

Functional substitution: expanding the possibilities

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Bottom Line

- Functional substitution - applying function as a lens to identify, evaluate, and select safer alternatives for achieving a particular function, end use, or service – can accelerate the development of and transition to safer alternatives
- Goal is informed transition – a considered transition to a chemical or non-chemical option that is safer and more sustainable using the best available information

Typical way address chemical risks

- Focus on the chemistry/chemistry type and a chemical-by-chemical approach (sometimes looking at groups)
- Focus on specific applications
- Focus on levels of exposure and risk management

Value of focusing on function

- Chemicals often serve important functions in processes and products.
- The chemicals currently used to perform a particular function may not be the safest option or the only way to achieve them.
- Sometimes the function isn't even needed or overprescribed.
- Starting with considerations of function provides a broader solutions-oriented lens to reduce risk associated with various chemical uses.

Defining Functional Substitution

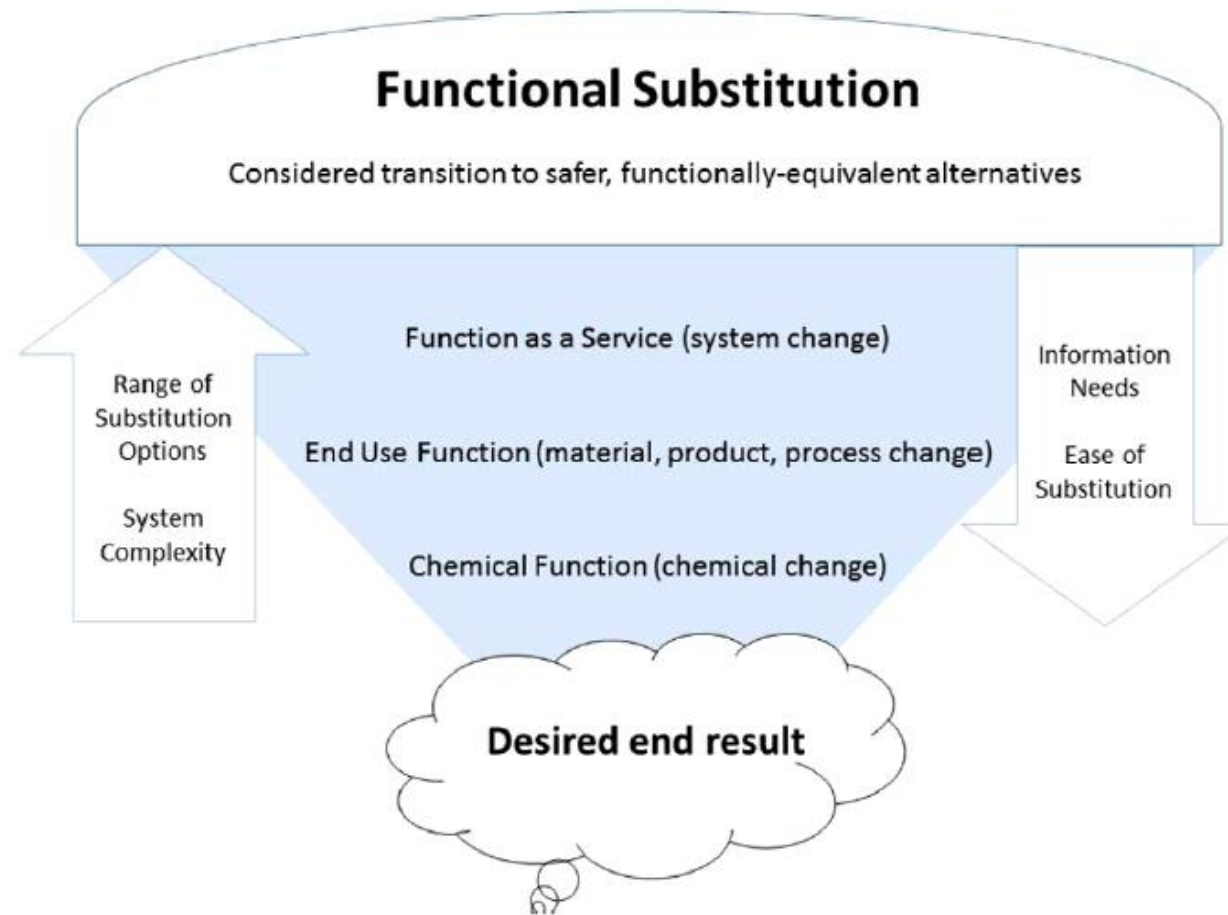
- The application of information on function to identify, evaluate, and select safer alternatives that achieve a particular result.
- Three conceptual levels
 - Chemical Function
 - End use function
 - Function as service
- Starting point is to understand the function and functional requirements. Is it necessary?

