HAZARDOUS SUBSTANCES: How to Identify ‘Green’ Alternatives to Hazardous Chemicals

Ontario requires certain companies to reduce the number and amount of toxic chemicals used and created in the workplace. One way to comply is by switching to “green” alternatives that are safer for the environment and workers. But companies across Canada can benefit from making such a switch.

5 Steps to Identifying Green Chemical Alternatives:

1) Identify the chemicals you currently use that could be replaced;

2) Identify possible alternatives to those chemicals;

3) Conduct a preliminary assessment of this list to narrow it down;

4) Conduct a detailed assessment of those alternatives on your short list; and

5) Select, implement and monitor your preferred alternative.

Ontario’s *Toxics Reduction Act* requires covered companies to reduce the number and amount of toxic chemicals they use and create in the workplace. One way to satisfy this requirement is by switcher to “green” alternatives to hazardous chemicals. Companies outside of Ontario can benefit from switching to greener chemicals even if they’re not required to do so. For example, green chemicals are safer for both the environment and workers. But how do you identify appropriate green alternatives to hazardous chemicals’ Ontario’s Ministry of the Environment (MOE) recently released a guide on how to assess safer chemical alternatives. We’ll explain the steps in the assessment process and how to use them to switch to green chemicals in your workplace.

BENEFITS OF USING GREEN CHEMICALS

If you’re not based in Ontario, you don’t have to comply with that province’s *Toxics Reduction Act* and so aren’t required to reduce the hazardous substances in your workplace. But there are still reasons to do so anyway. For example, according to Ontario’s MOE, companies that reduce their use and creation of toxic substances can:

- Save money by improving efficiencies and reducing capital investment, insurance costs, required inputs, energy, disposal and treatment of hazardous waste costs;
- Improve their market position with greener products;
- Minimize the risk of liability from improper waste management, chemical spills or other environmental incidents or worker exposure to hazardous substances; and
- Lower regulatory compliance costs.

HOW TO COMPLY

The MOE guide, Reference Tool for Assessing Safer Chemical Alternatives, provides an overview of the steps you should take to identify substances that are appropriate green alternatives to toxic chemicals you’re currently using or creating in your work processes. You can follow these steps to conduct an alternatives assessment for your company.

Step #1: Identify Chemicals that Could Be Replaced

Before an alternatives assessment can be conducted, you should examine the company’s processes to identify where a safer chemical alternative may be required or beneficial. A good place to start is with a process flow diagram and mass balance, which can help you identify target chemicals as well as any functionality requirements they have.

A process flow diagram can not only identify target chemicals for the alternatives assessment but also provide information for the other steps in the assessment, such as the economic feasibility analysis. A process flow diagram can have varying levels of detail. In its simplest form, it show the flows into and out of a production process, including the raw material inputs, products and non-product output streams. A more detailed diagram may also include piping information, operating conditions, etc. It may be useful to prepare a more detailed flow diagram by including a “mass balance,” that is, labelling all process streams with flow rates of all chemicals.

An alternatives assessment may be beneficial if your process flow diagram identifies:

- A chemical in one or more processes that’s going to be subject to new or stricter

[box]**The 12 Principles of Green Chemistry**

Green chemistry is the design of chemical products and processes that reduce or eliminate the use or generation of hazardous substances. The 12 principles of green chemistry are:

1. It’s better to prevent waste than to treat or clean up waste after it’s formed.

2. Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product.

3. Wherever practicable, synthetic methods should be designed to use and generate substances that possess little or no toxicity to human health and the environment.

4. Chemical products should be designed to preserve

regulations;
- A chemical in one or more processes that requires separate, costly disposal options, e.g., it’s hazardous waste;
- A high risk of environmental or human exposure to a hazardous chemical used or produced in the process;
- A chemical in one or more processes that’s on an existing list of chemicals of concern;
- A particular process or equipment that requires a hazardous substance for cleaning; or
- A chemical in one or more processes that’s non-renewable.

Once you’ve identified target chemicals that could be replaced, you must determine their functionality requirements, such as density, water solubility, colour, boiling point/melting point, odour and vapour pressure. To identify such requirements, describe the role of the chemical in the process and define all operating conditions under which it’s used, such as temperature, pressure, etc. For example, are there ignition sources directly near the process area so that highly volatile chemicals must be avoided’ Does the end product require all raw materials to be water soluble’

Once you’ve determined the target chemical’s functionality requirements, the physical and chemical properties that an alternative to it must possess should be clear. You’ll use this information for both the preliminary and detailed assessments of the identified possible alternatives.

