

Green Chemistry Module for Environmental Chemistry

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Topic: Sea-nine
Antifoulant

A Marine Pesticide

Chemical Pesticides

- Insecticides
- Herbicides
- Disinfectants
- Rodenticides
- Algicides
- Molluscicides
- Piscicides
- Fungicides
- Avicides

Foulants

- Soft Foulants (algae and seaweed)
- Hard Foulants (barnacles and diatoms)

\$ Costs of Fouling

- Increased fuel consumption, \$3 billion/year
- Increased time in Dry-dock, \$2.7 billion/year

\$ To clean ship

\$ For being out of service

Environmental Costs of Fouling

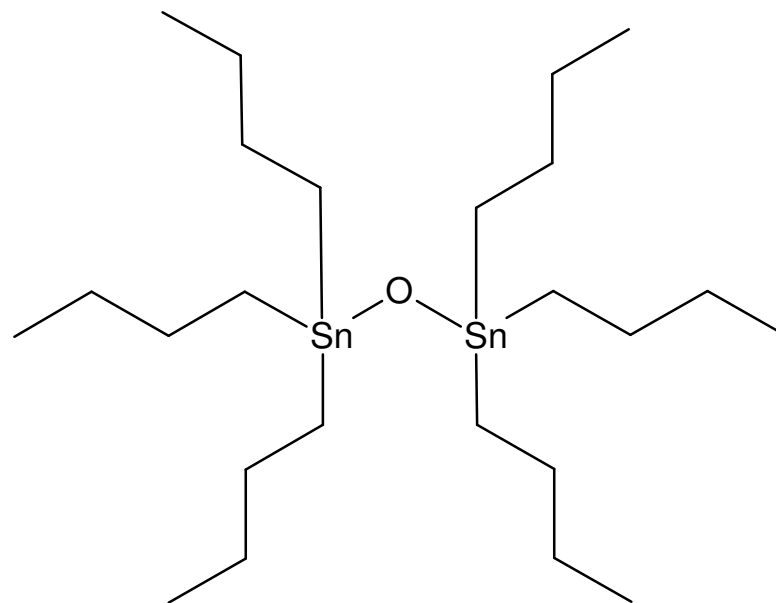
- Increased consumption of fossil fuels (a nonrenewable resource)
- Increased formation of carbon dioxide (a greenhouse gas)
- Increased formation of other atmospheric pollutants (nitrogen oxides, sulfur oxides, unburned hydrocarbons, ozone etc.)

Antifoulants

- Used to control the growth of marine organisms (algae and seaweed-soft foulants; barnacles and diatoms-hard foulants)
- Usually mixed with the paint as it is applied to the hull
- Slowly leach from the surface of the hull

Organotin Antifoulants

- Tributyltin Oxide
TBTO



Environmental Concerns of TBTO

- Half-life of TBTO in seawater is > 6 months
- Bioconcentration, 10^4
- Chronic Toxicity
 - ✓ Thickness of oyster shells
 - ✓ Sex changes in whelks
 - ✓ Imposex in snails
 - ✓ Immune system in dolphins and others?

Ban on Organotin Antifoulants

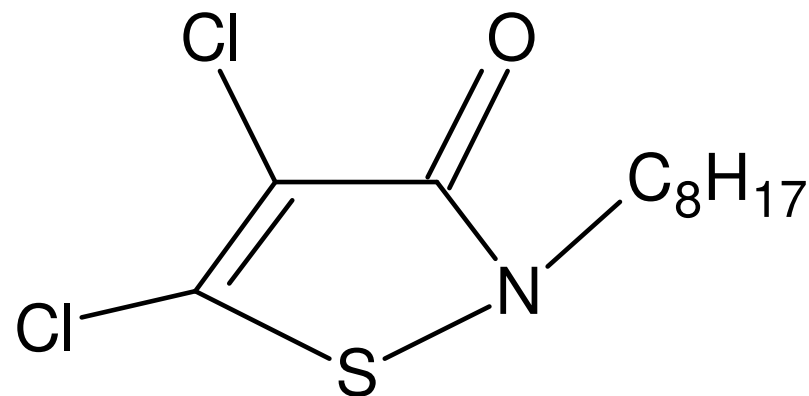
- US -Organotin Antifouling Paint Control Act of 1998 (OAPCA)
- Ban by Japan
- International Maritime Organization (IMO) complete ban on 1/1/03

