OCCUPATIONAL SAFETY AND HEALTH GUIDELINE FOR CATECHOL

INTRODUCTION

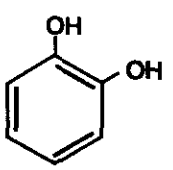
This guideline summarizes pertinent information about catechol for workers and employers as well as for physicians, industrial hygienists, and other occupational safety and health professionals who may need such information to conduct effective occupational safety and health programs. Recommendations may be superseded by new developments in these fields; readers are therefore advised to regard these recommendations as general guidelines and to determine periodically whether new information is available.

SUBSTANCE IDENTIFICATION

- **Formula**

  $C_6H_4(OH)_2$

- **Structure**



- **Synonyms**

  1,2-Benzenediol; pyrocatechol; o-dihydroxybenzene; pyrocatechin; o-diphenol; Durafur Developer C; o-hydroquinone; o-hydroxyphenol; oxyphenic acid; Pelagol Grey C; o-phenylenediol; pyrocatechinic acid

- **Identifiers**

  1. CAS No.: 120-80-9
  2. RTECS No.: UX1050000
  3. DOT UN: None
  4. DOT label: None

- **Appearance and odor**

  Catechol is a colorless, crystalline solid that has a faint odor and sublimes easily.

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**

  1. Molecular weight: 110.11
  2. Boiling point (760 mm Hg): 245.5°C (473.9°F)
  3. Specific gravity (water = 1): 1.344 at 40°C (104°F)
  4. Vapor density (air = 1 at boiling point of catechol): 3.79
  5. Melting point: 105°C (221°F)
  6. Vapor pressure at 118°C (244°F): 10 mm Hg
  7. Solubility: Soluble in water, ether, alcohol, hot benzene, and chloroform; very soluble in pyridine and acetone

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health
Education and Information Division

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

8. Evaporation rate: Data not available

Reactivity

1. Conditions contributing to instability: Heat, flame, light, or air

2. Incompatibilities: Contact of catechol with strong oxidizing agents may cause fires or explosions.

3. Hazardous decomposition products: Toxic gases (such as carbon monoxide and carbon dioxide) may be released in a fire involving catechol.

4. Special precautions: None reported

Flammability

The National Fire Protection Association has not assigned a flammability rating to catechol; other sources rate catechol's fire hazard as slight.

1. Flash point: 127.2°C (261°F) (closed cup)

2. Autoignition temperature: Data not available

3. Flammable limits in air: Data not available

4. Extinguishant: Use water, dry chemical, or carbon dioxide to fight fires involving catechol.

Fires involving catechol should be fought upwind from the maximum distance possible. Isolate the hazard area and deny access to unnecessary personnel. Firefighters should wear a full set of protective clothing and self-contained breathing apparatus when fighting fires involving catechol.

EXPOSURE LIMITS

OSHA PEL

The Occupational Safety and Health Administration (OSHA) has not promulgated a permissible exposure limit (PEL) for catechol [29 CFR 1910.1000, Table Z-1].

- **NIOSH REL**

The National Institute for Occupational Safety and Health (NIOSH) has established a recommended exposure limit (REL) of 5 ppm (20 mg/m^3) as a TWA for up to a 10-hr workday and a 40-hr workweek. The NIOSH REL also bears a "Skin" notation, which indicates that the cutaneous route of exposure (including mucous membranes and eyes) contributes to overall exposure [NIOSH 1992a].

- **ACGIH TLV**

The American Conference of Governmental Industrial Hygienists (ACGIH) has assigned catechol a threshold limit value (TLV) of 5 ppm (20 mg/m^3) as a TWA for a normal 8-hr workday and a 40-hr workweek [ACGIH 1993].

- **Rationale for limits**

The ACGIH limit is based on the risk of skin and respiratory tract irritation and central nervous system effects associated with exposure to catechol.

HEALTH HAZARD INFORMATION

- **Routes of exposure**

Exposure to catechol can occur through inhalation, ingestion, eye or skin contact, and percutaneous absorption.

