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Presence and Fate of Estrogenic Alkylphenols in Sewage Sludge

Overview

Alkylphenols (APs), biodegradation products from commonly used nonionic surfactants, are of interest because they have been shown to act as weak estrogens. While it is of interest to know how these compounds behave in a real-world setting by examining the amounts of these compounds in sewage sludge, it is also very important to understand the genetics and biochemistry associated with the biodegradation of APs since very little is known about the mechanism. The ultimate goal is to identify all of the genes involved in octylphenol biodegradation in order to look for expression of these genes in areas that have high levels of these compounds.

Environmental Issue

- Alkylphenol (AP) formation
  - APs form from the anaerobic biodegradation products of alkylphenol polyethoxylates (APEs), a class nonionic surfactants.
  - APEs have a multitude of uses, such as wetting agents and detergents. These are mainly found in the agricultural and industrial settings, but a small fraction can also be found in household cleaners and personal care products.
  - APs tend to persist in anaerobic environments, indicating that any biodegradation occurring under these conditions is very slow.
- AP as xenoestrogens
  - The most commonly used APs, octylphenol (OP) and nonylphenol (NP), have been implicated in changing sex ratios in certain fish populations, causing feminization of male trout, and reducing hatching rates in fish. There have also been instances of intersex, in which the individuals have both male and female gonadal characteristics

Research Approach

- Objective:
  - The goal is to study the amounts of APs in local sewage sludge, and to understand how these compounds are degraded in the environment
- Approach: A combination of analytical chemistry and molecular biology/biochemistry
  - This work offers a multi-disciplinary approach to studying APs in sewage sludge. The use of analytical chemistry techniques for examining the presence of APs in sewage sludge combined with microbiology and molecular techniques for examining biodegradation will present a more complete picture as to the fate of these compounds in the environment.
  - Previous work at Cornell by Pryor et. al (2002)* have showed NP concentrations in anaerobically digested sludge in New York State to range between 1,100 and 1,800 mg/kg, with the lowest concentration belonging to a waste water treatment plant accepting only domestic, not industrial, waste. These concentrations were much higher than other NP sludge concentrations in Canadian sludge.
  - Various techniques to screen our isolated organism for OP biodegradation genes will be employed. One such example is using Southern blots with probes generated against phenol biodegradation genes. Another method study this is to create a fosmid library in *E. coli* and screen these clones for OP-biodegradation activity. Fosmid libraries are comprised of F-type plasmids that are able to contain large fragments of unknown DNA.
  - Preliminary results in our lab have indicated that the first step in OP biodegradation occurs as ring hydroxylation (see Fig. 1) by a phenol monooxygenase, an oxygen-dependent enzyme.

***Pryor SW, AG Hay and Walker LP.** 2002. Environ. Sci. Technol. **36:**3678-3682.

Impact

Benefits of understanding the mechanism for biodegradation

- Currently there are known NP degrading organisms, but the pathway for both NP and OP is not known
- By understanding the genes associated with these processes it will be possible to make a determination as to whether or not biodegradation is occurring.
- Knowledge of the biochemistry of OP biodegradation could provide information to create better engineering solutions for OP removal.
- Realizing that the initial aerobic biodegradation step appears to be oxygen dependent and that APs tend to be recalcitrant in anaerobic environments, this will also provide a better understanding of the environmental constraints to biodegradation, such as oxygen limitations.

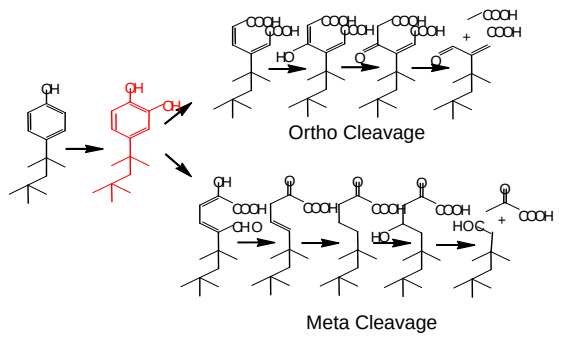

Fig. 1. A diagram of the possible pathway for OP biodegradation. The ring hydroxylation product is the red molecule. The type of ring cleavage (ortho or meta) is unknown.

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