A “Green Oxidant” for In-Situ Chemical Oxidation

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The New Era of Environmentalism

- **Green**
- **Sustainable**
- **Renewable**

Energy
Chemistry
Vehicles
Farming
Technologies
Lifestyles
Resources
Feedstocks
Fuels
Companies

Environmental Remediation: Impacts from the Approaches we take

- Mitigates the effects of toxic chemical releases
- Smaller environmental impact than physical systems
- Commodity and Specialty chemicals employed for in-situ remediation
  - “Green” is a continuum
  - Assessing/comparing environmental impact across technologies is difficult without a universal accounting standard

US EPA Definition

"Green chemistry consists of chemicals and chemical processes designed to reduce or eliminate negative environmental impacts"

- Reduced waste Products
- Non- toxic components
- Improved efficiency

http://www.epa.gov/greenchemistry/pubs/about_gc.html

ACS and US EPA Book Citation

Green Chemistry: Theory and Practice
Paul Anastas and John Warner
Oxford University Press: New York, 1998

- Manufacture
- Use
- Residuals

12 Principles of Green Chemistry

http://www.epa.gov/greenchemistry/pubs/about_gc.html

12 Principles of Green Chemistry

I. Prevent waste
II. Design safer chemicals and products
III. Design less hazardous chemical syntheses
IV. Use renewable feedstocks
V. Use catalysts, not stoichiometric reagents
VI. Avoid chemical derivatives

12 Principles of Green Chemistry

VII. Maximize atom economy

VIII. Use safer solvents and reaction conditions

IX. Increase energy efficiency

X. Design chemicals and products to degrade after use

XI. Analyze in real-time to prevent pollution

XII. Minimize the potential for accidents

RegenOx™

GREEN CHEMISTRY

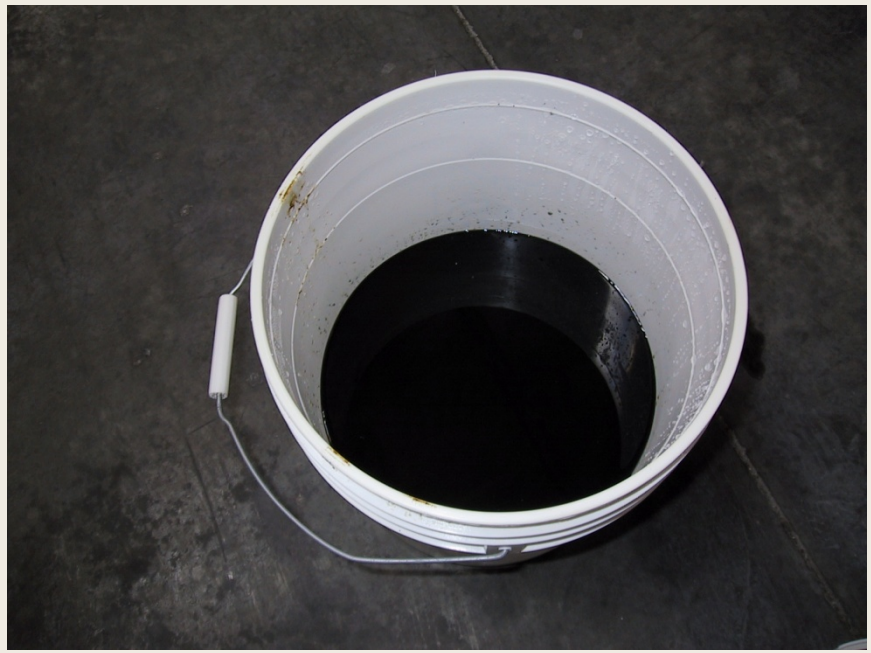
In Situ Chemical Oxidation

- Regenesis technology, patent pending
- Fast and complete reaction with contaminants
- Treats a wide range of contaminants
- Does not leave toxic or undesired residual byproducts
  - Effective transition from ISCO to bioremediation
- Cost Effective
- Easy to apply
- Safe

