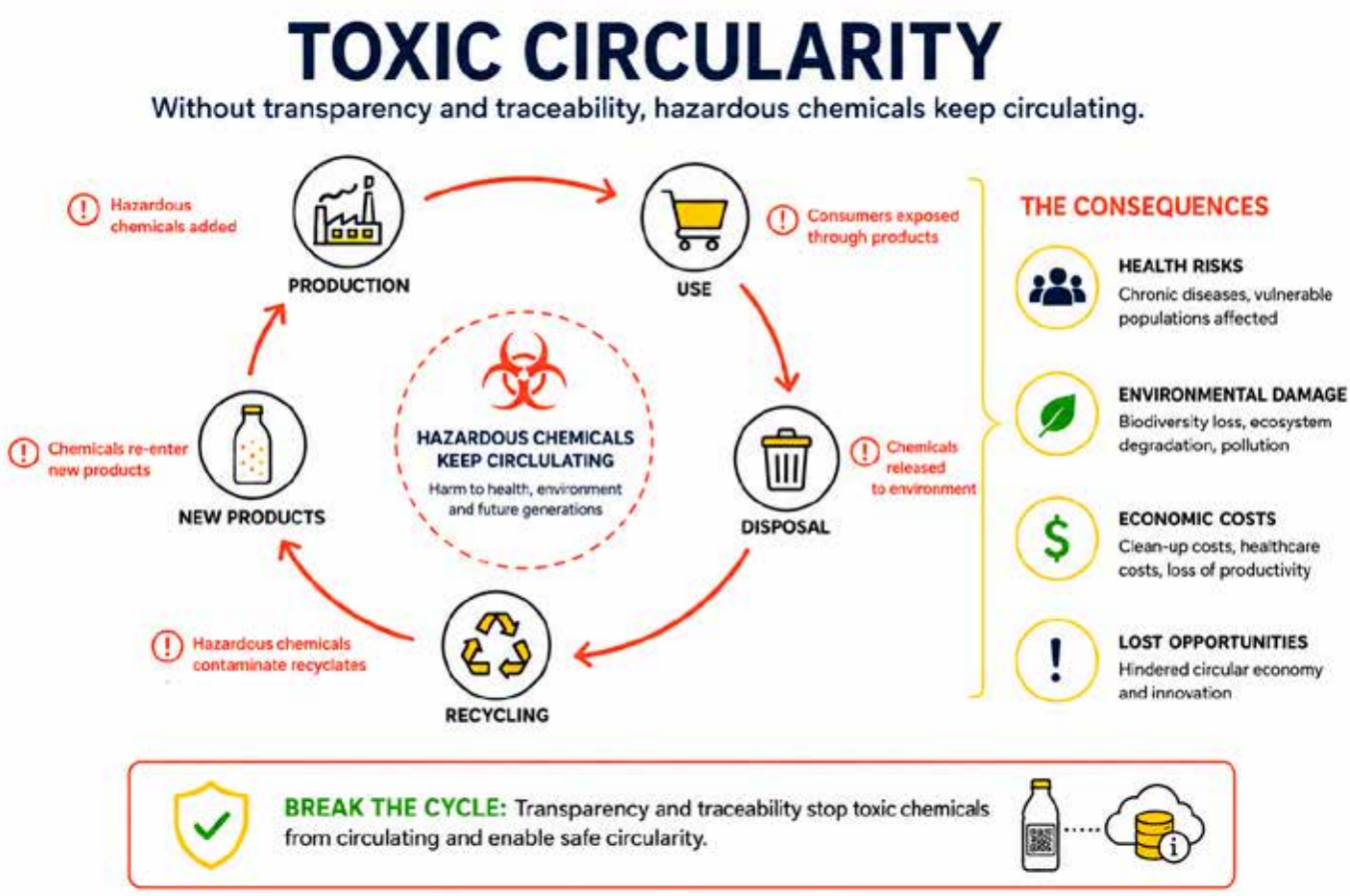
The Treaty should include provisions on "waste sorting, waste minimization, reuse, and recycling". The effectiveness of the control measures outlined in Article 8 of the INC-5.2 draft treaty text depends on informed decision-making by stakeholders across the plastics life cycle, supported by access to information on the presence and identity of chemicals in individual plastic items.
Moreover, Articles 3, 5, and 8 of the INC-5.2 draft treaty text emphasize the circular economy. Its safe functioning depends on informed decision-making regarding the chemical composition of individual plastic items.

Another control measure envisaged for the Treaty is "clean-up activities" (Article 9), which can feed into waste handling, reuse and recycling (Article 8). As noted above, these processes depend on informed decision-making regarding the chemical composition of individual plastic items.

