PUBLIC HEALTH STATEMENT
Phenol
CAS#: 108-95-2

Division of Toxicology and Environmental Medicine **September 2006**

This Public Health Statement is the summary chapter from the Toxicological Profile for Phenol. It is one in a series of Public Health Statements about hazardous substances and their health effects. A shorter version, the ToxFAQs™, is also available. This information is important because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present. For more information, call the ATSDR Information Center at 1-800-232-4636.

This public health statement tells you about phenol and the effects of exposure to it.

The Environmental Protection Agency (EPA) identifies the most serious hazardous waste sites in the nation. These sites are then placed on the National Priorities List (NPL) and are targeted for long-term federal clean-up activities. Phenol has been found in at least 595 of the 1,678 current or former NPL sites. Although the total number of NPL sites evaluated for this substance is not known, the possibility exists that the number of sites at which phenol is found may increase in the future as more sites are evaluated. This information is important because these sites may be sources of exposure and exposure to this substance may harm you.

When a substance is released either from a large area, such as an industrial plant, or from a container, such as a drum or bottle, it enters the environment. Such a release does not always lead to exposure. You can be exposed to a substance only when you come in contact with it. You may be exposed by breathing, eating, or drinking the substance, or by skin contact.

If you are exposed to phenol, many factors will determine whether you will be harmed. These factors include the dose (how much), the duration (how long), and how you come in contact with it. You must also consider any other chemicals you are exposed to and your age, sex, diet, family traits, lifestyle, and state of health.

1.1 WHAT IS PHENOL?

Phenol is a colorless-to-white solid when pure; however, the commercial product, which contains some water, is a liquid. Phenol has a distinct odor that is sickeningly sweet and tarry. Most people begin to smell phenol in air at about 40 parts of phenol per billion parts of air (ppb), and begin to smell phenol in water at about 1–8 parts of phenol per million parts of water (ppm; 1 ppm is 1,000 times more than 1 ppb). These levels are lower than the levels at which adverse health effects have been observed in animals that breathed air containing phenol or drank water containing phenol. Phenol evaporates more slowly than water, and a moderate amount can form a solution with water. Phenol can catch on fire.

Phenol is both a manufactured chemical and produced naturally. It is found in nature in some foods and in human and animal wastes and decomposing organic material. The two major uses of phenol are as an intermediate in the production of phenolic resins (human made polymers consisting of phenol) and in the production of bisphenol A (which is used in the manufacture of other synthetic polymers). It is also used in the production of caprolactam (which is used in the manufacture of

nylon 6 and other synthetic fibers). Phenol is also used as a slimicide (a chemical toxic to bacteria and fungi characteristic of aqueous slimes), as a disinfectant, and in medicinal preparations such as over-the-counter treatments for sore throats. Phenol ranks in the top 50 in production volumes for chemicals produced in the United States. Phenol is formed in petroleum products such as coal tar and creosote. Phenol can be released during the combustion of wood, fuel emissions and tobacco. Phenol is naturally formed as a breakdown product of benzene.

1.2 WHAT HAPPENS TO PHENOL WHEN IT ENTERS THE ENVIRONMENT?

Following small, single releases, phenol is rapidly removed from the air, with half of the material removed in less than 1 day. It is also relatively short-lived in the soil (generally, complete removal in 2–5 days). However, it can remain in water for a week or more. Phenol can remain in the air, soil, and water for much longer periods of time if a large amount of it is released at one time, or if it is constantly released to the environment. Levels of phenol above those found naturally in the environment are usually found in surface waters and surrounding air contaminated by phenol released from industrial activity and from the commercial use of products containing phenol. Phenol has been detected in the materials released from landfills and hazardous waste sites, and it has been found in the groundwater near these sites. One ppb or less of phenol has been found in relatively unpolluted surface water and groundwater, and low levels are also found in indoor environments and are principally derived from environmental tobacco smoke (ETS). Organisms that live in water containing low levels of phenol may also contain low levels of phenol.

1.3 HOW MIGHT I BE EXPOSED TO PHENOL?

The mostly likely source of exposure to phenol is at manufacturing and hazardous waste sites; therefore, people living near landfills, hazardous waste sites, or plants manufacturing phenol are the most likely populations to be exposed. Other possible direct exposure may occur through use of consumer products containing phenol. Phenol is present in a number of consumer products that are swallowed, rubbed on, or applied to various parts of the body. These include throat lozenges, mouthwashes, gargles, and antiseptic lotions. Phenol has been found in drinking water, tobacco smoke, air, and certain foods, including smoked summer sausage, fried chicken, mountain cheese, and some species of fish.

