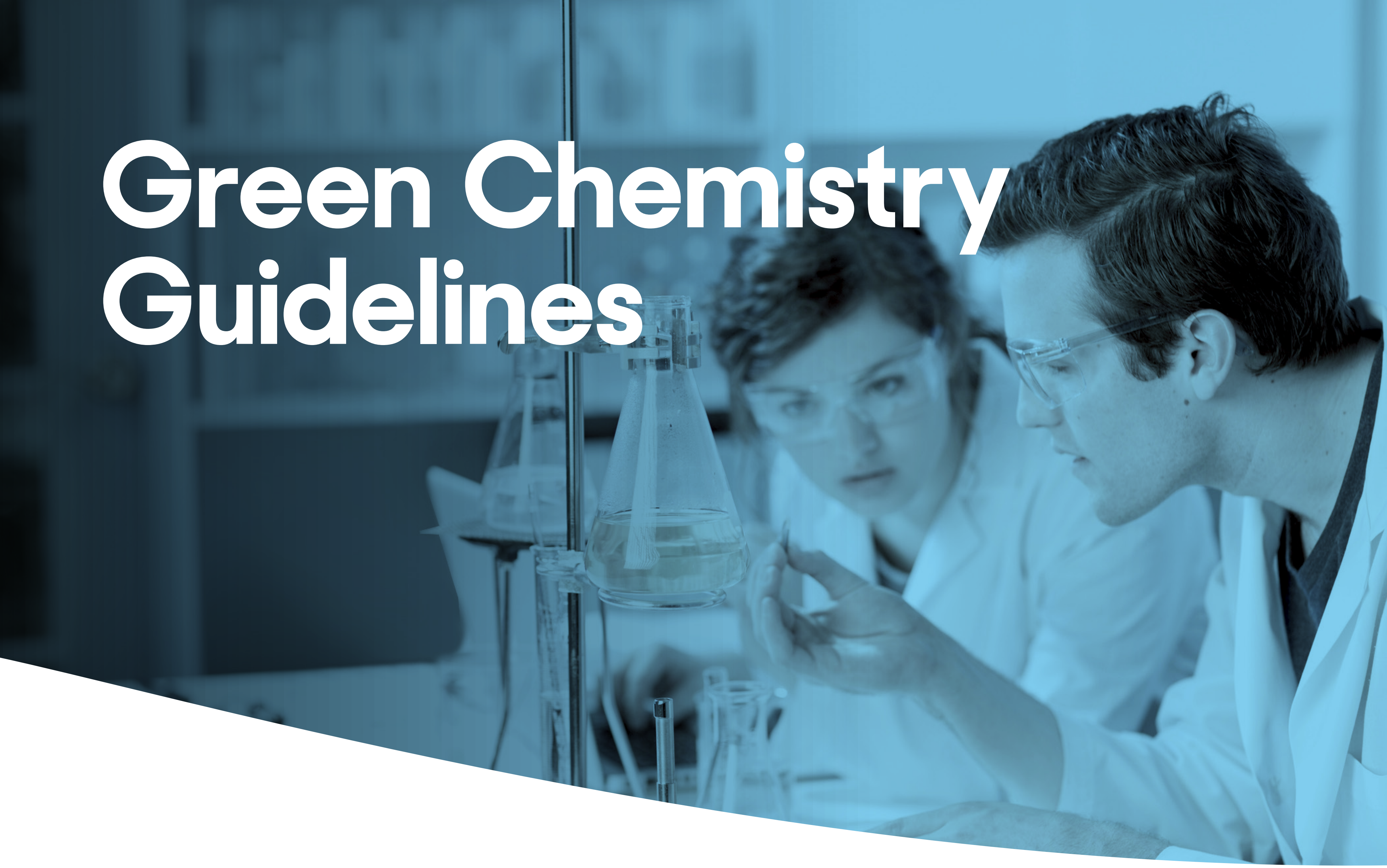
Green Chemistry Guidelines



Quaker Houghton™
Forward Together™

Table of Contents

Introduction

Introduction

The guidelines are based on the 12 Principles of Green Chemistry[1] reported by the American Chemical society and re-written to better fit Quaker Houghton's activities."

