

Interpreting ChemFORWARD Chemical Hazard Ratings

The ChemFORWARD platform allows users to access information on chemical hazards in a tiered way to accommodate different levels of complexity and quantities of data:

1. At the highest level, **HAZARD BANDS** provide an overall chemical rating that allows for easy comparisons between chemicals. Hazard bands provide the least granularity with respect to the details of toxicological or physical chemical data.
2. **HAZARD SUMMARY TABLES** present hazard classifications for each individual hazard endpoint associated with a chemical, along with a concise rationale for why each hazard was classified as such by a Licensed ChemFORWARD Assessor.
3. At the foundation of the information pyramid, detailed **DATA SUMMARIES** are entered into ChemFORWARD platform by Licensed Assessors to document results from literature reviews, toxicological testing, models, and other scientific data used to classify hazard endpoints for each chemical. As part of the research and documentation process, Assessors summarize the data summaries into rationales for classification that are viewable via the hazard summary tables.



Figure 1. Tiered Levels of Information on Chemicals in ChemFORWARD

Hazard Bands indicate the overall level of severity associated with a chemical's inherent hazards. Two chemicals may share the same hazard band but have different inherent hazards. For example, one chemical may be assigned the C hazard band based on a C2CC chemical rating of x/c for skin irritation while another chemical may be assigned the C hazard band based on a C2CC chemical rating of x/c for moderate aquatic toxicity. While the hazards are different, the overall level of severity of the hazards are considered moderate to high, resulting in predicted levels of **moderate** risk.

Hazard Bands

Hazard Bands can also indicate equivalency between different chemical hazard assessment (CHA) programs that use similar approaches to hazard classification as those that are used in ChemFORWARD. For example, a chemical that is rated as GreenScreen Benchmark 3 is considered equivalent to a chemical assigned the B hazard band based on a C2CC chemical rating of b or b/c.

Equivalency does not mean identical. However the equivalent programs are all aligned with respect to how they prioritize the elimination of high hazard chemicals that are of high risk in most scenarios. And they all prioritize the adoption of chemicals with low hazard, low risk based on intended and foreseeable uses, and good data quality and completeness.

Harmonized Hazard Band	Implications	Program Equivalency		
		C2CC Chemical Rating	US EPA SCIL	GreenScreen Benchmark
A	Low hazard and low risk	a	--	4
B	Some moderate hazards, low risk	b or c/b	green full circle	3 (3tp, 3dg)
C	Moderate to high hazards and moderate risk; or uncertainty that could result in moderate risk	C, x/c, x/c-CMR(Cat 2), grey/c, c/b-CRE	green half circle, yellow triangle	2 (2tp, 2dg)
F	High hazards and high risk in most scenarios	x-PBT, x-CMR, x/c-CMR(Cat 1), x/c-E, x*, x*-CMR, banned	grey square	1 (1tp), LT-1
U	CHA completed with excessive data gaps, rating is not possible		--	BM U
?	Request a CHA to inform a decision	No CHA	No CHA	No GS, , LT-UNK, LT-P1

Figure 2. Hazard Bands, Hazard Equivalency and CHA Program Equivalency

Summary Hazard Tables

Summary hazard tables are useful to those who want more information about the specific hazards and/or data gaps associated with a chemical. ChemFORWARD was designed to present toxicological and physical/chemical hazard information using different chemical hazard assessment (CHA) methods. Currently the two methods built

into ChemFORWARD are the Globally Harmonized System of Classification and Labeling of Chemicals (GHS) and the Cradle to Cradle Certified Material Health Assessment Method (MHAM). Users can toggle between the summary hazard tables generated from the two different systems, allowing for slightly different perspectives on the SAME data for the same hazard endpoints. The C2CC MHAM includes several hazard endpoints that are not found in GHS (e.g. endocrine disruption, environmental persistence, bioaccumulation, etc.). Summary hazard tables display the results by exposure route (oral, dermal, or inhalation) so users can see what is known, and not known, about hazards via different exposure routes.

The Globally Harmonized System of Classification and Labeling of Chemicals (GHS)

All chemical hazard assessment (CHA) methods are significantly based on the Globally Harmonized System of Classification and Labeling of Chemicals (GHS). GHS is an internationally agreed-upon standard managed by the United Nations that was set up to consolidate and replace the assortment of hazardous material classification and labeling schemes previously used around the world. It aims at ensuring that information on physical hazards and toxicity from chemicals be available in order to enhance the protection of human health and the environment during the handling, transport, and use of these chemicals. GHS is updated every two years and the most current version of GHS is used in ChemFORWARD.

GHS uses a system of chemical hazard endpoint classifications that result in different **Categories**. A Category 1 (Cat 1) hazard is the most severe. Some hazard endpoints just have 1 or 2 Categories for classification. Others, such as acute mammalian toxicity and acute aquatic toxicity have at least 4 Categories, with Category 4 being the least severe.

