5.3 Guidance
Substitution and alternatives assessment

This document is part of the *International Chemicals Management Toolkit for the Toy Supply Chain* developed by the United Nations Environment Programme (UNEP) Chemicals and Health Branch in collaboration with the Baltic Environmental Forum (BEF) within the framework of the Global Environment Facility (GEF) project ID: 9771 on Global Best Practices on Emerging Chemical Policy Issues of Concern under the Strategic Approach to International Chemicals Management (SAICM).

Overview of the substitution process

The following steps are normally undertaken in a substitution process of chemicals of concern (CoC) starting from the identified problem (already prioritised CoC). A substitution to an alternative technology or material could follow the same steps.

1) Define the scope of the substitution process
2) Search for alternatives
3) Assess, compare, and select potential alternatives
4) Test potential alternatives
5) Implement and check

1) Define the scope of the substitution process

For companies in different positions within the toy supply chain, the course of the substitution process and its complexity may differ:

A. Polymer producers and producers of polymer compounds as well as of other chemical mixtures used in toy production, such as glues or lacquers may either change individual constituents in their chemical product or completely reformulate it.
B. For manufacturers of toys and toy parts (made from polymers) substitution options may be:
    a. using an entirely different polymer blend without the CoC (substitute the input material as such) or
    b. requesting that the polymer supplier substitutes the concerning chemical/ additive in the polymer input material as it is a common process.
C. Assemblers of toys can:
    a. substitute an individual component or toy part (i.e., by choosing a different supplier),
    b. request that the supplier phases out the concerning chemical in the input parts.

Hence, substitution requests may start from the bottom of the toy supply chain (i.e., assemblers of toys or even retailers) and be communicated upwards until it is either implemented or 'turned down'.

Table 1: Examples of substitution focus and options for different supply chain actors

Role	Example of focus for substitution	Type of substitution
Manufacturer of polymer pellets	Substances included in the polymer pellets (additives), such as: Softeners (DEHP); heavy metal containing pigments (e.g., pigment yellow 35 with cadmium)	Change composition of own product (drop-in or more extensive reformulation)
Manufacture of toy parts and toys	CoCs in polymers or polymer compounds as such Ready-blended polymer with CoC Cadmium pigment in polymer pellet	Exchange of polymer (drop-in) Request that polymer pellet producer substitutes pigment
Assembler of toys from toy parts	Toy parts, chemicals used for assembly, such as: Plastic duck eyes, dye coating, adhesive	Re-design to avoid the need of separate duck-eyes and paint them onto the main body Purchase different duck eyes or glues (drop-in) Request that producers of duck eyes change product Request that glue producer changes the product composition

Before starting the substitution process, you may discuss this with the company management and estimate how much time and resources need to be allocated for the substitution project. This may guide your decision on whether you yourself will make the substitution or if you want to request substitution from your suppliers. If substitution is necessary within your company, you may also assess if you have sufficient in-house expertise and capacity for this project, or if you might be more effective and efficient with the help of either your suppliers and customers or with the help of consultant firms or research institutions.

The training materials by the Lowell Center for Sustainable Production developed for the European Chemicals Agency's behalf provide more tips on setting the scope of a substitution project (ECHA 2019) and defining quality criteria for alternatives.

2) Search for alternatives

The first step in the search for alternatives is the definition of criteria that would make an alternative suitable for your application. These criteria could cover aspects like hazardous chemical properties, costs, technical performance, or other aspects. The criteria should ideally be specific and quantified (e.g., costs). Be aware that if you aim for low-price alternative chemicals, in particular if these are in use already for a long time, these may be of inferior (chemical) quality and/or have similar hazards as the chemical you aim to replace (regrettable substitution). You should avoid the latter to prevent that you have to another substitution substitute again at a later time, where the alternative is regulated as well due to the hazardous properties. Thus careful analysis of chemicals information and testing may be needed. Chemicals which have only recently been identified as alternatives or are being placed on the market for only a short time may be more expensive because their markets are still small. But this may change over time, as more companies decide to use them.

It is important that you also communicate economic aspects as well as the availability or lack of (hazard) information on alternatives to your customers. More information is provided in the communication guidance of this section #5.4_Guidance_communication_about_substitution

For “new” chemicals, less information on hazards may be available, carrying the risk that hazards are identified later. Changes in costs have to be compensated in the supply chain and even if an alternative does not cost more, there may be additional costs for substitution, such as (staff for research and development, sampling, testing etc.).