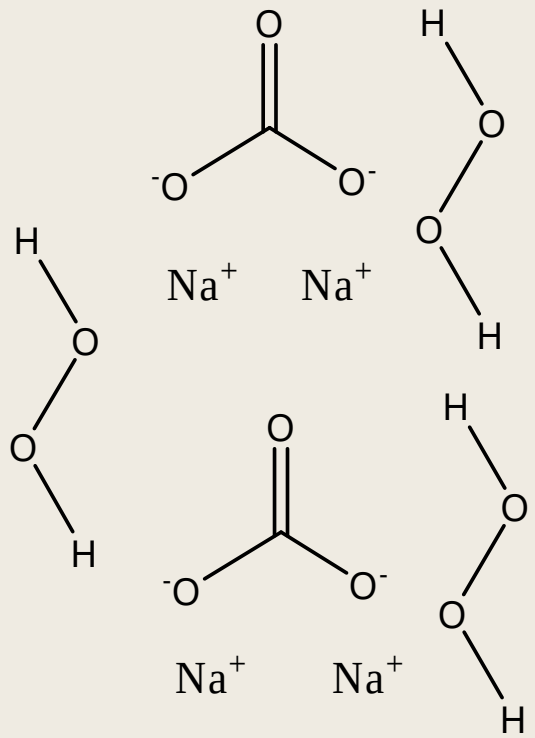
Two Part Formulation

Part A: Solid Oxidizer Complex

Part B: Liquid Activator Complex



Activated Sodium Percarbonate

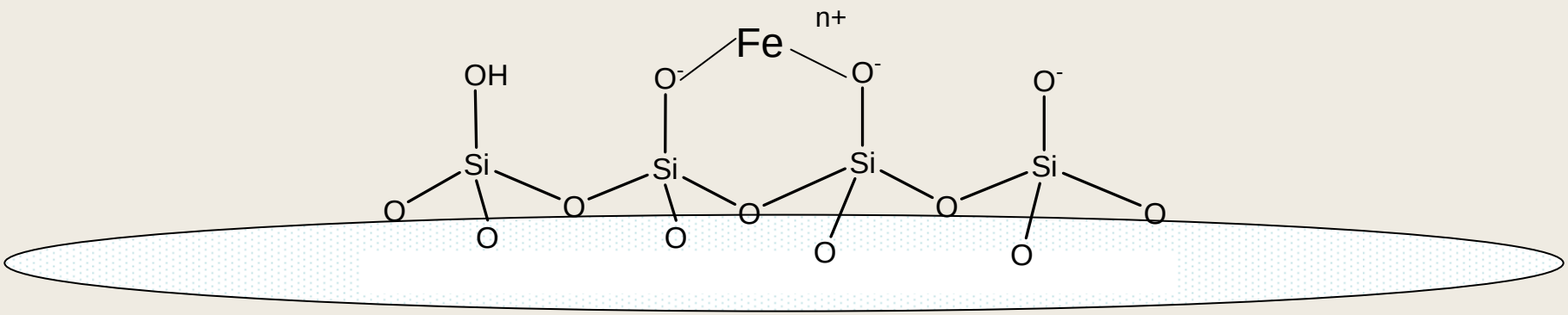


- RegenOx™ Part A: Oxidizer
  - Formulation of Sodium Percarbonate
  - Easy to handle
  - Non-corrosive

Catalyst System

RegenOx Part B: catalyst (activator)

- Alkaline formulation of silicates and iron
- Forms catalyst particles upon dilution



Silica particle surface

Chemistry of Contaminant Destruction

Catalytic peroxide activation and contaminant degradation under alkaline conditions

- **Desorption** (detergent-like properties)
- **Surfactants generated by oxidation of organics**
- **Surface-Mediated Oxidation**
  - Adsorption➔Degradation
- **Direct Oxidation**
  - Highly-active iron centers
- **Free Radical Oxidation**

Six Green Principles regarding Manufacturing

GREEN CHEMISTRY

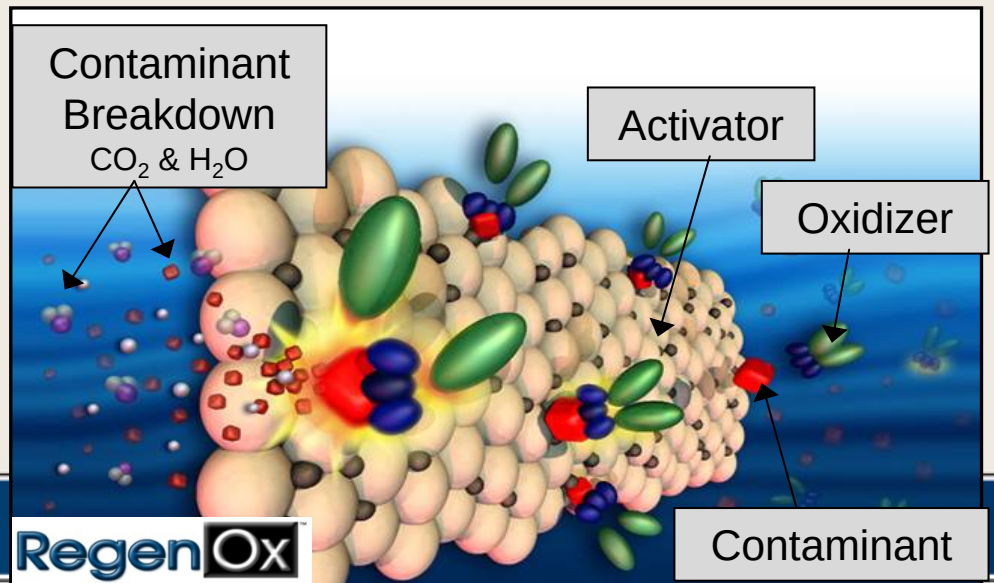
1. Prevent waste
2. Design less hazardous chemical syntheses
3. Avoid chemical derivatives
4. Maximize atom economy
5. Use safer solvents and reaction conditions
6. Increase energy efficiency

Two Green Principles Regarding Use

GREEN CHEMISTRY

7. Use catalysts, not stoichiometric reagents

The part B (catalyst) provides for selective, efficient, preferential oxidation of contaminants



Two Green Principles Regarding Use

8. Minimize the potential for accidents

Lacks the corrosivity and temperature increases associated with other oxidants

Compatible with Engineering Equipment?

