



A Framework for Green Chemical Ranking: Development, Evaluation, and Implementation

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Basic Issue

- Growing B2B, public, & legislative/regulatory pressure for the development and utilization of “greener” chemical products and processes
- This is an issue in many diverse industrial sectors
- Has become a primary issue in the Hydraulic Fracturing industry and gas production processes
- Greener is required!



Project Scope

- Develop a prototype “Green” Ranking System for oil field services company utilizing fracturing process chemicals
- Desired attributes
 - Credible
 - Transparent
 - Scientifically sound
 - Based on existing systems and criteria
 - Practical considering data normally available
 - Tested
- Quantitative in nature to allow for relative “Greenness” decisions and marketing



Project Elements

- Reviewed national / international ranking and approval systems
- Identified common criteria
- Picked criteria relevant for client's needs
- Drafted quantitative approach for evaluations / ranking (spreadsheet application)
- Tested the system on pilot products
- Developed “users manual”
- Continual modifications based on experience



Reviewed National and International Ranking & Approval Systems

- EPA DfE
- Green Seal
- EcoLogo
- Ecocert
- Nordic Ecolabel (Swan)
- CEFAS (OCNS)
- EU Eco-label (Flower)
- The Blue Angel
- Environment Canada Screening Criteria
- EPA PBT Profiler
- REACH
- Green Good Housekeeping Seal



Common Criteria Selected

- **Human Health**
 - Acute mammalian toxicity
 - Irritation/corrosion
 - Carcinogenicity
 - Genetic toxicity
 - Reproductive and developmental toxicity
- **Environmental**
 - Acute / chronic aquatic toxicity
 - Bioaccumulation
 - Biodegradation
 - Priority pollutants
 - VOC content
- **Physical hazards**
 - Explosive
 - Flammability
 - Oxidizer
 - Corrosive



Ranking of Criteria

- There is no recognized standard for “greenness” criteria
- Wide range of criteria utilized in regulatory and private schemes
- The Globally Harmonized System of Classification and Labeling of Chemicals (GHS) has brought a significant level of international consensus to hazard criteria and definitions
- GHS is:
 - A system for standardizing and harmonizing the classification and labeling of chemicals
 - Addresses health, physical and environmental hazards of chemicals
 - A classification process that uses available data on chemicals for comparison with the defined hazard criteria; and
- Primary criteria standard chosen for the system
- Allows for quantitative scaling
- Some “list based” criteria also used



Ranking System Tool

- A spreadsheet application was developed
- Individual components ranked
- A scale of 0-3 for each end point for each component
- For systems, or mixtures, volume percentage contribution used to calculate the overall score
- Separately ranks the three sets of criteria (Human Health, Environmental, Physical)
 - Allows for individual or aggregate ranking
 - Allows for a scaling of the score if one particular area of concern is most important
- Allows for a quick identification of where effort should be focused to reduce the score for the systems
- Overall product (formulation) scale of 0-100



Ranking System Issues

- CBI issues
- General availability of tox/ecotox data
- Ranking results communication
- Criteria based on “inherent” hazards with no exposure consideration
- Mixture toxicity issues
- Degree of hazard based on GHS criteria when applicable
- Degree of weighting based on “importance” of criteria
- Number of lists (Prop 65, SARA 313, etc.) to include
- Is a high number good or bad



Issues: Carcinogenicity Ranking

- Current US System is List-Based
 - Leads to “yes / no” determination
 - Is it on specific lists or not (IARC, NTP, OSHA regulated)
- GHS has a Gradation of Carcinogenicity
 - Results in relative ranking in the carcinogenicity category
 - More substances could be included in this category as only a limited number have been classified/ranked to date for the “lists” utilized in the US
- Degrees of carcinogenicity may not be appreciated by customers and public
- Degrees do give more decision making latitude when formulating



Criteria/Ranking Issues

- Human health irritation indices
 - Qualitative statements are the norm
 - Ranking ability based on “words” was needed
 - Utilizing HMIS convention
- Reproductive Toxicology
 - Utilizing “0” or “3” based on profile of the issue
- Acute aquatic toxicity approach
 - Fish first when multiple species available