4.4 Recycling and why recycling without transparency is unsafe

Multiple projections indicate that plastic production and consumption will continue to increase exponentially unless we take concerted action through global regulatory measures. In the case of inaction, the volume of plastic waste will grow in tandem with production and consumption. This is the case for UNEP's Resolution 5/4 that gave the mandate to negotiate the Global Plastic Treaty.
In the INC negotiations, both caps on virgin plastic production and recycling have been highlighted as key strategies to reduce plastic waste. While discussions around production caps are highly politicized and contentious, recycling is often seen as less controversial. However, this perception deserves closer scrutiny.

From a material resource efficiency perspective, increasing the reuse and recycling of materials and products is essential. Doing so can reduce land use, as well as energy, water, and chemical


TOXIC CIRCULARITY
Without transparency and traceability, hazardous chemicals keep circulating.
Hazardous chemicals added
PRODUCTION
USE
Consumers exposed through products
HAZARDOUS CHEMICALS KEEP CIRCLULATING
Harm to health, environment and future generations
Chemicals re-enter new products
NEW PRODUCTS
DISPOSAL
Chemicals released to environment
Hazardous chemicals contaminate recyclates
RECYCLING
THE CONSEQUENCES
HEALTH RISKS
Chronic diseases, vulnerable populations affected
ENVIRONMENTAL DAMAGE
Biodiversity loss, ecosystem degradation, pollution
ECONOMIC COSTS
Clean-up costs, healthcare costs, loss of productivity
LOST OPPORTUNITIES
Hindered circular economy and innovation
BREAK THE CYCLE: Transparency and traceability stop toxic chemicals from circulating and enable safe circularity.

demands associated with the extraction, production, and refining of virgin raw materials into usable feedstocks, and the subsequent manufacturing of products.

However, reuse and recycling must be guided by informed decision-making. This depends on three key requirements:

- disclosure of the presence and identity of chemicals of concern, including those that may hinder circularity;
- traceability of chemical content data throughout the value chain; and
- well-functioning separation of waste into fractions based on material and chemical content.

These requirements are supported by digital product information systems, as further discussed in Section 6.

Because plastics are complex chemical products that may contain a wide range of hazardous substances, their reuse and recycling cannot be considered safe when the chemical composition of input materials is unknown, and when mixed plastic waste is processed.
Moreover, a serious discussion of what actually qualifies as "recycling" of plastics is needed.

A new OECD report[27] highlights a critical challenge for the circular economy: recycled plastics can contain thousands of chemicals, including hazardous additives, contaminants, and non-intentionally added substances, many of which remain poorly characterized and are not comprehensively regulated.

The report confirms that chemicals of concern can persist and accumulate in recycled plastics, potentially increasing risks to human health and the environment. It also underscores that no single analytical method can identify all substances in recycled materials, and that traceability and transparency across plastic value chains remain highly limited.

Importantly, the OECD identifies several key priorities that closely align with growing calls from civil society, scientists, and health advocates:

- reducing problematic chemicals at the design stage;
- improving transparency and disclosure of chemical content;
- developing harmonized standards and product information systems;
- strengthening traceability throughout value chains;
- and supporting safer recycling systems that avoid toxic circularity.

However, chemical recycling, often presented as a key future solution for plastic waste management, cannot, in fact, be considered such. Zou et

al. (2025)[28] report that life cycle assessment (LCA) estimates of greenhouse gas (GHG) emissions from chemical recycling vary widely, ranging from negative values to relatively high emission intensities (kg CO_2-equivalents per kg plastic), depending on the specific technology and system boundaries considered.

In some studies, GHG emissions from chemical recycling appear lower than those from alternative waste management options, or even net negative when credits for avoided virgin plastic production are included. This is because virgin polymer production is highly energy- and emissions-intensive and can dominate the overall climate impact. In particular, processes that convert plastic waste into monomers or hydrocarbon feedstocks such as ethylene and propylene – which are used to produce polyethylene and polypropylene plastics – may, under certain assumptions, result in net-negative emissions relative to virgin production.

However, many industrial processes labelled as "chemical recycling" are in practice waste-to-energy or fuel production pathways, where plastic-derived outputs are ultimately combusted. In such cases, climate benefits are absent.

In the absence of transparency and traceability systems, waste operators usually lack reliable information on the hazardous chemical content of materials entering combustion processes. Plastics and other manufactured products may contain PFAS, brominated flame retardants, chlorinated paraffins, heavy metals, phthalates, bisphenols, and numerous other hazardous substances that can influence emission profiles during thermal treatment. Depending on combustion conditions and waste composition, incineration may release hazardous substances into air emissions, wastewater, fly ash, bottom ash, and other secondary residues that require further management. Without prior knowledge of chemical composition, regulators and facility operators cannot adequately assess risks, optimize treatment conditions, or ensure environmentally sound waste management. Waste-to-energy systems therefore do not eliminate the need for upstream chemical transparency; on the contrary, they underscore the need for information on chemicals in products to remain accessible throughout the entire life cycle. It is also important to note that many LCA studies do not fully capture broader environmental impacts. These may include the formation of micro- and nanoplastics in certain processes, the generation of toxic by-products (including residues of additives and processing chemicals, as well as substances formed thrugh incomplete combustion), and wider environmental justice implications associated with emissions and waste handling.