Quaker Houghton's activities. The guidelines take a cradle to gate approach, in line with the corporate sustainability goals, while not neglecting cradle to grave effects. They are meant to guide, not dictate, and should always be placed in the context of specific product lines and/or technologies.

Always follow the guidelines within the constraints of customer requirements, commercial interests, general performance and local legislation.

Specific and more detailed KPI's on our sustainability targets are being formulated and rolled out. These targets are likely more focused on groups of chemistry or labeling and will provide the prioritization. These guidelines provide a wide vision on green chemistry that will exist alongside the organizational KPI's to minimize our impact on the environment.

On the next pages you find the guidelines with added explanation, context and examples to make it easy to understand and help you Innovate together for a better tomorrow.

1. *Green Chemistry: Theory and Practice; Paul T. Anastas, John Charles Warner; 1998*

Guideline 1: Prevent Waste

General Description

It is better to prevent waste than to treat or clean up waste after it has been created. Consider for instance:

- Cleaning of the production vessels
- Maximize reaction yield
- Product shelf life
- Packaging (reclaimed package) design for robustness
- Design robust products

Details and Examples

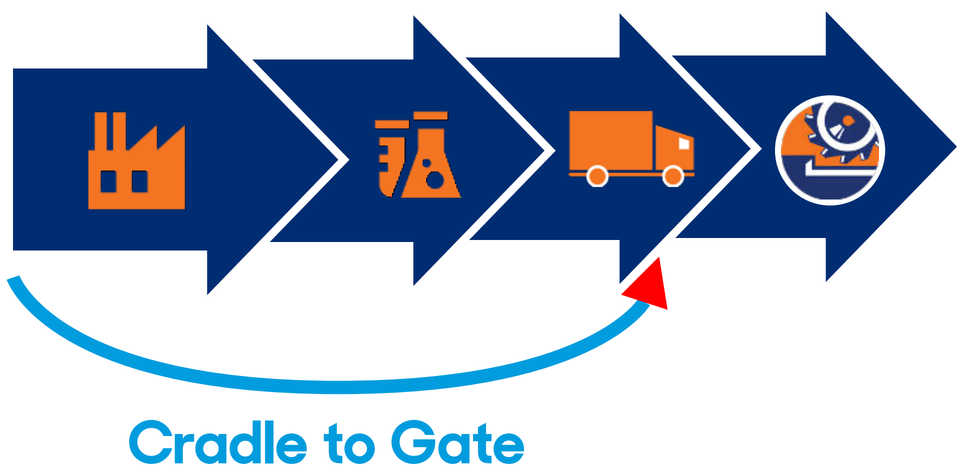
Many of the above mentioned points can be achieved by designing products that are robust to variations and contaminations and have a high stability over time. This will not only prevent waste on our end but brings advantages for our customers as well.

Highly dependent of the production layout and product line in question, there are always cleaning of flushing steps before and/or after a batch is produced. When developing a product, consider that either easy cleaning or a level of robustness for contamination can result in significant advantages during production. Work together with relevant production sites to achieve minimal impact on waste streams.

Maximizing the reaction yield of for example esters will minimize the need for purification steps. Any side products or other impurities are most likely discarded at the end of the process.

Designing a product with a long shelf life brings several apparent benefits for both our internal and our external warehouse. One of which is preventing potential waste in case of expiring. In case of expired stock, it is advised to rework the concerning batch and/or packages instead of discarding. The ability to have a long shelf life is highly dependent on the reactivity of the used chemistry, and therefore on the product line in question.

Another advantage of designing a robust product is to be able to use recycled or re-usedpackaging. These package types might contain some slight contamination, therefore, if a product is designed robust enough, the selected packaging can be both cost effective and reducing waste.



Guideline 2: Select Safest, Least Hazardous Raw Materials

General Description

Select raw materials based on the lowest hazard profile possible both for humans and the environment considering the entire process from product development to the manufacturing process.

