Introducing the Rationale for Including Plastic Polymers in the International Legally Binding Instrument on Plastic Pollution

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What are polymers?

Plastics consist of synthetic or semi-synthetic polymers, monomers and other chemicals including additives and non-intentionally added substances (NIAS).

Monomers are the building blocks of plastics polymers. "Monomer" means a molecule that can form covalent bonds with two or more like or unlike molecules under the conditions of the relevant polymer-forming reaction used for the particular process. They are defined in paragraph 8 of the OECD Expert Group on Polymer Definition: Chairman's Report [ENV/MC/CHEM (91)18]

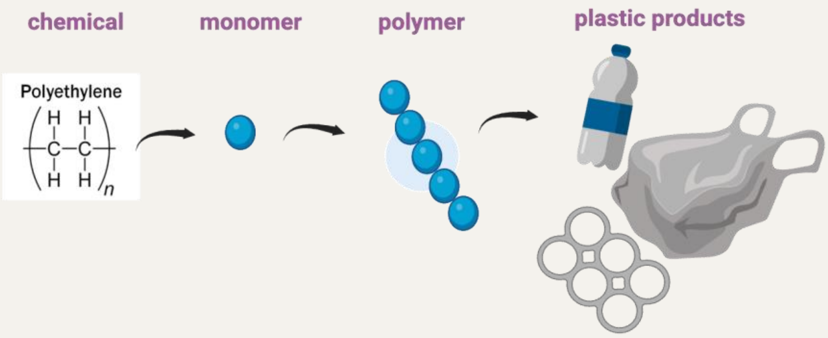

Figure 1. A depiction of the chemical makeup of plastic products (BioRender, 2024)

These hydrocarbon-based monomers are bonded together into long repeating chains, called polymers. The OECD definition of polymer developed by the Expert Group on Polymer Definition in 1990–1991 states: a 'polymer' means a substance consisting of molecules characterized by the sequence of one or more types of monomer units and comprising a simple weight majority of molecules containing at least three monomer units, which are covalently bound to at least one other monomer unit or other reactant.

More specifically, primary plastic polymers are plastic materials made of virgin synthetic and semi-synthetic polymers that are used for the first time to create plastic products in any form, including thermoplastic, thermoset, elastomer and composite resins made from bio-based and fossil-based feedstocks (Scientists' Coalition 2023a, Baztan et al., 2024).

How can polymers be of concern?

Plastics polymers are plastic chemicals, which encompass the primary polymer backbone as previously described (Figure 1., cite BioRender), as well as intentionally and non-intentionally added chemicals (Brander et al., 2024; Wagner et al., 2024). They contain monomers, polymers, oligomers (a chain of a relatively small number of monomers), additives, processing agents, and non-intentionally added substances (NIAS). Plastic materials are often referred to by their polymer type. Each product may contain up to 400 chemicals of concern, though we have incomplete knowledge on many of these chemicals (Wagner et al. 2024). Most polymers have undergone only a minimal safety assessment based on outdated criteria or are exempt from regulation altogether. This, and evidence that their components are hazardous, can be the reasons they are "of concern." (See the Scientists' Coalition's policy brief on chemicals and polymers of concern.)

Monomers themselves may have hazardous properties. Styrene, used to produce polystyrene (PS), and vinyl chloride, used to produce polyvinyl chloride (PVC), are known to have hazard properties including carcinogenicity and reproductive toxicity that lead to negative health impacts (Seewoo et al., 2024). It is important to consider the full life cycle of plastics, as these monomers can be released into the environment and expose wildlife or cause human exposures at all life cycle stages from production of the monomers using raw materials, through to the transportation, use, and waste stages (see the Scientists' Coalition fact sheet on plastics pollution at each life stage).

What can be done to address polymers of concern?

If plastic chemicals are to be addressed by the treaty, this by definition also includes polymers. This is because polymers are chemicals, too.

Polymers can be problematic on their own, considering their potential toxicity and persistence, and that their presence has been documented to impact critical processes such as carbon cycling (Baztan et al., 2024; Zhu et al., 2021). Hazard classification, molecular weight, and residual monomer content are examples of criteria that can be used to assess polymers (Groh et al 2023). Scientific understanding of the impacts of polymers has advanced considerably. Previous assumptions that high molecular weight molecules are biologically inert have been challenged, and the understanding of the possible toxicity of polymers, oligomers, monomers, and associated plastics chemicals has strengthened.

We suggest that approaches such as chemical simplification with an eye towards safety and sustainability, which reduces the complexity and redundancy of plastic chemicals (including polymers), offer a way to reduce plastic impacts (Wagner et al., 2024; Brander et al., 2024). It is therefore appropriate that policies encourage the use of fewer and safer chemicals, and that they reduce the use of polymers that require large numbers of additional chemicals to be made functional or that are difficult to recycle. Adopting essential-use and safe-and-sustainable-by-design approaches would enable this (see the European Commission's program) as well as building the capacity to create safer plastics in the public and private sectors while providing equal access to technical capacities.

Mandatory global plastic pollution prevention policies along with a move towards increased transparency and traceability from industry could incentivize these measures, and could even include tax breaks or subsidies supporting safer and more sustainable alternatives, while also including disincentives such as restrictions, bans, or fees on unsustainable options (Brander et al., 2024; UNEP's Life Cycle Thinking 2021; Lau et al. 2020).

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