Chemical recycling is not currently a viable option in any country, including low- and middle-income countries and small island developing states. Mechanical recycling in informal or poorly regulated settings can also pose environmental and health risks. In such contexts, reuse options should be prioritized, but their safety ultimately depends on access to traceable chemical composition information to support informed decision-making.

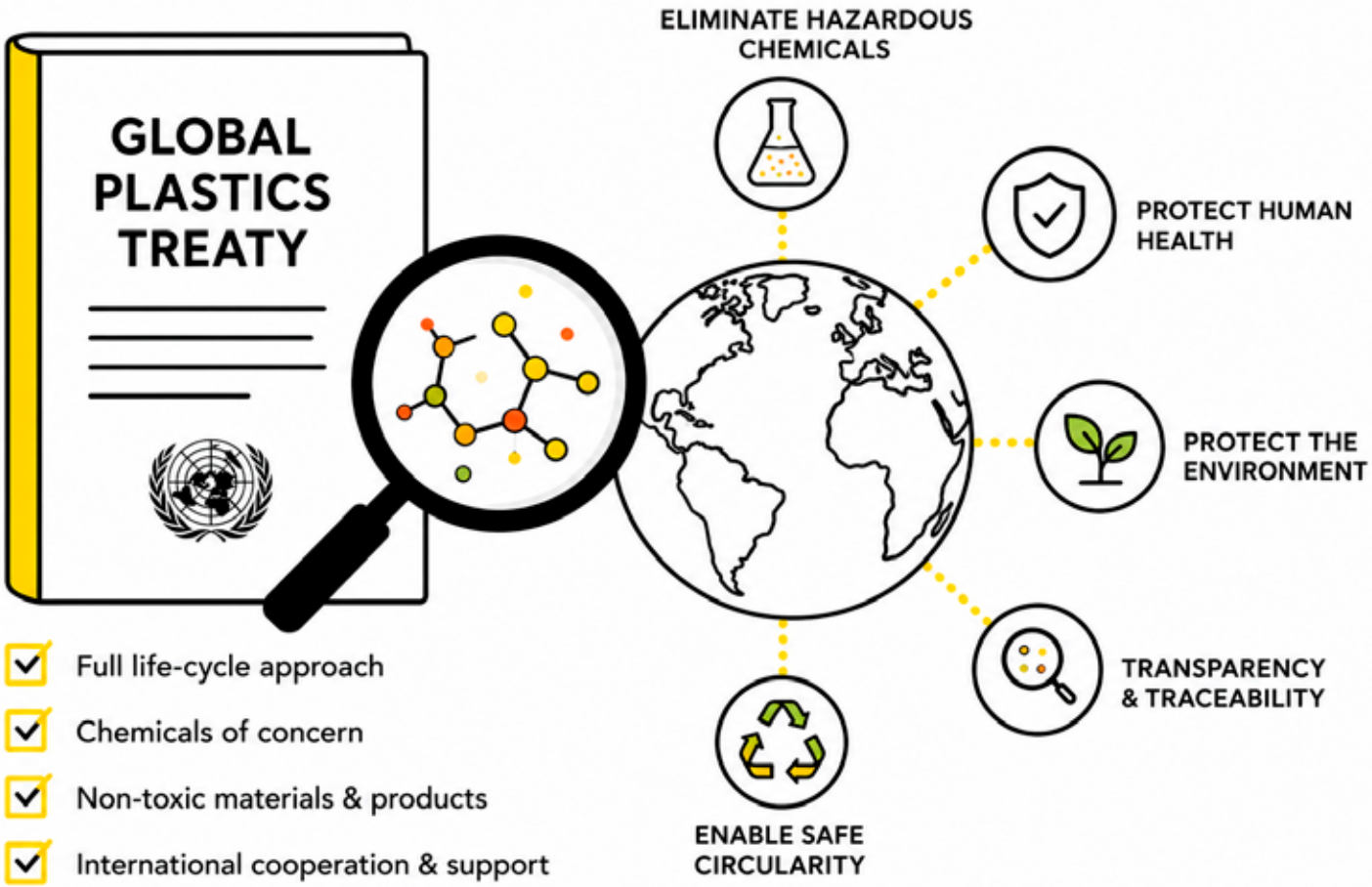
4.5 Why a global approach to chemical transparency and traceability information systems is preferable