- **Summary of toxicology**

1. *Effects on Animals:* Catechol is a potential corrosive to the eyes, nose, upper respiratory tract, and skin. Aqueous solutions of up to 55% (0.05 M) were not injurious when instilled into rabbits' eyes [Grant 1986]. Application of 100 mg of dry catechol onto rabbits' eyes caused erythematous and edematous conjunctiva, moderate exudate, and corneal opacities (Draize score 103/110) within 24 hr. The 72-hr evaluation revealed severe conjunctivitis, iritis, and diffuse corneal opacities (Draize score 78/110). On the 14th day, corneal vascularization, granulation, and conical protrusion were observed [Flickinger 1976]. Administration of catechol onto rabbit skin produced moderate erythema and slight edema of the intact sites while necrosis occurred at the abraded areas. Catechol was thereby classified as a primary irritant (Draize score 5.5/8.0) [Flickinger 1976]. The dermal LD_{50} in the rabbit is 800 mg/kg [NIOSH 1992b]. Rats tolerated an 8-hr inhalation exposure to 1,500 mg/m^3 catechol without visible effects, but exposure to 2,000 or 2,800 mg/m^3 caused tremors after 6 to 7 hr. The tremors disappeared following the first experimental day. In addition, the 2,000- and 2,800-mg/m^3

concentrations caused the animals to develop irritated and blackened extremities and tails. Two of six rats exposed to 2,000 mg/m^3 developed blackened tails of which the terminal one inch was lost (undefined). Six out of six rats exposed to 2,800 mg/m^3 had both blackened tails and toes. All lost the terminal inch of their tails, while several had missing toes. The author concluded that severe exposure could lead to necrosis and sloughing of peripheral tissues [Flickinger 1976]. Lethal oral doses have induced hyperemia of the stomach and intestines of rats [Clayton and Clayton 1981]. The lowest reported oral LD_{50}s for the rat and mouse are 260 and 260 mg/kg, respectively [NIOSH 1992b]. Large doses (amounts not specified) of catechol can cause depression of the central nervous system, a prolonged rise in blood pressure, and degenerative changes in the renal tubules. Deaths from lethal doses or exposures in animals are caused from respiratory failure [Clayton and Clayton 1981; ACGIH 1991]. Rabbits that received repeated sublethal oral doses (200 mg/kg) had altered sleep times, leukopenia, anemia, and methemoglobinemia [Clayton and Clayton 1981; NIOSH 1992b]. An in vitro micromass teratogen test confirmed that catechol inhibits cell differentiation of rat embryo midbrain and limb cells [Flint and Maclean 1988]. Conversely, in an in vivo Chernoff/Kavlock assay, rats received one oral dose of 333, 667, or 1,000 mg catechol/kg on day 11 of pregnancy. The lethality rates in dams were 1/15, 5/15, and 10/15, respectively. The two upper levels caused a statistically significant dose-related decrease in litter size and an increase in perinatal loss. The 333-, 667-, and 1,000-mg/kg dose levels induced a 23.1%, 66.7%, and 80% incidence of hind limb tetany and paralysis, short or kinky tails, and urogenital malformations in the pups, respectively [Kavlock 1990]. Catechol is mutagenic in bacterial and mammalian test systems [NIOSH 1992b]. Groups of 50 Swiss mice received 5 g benzo(a)pyrene [B(a)P] with or without 2-mg catechol in acetone, three times per week for 52 weeks. Catechol plus B(a)P significantly increased the number of squamous cell carcinomas of the skin (31) when compared to benzo(a)pyrene alone (10), acetone controls (0), or negative controls (0). The rate of skin papillomas per affected mouse was also tripled when catechol plus B(a)P were administered. Catechol alone was not investigated in this study [IARC 1977]. When 2-mg catechol were suspended in 10-mg cholesterol pellets and implanted into the urinary bladders of mice for 25 weeks, a significant increase ($p=0.03$) in undefined carcinomas was induced above the control incidence [IARC 1977]. IARC found no adequate human studies and inadequate evidence of carcinogenic potential for the above animal studies. They classified it as a Group 3 chemical: The agent is not classifiable as to its carcinogenicity to humans [IARC 1977].

2. *Effects on Humans:* In humans, catechol is an eye and skin irritant, a skin sensitizer, and a depressant of the central nervous system. Catechol also causes eye burns that are slow to heal [Grant 1986]. Contact of catechol with the skin causes an eczematous dermatitis in sensitized workers. Absorption through the skin has resulted in signs and symptoms of illness resembling those of phenol poisoning, except that catechol-induced convulsions are more severe than those caused by phenol poisoning [ACGIH 1991]. Catechol is mutagenic in human test systems [NIOSH 1992b].