Ranking System Issues

- How to deal with data gaps in scoring
 - Short term and long term solutions
 - Default to a conservative ranking
 - Literature searches
 - Read across
 - Supplier communications/requests



MSDS Issues/Limitations

- OSHA Hazard Communication Requirements “limit” data found on MSDS’s
 - Only hazardous material disclosure required
 - Specific data for health hazards not required: appropriate hazard warning is
 - Environmental data not required
- Common practice in Industry to have 16 section MSDS with Toxicology and Environmental section included
 - Qualitative hazard statements still very common
 - Examples
 - Slight irritant
 - Biodegradable
 - Not expected to present reproductive hazards
- Creates challenges for “ranking”, even with high quality MSDSs



CBI Issues

- Disclosure of a CAS# and precise constituent percentages not common on MSDSs
- CBI issues throughout the supply chain
- Needed a third party acting as a confidential receiver of information to achieve evaluations
- Hazard evaluations/rankings provided in a manner that protects the CBI claimed



Supplier CBI Communication Experience

- Negotiating confidentiality agreements does take time
- Suppliers are sensitive to the intent of the process
- Common results to date
 - Better formulation % information
 - Environmental data disclosed
 - Full ingredient disclosure can create new issues
- How to provide results of confidential ranking to the client



Hazard Ranking Spreadsheet

Component	Chemical A	Chemical B	Water	Total Score	Weight Score
CAS Number	1234-56-7	23-45-6	7732-18-5		
%	20	40	40		
Environmental Criteria					
Acute Aquatic Toxicity	1	1	0		
Air Pollutants (VOCs)	0	0	0		
Priority Water Pollutants	0	0	0		
Bioaccumulation	0	1	0		
Biodegradation	0	1	0		
total score/component	20	120	0	140	3.5
Toxicological Criteria					
Acute Mammalian Toxicity	0	1	0		
Carcinogenicity	0	1	0		
Genetic Toxicity	0	0	0		
Reproductive and Developmental	3	0	0		
Corrosive/Irritant	1	1	0		
total score/component	80	120	0	200	5.0
Physical Hazards					
%				100	
Explosive				0	
Flammable				0	
Oxidizer				0	
Corrosive				0	
total score				0	0.0
Product Score (Environmental, Toxicological and Physical Hazard Criteria)				340.0	8.5
Data gap = 1				(out of 100)	



Client View

✓ Advantages

- ✓ Scientific “ranking” process
- ✓ “Clearing House” approach verified
 - ✓ Allows analysis of 3rd party proprietary products
 - ✓ Adds credibility
- ✓ Understanding of potential environmental, toxicological and physical hazards
- ✓ Solid basis to guide R&D efforts
- ✓ Support for marketing claims

✓ Limitations

- ✓ Weighting of sub-categories is arbitrary
- ✓ Comparing solids with liquids
- ✓ Mixture toxicity issues



GHS Acute Toxicity Example (if needed)

Route	Unit	Cat. 1	Cat. 2	Cat. 3	Cat. 4	Cat. 5**
Oral	mg/kg	≤ 5	≤ 50	≤ 300	≤ 2000	≤ 5000
Dermal	mg/kg	≤ 50	≤ 200	≤ 1000	≤ 2000	$\leq 5000^*$
Inhalation						
Gas	ppm	≤ 100	≤ 500	≤ 2500	≤ 5000	*
Vapour	mg/l/4h	≤ 0.5	≤ 2	≤ 10	≤ 20	*
Dust/Mist	mg/l/4h	≤ 0.05	≤ 0.5	≤ 1	≤ 5	*



Carcinogen Categories

CATEGORY 1: Known or presumed human carcinogens

Category 1A: Known to have carcinogenic potential for humans. Classification in this category is largely based on human evidence.

Category 1B: Presumed to have carcinogenic potential for humans. Classification in this category is largely based on animal evidence.

CATEGORY 2: Suspected human carcinogens



Ranking Tool



Microsoft Office
Excel Worksheet