Trade is global, and hazardous chemicals move across borders through feedstocks, materials, product components, finished products, and waste streams. A GMTS approach can help prevent double standards in international trade by ensuring that a baseline level of information accompanies products and materials wherever they are manufactured, marketed, used, recycled, or disposed of. Without globally harmonized minimum requirements, restrictions and transparency obligations in one jurisdiction may simply shift production, trade, and waste flows to regions with weaker regulatory frameworks, resulting in continued exposure to hazardous chemicals and unequal levels of protection. By establishing common minimum disclosure requirements while allowing countries and sectors to adopt more ambitious measures, GMTS can support regulatory coherence, reduce reporting burdens through interoperable data systems, facilitate market access, and promote a more equitable level of environmental and health protection across global value chains.

In this context, national or industry-specific chemical information systems may fragment the broader information ecosystem due to data gaps, restricted information access for some stakeholders, and interoperability challenges, thereby increasing implementation costs and creating trade barriers.

Data gaps may arise when industries or jurisdictions apply disclosure standards with differing scopes of chemicals, criteria for identifying chemicals of concern, and disclosure thresholds. They will also arise when information systems are purely voluntary, at the industry level.

Industry information systems are typically voluntary and often restrict access to information to actors within narrow supply chains, excluding regulators, consumers, waste managers, and the reuse and recycling sectors from the information needed to support informed decision-making across the full life cycle of a material or product. For national information systems, regulators may require disclosure of chemical composition data to all stakeholders, including downstream actors in supply chains.


GLOBAL PLASTICS TREATY
ELIMINATE HAZARDOUS CHEMICALS
PROTECT HUMAN HEALTH
PROTECT THE ENVIRONMENT
TRANSPARENCY & TRACEABILITY
ENABLE SAFE CIRCULARITY
Full life-cycle approach
Chemicals of concern
Non-toxic materials & products
International cooperation & support

Traceability systems that do not apply harmonized data-entry standards or rely on proprietary software may face challenges in transferring information between systems or generate incompatible datasets.

Small and medium-sized enterprises (SMEs) often lack the resources to navigate multiple information systems and would clearly benefit from a single global system. Companies in low- and middle-income countries are particularly vulnerable to the burden of overlapping or inconsistent requirements. In practice, multiple information systems may act as a de facto trade barrier for SMEs by limiting participation in multinational supply chains, even if they do not constitute a trade barrier in a legal sense, because the same requirements formally apply to all suppliers of the same goods and services.

Global harmonization of data-entry and disclosure standards, along with interoperability requirements, on the other hand, helps reduce barriers to international trade and can simplify border control procedures for goods.

This is acknowledged in the WTO Agreement on Technical Barriers to Trade (ATBT). Article 2.4. states that "Where technical regulations are required and relevant international standards exist or their completion is imminent, Members shall use them, or the relevant parts of them, as a basis for their technical regulations except when such international standards or relevant parts would be an ineffective or inappropriate means for the fulfilment of the legitimate objectives pursued, for instance because of fundamental climatic or geographical factors or fundamental technological problems".
Furthermore, article 2.6 says, "With a view to harmonizing technical regulations on as wide a basis as possible, Members shall play a full part, within the limits of their resources, in the preparation by appropriate international standardizing bodies of international standards for products for which they either have adopted, or expect to adopt, technical regulations."

Article 11 of the ATBT provides for technical assistance to developing countries to support compliance with standards, while Article 12 addresses special consideration of developing country needs that may affect the timeline for meeting those standards.

However, in the context of the Plastic Treaty negotiations, Article 12 in the ATBT should not be interpreted as a basis for adopting weaker or less specific national standards on the grounds of national circumstances. Instead, the focus should be on technical assistance that enables countries in need to meet agreed standards as early as possible. This approach ultimately represents a win–win outcome for all stakeholders and the environment.
Sector- or country-specific needs can be addressed by adding supplementary requirements to a globally agreed information benchmark.

4.6 WHY GHS is not sufficient for addressing the transparency of chemicals in plastic materials and plastic products.

The Globally Harmonized System of Classification and Labelling of Chemicals (GHS)[29] is a set of international guidelines for classifying chemicals and communicating their hazards. It standardizes hazard classification based on intrinsic properties, defines harmonized hazard pictograms for labels, and specifies the content and format of Safety Data Sheets (SDSs) provided to downstream users. GHS applies to chemical substances and mixtures, primarily in industrial and professional contexts, including process chemicals and pesticides. It is not designed for communicating hazards of chemicals embedded in finished materials and products, where different regulatory frameworks typically apply.