The magnitude, frequency, and likelihood of exposure, and the relative contribution of each exposure route and source to total phenol exposure cannot be estimated using information currently available. Nonetheless, for persons not exposed to phenol in the workplace, possible routes of exposure include: breathing industrially contaminated air; smoking or inhaling ETS polluted air; drinking water from contaminated surface water or groundwater supplies; swallowing products containing phenol; and coming into contact with contaminated water and products containing phenol through bathing or skin application. Populations residing near phenol spills, waste disposal sites, or landfill sites may be at risk for higher exposure to

phenol than other populations. If phenol is present at a waste site near homes that have wells as a source of water, it is possible that the well water could be contaminated. If phenol is spilled at a waste site, it is possible for a person, such as a child playing in dirt containing phenol, to have skin contact or to swallow soil or water contaminated with phenol. Skin contact with phenol or swallowing products containing phenol may lead to increased exposure. This type of exposure is expected to occur infrequently and generally occurs over a short time period.

At the workplace, exposure to phenol can occur from breathing contaminated air. However, skin contact with phenol during its manufacture and use is considered the major route of exposure in the workplace. It has been estimated that about 584,000 people in the United States are exposed to phenol at work. Total exposure at the workplace is potentially higher than in non-workplace settings. Chapter 6 contains more information on sources of exposure.

Phenol is a product of combustion of coal wood and municipal solid waste; therefore, residents near coal and petroleum fueled facilities as well as residents near municipal waste incinerators may have increased exposure to phenol. Phenol is also a product of auto exhaust, and therefore, areas of high traffic likely contain increased levels of phenol.

1.4 HOW CAN PHENOL ENTER AND LEAVE MY BODY?

Phenol can enter the body when a person drinks contaminated water, eats contaminated food, or swallows products containing phenol. Phenol spilled on the skin easily penetrates the skin and enters the body. Phenol also enters the body through the lungs when a person breathes in air or inhales smoke from tobacco, which contains phenol. Phenol may be given in injections to treat hemorrhoids or certain nerve disorders.

The amount of phenol that enters the body from skin contact with water containing phenol depends on the concentration of phenol in the water, the length of time of skin contact, and the amount of skin that makes contact with the contaminated water. Greater amounts of phenol will enter the body if large areas of skin come into contact with weaker solutions of phenol than if small areas of skin come into contact with the solutions of phenol. If a person is exposed to air containing phenol, then phenol can enter the body through the skin and lungs. It has been determined that entry through the skin can account for as much as one-half of the phenol that enters the body when a person is exposed to phenol in air. Although it is possible for a person to be exposed to air contaminated with phenol at a waste site, such an exposure is not likely because spilled phenol will mostly remain in soil or water rather than evaporate into air. If a person swallows phenol, the intestines will change much of it to a less harmful substance. If phenol enters through the skin, it may reach organs and cause adverse effects before it is changed into a less harmful substance.

Very small amounts of phenol are produced by the body and excreted independent of external exposure to the compound. Phenol is produced by the action of bacteria on normal constituents of the diet in the gut. Some of this internally-produced phenol may be eliminated in the feces and some may pass to the

blood. The normal range of phenol in the urine of unexposed individuals is 0.5–80 milligrams of phenol per liter of urine (mg/L).

1.5 HOW CAN PHENOL AFFECT MY HEALTH?

Scientists use many tests to protect the public from harmful effects of toxic chemicals and to find ways for treating persons who have been harmed.

One way to learn whether a chemical will harm people is to determine how the body absorbs, uses, and releases the chemical. For some chemicals, animal testing may be necessary. Animal testing may also help identify health effects such as cancer or birth defects. Without laboratory animals, scientists would lose a basic method for getting information needed to make wise decisions that protect public health. Scientists have the responsibility to treat research animals with care and compassion. Scientists must comply with strict animal care guidelines because laws today protect the welfare of research animals.

A number of effects from breathing phenol in air have been reported in humans. Short-term effects reported include respiratory irritation, headaches, and burning eyes. Chronic effects of high exposures included weakness, muscle pain, anorexia, weight loss, and fatigue; effects of long-term low-level exposures included increases in respiratory cancer, heart disease, and effects on the immune system. Virtually all of the workplace exposures associated with these effects involved exposures to other chemicals; thus, it is difficult to determine whether these are solely due to phenol, or are the result of mixed, multiple, or other chemical exposures.