Step #2: Identify Possible Alternative Chemicals

Once you’ve identified target chemicals that could be replaced, you must identify any possible alternatives that exist for those chemicals, paying particular attention to those that are designed for the same use as the target chemicals. The Ontario guide provides a list of resources that may help you identify possible alternatives:

- US EPA Green Chemistry site;
- US EPA Sustainable Futures Initiative (SF);
- Green Chemical Alternatives Purchasing Wizard;
- CleanGredients®; and
- Toxics Use Reduction Institute (TURI).

efficacy of function while reducing toxicity.

5. The use of auxiliary substances, such as solvents, separation agents, etc., should be eliminated wherever possible and innocuous when used.

6. Energy requirements should be recognized for their environmental and economic impacts and should be minimized. Synthetic methods should be conducted at ambient temperature and pressure.

7. A raw material or feedstock should be renewable rather than depleting wherever technically and economically practicable.

8. Unnecessary derivization should be avoided whenever possible.

9. Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.

10. Chemical products should be designed so that, at the end of their use, they don’t persist in the environment and break down into innocuous degradation products.

11. Analytical methodologies need to be further developed to allow for real-time, in-process monitoring and control prior to the formation of hazardous substances.

12. Substances and the form of a substance used in a chemical process should be chosen so as to minimize the potential for chemical accidents, including

Step #3: Conduct Preliminary Assessment

An alternatives assessment can be time and labour intensive. Although a large company may have the resources to do a full assessment of all possible alternatives, many smaller companies won’t. So in many cases, it makes sense to narrow down your list of potential alternatives to your target chemicals by doing a preliminary assessment to eliminate chemicals that aren’t economically or technically feasible or that may pose potential concerns based on their presence on one or more priority or regulatory lists.

releases, explosions and fires.

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Technical assessment. The preliminary technical assessment evaluates the alternative chemicals on the basis of their fulfillment of the target chemicals’ functionality requirements. Information on these properties can generally be found on a chemical’s MSDS. For example, if an end product requires the raw materials to be water soluble and an alternative chemical isn’t water soluble, then that chemical isn’t a technically feasible alternative and so it wouldn’t be logical to conduct a detailed assessment on it. Other considerations can include performance characteristics such as durability or longevity of the end product, maintenance requirements, energy consumption, etc.

Economic assessment. One of the most important factors to consider in an alternatives assessment is that the alternative should yield a profitable end product. There are many components to an economic analysis, including a cost assessment, cost/benefit analysis and financial evaluation. Also consider the availability of the alternative chemical. Will it be relatively easy to obtain the alternative chemical’ Is it available locally or only from suppliers that are far away’ Are there multiple suppliers so that if one supplier shuts down, there are other options for obtaining the chemical’

In terms of the preliminary cost assessment, you can simply compare the direct and indirect costs of the target chemical and its alternatives. In general, the raw material costs play a large role in determining the end product’s profitability. If no major process change is expected as a result of implementing an alternative chemical, then to be profitable, the raw material cost of the alternative chemical should be similar to that for the target chemical. So in the preliminary assessment, conduct a search of various chemical suppliers to determine approximate raw material costs for the alternative chemicals.

Presence on priority lists. Some chemicals are present on one or more regulatory lists as a result of high use, production rates, emissions rates, etc. or because of their hazardous properties or high potential for exposure. These chemicals may be considered among the more hazardous substances and may currently be subject to environmental regulation—or may be subject to regulation in the future.

If an alternative chemical is on one or more of these lists, it doesn’t mean that you should automatically drop it from further consideration. For example, the alternative may still be less toxic than the chemical you’re currently using. In addition, you may be able to use the alternative chemical in smaller quantities, thus reducing some of the concerns related to it.

Some lists established under the federal *CEPA* that you should consult include:

- Domestic Substances List;
- Non-Domestic Substances List;
- Priority Substances List;
- Toxic Substances List (Schedule 1 of *CEPA*);
- Virtual Elimination List [Hexachlorobutadiene and perfluoroctane sulfonate (and its salts) are the only substances currently on this list.]; and
- Non-Statutory List.

To see if an alternative chemical is on any of these lists, use the search engine for chemicals and polymers. Note that these lists aren't exhaustive and high priority substances may also be identified elsewhere.

In short, if an alternative chemical is on one of these lists, you may want to eliminate it from contention. And if you select it anyway, just be aware that there may be issues associated with its use, such as stricter or more cumbersome reporting requirements.

Step #4: Conduct Detailed Assessment of Short List

Small companies that lack the resources for a full assessment may need to select an alternative based on the results of their preliminary assessment. But if you can do a full assessment of your short list of alternatives, you should do so. A detailed assessment will allow you to select an alternative that's consistent with your company's environmental, technical, economic and social priorities. This second assessment may revisit some of the areas already covered in your preliminary assessment, such as functionality and economic feasibility, but do so in more depth.