As part of its product stewardship efforts under the Responsible Care Initiative[30], the International Council of Chemical Associations (ICCA) is developing an expanded Safety Data Sheet (eSDS) as an enhanced risk communication tool. The eSDS will incorporate sector-specific uses of chemical products and, based on these, provide typical exposure scenarios, standardized exposure models, and recommended risk reduction measures. It will also support machine-readable exchange formats. While this is undoubtedly a positive initiative, it is important to recognize that its scope remains limited to chemical substances and mixtures. Its primary objective is to manage risks associated with industrial and professional use and to control occupational and environmental exposure – not to address chemicals contained within materials and finished products.

GHS is non-binding and is also implemented unevenly across jurisdictions. Countries and regions may adopt different versions, include exemptions or additions, and vary in how requirements are applied. For example, some jurisdictions mandate disclosure of both health and environmental hazards, while others require only health hazards.

In addition, current versions of the GHS do not address hazard properties such as persistence, bioaccumulation, mobility, and endocrine disruption, which are important for assessing chemicals in plastics and other manufactured materials. To our knowledge, the EU Classification, Labelling and Packaging (CLP) Regulation[31] is among the few regulatory frameworks that have begun incorporating these hazard properties into a GHS-based system.

Consequently, addressing intentionally added chemicals in manufactured materials and products will require a complementary disclosure system to be developed. The proposed GMTS approach could help bridge this information gap.

5. Digital systems, databases and product identifiers

A functional transparency and traceability system for chemicals should integrate four key elements: harmonized disclosure rules; clearly defined scope and product-level granularity; digital infrastructure to support data tracking; and physical or digital identifiers that link products to underlying data.

A growing number of digital information-sharing systems could incorporate the GMTS concept, enabling traceability of chemical composition at the level of materials, products, and components, while supporting scalable disclosure.
Some systems are being developed at national or regional levels, such as the mandatory DPPs under the EU ESPR[32]. This is likely to be the first initiative of its kind implemented across a major regional jurisdiction.

Other initiatives operate at the international level. The main ones are outlined below.
The UNECE Transparency Protocol (UNECE TP)[33] provides the technical protocols and data-exchange rules that enable trusted, interoperable sharing of sustainability data across material and product value chains.

It is based on a decentralized data model, i.e no central database rather data sits with suppliers and manufacturers, and it describes how data should be structured, shared, verified, and located across decentralized data sources.

It builds on the following core data concepts:

- DPP. This is a kind of digital "identity card" for a product that stores key information about it throughout its entire life cycle.
- Product identifiers (elaborated further below)
- Digital Facility Record (DFR). It is a structured, verifiable record describing who operates a supplier or manufacturer facility, where it is located, what it does, and under what compliance conditions it operates.
- Digital Conformity Credential (DCC). It is a verifiable digital proof that a product, material, process, or facility complies with a defined requirement or standard, and it is designed for machine readability and verification across value chains.
- Digital Traceability Event (DTE). This is a standardized, verifiable record of something that happened to a product, material, or shipment at a specific point in time and place within a value chain. It captures moments such as production steps, material transformations, shipments and handovers, storage conditions, quality checks, recycling or disposal events, etc.

The UNEP Digital Product Information Systems (DPIS)[34] provides a conceptual and architectural framework – a blueprint – for how digital product

information systems should be governed and aligned globally. It serves as a reference architecture to guide and harmonize their development and implementation, articulating shared principles for governance, sustainability data, interoperability, and alignment with standards across sectors and countries.

The Digital for Circular Economy Initiative (D4CE)[35] is a multi-stakeholder coordination platform that promotes convergence and interoperability across DPIS-related efforts. It brings together UN agencies – including UNEP, the International Telecommunication Union (ITU), and the United Nations Industrial Development Organization (UNIDO) – along with industry, academia, and civil society to align and harmonize these systems in practice. Rather than defining technical architecture, D4CE facilitates coordination across diverse initiatives, supporting the consistent development of digital infrastructure, standards, and data ecosystems that support circular economy objectives.

DPP is an emerging concept primarily driven by the EU's regulatory framework, which aims to standardize how product lifecycle data is created, shared, and accessed. International bodies such as ISO and UNECE contribute to the development of supporting standards and interoperability principles (UNECE/ISO DPP initiative)[36]. No single global authority governs DPP. Instead, it is evolving as a standards-based ecosystem intended to enable interoperability across regions, industries, and digital systems.

Initiative	Functional layer
UNECE TP	Technical specifications that define how data is to be structured, verified, and shared to ensure interoperability across decentralized data architectures.
UNECE/ISO DPP	Standard defining principles, data structures, and interoperability for DPPs; not fixed content requirements.
UNEP DPIS	A high-level conceptual framework for a global ecosystem of interoperable digital product information systems, managing product lifecycle data.
D4CE	Global initiative aligning and harmonizing those systems in practice.