Details and Examples

Try to select RM's with lowest hazard profile. See below in a general order of most to least severe classification:

1. **CMR** (Carcinogen, Mutagens, and Reproductive Hazard)
    a. Category 1 – Least preferred, new CMRs in Category 1 are not being approved, CMRs in Category 1 are known human carcinogens, mutagens, or reproductive toxicity hazards either by known historical data or by positive animal testing.
    b. Category 2 – are suspected Carcinogens, Mutagens, or Reproductive hazards where some effects have been noted. These are less preferred than no CMR hazards.
    c. No CMR hazard is most preferred.
2. **Aquatic Toxicity** – Can have some additional local legislations. In general:

AQUATIC CLASSIFICATION	RANKING
M factor assigned/Acute or Chronic Aquatic 1	Not Preferred
Acute 1 (H400) or Chronic 1 (H410) Aquatic Toxicity	Not Preferred
Chronic Aquatic 2 (H411) Aquatic Toxicity	Less Preferred
Acute Category 2 (H401), Acute Category 3 (H402), or Chronic Aquatic Category 3 (H412)	More Preferred
No Aquatic classification	Most Preferred

3. **Specific Target Organ Toxicity – or STOT** – Indicated significant health effects whether via a single exposure or repeated exposure. Quaker Houghton most commonly sees STOT-Single effects of respiratory irritation (H335) or Repeated effects (H372, H373). Some examples of STOTs are:
    a. Ethylene Glycol poisoning
    b. Narcotic Effects (H336) from Alcohols

    The STOT-RE classification has the health (Exploding Chest) pictogram.
4. **Skin corrosive** – is less desirable than irritation or no classification for corrosivity. This is a Dangerous Good for transport.
5. **Volatile/flammable** – Flammables are often volatile organic compounds (VOCs), and have specific risk management and handling at Quaker Houghton sites and at our customer sites.

FLAMMABILITY	RANKING
Category 1	Not Preferred – typically not permitted in many areas
Category 2	Not Preferred – typically not permitted in many areas
Category 3	Less Preferred
Category 4	More Preferred
None, Flash Point higher than 93°C	Most Preferred

Guideline 2: Select Safest, Least Hazardous Raw Materials

6. **Hazardous air pollutants** – Like VOCs, hazardous air pollutants are strictly regulated and may require permitting.
7. Other classifications like skin/eye irritation that do not have any GHS symbol
8. Raw material free of labeling and hazard statements

Some examples to get to more benign raw material selection are:

- When choosing new ethoxylated alcohols/amines, working with a higher degree of ethoxylation will trend towards a lower Aquatic toxicity hazard.
- Choosing a skin irritation raw material to replace a corrosive one.
- Replacing Volatile coatings with low VOC chemicals.

When selecting raw materials also consider the minimizing the potential for chemical accidents, including loss of containment, exposure, explosions and fires:

- Exposure during handling. Think about for instance dust or vapor
- Strong exothermic reactions
- Side reactions

These are not necessarily connected to any GHS pictograms or hazard statements. The list of hazards mentioned is not exhaustive, but are the most common in our industries. When encountering hazards that are not mentioned in the guideline, adhere to the principle to strive for a labeling as low as feasible.

The default source of information on hazards of raw materials is the Safety Data Sheet. The SDS however only reflects the currently proven hazards. Situation can occur where a substance is under review and a negative change in labeling is likely to (typically) happen in the next 2-4 years.

Guideline 3: Use Renewable Feedstocks

General Description

Select raw materials coming from a renewable feedstock. Consider the pre-cursers of the selected raw material as well.

While designing new products, careful raw material selection is essential for many reasons like quality, functionality, safety and cost efficiency. On top of that, another factor that should be considered is the source of the raw material. The order of preferred feedstock is as follows:

1. Vegetable – easily renewable and least impact on environment
2. Animal – renewable but requires significantly more resources to obtain compared to vegetable
3. Recycled – fossil-based materials that are recycled
4. Fossil – non-renewable like metals and fossil materials

Fossil sources are not preferred at all, but cannot always be avoided

Details and Examples

In this context non-renewable means there is a finite supply on earth, even if a material (like metallic metals) can easily be recycled, the better choice is a fully renewable feedstock like plant or animal sourced that is preferably not competing with the food industry. The aspirational corporate sustainability goal for 2030 is to reduce the overall consumption of fossil based raw material by 30%.

Most of our raw materials have been made by chemical reactions or refineries, therefore the precursors of the materials are of importance as well. Taking a simple non-ionic emulsifier as an example, the carbon chain can be sourced from vegetable sources but the ethoxylate group is much more complex to source/manufacture in a renewable way. In this example even a partially renewable sourced raw material is preferred over a fully petrochemically based material.

