

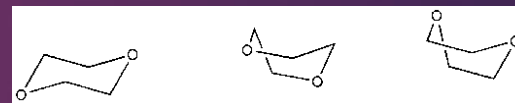
# 1,4-Dioxane Removal from Personal Care Products – Opportunities, Benefits, and Costs

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1,4-DIOXANE AND OTHER SOLVENT STABILIZERS" (CRC PRESS, 2010)



# MOTIVATION: Why remove 1,4-dioxane?

- ▶ **If not mandated by regulation, what is the incentive to remove 1,4-dioxane and add to production costs?**
- ▶ **If the majority of public water supply wells with 1,4-dioxane contamination appear to be associated with chlorinated solvent release sites, what is the benefit?**
- ▶ **If the toxicology used to establish risk from ingesting or inhaling 1,4-dioxane is unsettled, why invest in 1,4-dioxane removal?**

# BENEFITS to 1,4-dioxane Removal

- ▶ **REDUCE EXPOSURE:** *Domestic wells serve >13 million families in USA (~1.2 million people in California).* Nearly all households using domestic wells are also on septic tanks, which do not effectively remove 1,4-dioxane. There have been numerous instances of 1,4-dioxane contamination of domestic wells emanating from septic tank effluent.
- ▶ **REDUCE RISK:**
  - ▶ 1,4-Dioxane is not a tumor initiator, but it is classified as a tumor promoter.
  - ▶ We are rarely exposed to one chemical at a time.
  - ▶ The synergistic effects of exposure to multiple chemicals by multiple routes of exposure at different life stages is unknown, but may be more than additive.
  - ▶ In the face of uncertainty regarding adverse outcomes from chemical exposure, applying the Precautionary Principal is a prudent way to protect the development of healthy children in utero, as infants, children, and to protect other sensitive populations.

# BENEFITS to 1,4-dioxane Removal

- ▶ **REDUCE RISK:** 1,4-dioxane's limited or low dermal toxicity has led FDA and industry toxicologists to regard 1,4-dioxane as "safe" for wastewater and effluent discharge to rivers.
  - ▶ The contribution of 1,4-dioxane to domestic wells, surface water intakes for drinking water plants, and indirect potable reuse of recycled water has not been fully considered in plant design.
  - ▶ In addition to ingestion and inhalation risks, the risk from dermal exposure can vary six-fold between adults and infants by skin location (adult male forehead vs. infant scrotum).
- ▶ Sodium Laureth Sulfate in chemical mixtures enhances the dermal absorption of dioxane; ethanol was found to have the greatest ability to increase the dermal permeation of dioxane (Mahdi, 2014)

# BENEFITS to 1,4-dioxane Removal

- ▶ **REDUCE LIABILITY:** Manufacturers of products containing residual 1,4-dioxane as a by-product of surfactant production may face product liability litigation. Cases are pending in New York.
- ▶ **MARKETING:** Numerous brands have enhanced their image by marketing their products as “free of toxic chemicals”.
- ▶ Green marketing has been leveraged to raise brands’ profiles among a consumer base whose environmental conscience leads them to select non-toxic products. For example, ECOS marketed a “1,4-Dioxane Free” detergent.

# COSTS to Remove 1,4-Dioxane from Surfactant-based products

- ▶ 1,4-dioxane is *hydrophilic*, i.e. infinitely soluble in water and many other media, owing to its high polarity.
- ▶ High solubility means it is difficult to strip 1,4-dioxane from finished products, i.e., 1,4-dioxane is not volatile.
- ▶ 1,4-Dioxane volatility increases with decreasing pressure. Heating a product and dividing it into fine droplets can enhance stripping, as can maximizing surface area using trays, membranes, or packing media. Vacuum stripping has been patented for 1,4-dioxane removal from surfactant concentrates.