Table 1: Summary of the function of the UNTP, UNECE/ISO DPP, UNEP DPIS and D4CE initiatives.

The UNECE/ISO Digital Product Passport (DPP)[37] initiative is an international standardization effort led by UNECE and the International Organization for Standardization (ISO) to define common principles, data models, and interoperability requirements for DPPs. Its objective is to enable product information – such as composition, origin, environmental footprints, repairability, and end-of-life options – to be created, exchanged, and accessed consistently across borders, sectors, and digital systems throughout a product's lifecycle. Rather than establishing a single platform or central database, the initiative provides a standards-based framework that allows diverse regulatory approaches (including the EU's emerging DPP requirements) and industry-led systems to interoperate. By bringing together governments, standards bodies, industry stakeholders, and technical experts, the initiative seeks to align technical specifications and ensure that DPP implementations are compatible, scalable, and globally usable across complex supply chains.

How does GMTS fit into these initiatives?

None of them specifies the content to be disclosed in DPPs – such as chemical identity information – or how and when such disclosure should occur, for example via concentration thresholds that trigger reporting. GMTS addresses this gap.

The UNECE/ISO DPP standard is expected to recognise chemical composition and material information as a core and common data category in principle, while leaving decisions on specific DPP content to regulations and sector- or product-specific implementations.

There are two plausible entry points for aligning the GMTS concept with the UNECE/ISO DPP:

- Integration via a dedicated module within the DPP standard. UNECE/ISO could establish a technical committee to develop a GMTS module for direct incorporation into the DPP framework. This approach is technically feasible and would promote a high degree of interoperability.

However, it is likely to be politically sensitive, given differences in national chemical regulatory regimes and governance preferences.

- Development of GMTS as a standalone ISO standard. Alternatively, ISO could develop GMTS as an independent standard, which could later be referenced by the UNECE/ISO DPP – either normatively (a "hard" linkage) or informatively (a "soft," recommendation-based linkage) for relevant material or product categories. This pathway is likely to be more politically and procedurally feasible.

In summary, we see the linkages as follows:

- GMTS establishes the criteria and thresholds for chemical disclosure. ISO can build on this by developing (1) a standard formalizing these criteria and thresholds, and (2) a linkage to standardized DPP frameworks.
- UNTP defines how chemical data should be structured – e.g. within DPPs – and how it can be securely transmitted, connected, and trusted across companies and borders.
- UNEP's DPIS initiative, together with the D4CE initiative, focuses on the architecture and implementation of digital product information systems, as well as stakeholder coordination, helping to avoid fragmentation and incompatible solutions.
- Close alignment with UNTP, UNEP DPIS, and D4CE is therefore essential to ensure that any future ISO standard based on GMTS – and its integration with standardized DPPs – is implemented effectively and consistently.

Let us now take a closer look at "product identifiers", mentioned in connection with the UNTP initiative.

Information about a material, component, or product in a database – e.g. structured as a DPP – is associated with a unique product identifier, typically a numeric or alphanumeric code. Linking this identifier to the physical item requires tagging it with an appropriate data carrier.

There is no one-size-fits-all solution. Different types of data carriers are suitable for different items, and products may carry multiple data carriers across the product and its packaging. Examples of data carriers include QR codes, barcodes, watermarks, radio-frequency identification (RFID) chips, and traditional hang tags or adhesive labels.

For plastics, digital watermark-based labelling has proven particularly promising. In the HolyGrail initiative[38], these imperceptible optical codes are embedded either within packaging label artwork or embossed directly into plastic moulds, typically replicated many times as a tiled pattern across the package surface. This redundancy ensures that the watermark remains detectable even on small or partially damaged fragments under industrial sorting conditions, thereby improving identification, sorting, and recycling processes. The watermarks encode product and material attributes that can be decoded by optical readers, which may be stationary (as in the Holy Grail initiative) or mobile (for example, smartphone applications). The European Brands Association (AIM), together with the Alliance to End Plastic Waste, has made