Producing renewable carbon materials can be more complex and/or consume more energy compared to fossil sources. Therefore, raw materials based on renewable feedstock can occasionally have an increased CO2 emission depending on the calculation method used. This must be reviewed on a case to case basis.

On many occasions it might not be clear what feedstock is used in making specific materials. It will be a continuous process over the coming years to gather information and make it available for all chemists to make the best choices for specific situations.

Guideline 4: Design Safer, More Sustainable Products

General Description

Quaker Houghton products should be designed to minimize the overall hazard profile while preserving their efficacy. This will show in lower labeling and less Hazard statements in the Safety Data Sheet, creating value for our customers, lowering potential environmental impact if products are spilled or disposed of and creating a safer working environment.

Details and Examples

Quaker Houghton's Green Chemistry Guidelines state that we strive to select the safest, most benign raw materials when formulating. This is described in **guideline 2**. However, it is understood that the use of certain raw materials may be unavoidable due to product performance and application. Therefore, use of raw materials with environmental impact and negative product labeling should be minimized. The aspirational corporate sustainability goal for 2030 is to eliminate all CMR category 1 labeled finished goods from the portfolio. This excludes CMR risks through oral exposure route.

- If it is necessary to formulate with CMRs or Aquatic Toxic raw materials, the usage amount in the formula should be optimized and minimized.
- When using flammable raw materials, quantities should be minimized to avoid flammability labels due to a low flash point.
- Local regulations should be considered when designing products. For example, some regions do not permit phosphorus, or have VOC limits.
- For more information on labeling thresholds see R and D Sandbox Training and Tool 2022
- Prevent animal testing to lower labeling of end products

Guideline 5: Design for Energy Efficiency

General Description

Minimize the energy required to produce Quaker Houghton products by design. Consider the complete production process.

- Minimize mixing times
- Minimize need for cooling & heating
- Maximize yield and purity
- Manufacture at ambient pressure & atmosphere

Details and Examples

Most of the global energy supply is produced by fossil fuels, therefore lowering the energy demand by product design lowers the environmental impact. Energy remains a valuable and scarce resource, even if renewable sources are being used.

Product manufacturing should be conducted as close to ambient temperature and pressure as possible. Both heating and cooling, are high energy consuming processes and should therefore be avoided as much as possible.

Selecting fluid raw materials instead of solids is one way of reducing the need for mixing and heating, however this can conflict with the impact of shipment at increased volumes and weight for example when a 10% solution of a given material is used instead of the corresponding solid.

It is important to design new molecules/reaction/process with detailed and extended consideration of how energy will be used, minding the gap between lab scale and industrial scale.

Products, processes and systems should be designed to maximize the efficiency in terms of: energy, space (blender/reactor capacity), and time. By designing the process for high purity and conversion there is less need for purifications steps later in the production process and therefore also saving energy and time.This also relates to **guideline 1: Prevent Waste.**

In the context of time efficiency: the longer a production process takes for completion, the more resources are spent. In addition, the longer the reaction runs, it is consuming valuable reactor real estate. The ideal is to perform chemical reactions as quickly as possible, while still being as efficient and safe as possible. Speed and energy efficiency are often contradicting directions. A careful consideration is to be made on a case to case basis to find the optimum between the two parameters.

Guideline 6: Design for Disposability and Natural Degradation

General Description

Quaker Houghton products should be designed so that at the end of their function they can easily and safely be disposed of without hazardous components persisting in the environment.

Details and Examples

By preventing waste **(guideline 1)** selecting safe and least hazardous raw materials **(guideline 2)** and designing safe and sustainable products **(guideline 4)** we have already taken big steps to preventing hazardous chemistry from entering and persisting in the environment. If on top of that we design our products for commonly used methods of waste treatment and keep biodegradability in mind we can further minimize the impact on the environment. This approach can also potentially make it less expensive for our customers to dispose of waste.

Waste treatment at the end of our products life will be different for every product line and it is therefore difficult to provide universal guidelines. Some ideas to keep in mind:

- Reclaiming/recycling raw materials. Think about oils, amines or emulsifiers
- Reusing water after wastewater treatment
- Separating hazardous components from bulk waste volumes
- Biodegradability (for example: Low Chemical and Biological Oxygen Demand, OECD 301, OECD)