- **Signs and symptoms of exposure**

1. *Acute exposure:* Acute exposure to catechol can cause redness, pain, and tearing of the eyes, runny nose, scratchy throat, and difficult breathing. Contact of catechol with the eyes may cause burns and permanent impairment of vision. Severe overexposure may cause convulsions.

2. *Chronic exposure:* Continued low-level exposure to catechol can cause eczematous dermatitis, with red, raised, and oozing areas of the skin.

- **Emergency Procedures**

WARNING!

Exposed victims may die!
Transport immediately to emergency medical facility!

Keep unconscious victims warm and on their sides to avoid choking if vomiting occurs. ***Immediately*** initiate the following emergency procedures, continuing them as appropriate en route to the emergency medical facility:

1. *Eye exposure:* Tissue destruction and blindness may result! ***Immediately but gently*** flush the eyes with large amounts of water for at least 15 min, occasionally lifting the upper and lower eyelids.

2. *Skin exposure:* Severe burns, skin corrosion, and absorption of lethal amounts may result! Immediately remove all contaminated clothing! ***Immediately, continuously, and gently*** wash skin for at least 15 min. Use soap and water if skin is intact; use only water if skin is not intact.

3. *Inhalation exposure:* If particulates, mists, or vapors of catechol are inhaled, move the victim to fresh air ***immediately***. Have the victim blow his or her nose or use a soft tissue to remove particulates or residues from the nostrils.

   If the victim is not breathing, clean any chemical contamination from victim's lips and perform cardiopulmonary resuscitation (CPR); if breathing is difficult, give oxygen.

4. *Ingestion exposure:* Take the following steps if catechol or any material containing it is ingested:

   —Do ***not*** induce vomiting.

   —Have the victim rinse the contaminated mouth cavity several times with a fluid such as water. Immediately after rinsing, have the victim drink one cup (8 oz) of fluid and ***no more***.

   —Do ***not*** permit the victim to drink milk or carbonated beverages!

   —Do ***not*** permit the victim to drink any fluid if more than 60 min have passed since initial ingestion.

NOTE: These instructions must be followed exactly. Drinking a carbonated beverage or more than one cup of fluid could create enough pressure to perforate already damaged stomach tissue. The tissue-coating action of milk may impede medical assessment of tissue damage. Ingestion of any fluid more than 60 min after initial exposure could further weaken damaged tissue and result in perforation.

5. *Rescue:* Remove an incapacitated worker from further exposure and implement appropriate emergency procedures (e.g., those listed on the material safety data sheet required by OSHA's hazard communication standard [29 CFR 1910.1200]). All workers should be familiar with emergency procedures and the location and proper use of emergency equipment.

EXPOSURE SOURCES AND CONTROL METHODS

The following uses may involve catechol and result in worker exposures to this substance:

—Use as an intermediate in the manufacture of 4-tertiary-butyl-catechol and certain chlorinated dibenzo-para-dioxins

—Use as a constituent of polymerization inhibitors and antioxidants

—Use in electro-sensitive copying papers, in photography, and in rubber compounding

—Use as a photographic developer, as an oxidation base in hair dye preparations, and as an analytical reagent

—Use as an antiseptic

—Use in the manufacture of specialty inks and light stabilizers

The following methods are effective in controlling worker exposures to catechol, depending on the feasibility of implementation:

—Process enclosure

—Local exhaust ventilation

—General dilution ventilation

—Personal protective equipment

Good sources of information about control methods are as follows:

1. ACGIH [1992]. Industrial ventilation—a manual of recommended practice. 21st ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

2. Burton DJ [1986]. Industrial ventilation—a self study companion. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

3. Alden JL, Kane JM [1982]. Design of industrial ventilation systems. New York, NY: Industrial Press, Inc.

4. Wadden RA, Scheff PA [1987]. Engineering design for control of workplace hazards. New York, NY: McGraw-Hill.

5. Plog BA [1988]. Fundamentals of industrial hygiene. Chicago, IL: National Safety Council.

MEDICAL MONITORING

Workers who may be exposed to chemical hazards should be monitored in a systematic program of medical surveillance that is intended to prevent occupational injury and disease. The program should include education of employers and workers about work-related hazards, early detection of adverse health effects, and referral of workers for diagnosis and treatment. The occurrence of disease or other work-related adverse health effects should prompt immediate evaluation of primary preventive measures (e.g., industrial hygiene monitoring, engineering controls, and personal protective equipment). A medical monitoring program is intended to supplement, not replace, such measures. To detect and control work-related health effects, medical evaluations should be performed (1) before job placement, (2) periodically during the term of employment, and (3) at the time of job transfer or termination.