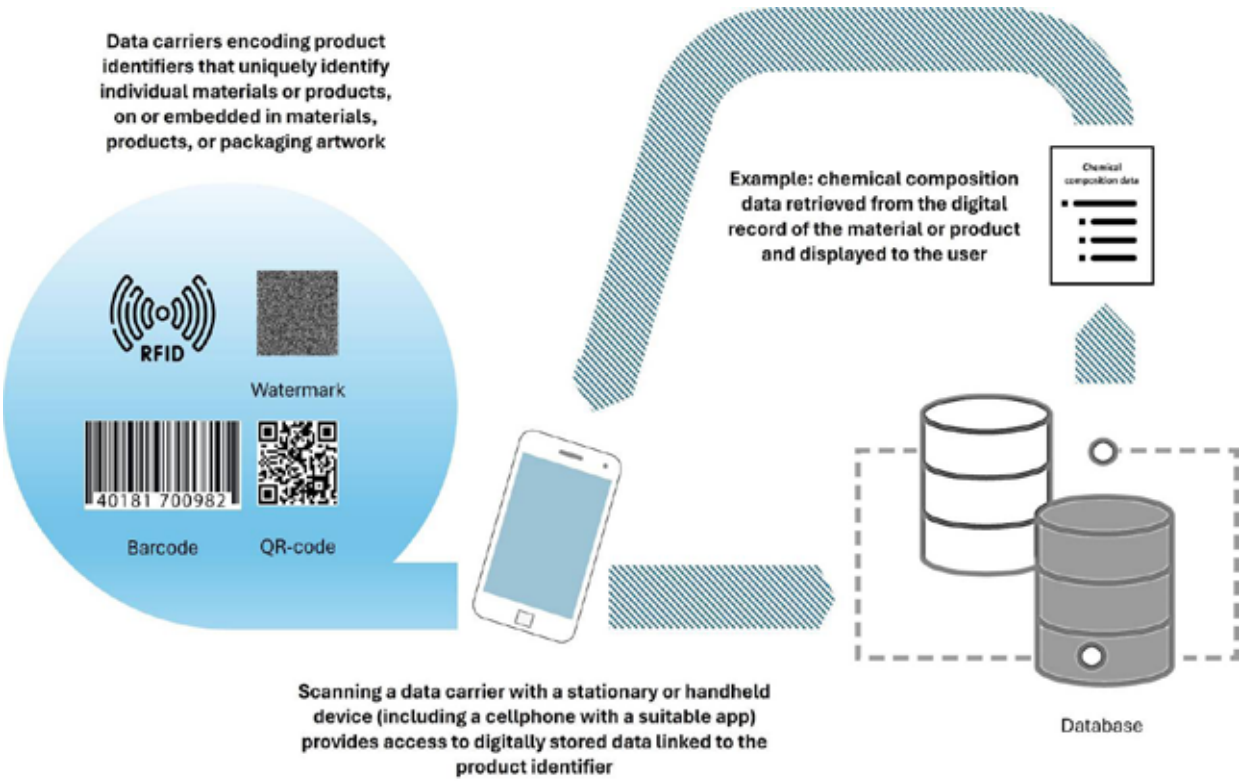


Figure 2: illustrates a simple transparency and traceability system in which digitally stored product information can be retrieved via a data carrier scanning function, enabled through a mobile phone application.

substantial investments in developing and scaling this technology within the EU, generating extensive technical and operational insights through the HolyGrail projects.

An important consideration is that data carriers should remain intact and readable for as long as possible across all stages of a product's lifecycle. However, when products are dismantled at end-of-life or fragment into waste streams, physical data carriers are ultimately degraded or lost. External data carriers, such as labels on packaging, or surface markings on products are typically the first to be removed or destroyed. For this reason, it is beneficial for individual components within a product to also carry their own identifiers, enabling continued traceability even after disassembly. This hierarchical approach increases the longevity of access to digital records throughout material recovery and recycling processes.

It will be important to mainstream the GMTS concept for hazardous chemicals across all international digital product information initiatives. GMTS could serve as a cross-cutting, harmonized disclosure benchmark, defining what information must be made transparently available to value chain stakeholders, while individual initiatives define how that information is structured, exchanged, and governed.

6. How do we see the way forward?

We need to work in parallel to establish the GMTS concept across multiple policy processes. Over time, this will create increasing synergies that help address information gaps related to chemicals in manufactured materials and products.

Without upstream life-cycle measures that include mandatory requirements for transparency and traceability of chemicals in plastics, the Plastics Treaty will fail to achieve safe and sustainable circularity for plastic materials. The shortcomings that led to chemical information gaps under the Basel, Stockholm, and Minamata Conventions must not be repeated.

Work should continue with the Secretariats of the Basel, Rotterdam and Stockholm Conventions and the Minamata Convention to introduce binding requirements for transparency and traceability of information on convention-restricted chemicals in materials and products.

In the work with the GFC measurability framework [39](Global Framework on Chemicals), indicators that truly reflect the practical implementation of transparency and traceability measures for chemicals in manufactured materials and products must be secured, specifically for Targets B2 and B3.

In parallel, a transparency and traceability framework based on the GMTS concept – incorporating elements of the UNEP CiP Programme and lessons learned from the EU SCIP database – should be developed under the GFC Industry Implementation Programme. This would include establishing criteria for identifying chemicals of concern and defining concentration thresholds that trigger information disclosure.