# Do Non-Consumer Surfactant Uses Comprise a Significant Source of 1,4-Dioxane?

## Draft Progress Report

January 16, 2013

### Sample Information

Matrix: OIL  
 Location Code: **Car Wash Soap Co**  
 Rush Request: 24 Hour  
 P.O.#:



### Laboratory Data

Project ID: DIOXANE-TEST  
 Client ID: K1215

Parameter	Result	RL/ PQL	Units	Date
<b>1,4-dioxane</b>				
1,4-dioxane	760000	100000	ug/kg	01/16/13

- Car Washes
- Fleet Washing
- Industrial Laundries
- Degreasing

760 mg/kg  
 1,4-dioxane in  
 car wash soap concentrate

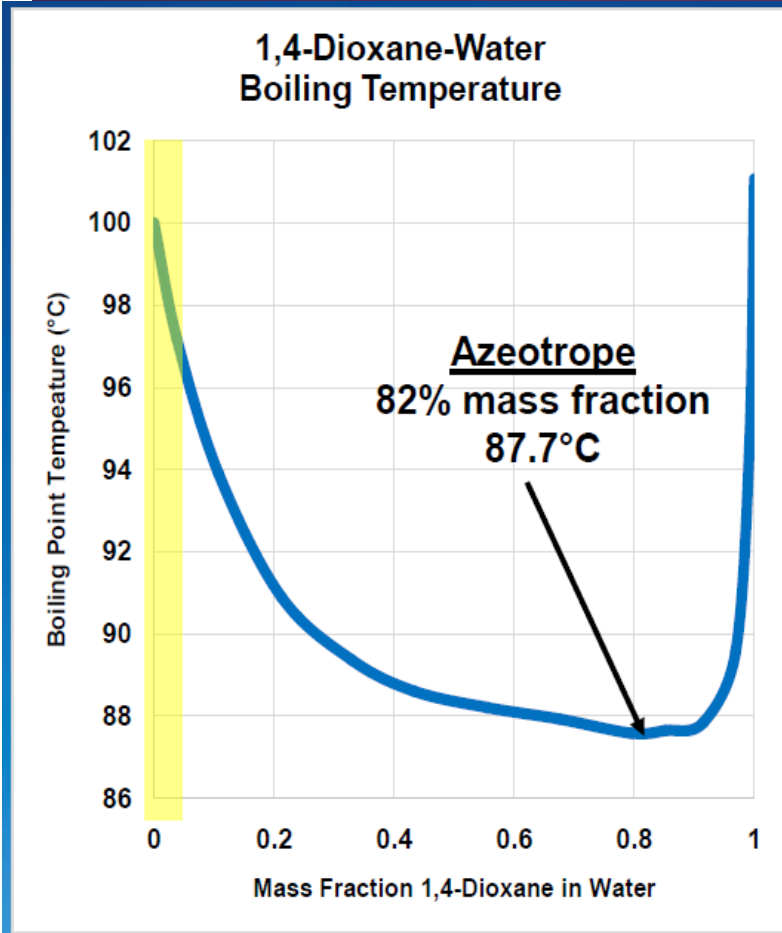
New Hampshire DES  
 January 2013

# COSTS to Remove 1,4-Dioxane from Surfactant-based Products

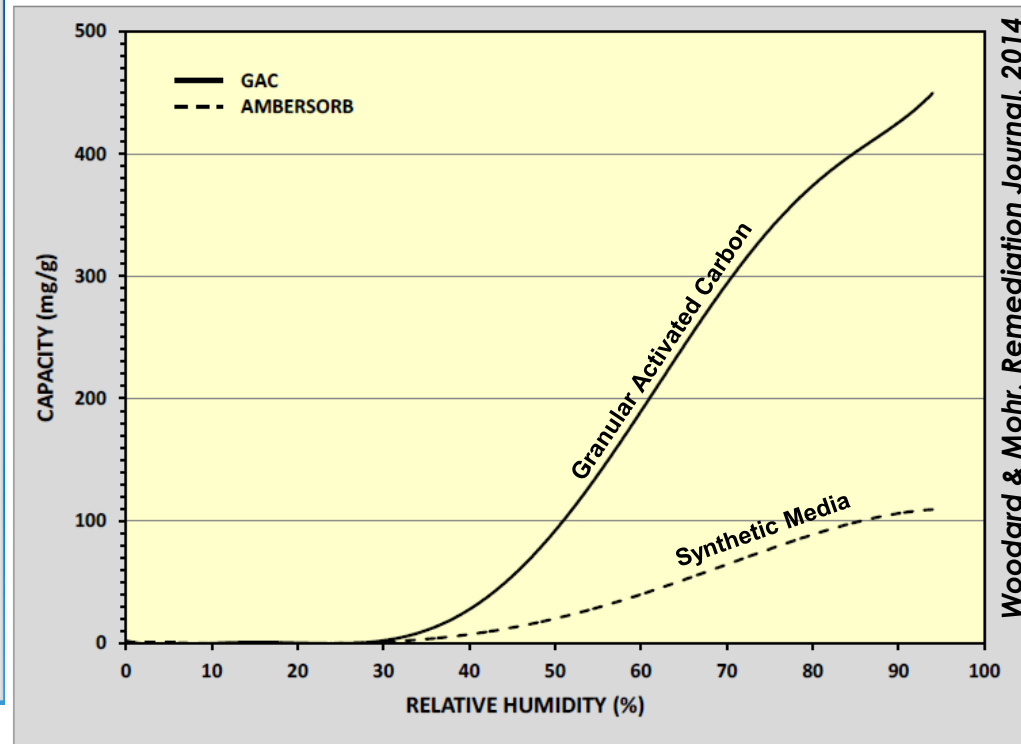
- ▶ **Chemical Engineering** requirements to remove 1,4-dioxane, while preserving key product attributes, are complex, but nonetheless attainable
- ▶ Since 1980 or earlier, surfactants industry has identified the formation of 1,4-dioxane as an impurity of alcohol ethoxy sulfate based surfactants
- ▶ Successful process modifications have been undertaken since 1997 and again more recently to limit the degree of 1,4-dioxane formation, and to remove 1,4-dioxane from products.
- ▶ Example: 2009 – Cognis innovates improvements to production line to substantially reduce 1,4-dioxane formation
- ▶ 2013: Procter & Gamble reformulates Tide to reduce 1,4-dioxane contamination
