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Office of Pollution Prevention

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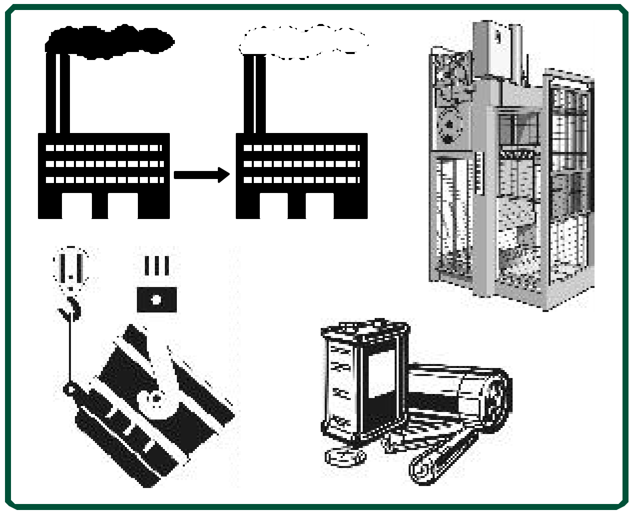
Pollution Prevention Opportunities for PBT Chemicals

Phenol

A number of effects from breathing phenol have been reported in humans. Short-term effects include respiratory irritation, headaches and burning eyes. Chronic effects of high exposures include weakness, muscle pain, anorexia, weight loss and fatigue. Effects of chronic low-level exposures include increases in respiratory cancer, heart disease and effects on the immune system.

Repeated exposure to low levels of phenol in drinking water has been associated with diarrhea and mouth sores in humans. Ingestion of very high concentrations of phenol has resulted in death.

People who had skin exposure to phenol experienced liver damage, diarrhea, dark urine and red blood cell destruction. Skin exposure to a relatively small amount of concentrated phenol has resulted in the death of humans. It is not known if phenol alone causes cancer in humans.



Phenol is used primarily as an intermediate in the production of phenolic resins. It is used in the manufacture of nylon, polycarbonate and epoxy resins. Phenol also is used in slimicides (chemicals that kill bacteria and fungi in slimes), as a disinfectant, as an antiseptic and in medicinal preparations, such as mouthwash and sore throat lozenges.

Where are Opportunities for Pollution Prevention?

Phenol exists naturally and is manufactured in large quantity. It is found in nature in some foods, in human and animal wastes, and in decomposing organic material. Phenol is produced by the body and excreted independent of external exposure or intake.

What is Pollution Prevention?

Pollution prevention means using source reduction techniques in managing waste problems and, as a second preference, environmentally sound recycling. The benefits of practicing pollution prevention include reduced operating costs, improved worker safety, reduced compliance costs, increased productivity, increased environmental protection, reduced exposure to future liability costs, continual improvement, resource conservation and enhanced public image. For more details, see Ohio EPA's Office of Pollution Prevention fact sheet, *What Is Pollution Prevention?* at **www.epa.state.oh.us/opp/fact1_web.pdf**.

Phenol Pollution Prevention in Industries

Pollution prevention in a manufacturing setting generally means material substitution, process improvement and product change or redesign. Often, pollution prevention practice involves applying one or more of these strategies in tandem.

Process Improvement means to improve the operational process, thereby reducing or eliminating the need for phenol usage. This includes, for example, increasing the operating efficiency of an equipment or a process, good maintenance programs and training to reduce the risk of waste generation.

A chemical manufacturer produces phenol and phenol derivatives. By upgrading the packing in two phenol stripping columns, it was able to reduce wastewater generation by four million gallons a year. In the extractive distillation column, the packing was replaced with graphite trays. This modification decreased the amount of phenol in the wastewater by 147,000 pounds a year.

Material Substitution is to use a different material or materials that are less toxic or nontoxic. This may include the use of a phenol-free raw material or different equipment that does not require phenol.

Product Change or Redesign has the potential to eliminate the phenol usage altogether from the manufacturing process, especially where phenol becomes incorporated into the product.

The manufacturing process for traditional fiberglass insulation products utilizes a thermosetting phenol-formaldehyde-based resin or binder. Glass fibers will not stick together by themselves. To hold the glass fibers together an adhesive (called a binder) is sprayed on the fibers. After curing in an oven, the binder holds the fibers together to keep their shape and overall form. This results in corresponding releases of ammonia, formaldehyde and phenol.

Recently, a line of insulation products that utilizes a new acrylic-based binder has been introduced. The acrylic binder used in this new fiberglass holds the fibers together just like the phenol-formaldehyde resin used in conventional fiberglass. It is a thermosetting resin and heat is used to cure the binder same as with the traditional process.