- **Preplacement medical evaluation**

Before a worker is placed in a job with a potential for exposure to catechol, a licensed health care professional should evaluate and document the worker's baseline health status with thorough medical, environmental, and occupational histories, a physical examination, and physiologic and laboratory tests appropriate for the anticipated occupational risks. These should concentrate on the function and integrity of the respiratory system and skin. Medical monitoring for respiratory disease should be conducted using the principles and methods recommended by the American Thoracic Society [ATS 1987].

A preplacement medical evaluation is recommended to detect and assess medical conditions that may be aggravated or may result in increased risk when a worker is exposed to catechol at or below the prescribed exposure limit. The licensed health care professional should consider the probable frequency, intensity, and duration of exposure as well as the nature and degree of any applicable medical condition. Such conditions (which should not be regarded as absolute contraindications to job placement) include a history of allergies and other findings consistent with diseases of the respiratory system or skin.

- **Periodic medical examinations and biological monitoring**

Occupational health interviews and physical examinations should be performed at regular intervals during the employment period, as mandated by any applicable Federal, State, or local standard. Where no standard exists and the hazard is minimal, evaluations should be conducted every 3 to 5 years or as frequently as recommended by an experienced occupational health physician. Additional examinations may be necessary if a worker develops symptoms attributable to catechol exposure. The interviews, examinations, and medical screening tests should focus on identifying the adverse effects of catechol on the respiratory system and skin. Current health status should be compared with the baseline health status of the individual worker or with expected values for a suitable reference population.

Biological monitoring involves sampling and analyzing body tissues or fluids to provide an index of exposure to a toxic substance or metabolite. Although catechol can be measured in the urine of exposed individuals, no correlation between urinary and airborne catechol concentrations has yet been established. Therefore, no biological monitoring test acceptable for routine use is available for catechol.

- **Medical examinations recommended at the time of job transfer or termination**

The medical, environmental, and occupational history interviews, the physical examination, and selected physiologic or laboratory tests that were conducted at the time of placement should be repeated at the time of job transfer or termination to determine the worker's medical status at the end of his or her employment. Any changes in the worker's health status should be compared with those expected for a suitable reference population.

WORKPLACE MONITORING AND MEASUREMENT

A worker's exposure to airborne catechol is determined by using an XAD-7 tube (100/50-mg sections, 15/50 mesh). Samples are collected at a recommended flow rate of 0.1 liter/min until a recommended air volume of 24 liters is collected. Analysis is conducted by high performance liquid chromatography using an ultraviolet detector. This method is included in the OSHA Laboratory In-House Methods File [OSHA 1989].

PERSONAL HYGIENE

If catechol contacts the skin, workers should immediately wash the affected areas with soap and water.

Clothing contaminated with catechol should be removed immediately, and provisions should be made for safely removing this chemical from these articles. Persons laundering the clothes should be informed of the hazardous properties of catechol, particularly its potential to cause eye and skin burns on contact.

A worker who handles catechol should thoroughly wash hands, forearms, and face with soap and water before eating, using tobacco products, using toilet facilities, or applying cosmetics.

Workers should not eat, drink, use tobacco products, or apply cosmetics in areas where catechol or a solution containing catechol is handled, processed, or stored.

STORAGE

Catechol should be stored in a cool, dry, well-ventilated area in tightly sealed containers that are labeled in accordance with OSHA's hazard communication standard [29 CFR 1910.1200]. Containers of catechol should be protected from physical damage and should be stored separately from strong oxidizers, light, heat, sparks, and open flame. Because containers that formerly contained catechol may still hold product residues, they should be handled appropriately.

SPILLS

In the event of a spill involving catechol, persons not wearing protective equipment and clothing should be restricted from contaminated areas until cleanup is complete. The following steps should be undertaken following a spill:

1. Do not touch the spilled material.
2. Notify safety personnel.
3. Remove all sources of heat and ignition.
4. Ventilate the area of the spill.
5. Avoid raising dust during cleanup.
6. Sweep or vacuum the spilled material and gently place into a clean, dry container creating as little dust as possible; cover and remove the container from the spill area.

SPECIAL REQUIREMENTS

U.S. Environmental Protection Agency (EPA) requirements for emergency planning, reportable quantities of hazardous releases, community right-to-know, and hazardous waste management may change over time. Users are therefore advised to determine periodically whether new information is available.