- ▶ Chemithon Dioxane Removal System for AES production lines: 8-fold reduction
- ▶ Reducing the SO<sub>3</sub> gas concentration from 4% to 2.5% cuts amount of 1,4-dioxane in half, but also significantly impacts productivity rates, and may impact product quality



# Dioxane Waste Stream Treatment is Manageable, but Costly



Scheider and Lynch, *J Am Chem Soc* 65(6), 1943



Woodard & Mohr, *Remediation Journal*, 2014

# COSTS to Remove 1,4-Dioxane: Limits

- ▶ Regulation of 1,4-dioxane in surfactant-based consumer products should not place U.S. manufacturers at a disadvantage to imported products; all products must be held to the same standard.
- ▶ A “zero 1,4-dioxane” limit is not realistic, as the threshold of detection gets lower and lower.
- ▶ A consumer product dioxane limit should account for dilution factors for three scenarios:
  - ▶ Surface water intakes downstream of wastewater treatment plants and industrial dischargers
  - ▶ Domestic wells with well screens in close proximity to septic leach fields
  - ▶ Production wells whose zones of contribution include irrigation with tertiary treated recycled water and exfiltrating sewer lines (4-10% loss is common).
- ▶ Intrinsic biodegradation of 1,4-dioxane, while proven to occur, should not be relied upon to calculate concentration reduction, as it occurs very slowly and has not slowed migration at numerous groundwater contamination sites.