Another new product is produced by fusing two different types of glass together. This results in a naturally curly fiber. The glass fibers intertwine and lock themselves together. The binder is eliminated from the manufacturing process of this new product.

This new product also has some additional benefits, according to the manufacturer. The fibers are more resilient, stronger and less prone to breakage, so fewer fiber particles will get into the air or into the installer's skin. The company describes the material as non-itchy. Further, because the new product is more springy than conventional fiberglass and made without binders, rolls can be packed much more tightly. Rolls of this new product rated at R-25 are just 13.8 inches in diameter, compared with rolls of conventional fiberglass that are 27.6 inches in diameter. This means that shipping is considerably more efficient.

Systematic Approaches to Pollution Prevention

A systematic approach to pollution prevention establishes and maintains a systematic management plan designed to continually identify and reduce environmental impacts through pollution prevention. Many facilities are incorporating pollution prevention into their quality programs or environmental management systems.

A producer of phenol and phenol-derivative chemicals was generating phenol-containing wastewater from its bisphenol A (BPA) plant. The possibility of recovering phenol from this process water was investigated. The sources of the water streams from the BPA plant were studied for flow, phenol concentration and variability. The principle source of water was from the hydrochloric acid (HCl) recovery process. It was found to have a wide variability in phenol concentration due the operational and mechanical instabilities of the HCl recovery column.

The facility studied distillation, adsorption and liquid-liquid extraction as possible phenol recovery technologies.

Distillation was determined to be infeasible as the distillate phenol stream would be too high in water content to be returned directly to any on-site processes. The facility further considered concentrating the recovered phenol using membrane technology. This technology was found to be untried in this service and extremely expensive.

Adsorption processes using either a resin or activated carbon were studied. While these were potentially feasible, they were rejected due to operational concerns and high capital and operating costs.

Liquid-liquid extraction using cumene with a caustic wash to recover the extracted phenol was investigated thoroughly in the laboratory and in a pilot operation. This scheme proved to be effective in removing phenol. But there were major drawbacks. The recovered phenol contained caustic which could not be returned to the BPA process. The recovered material could contain chlorides from the BPA process which would make returning it to another process of the facility objectionable. In addition, the presence of chlorides required more expensive construction materials. These concerns made the liquid-liquid extraction marginally attractive.

The facility undertook further study and investigation of the BPA process and the process water streams it generates. The wide variability in the phenol concentration was found to be due to operational problems and mechanical instabilities of the HCl recovery column. This portion of the process was targeted for improvements. It was determined that improvements could be made to reduce the phenol concentration of the BPA process water to approximately the same level as any add-on recovery system. This would reduce the causes of phenol concentration variability and be much less costly to install than any add-on system.

Actual plant data and operational experience was used to identify the systematic causes of the mechanical and operational instabilities. Two major causes were identified and pursued.

The first problem was heat exchanger fouling. This causes the inability to flush the required amount of water from the column's bottom system, which leads to the column being overloaded resulting in high phenol loss. To address this problem, a spare exchanger designed to better withstand the fouling tendencies of the system was installed. This spare exchanger will permit switching the exchanger if the unit on-line does foul.

The second problem area was the periodic plugging or failure of the column's overhead accumulator. The column recovers phenol through this overhead accumulator. When it plugs or fails, there is no means of capturing the phenol in the feed to the column. During these situations the phenol is forced out of the system via the column's bottoms water stream. To deal with this problem, a second accumulator was installed. The second accumulator can be operated in series or independently of the original accumulator.

In summary, the company used a successful systematic approach to address phenol waste problems by doing a step-by-step analysis of process waste stream and the conditions which affect its quantity. This was a successful application of pollution prevention in an industrial setting.

Contact OPP

For more information and assistance on pollution prevention, contact Ohio EPA's Office of Pollution Prevention (OPP) at (614) 644-3469 or visit OPP's Web site at **www.epa.state.oh.us/opp.**

Ohio's Materials Exchange (OMEx) at **www.epa.state.oh.us/opp/omex**, lists "*materials wanted*," including metal wastes, metal-bearing sludges and filter cakes. Users may also post their "*materials available*" on the listing. The exchange proves valuable in the reuse of materials and preventing them from becoming a waste.

www.epa.state.oh.us/opp

The Office of Pollution Prevention was created to encourage multi-media pollution prevention activities in Ohio to reduce risk to public health, safety, welfare and the environment. Pollution prevention stresses source reduction and, as a second choice, environmentally-sound recycling, while avoiding cross media transfers. The office develops information related to pollution prevention, increases awareness of pollution prevention opportunities, and can offer technical assistance to business, government and the public.

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