Environmentally Preferable Antifoulants

- Ideal Properties
 - ✓ Rapid degradation
 - ✓ Nonhazardous environmental concentrations
 - ✓ Limited bioavailability
 - ✓ Toxic only to target organisms
 - ✓ Minimum Bioconcentration

Sea-Nine 211 Antifouling

- Rohm and Haas
- Presidential Green Chemistry Challenge Award
- Active ingredient
4,5-dichloro-2-n-octyl-4-isothiazolin-3-one
(DCOI)
- Mode of action



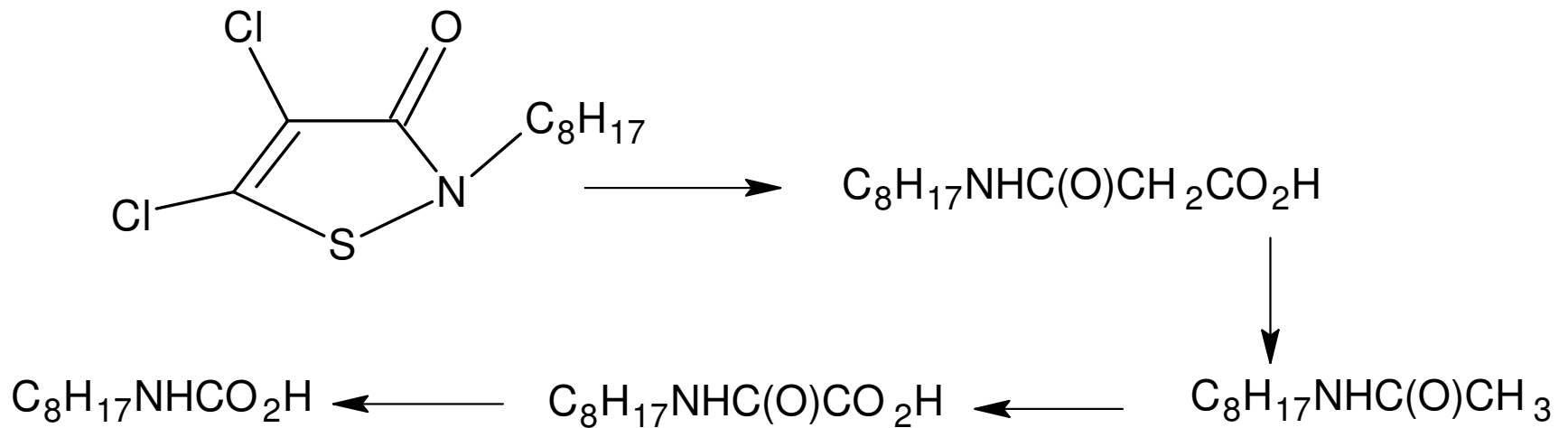
Environmental Risk

- $ER = f(\text{toxicity and exposure})$
- DCOI limits ER by limiting exposure

Properties of DCOI

- Acutely toxic to a wide range of marine organisms (effective antifoulant)
- Rapid biodegradation to nontoxic products
($\frac{1}{2}$ life < 1hour)
- Low Bioconcentration
(bioconcentration =13)
- Environmental Conc. < Acute Toxicity level
- No Chronic Toxicity
- Rapid partitioning to the sediment
(low bioavailability)

Biodegradation of DCOI



Risk Quotient

$$RQ = PEC/PNEC$$

- DCOI RQ = 0.024-0.36
- TBTO RQ = 15-430

PEC (predicted environmental concentration)

PNEC (predicted no-effect environmental concentration)