There are various options as to where to look and whom to ask for possible alternatives for the use of a CoC and/or a CoC containing mixture or toy (part). Start asking inside your company, as the purchasing department, the sales department or the technical officers may have good advice about products or suppliers to contact. You may ask your suppliers if they offer alternatives for the particular chemical product, polymer compound, or toy part that you want to substitute. You may contact other suppliers of similar types of products and ask them. You can research alternative chemicals, polymer compounds, or toy parts on the internet using search engines, screening scientific literature, contacting industry associations, governmental authorities, universities or other experts who may consult on safer chemicals and product design.

It is sometimes useful to form multi-stakeholder co-operations to join forces in the phasing-out of particular CoCs. This was successful for the elimination of lead from paint in many companies around the world (UNEP 2020), for example. You can also look for case examples of successful substitution published in the Subsport plus database or look at the Chemsec Marketplace, which is an online platform where suppliers of safe alternatives can introduce their products and you can get in contact with them.

The need to consider approaches beyond the drop-in solution is however evident when the functionality of the chemical to be replaced in the product (including polymer compounds) is kept in mind. For example, if a toy is intended to attract the attention of small children using sounds, different types of materials may be tested that would result in different sounds (and different chemical compositions). The functionality of a toy duck (swims on water, looks like a duck and is yellow) may be fulfilled by a pigmented and softened polymer (containing cadmium and phthalates) or a wooden, lacquered duck. Whether or not this change in quality of the toy duck is acceptable and/or is likely to open new markets (while losing old ones) must be assessed through communication with the customers.

As a result of your research, you should identify at least one alternative that meets your quality criteria. If you identify more than one, you may consider them in step 3 and compare their advantages and disadvantages.

3) Assess, compare, and select alternatives

As a minimum condition, all alternatives should be compliant with regulatory requirements of your target markets and should not be banned or restricted by regulation. Any alternative that is banned or restricted for use should be excluded.

For the remaining alternatives the assessment should cover a hazard and risk assessment, an assessment of technical feasibility and an assessment of economic viability. In addition, you should communicate with your customer about the substitution to ensure you do not select an alternative that they consider unacceptable. A structured compilation (structured similarly to chemicals inventory) of all aspects of the alternatives is suggested to get the best overview and select the best option and avoid regrettable substitution.

Hazard and exposure assessment

To compare the chemical hazards, it is easiest if a GHS classification exists, e.g. in the supplier's safety data sheet. If no safety data sheet or other information is provided with the chemical, ask the supplier. Alternatively, you may research the classification from databases. To check if an alternative is better with regard to its hazardous properties, you may use the grouping of classification for prioritising CoCs for action. If no hazard classification exists, you may need external help to identify if the chemical is actually of very low hazard or if there might be hazards but these are not (yet) known as the chemical has not been tested.

If you implement a drop-in substitution, the exposure levels expected from the alternative may be quite similar to the CoC to be replaced. However, it is useful to check e.g. the water solubility and the vapour pressure of a substance as indicator of their mobility and/or to inquire about the migration behaviour of a chemical, in particular if an additive in polymers should be replaced.

If you implement more far-reaching substitutions, the exposure potential may change more significantly, and it is recommended to consider this in the assessment.

In addition, the hazard and exposure assessment may be facilitated by alternatives assessment tools:

- **Simple assessment**: the MS Access® based alternatives assessment tool SubSelect guides the user through a series of questions about hazards of chemicals and allows the comparison of up to 5 substances and mixtures with regard to their hazards. In addition, some parameters specifying other environmental impacts are considered.
- **Detailed and more challenging assessment**: The USEtox near-field/far-field model is a tool for characterising impacts of chemical emissions from consumer products on human health and the environment. It contains a dedicated user interface to assess chemicals in children's toys. Based on the input of some data, such as on the identity of the chemical, the type of application / toy and other parameters it allows to determine, among other things, the characterisation factors (which can be compared to make a conclusion as to whether an alternative is less harmful than the CoC to be replaced or another alternative) and the emissions and exposures.
- Several alternative assessment tools of different levels of ambition and sophistication are made available on the OECDs webpage about a substitution toolbox.

A careful and thorough assessment of potential alternatives is necessary to avoid regrettable substitution, i.e., the replacement of a CoC by a chemical with similar or even worse hazards. Regrettable substitution is a real problem in the industry and unfortunately is commonly occuring (Zimmerman and Anastas 2015; Allen 2016). The consequences of regrettable substitution may include: a need to substitute again in the future, risk of workers exposure to hazardous chemicals and/ or environmental pollution, risk of consumer exposure, risk of bad reputation and loss of clients, etc.

After the hazard and exposure assessment, you may exclude one or several of the initially identified alternatives from your list if they turn out not to be improvements.

