ProChemTech
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The USEPA utilizes the "The Twelve Principles of Green Chemistry" as published by Anastas and Warner in "Green Chemistry: Theory and Practice", Oxford University Press, New York, NY, 1998, to evaluate the environmental impact of chemical production operations and the products produced. We have evaluated ProChemTech production operations, products, and technologies against these twelve principles as follows:

1. **Prevent waste:** Design chemical syntheses to prevent waste, leaving no waste to treat or clean up.

   By careful selection of raw materials and formula design, our production processes produce no byproducts or waste for disposal. The only process waste produced by our two chemical manufacturing plants is rinse, or cleanup, water. The Apache Junction, AZ, plant is zero process wastewater discharge, all rinse waters are evaporated. At the Brockway, PA, plant, all rinse waters are checked and batch treated, if needed, prior to permitted discharge to the local POTW.

2. **Design safer chemicals and products:** Design chemical products to be fully effective, yet have little or no toxicity.

   Biocide products are the most toxic products utilized in water management programs. We have addressed this problem by commercialization of our electrolytic bromine (ElectroBrom and MiniBrom) technology, which utilizes no toxic materials in the process and which uses renewable resources. It is the only biocide available which does not use hazardous chemicals.

   We have had a continuing effort to reduce the toxicity and hazards associated with water management products for the past ten years. A typical formula revision would involve removal of sodium hydroxide from a product to reduce its pH, changing it from a hazardous corrosive to a non-corrosive product. The result is that the many of our products are now non-hazardous and non-toxic.

   Molybdenum, noted by the USEPA to cause problems with reuse of POTW sludge, has been almost totally eliminated from our product line. It has been replaced as a tracer in our products by food grade colorants (BlueTrace).

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3. **Design less hazardous chemical syntheses:** Design syntheses to use and generate substances with little or no toxicity to humans and the environment.

   As noted in items 1 and 2, our production processes produce no process wastes while many of our finished products have no or minimal toxicity. The electrolytic bromine technology we developed replaces an entire class of extremely toxic, hazardous chemicals (biocides) used for control of micro-organisms in cooling waters.

4. **Use renewable feedstocks:** Use raw materials and feedstocks that are renewable rather than depleting. Renewable feedstocks are often made from agricultural products or are the wastes of other processes; depleting feedstocks are made from fossil fuels (petroleum, natural gas, or coal) or are mined.

   Electrolytic bromine is unique in that the basic raw material, bromide ion, is found at a level of 65 mg/l in sea water and that when used in our process is eventually returned to the sea. It is the only water management chemistry which is totally renewable.

   Product containers are the largest user of depletable feedstocks in the water management business. We have addressed this issue by accepting return of all our product containers for either reuse or recycle.

   To reduce shipping costs and use of petroleum based fuels, all of our products are formulated to provide the maximum amount of actives per pound of product. In several cases, our products provide more actives per pound than equal chemistry non-liquid, or solid, products.

5. **Use catalysts, not stoichiometric reagents:** Minimize waste by using catalytic reactions. Catalysts are used in small amounts and can carry out a single reaction many times. They are preferable to stoichiometric reagents, which are used in excess and work only once.

   As noted, no process wastes are produced during production of our water management products in our two plants due to careful selection of raw materials and formulation.

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6. **Avoid chemical derivatives:** Avoid using blocking or protecting groups or any temporary modifications if possible. Derivatives use additional reagents and generate waste.

   Our production processes use no blocking or protecting groups, or any temporary modifications.

7. **Maximize atom economy:** Design syntheses so that the final product contains the maximum proportion of the starting materials. There should be few, if any, wasted atoms.

   All of the raw materials that enter our reactors leave as finished product, we waste no atoms.

8. **Use safer solvents and reaction conditions:** Avoid using solvents, separation agents, or other auxiliary chemicals. If these chemicals are necessary, use innocuous chemicals.

   We do not use any solvents, separation agents, or other auxiliary chemicals in our production processes.

9. **Increase energy efficiency:** Run chemical reactions at ambient temperature and pressure whenever possible.

   The vast majority of our reactions are exothermic, we actually must cool the reactors. A recent upgrade project reduced the cooling system power requirements at the Apache Junction plant from 20 horsepower to 8 horsepower via installation of a new, much more efficient cooling tower. We continue to review our production processes to reduce our plant energy use per pound product produced.

10. **Design chemicals and products to degrade after use:** Design chemical products to break down to innocuous substances after use so that they do not accumulate in the environment.

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All of our water management products are designed to break down following use into innocuous substances. A good example is our replacement of molybdenum, a heavy metal element which does not break down, as a tracer in cooling water products with food grade organic colorants (BlueTrace), which are readily biodegraded.

Our electrolytic bromine process was recently tested in a cooling tower for persistence of the produced biocide, we found that it had degraded to non-detectable levels in less than one hour following end of the dose period.

11. **Analyze in real time to prevent pollution:** Include in-process real time monitoring and control during syntheses to minimize or eliminate the formation of byproducts.

Our production processes are all batch type so real time monitoring is not applicable. All of our formulations are designed to eliminate formation of any byproducts.

12. **Minimize the potential for accidents:** Design chemicals and their forms (solid, liquid, or gas) to minimize the potential for chemical accidents including explosions, fires, and releases to the environment.

The majority of our chemical products are non-hazardous and thus present minimum risk for chemical accidents.

Our electrolytic bromine biocide system represents a paradigm shift in reduction of the potential for chemical accidents. The total elimination of many millions of pounds of hazardous, toxic chemicals from commerce will substantially improve chemical safety in the water management field.

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