In animals, exposure to high concentrations of phenol in air for a few minutes irritates the lungs, and repeated exposure for several days produces muscle tremors and loss of coordination. Exposure to high concentrations of phenol in the air for several weeks results in paralysis and severe injury to the heart, kidneys, liver, and lungs, followed by death in some cases. When exposures involve the skin, the size of the total surface area of exposed skin can influence the severity of the toxic effects.

The seriousness of the effect of a harmful substance can be expected to increase as both the level and duration of exposure increase. Repeated exposure to low levels of phenol in drinking water has been associated with diarrhea and mouth sores in humans, but there may have been also simultaneous exposure to other chemicals. Ingestion of very high concentrations of phenol has resulted in death. In animals, drinking water with extremely high concentrations of phenol has caused muscle tremors and loss of coordination.

Effects reported in humans following dermal exposure to phenol include 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. Small amounts of phenol applied to the skin of animals for brief periods can produce blisters and burns on the exposed surface, and spilling dilute phenol solutions on large portions of the body (greater than 25% of the body surface) can result in death.

It is not known if phenol causes cancer in humans. However, cancer has been shown to occur in mice when phenol was applied to the skin several times each week during the whole lifetime of the animal. When it is applied in combination with certain cancer-causing chemicals, a higher rate of cancer occurs than when the carcinogens are applied alone. Phenol did not cause cancer in mice or rats when they drank water containing phenol for 2 years. The International Agency for Research on Cancer (IARC) considers phenol not classifiable as to its carcinogenicity in humans. The EPA determined that phenol is not classifiable as to human carcinogenicity. Under updated guidelines, the EPA information available on the carcinogenicity of phenol is inadequate for an assessment of the potential for phenol to cause cancer in humans.

Phenol can have beneficial effects when used for medical reasons. It is an antiseptic (kills germs) when applied to the skin in small amounts and may have antiseptic properties when gargled as a mouthwash. It is an anesthetic (relieves pain) and is a component of certain sore-throat lozenges and throat sprays or gargles. Small amounts of phenol in water have been injected into nerve tissue to lessen pain associated with certain nerve disorders. Phenol destroys the outer layers of skin if allowed to remain in contact with skin, and small amounts of concentrated solutions of phenol are sometimes applied to the skin to remove warts and to treat other skin blemishes and disorders.

1.6 HOW CAN PHENOL AFFECT CHILDREN?

This section discusses potential health effects in humans from exposures during the period from conception to maturity at 18 years of age.

The exposure of children to phenol is likely to occur by most of the same routes experienced by adults, the major exception being that children are unlikely to be exposed due to their parents' occupations. There are no unique routes of exposure for children. However, there is evidence that children are at greater risk of accidental ingestion of certain products than adults. In the case of one product, a disinfectant containing 26% phenol, children under the age of 5 represented 60 of 80 (75%) of the poisoning cases associated with this product reported to a major poison control center between 1987 and 1991. Oral exposure was the predominant route of exposure, underscoring the need for parents to keep cleaning or disinfectant products out of the reach of children. Vomiting and lethargy were the main signs of toxicity that were observed.

Information on the toxic effects of phenol in infants and children also comes from the use of phenol in medical treatments. Phenol was once used as an antiseptic in wound dressing products and there are several reports of deaths in children and infants following overzealous application of such products to burns or open wounds. All of these cases occurred decades ago, however, and there is little indication that such products, which contained relatively high levels of phenol, are still in use.

Other phenol-containing products are used as "chemical peels" to remove skin lesions, and in the

treatment of chronic pain or spasticity. These uses have occasionally been associated with adverse outcomes, like cardiac arrhythmias, that have been seen in both adults and children. These effects do not appear to occur more frequently in children than adults; however, the information on such effects in children is very limited. It is unknown whether infants or children are more susceptible than adults to the adverse effects of phenol.

The effects of exposure to phenol on reproduction and the developing human fetus are unclear. Several studies in animals have not shown phenol to be active in developmental toxicity. In general, adverse developmental effects, such as low birth weights and minor birth defects, have occurred at exposure levels that also were toxic to the pregnant mothers. It seems likely that any adverse developmental effects would require much higher doses than would normally be encountered at hazardous waste sites.

1.7 HOW CAN FAMILIES REDUCE THE RISK OF EXPOSURE TO PHENOL?

If your doctor finds that you have been exposed to substantial amounts of phenol, ask whether your children might also have been exposed. Your doctor might need to ask your state health department to investigate.