There are several components of a detailed assessment:

Hazard assessment. As per the 12 Principles of Green Chemistry (see the box), a safer chemical alternative should possess little to no toxicity to the environment and humans, and should break down into innocuous degradation products. So your hazard assessment should involve the collection of data for both the chemical currently used and the identified alternatives on their:

- Environmental hazards, including the chemical's persistence in the environment, bioaccumulation and the toxicity of the chemical and its degradation products to plant, aquatic life and wildlife;
- General human health hazards, including effects on the general public and any sensitive sub-populations such as children, the elderly or pregnant women; and
- Occupational health and safety hazards, including any relevant occupational exposure limits and risks that may apply to workers but not the general public.

Technical feasibility. The technical feasibility of an alternative chemical is arguably the most important aspect of its evaluation. After all, an alternative isn't viable if it doesn't perform like the chemical it's replacing. Your detailed assessment should cover three broad areas:

- *Health and safety standards*—that is, are there any standards the chemical must meet to ensure the health and safety of workers exposed to it’
- *Functionality requirements*—that is, does the alternative meet all requirements for its intended function’
- *Performance characteristics*—that is, will changing to the alternative require significant equipment and process adjustments’ Are these changes possible or feasible’ Will customers continue to be satisfied with the quality of the product if we make these changes’

Economic feasibility. As discussed above, an alternative should be economically feasible to be practical. You’ve already considered the basic economic feasibility of the chemicals on your short list in your preliminary assessment. A more complete assessment of economic feasibility should include the following:

- *Detailed cost assessment*. The detailed cost assessment quantifies the direct and indirect costs associated with use of the target chemical and its identified alternatives. This assessment should also consider future price changes;
- *Cost/benefit analysis*. This assessment should analyze the costs of switching to the alternative and benefits of doing so, including the costs and benefits of changing technology or processes to use the alternative chemical and any regulatory impact from making this switch; and
- *Financial evaluation*. This analysis investigates the long-term financial implications of using the current and alternative chemicals. Examples of long-term financial indicators include net present value, payback period and internal rate of return.

Social impact. You should also consider the socio-economic impacts on the market and local economy of switching to an alternative chemical. For example, does the alternative replace a locally sourced material with a foreign material, leading to job loss locally’ Does the alternative create jobs locally’ Could the alternative cause pollution that impacts local health and recreation’ Does the alternative affect worker productivity or job satisfaction’

Life cycle analysis. A life cycle analysis (LCA) prevents the inadvertent transfer of environmental impacts from one medium to another or from one life stage of a product to another. An LCA identifies and evaluates the environmental burdens of a product at all stages in its life cycle—resource extraction, production of materials, product parts and the product itself, use of the product and disposal of it—and provides a “big picture” comparison. It’s important to consider the results of an LCA in the selection of alternatives since it’s a broad consideration of environmental, social and/or economic issues across a chemical’s entire life cycle. See the diagram on below for an overview of this process.

Step #5: Select, Implement & Monitor Preferred Alternative

The selection of a preferred alternative is complex. It’s unlikely that one alternative chemical will be superior to all others across the board. So you’ll have to prioritize the various attributes to select an alternative. In other words, consider the attributes of the alternatives within the context of the specific features that are the most important to your company and in sync with its principles and goals. Place less importance on factors that aren’t as relevant for the selection.

Some general selection guidelines to consider that correspond to the 12 Principles of Green Chemistry:

- Avoid alternatives that are persistent, bioaccumulative or toxic (PBT) or which become PBT over their life cycle;
- Favour alternatives that eliminate undesirable chemicals/components from a process/formulation; and
- Favour alternatives that reduce resource consumption and are renewable.

After you've selected an alternative chemical, implement its use. Once the alternative is in place, monitor its use carefully to ensure that it's working as expected. For example, make sure the alternative is doing its job as well, if not better, than the chemical it's replacing and that it's not creating unforeseen environmental or workplace safety hazards.

BOTTOM LINE

Switching to green chemicals is a great idea for most companies, even those that aren't legally required to do so. But the selected alternative chemical should be less hazardous than the current chemical to humans and the environment and should also pose less risk, i.e., hazard combined with exposure potential. And the alternative must be technically and financially feasible while still producing a product that's acceptable to consumers. The Ontario guide provides a great framework for EHS coordinators to use to identify possible alternatives to hazardous substances in their workplaces and assess whether switching to those alternatives makes sense.

Figure 2.2 Overview of Life Cycle Analysis Process

Note: From U.S. EPA (1993, cited in U.S. EPA 2006b)