Examples of levels of Functional Substitution

Functional Substitution Level	Chemical in Product Bisphenol-a in Thermal Paper	Chemical in Process Methylene Chloride in Degreasing Metal Parts
Chemical Function (Chemical Change)	Is there a functionally equivalent chemical substitute (i.e., chemical developer)? Result: Drop-in chemical replacement	Is there a functionally equivalent chemical substitute (i.e., chlorinated solvent degreaser)? Result: Drop-in chemical replacement
End Use Function (Material, Product, Process Change)	Is there another means to achieve the function of the chemical in the product (i.e., creation of printed image)? Result: Redesign of thermal paper, material changes	Is there another means to achieve the function of the process (i.e., degreasing)? Result: Redesign of the process (e.g., ultrasonic, aqueous)
Function As Service (System Change)	Are cash register receipts necessary? Are there alternatives that could achieve the same purpose (i.e. providing a record of sale to a consumer)? Result: Alternative printing systems (e.g., electronic receipts)	Is degreasing metal parts necessary? Are there other alternatives that could achieve the same purpose (i.e., providing metal parts free of contaminants for other end uses)? Result: Alternative metal cutting methods

Tickner, et al. Environ. Sci. Technol. 2015, 49, 742–749

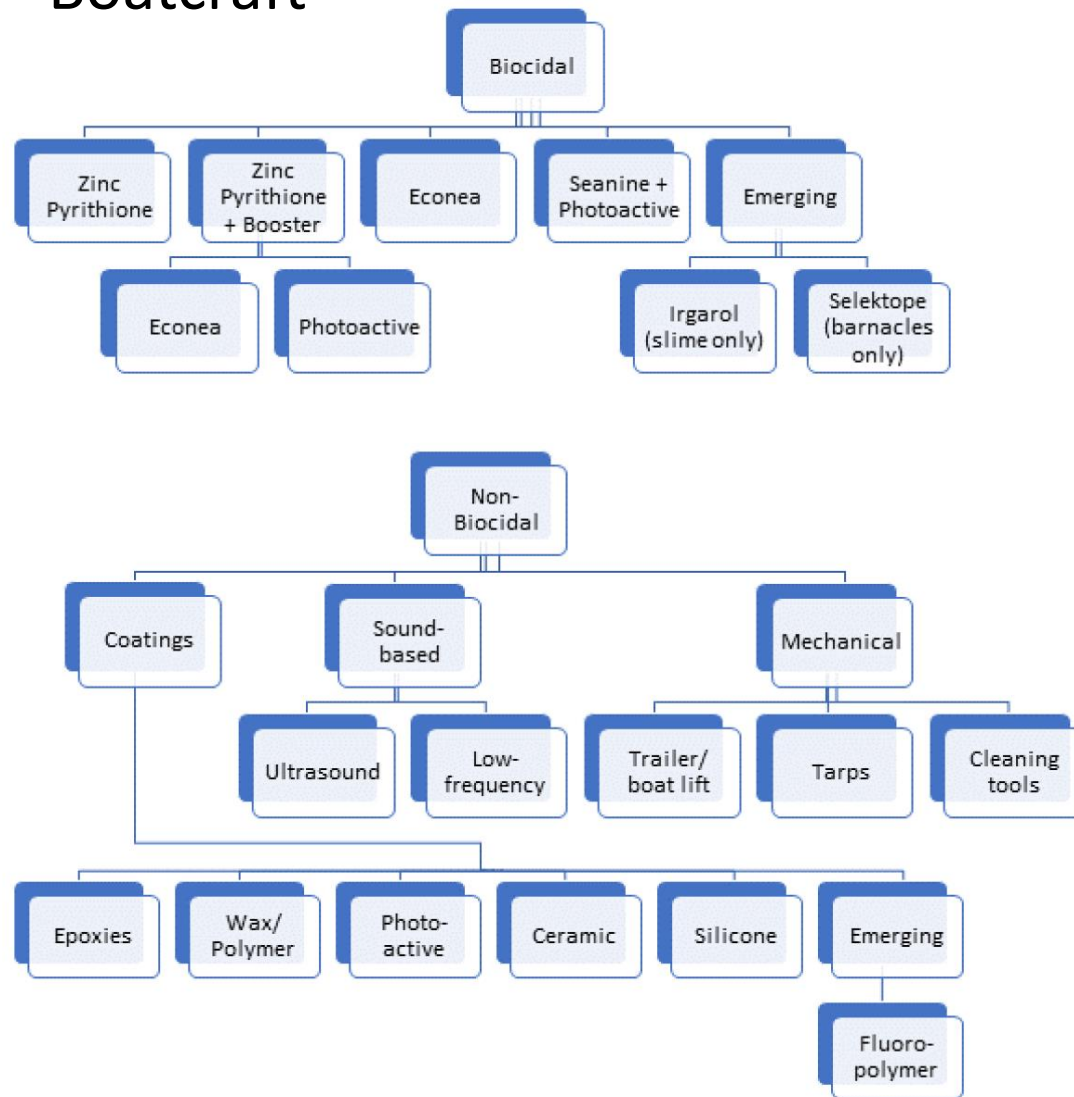
Moving towards a functional approach requires new information and a broader assessmer⁺