Compatible with Engineers?

Two Green Principles Regarding Fate

9. Design safer chemicals and products

   RegenOx components: percarbonate, silicates, silica, and iron salts are very low toxicity

10. Design chemicals and products to degrade after use

    Residuals after oxidation are carbonates, silicates, iron oxides, and other low-toxicity soil-like materials

Remaining Two Principles

11. Use Renewable Feedstocks

Inorganics are typically not considered renewable

12. Analyze in real time to prevent pollution

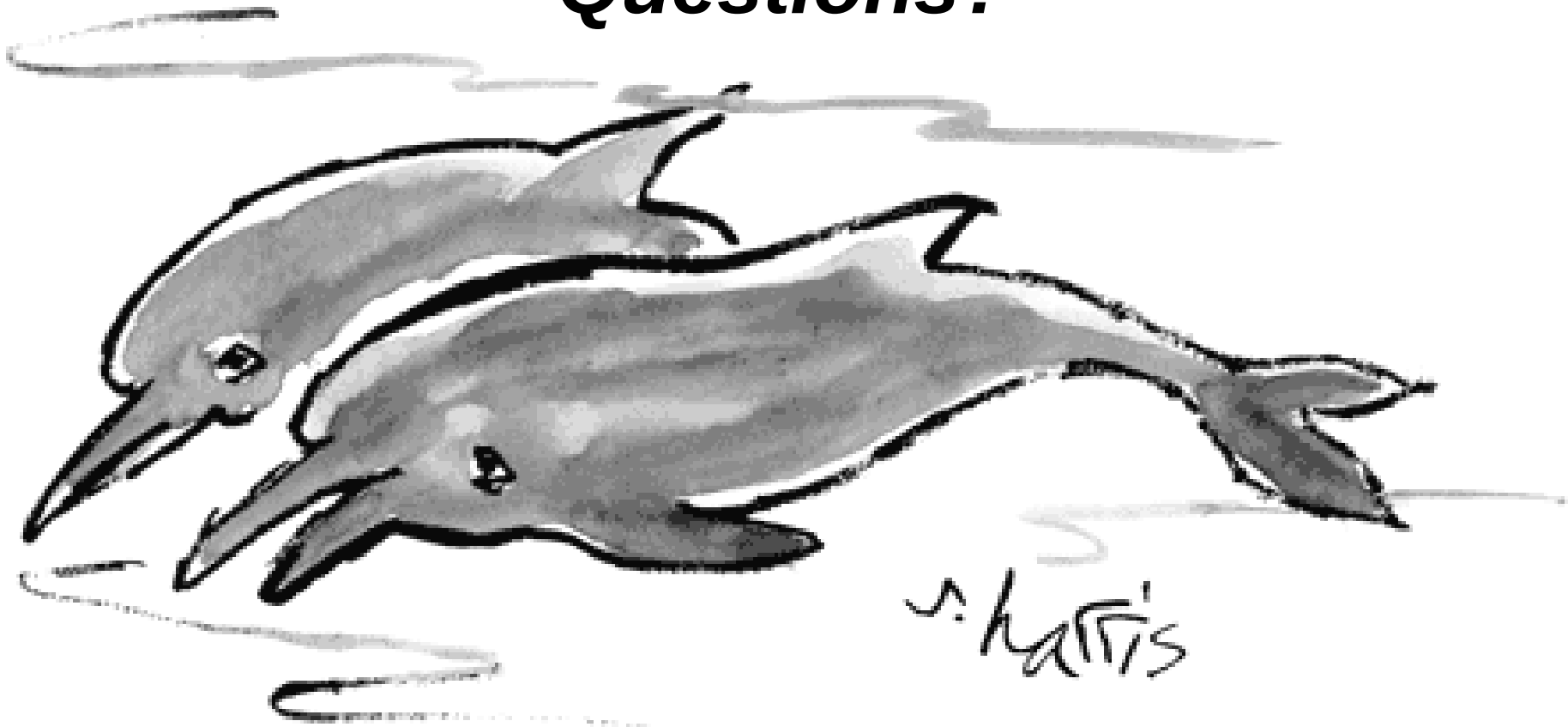
N/A

Conclusions

- ACS and EPA are providing guidance on Green Chemistry
- Regenesis' activated sodium percarbonate is a "Green" ISCO technology (10/12 principles)
  - Manufacture
  - Use
  - Residuals

- It has been applied on > 500 sites to date

Questions?



"Although humans make sounds with their mouths, and occasionally look at each other, there is no solid evidence that they actually communicate among themselves."

Thank You

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