Since ETS contains phenol, reducing the amount of smoking indoors will reduce phenol exposures. Household products and over-the-counter medications containing phenol should be stored out of reach of young children to prevent accidental poisonings and skin burns. Always store household chemicals in their original labeled containers. Never store household chemicals in containers that children would find attractive to eat or drink from, such as old soda bottles. Keep your Poison Control Center's number next to the phone. Communities can find out if phenol is a contaminant in nearby landfills or polluting facilities and petition for cleanup.

1.8 IS THERE A MEDICAL TEST TO DETERMINE WHETHER I HAVE BEEN EXPOSED TO PHENOL?

Urine can be tested for the presence of phenol. This test can be used to determine if the urine has a higher than normal concentration of phenol, thus suggesting recent exposure to phenol or to substances that are converted to phenol in the body (e.g., benzene). There is no test available that will tell if a person has been exposed only to phenol, since many substances are converted to phenol in the body. Because most of the phenol that enters the body is excreted in the urine within 24 hours, this test can only detect exposures that have occurred within 1 or 2 days prior to the test. The test results cannot be used to predict what health effects might result from exposure to phenol. Measurement of phenol in urine requires special laboratory equipment and techniques that are not routinely available in most hospitals or clinics. However, urine samples can be taken at a doctor's office and can be sent to specialized laboratories for analysis.

1.9 WHAT RECOMMENDATIONS HAS THE FEDERAL GOVERNMENT MADE TO PROTECT HUMAN HEALTH?

The federal government develops regulations and recommendations to protect public health. Regulations *can* be enforced by law. The EPA, the Occupational Safety and Health Administration (OSHA), and the Food and Drug Administration (FDA) are some federal agencies that develop regulations for toxic substances. Recommendations provide valuable guidelines to protect public health, but *cannot* be enforced by law. The Agency for Toxic Substances and Disease Registry (ATSDR) and the National Institute for Occupational Safety and Health (NIOSH) are two federal organizations that develop recommendations for toxic substances.

Regulations and recommendations can be expressed as "not-to-exceed" levels, that is, levels of a toxic substance in air, water, soil, or food that do not exceed a critical value that is usually based on levels that affect animals; they are then adjusted to levels that will help protect humans. Sometimes these not-to-exceed levels differ among federal organizations because they used different exposure times (an 8-hour workday or a 24-hour day), different animal studies, or other factors.

Recommendations and regulations are also updated periodically as more information becomes available. For the most current information, check with the federal agency or organization that provides it. Some regulations and recommendations for phenol include the following:

OSHA has set a limit of 5 ppm for phenol in air to protect workers during 8-hour workshifts of a 40-hour workweek. NIOSH recommends that the concentration of phenol in workroom air be limited to 5 ppm over a 10-hour work shift, and that the workroom air concentration should not exceed 16 ppm during a 15-minute period. Note that these workplace air limits assume no skin contact with phenol. NIOSH also considers a concentration of 250 ppm of phenol in air as immediately dangerous to life or health.

Phenol is listed on the FDA's EAFUS (Everything Added to Foods in the United States) List and is approved as a component of food packaging materials.

The EPA lifetime health advisory for phenol in water is 2 mg/L. EPA has determined that the level of phenol in ambient water (lakes, streams) should be limited to 21 mg/L in order to protect human health from the potential toxic effects of exposure to phenol through ingestion of water and contaminated aquatic organisms. EPA requires that spills of 1,000 pounds of phenol or more to the environment be reported to the Agency.

1.10 WHERE CAN I GET MORE INFORMATION?

If you have any more questions or concerns, please contact your community or state health or environmental quality department, or contact ATSDR at the address and phone number below.

ATSDR can also tell you the location of occupational and environmental health clinics.

These clinics specialize in recognizing, evaluating, and treating illnesses that result from exposure to hazardous substances.

Toxicological profiles are also available on-line at www.atsdr.cdc.gov and on CD-ROM. You may request a copy of the ATSDR ToxProfiles™ CD-ROM by calling the toll-free information and technical assistance number at 1-800-CDCINFO (1-800-232-4636), by e-mailing cdcinfo@cdc.gov, or by writing to

Agency for Toxic Substances and Disease Registry
Division of Toxicology and Environmental Medicine
1600 Clifton Road NE
Mailstop F-32
Atlanta, GA 30333
Fax: 1-770-488-4178

Organizations for-profit may request copies of final Toxicological Profiles from

National Technical Information Service (NTIS)
5285 Port Royal Road
Springfield, VA 22161
Phone: 1-800-553-6847 or 1-703-605-6000
Web site: http://www.ntis.gov/