In the GHS Hazard Summary Table view, ChemFORWARD presents classifications as **Category levels** (e.g. Cat 1, Cat 2). If a hazard endpoint is **Not Classified**, then ChemFORWARD presents the hazard summary for that endpoint as NC in the hazard summary table cell. NC indicates that the chemical is LOW hazard for that hazard endpoint. (It does NOT mean that the hazard endpoint has not been classified!) If there

are insufficient data for classification, then the hazard summary endpoint has CNP in the cell which stands for **Classification Not Possible**:

Cat = Category (1, 1A, 2, 3, etc.)

NC = Not Classified (equivalent to LOW hazard using GHS criteria)

CNP = Classification Not Possible (not data or insufficient data available for classification)

In the GHS hazard summary table, cells are color coded to help with interpretation. If the cell is:

GRAY: Classification is not possible (CNP)

RED: Category is accompanied by GHS signal word “Danger”

ORANGE: Category is accompanied by GHS signal word “Warning”

YELLOW: Category is accompanied by no GHS signal word

GREEN: Not Classified

Confidence

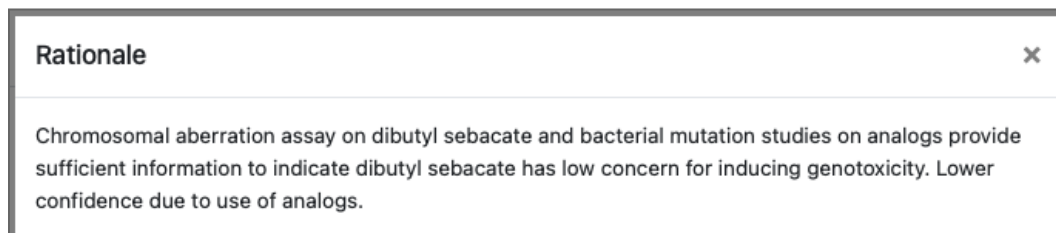
The summary hazard tables also include indicators of the Assessor’s confidence in the data supporting the classifications:

Classifications in **Bold** text indicate that the Assessor has high confidence in the classification.

Classifications in *(Italic text in parentheses)* indicate low confidence in the classification.

Confidence levels are not assigned to CNP, so CNP is written in Plain text.

Figure 3 provides an example GHS Summary Hazard Table for a chemical in ChemFORWARD. Click on any cell in the table to generate a popup window that displays the Rationale behind the classification such as the rationale for Mutagenicity displayed here.



	Carcinogenicity	Mutagenicity	Reproductive Toxicity	Developmental Toxicity	Acute Toxicity	STOT-Single	STOT-Repeated	STOT-Neurotoxicity-Single	STOT-Neurotoxicity-Repeated	Skin Sensitizer	Respiratory Sensitizer	Skin Corrosion/Irritation	Serious Eye Damage/Eye Irritation	Acute Aquatic Toxicity	Chronic Aquatic Toxicity	Ozone Depletion
Oral	NC	(NC)	(NC)	(NC)	NC	CNP	NC	(NC)	(NC)					(NC)	(Cat.2)	NC
Dermal	CNP		CNP	CNP	CNP	CNP	CNP	(NC)	(NC)	(NC)		(NC)	Cat.2B			
Inhalation	CNP		CNP	CNP	CNP	CNP	CNP	(NC)	(NC)		(NC)					

Figure 3. Example GHS Hazard Summary Table with Rationale for Mutagenicity

The Cradle to Cradle Material Health Assessment Methodology

The Cradle to Cradle Material Health Assessment Methodology assigns hazard ratings to 24 individual human and environmental health endpoints. The system is largely based on GHS with the addition of hazard endpoints including but not limited to Persistence, Bioaccumulation Potential and Endocrine Activity/Disruption. Like the GHS hazard summary table, hazard classifications are broken out by exposure route so that users will know what is known and not known about the hazards associated with a chemical based on its intended use and likely exposure route. See Figure 4.

All classifications are based on the most recent version of the Cradle to Cradle Material Health Methodology (Feb 2022). The Cradle to Cradle endpoint hazard rating uses colors to indicate the following:

- GREEN:** No hazard identified for the endpoint
- YELLOW:** Borderline hazard identified for the endpoint
- RED:** Considered hazardous for the endpoint
- PURPLE:** Highest hazard for persistence and bioaccumulation potential only
- GRAY:** Insufficient data available to determine hazard level for the endpoint

	Human Health										Environmental							Other			
	Carcinogenicity	Mutagenicity	Reproductive & Developmental Toxicity	Endocrine Activity / Disruption	Oral Toxicity	Dermal Toxicity	Inhalation Toxicity	Neurotoxicity	Skin, Eye, and Respiratory Corrosion/Irritation	Sensitization of Skin and Airways	Fish Toxicity	Daphnia Toxicity	Algae Toxicity	Terrestrial Toxicity	Persistence	Bioaccumulation	Climatic Relevance	Other (Human Health)	Organohalogen	Toxic Metals	Other (Environmental Health)
Oral	G	G	G		G						R	G	R	G	G	G	G	G	G	G	G
Dermal																					
Inhalation																					

Figure 4. Example C2CC MHAM Hazard Summary Table