The US-EPA Chemical Transformations Database (CHET)

A novel web application for storage, presentation, and comparative analysis of chemical transformations

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Motivation and Objective

Motivation: Chemicals in the environment are often transformed into different molecules in environmental and biological systems, and the resulting transformation products can differ from the parent chemical in their toxicity and physicochemical properties.

Objective: Collect data on a variety of chemical transformations from disparate sources and integrate them into a single database. Provide an interface for searching, filtering, comparing, and downloading data on chemicals, transformations, and transformation pathways from the database.

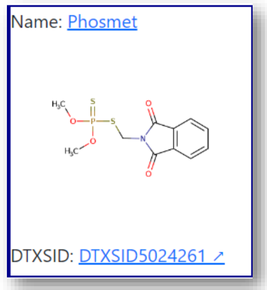
Abstract

Exposure and risk assessments generally focus on chemicals in their manufactured form, but most organic chemicals transform when they react with water or decompose via the action of sunlight, heat and other environmental conditions or are metabolized. These transformation products can have very different physiochemical properties and toxicity from their parent chemicals. The EPA Chemical Transformation Simulator (CTS) web-based application[1] can be used to predict the transformation of chemicals. The CTS uses a comprehensive database of reaction mechanisms to generate transformation products. To date, the underlying database has not been available. The US-EPA Chemical Transformations Database is a web-based application integrating the reaction libraries underpinning the Simulator with transformation data from other sources including the CompTox Chemicals Dashboard[2], publicly available data from the European Food Safety Authority, and subsets of data associated with the MetaPath database software. The Chemical Transformations Database application provides a flexible query interface and visualizations for interrogating a growing database of parent-product relationships. Transformations are searchable by chemical identifiers of parents and products (including DTXSID, InChI Key, CASRN, chemical name, and common synonyms). Reported data include reaction kinetics, experimental conditions and systems, and source information. Tools for editing, expanding, and exporting stored data and for visualizing and comparing reaction pathways are included.

The views expressed in this abstract do not necessarily reflect U.S. Environmental Protection Agency opinions or policy..

Data Sources and Validation

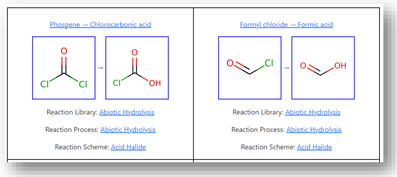
Chemicals are sourced from the underlying reaction libraries. Chemicals without DTXSIDs are then submitted for curation, evaluation, and entry into the DSSTOX database. Finally, chemicals and their associated DTXSIDs are added to the CHET database. Currently over 2000 chemicals and over 1700 transformations are stored in the database.



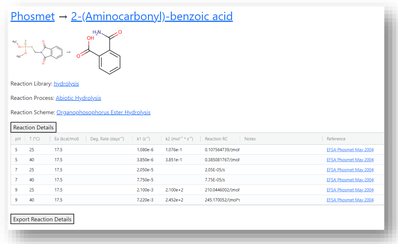
Phosmet in CHET

The Chemical Transformations Database (CHET)

The database can be searched by inputting a chemical identifier (individually or in a batch of many identifiers), browsing through chemicals or reactions contained within the database, or searching specific reaction libraries or schemes.



Search Results for Abiotic Hydrolysis

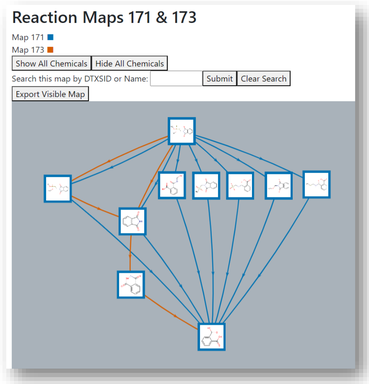


Typical Reaction Page

Reaction pages display details of the reaction including the library from which it derives, process, type, and scheme, as well as the kinematic or system information and notes recorded in its parent library and the original source for the reaction (hyperlinked where available). This information can be downloaded in CSV format from both the search and reaction pages.

Transformation Pathways and Comparisons

The underlying libraries for the CHET data often have maps of multiple related or sequential transformations. These reaction maps are stored in the database and can be viewed using a built-in visualization tool. Additionally, up to three maps can be viewed simultaneously to allow users to compare them. Furthermore, to help users explore reactions that have not been captured by a pre-specified map, the database can display a map of all chemicals connected by any sequence of reactions to a chemical of interest (with additional tools for highlighting existing maps or displaying only chemicals of interest).



Comparison of reaction maps

Future Work

- Expanding the database to include more reaction libraries and capture a greater part of possible chemical transformations
- Adding tools for handling unknown or missing chemicals, mixtures, and Markush representations in transformations where appropriate.
- Adding tools for representing and displaying predicted transformations and predicted kinematic values where appropriate

References

1. Prediction of Hydrolysis Products of Organic Chemicals under Environmental pH Conditions, Tebes-Stevens et al. https://doi.org/10.1021/acs.est.6b05412 accessible at https://qed.epa.gov/cts/
2. The CompTox Chemistry Dashboard: a community data resource for environmental chemistry, Williams et al. https://doi.org/10.1186/s13321-017-0247-6 accessible at https://comptox.epa.gov/dashboard

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