Needs for advancing functional-substitution-based approaches

- A system for consistent definitions, classification and characterization of functions
- Scientific tools to compare chemical and non-chemical alternatives for particular functions
- Rethinking measures of “performance”
- A broader engagement of stakeholders
- Models for translating a functional substitution approach into policy frameworks
 - Examples: Montreal Protocol; California Safer Consumer Products Act; US EPA Use Cluster Scoring

Example: Functional Substitution – Anti-Fouling for Recreational Boatcraft



<https://www.northwestgreenchemistry.org/news/release-of-the-washington-state-antifouling-boat-paint-alternatives-assessment-report>

Figure 4. Diverse mechanisms used to control hull fouling.

Lessons for Functional Substitution – Anti-fouling

- Stakeholder engagement is critical
- Hazards of alternatives vary across life cycle stages.
- Performance evaluation needs to involve users and must be designed to test a wide range of options.
- How costs are evaluated matters
- Alternatives may require changes in end-users' behavior and need support or new infrastructure.
- Education and awareness of alternatives is necessary
- A supportive policy environment is essential.

Applying Functional Substitution thinking about implications for biocides

- Is there a need for a specific biocidal function (what's the problem we are trying to solve and is the function necessary to achieve that goal).
- Is there an acceptable level of pests/contamination in specific circumstances
- Are there guidelines or laws might lead to requirements requesting a higher use of biocides than necessary – or only a specific type of alternative?
- Are there preventive measures against infestations that would eliminate the need for biocides or reduce the need for them?
- Are there functional (non-chemical) alternatives that could replace biocides?
- Are there safer chemistries that exist or could be designed to replace more toxic active ingredients
- [https://one.oecd.org/document/ENV/CBC/MONO\(2021\)4/en/pdf](https://one.oecd.org/document/ENV/CBC/MONO(2021)4/en/pdf)

Sustainable Use of Pesticides Directive as a model - DIRECTIVE 2009/128/EC

- Objective: This Directive establishes a framework to achieve a sustainable use of pesticides by reducing the risks and impacts of pesticide use on human health and the environment and promoting the use of integrated pest management and of alternative approaches or techniques such as non-chemical alternatives to pesticides.
- Goal is to substitute the use of pesticides and IPM techniques look at fundamental questions of need, tolerance levels, and a multitude of solutions to meet that need.
- Can this model be applied to biocides so that evaluation of alternatives as part of the substitution process for active ingredients requires examination of functional substitutes (<https://echa.europa.eu/regulations/biocidal-products-regulation/approval-of-active-substances>)

Thank You!

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For more information, visit:

Green Chemistry & Commerce Council (GC3) | www.greenchemistryandcommerce.org

Association for the Advancement of Alternatives Assessment (A4) | www.saferalternatives.org

Toxics Use Reduction Institute (TURI) | www.turi.org