Technical and economic assessment

The technical assessment of the feasibility of an alternative could include for example

- Some initial laboratory tests with the alternative chemical / polymer compound and/or toy part, for example, related to the durability, colour fastness, haptic properties etc.
- The compatibility of the alternative with other materials may be tested, e.g., whether the current glues can still be used or whether a lacquer can be applied to a certain material
- For product parts, the exactness of the size, the quality of any sub-parts or the part may be assessed

- The purity of a material may be tested in the laboratory to avoid that the alternative contains (other) unwanted CoCs

The economic assessment may include an analysis of

- Potentially necessary investment costs in new machinery
- Price of the alternative(s)
- Savings that may be realised due to a reduction in hazardous wastes
- Market potentials that could be gained or lost by a change of the product composition, including opportunities to apply for eco-labels
- Costs to train the employees
- Possibilities to increase the price of the own product

There may be various aspects that have to be considered and many of them can only be estimated rather than precisely calculated. However, asking these questions will complement the former considerations and may indicate potential challenges in the implementation or limitations for certain alternatives.

After this assessment, there may be further alternatives that are deselected from your list on the grounds that they are not feasible from an economic or technical perspective.

4) Test potential alternatives

The remaining alternatives (which are an improvement regarding hazards and risks) should be tested in the real production line. This is a crucial step in the final selection of the alternative because it will show which unforeseen technical challenges may have to be met and whether the quality of the final product will be acceptable.

Order small batches of potential alternatives from the suppliers. Then devise a plan for how to test the potential alternatives. Such a plan should include a list of quality criteria / properties of the final product that should be fulfilled (against which you will compare the alternatives). Additionally, other aspects may be considered, such as how well the existing equipment can process the alternative or whether the amount of production waste, water use or energy use changes.

When you receive the test batches of the alternative(s), the testing can start. This may need specific attention by the technical staff, as the manufacturing parameters may have to be changed due to the (partly different) properties of a new input material, i.e., a chemical, polymer compound or toy part. Ensure good documentation and record keeping of your testing so that details on the tests are available at later stages in the process.

Assess the products manufactured with the alternative regarding the quality criteria / properties defined as essential or minimum for the product. Assess which of the alternatives achieves the best performance regarding these parameters. Additionally, you may contract a chemical analysis of the product samples to ensure that no unwanted CoCs are contained in them. For example, it is possible that contaminants **#Section 1_9 impurities** form during the processing.

After completing the tests, analysing the results, and comparing all parameters of the potential alternatives, you will be able to select the best solution for your product.

5) Implement

The last step in the substitution process is the use of the selected alternative in your full-scale manufacturing process. It is likely that you will be able to improve manufacturing efficiency over time as you work with the new material.

Ensure that your customers are informed of the changed product composition and provide them with your arguments as to why this also benefits them.

If you engage in a continuous improvement process, you may move on to the second priority CoC in your list.

References:

- UNEP (2020). *Eliminating Lead Paint: The Role of the Paint Industry.* https://www.saicm.org/Portals/12/Documents/Publications/SAICM_Policy_Brief_Lead_in_Paint.pdf Accessed 20 December 2021.
- ECHA. How to substitute. https://echa.europa.eu/en/know-your-substances-and-needs-substitution. Accessed 20 December 2021.
- ECHA. Online training on analysis of alternatives. https://echa.europa.eu/de/online-training-on-analysis-of-alternatives. Accessed 20 December 2021.
- SubSport plus. Case story database. https://www.subsportplus.eu/subsportplus/EN/Cases/Case-story-database/case-story-database_node.html. Accessed 20 December 2021.
- Chemsec. Marketplace. https://marketplace.chemsec.org/. Accessed 20 December 2021.
- OECD. eCHEM portal. https://www.echemportal.org/echemportal/ghs-search. Accessed 20 December 2021.
- UBA (2020). *SubSelect - Guide for the Selection of Sustainable Chemicals*. https://www.umweltbundesamt.de/en/document/subselect-guide-for-the-selection-of-sustainable. Accessed 20 December 2021.
- OECD. OECD Substitution and Alternatives Assessment Toolbox. http://www.oecdsaatoolbox.org/. Accessed 20 December 2021.
- Zimmerman, J. B. and Anastas, P. T. (2015). *Chemistry. Toward substitution with no regrets. Science,* 347(6227), 1198-1199. Chemistry. Toward substitution with no regrets - PubMed (nih.gov). Accessed 30 May 2022.
- Allen, J. (2016). *Stop Playing Whack-a-Mole with Hazardous Chemicals. Washington Post, December 15, 2016.* *Stop playing whack-a-mole with hazardous chemicals - The Washington Post*. Accessed 30 May 2022.