While the architecture and infrastructure for digital tracking of information across material and product value chains are rapidly evolving, the content of DPPs remains largely undefined across many materials and product groups. It is essential to ensure that chemicals are included as core data elements in all relevant DPP discussions, regardless of whether future systems are voluntary or mandatory. Without traceability of chemical composition, a safe and sustainable circular economy cannot be achieved. Accordingly, efforts should be strengthened in collaboration with UNEP DPIS, D4CE, the UNECE TP, and the EU DPP under the ESPR to ensure that chemicals are fully mainstreamed as a fundamental information element in DPPs.

7. Stakeholder Benefits

Access to harmonized chemical information across material and product life cycles brings significant benefits to a wide range of stakeholders.

Governments and policy makers

- Support for implementation of multilateral environmental agreements, the GFC, and national and regional legislation implementation, in particular better conditions for enforcement of provisions on banned and restricted chemicals and product safety.
- Less reliance on expensive testing for compliance verification.
- Stronger market surveillance.
- Better protection against double standards and greenwashing.
- Informed policy-making, including proactive measures.

Industry

- Predictable data access and requirements.
- Level playing field.
- Easier communication between suppliers and buyers.
- Better substitution and design decisions.
- Better Expanded Producer Responsibility (EPR) systems that include sustainable product design criteria, avoidance and substitution of harmful chemicals, and the mandatory integration of hazardous substances into eco-modulation mechanisms that determine producer fees based on the environmental and health performance of products.

Recyclers and waste handlers

- Safer sorting, reuse, recycling and terminal waste management.
- Avoidance of perpetuating legacy contamination in secondary materials.
- Higher-quality secondary materials, which are likely to have a wider market.

Consumers, public procurers and communities

- Effective exercise of their right to know.
- Ability to make safer product choices.
- Ability to properly separate household waste for further sound management.
- Reduced exposure to hazardous chemicals.

8. Recommendations

1. Establish a globally harmonized minimum transparency standard for hazardous chemicals in products.
2. Require disclosure of chemical identity and hazard information for materials, products and components.
3. Link disclosed information to individual products through traceability tools.
4. Create a global database for chemical information in products.
5. Ensure public access to health- and environment-relevant information.
6. Include chemical transparency and traceability in the Plastics Treaty core text and annexes.
7. Align GMTS with DPP/DPIS, UNEP Chemicals in Products, GFC targets B2/B3, GHS, REACH/SCIP, ESPR, and relevant MEAs.
8. Provide technical and financial support for developing countries to implement the system.
9. Ensure that confidential business information claims do not override the right to know about hazardous chemicals.
10. Use transparency data for safe substitution, precaution, enforcement, circular economy policy and pollution prevention.

Conclusion

Chemical transparency and traceability are increasingly recognized as fundamental prerequisites for product safety, environmental protection, circularity, regulatory enforcement, and the public right to know. Throughout this report, we have shown that hazardous chemicals often remain effectively invisible once they enter materials, components, products, waste streams, reuse systems, and recycling markets. As a result, governments struggle to enforce legislation, businesses struggle to make informed design and substitution decisions, recyclers cannot reliably prevent the circulation of hazardous substances, and consumers and communities are denied access to information relevant to their health and the environment.

The challenge is particularly urgent for plastics and other complex material streams. Materials and products may contain thousands of chemicals, many of which are hazardous, insufficiently assessed, or unknown to downstream users. At the same time, global efforts to promote circularity, recycling, reuse, and resource efficiency are accelerating. Without reliable information on chemical composition, however, circular economy systems risk perpetuating the circulation of hazardous substances rather than preventing pollution. Safe circularity therefore depends not only on material flows but also on information flows.

The GMTS offers a practical pathway forward. By establishing a globally harmonized baseline for disclosing chemicals of concern in materials and products, GMTS can help reduce information gaps, prevent double standards in international trade, support informed decision-making across value chains, and strengthen the implementation of chemicals, waste, and product-related policies. The approach is designed to complement emerging digital infrastructures, including Digital Product Passports, the UNECE Transparency Protocol, UNEP's Digital Product Information Systems, and other international initiatives that seek to improve the traceability and interoperability of product information.

The rapid development of digital product information systems presents a unique opportunity. While significant progress is being made in defining how information can be exchanged, verified, and managed across global value chains, decisions about what information should be disclosed remain incomplete. It is therefore essential that chemical composition and hazard information become core elements of future digital product information systems. Failure to do so risks perpetuating the information gaps that currently undermine product safety, regulatory compliance, and environmental protection.

Ultimately, knowing what chemicals are present in products should not be treated as an optional feature of modern supply chains. It is a prerequisite for protecting human health and the environment, enabling a non-toxic circular economy, supporting sustainable production and consumption, and advancing environmental justice. The question is no longer whether transparency and traceability are needed, but how quickly governments, industry, and international organizations can collaborate to establish globally harmonized systems that deliver them.

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