- **Emergency planning requirements**

  Catechol is not subject to EPA emergency planning requirements under the Superfund Amendments and Reauthorization Act (SARA) [42 USC 11022].

- **Reportable quantity requirements for hazardous releases**

  Employers are not required by the emergency release notification provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) [40 CFR 355.40] to notify the National Response Center of an accidental release of catechol; there is no reportable quantity for this substance.

- **Community right-to-know requirements**

  Employers who own or operate facilities in SIC codes 20 to 39, who employ 10 or more workers, and who manufacture 25,000 lb or otherwise use 10,000 lb or more of catechol per calendar year are required by EPA to submit a Toxic Chemical Release Inventory Form (Form R) to EPA reporting the amount of catechol emitted or released from their facility annually.

- **Hazardous waste management requirements**

  EPA considers a waste to be hazardous if it exhibits any of the following characteristics: ignitability, corrosivity, reactivity, or toxicity as defined in 40 CFR 261.21-261.24. Although catechol is not specifically listed as a hazardous waste under the Resource Conservation and Recovery Act (RCRA) [40 USC 6901 et seq.], EPA requires employers to treat waste as hazardous if it exhibits any of the characteristics discussed above.

  Providing detailed information about the removal and disposal of specific chemicals is beyond the scope of this guideline. The U.S. Department of Transportation, EPA, and State and local regulations should be followed to ensure that removal, transport, and disposal of this

substance are conducted in accordance with existing regulations. To be certain that chemical waste disposal meets EPA regulatory requirements, employers should address any questions to the RCRA hotline at (800) 424-9346 or at (202) 382-3000 in Washington, D.C. In addition, relevant State and local authorities should be contacted for information about their requirements for waste removal and disposal.

RESPIRATORY PROTECTION

- **Conditions for respirator use**

Good industrial hygiene practice requires that engineering controls be used where feasible to reduce workplace concentrations of hazardous materials to the prescribed exposure limit. However, some situations may require the use of respirators to control exposure. Respirators must be worn if the ambient concentration of catechol exceeds prescribed exposure limits. Respirators may be used (1) before engineering controls have been installed, (2) during work operations such as maintenance or repair activities that involve unknown exposures, (3) during operations that require entry into tanks or closed vessels, and (4) during emergencies. Workers should use only respirators that have been approved by NIOSH and the Mine Safety and Health Administration (MSHA).

- **Respiratory protection program**

Employers should institute a complete respiratory protection program that, at a minimum, complies with the requirements of OSHA's respiratory protection standard [29 CFR 1910.134]. Such a program must include respirator selection, an evaluation of the worker's ability to perform the work while wearing a respirator, the regular training of personnel, respirator fit testing, periodic workplace monitoring, and regular respirator maintenance, inspection, and cleaning. The implementation of an adequate respiratory protection program (including selection of the correct respirator) requires that a knowledgeable person be in charge of the program and that the program be evaluated regularly. For additional information about the selection and use of respirators and about the medical screening of respirator users, consult the *NIOSH Respirator Decision Logic* [NIOSH 1987b] and the *NIOSH Guide to Industrial Respiratory Protection* [NIOSH 1987a].

PERSONAL PROTECTIVE EQUIPMENT

Protective clothing should be worn to prevent any skin contact with catechol. Chemical protective clothing should be selected on the basis of available performance data, manufacturers' recommendations, and evaluation of the clothing under actual conditions of use. No reports have been published on the resistance of various protective clothing materials to catechol permeation. If permeability data are not readily available, protective clothing manufacturers should be requested to provide information on the best chemical protective clothing for workers to wear when they are exposed to catechol.

If catechol is dissolved in water or an organic solvent, the permeation properties of both the solvent and the mixture must be considered when selecting personal protective equipment and clothing.

Safety glasses, goggles, or face shields should be worn during operations in which catechol might contact the eyes (e.g., through dust particles). Eyewash fountains and emergency showers should be available within the immediate work area whenever the potential exists for eye or skin contact with catechol. Contact lenses should not be worn if the potential exists for catechol exposure.

REFERENCES CITED

ACGIH [1991]. Documentation of the threshold limit values and biological exposure indices. 6th ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

ACGIH [1993]. 1993-1994 Threshold limit values for chemical substances and physical agents and biological exposure indices. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

ATS [1987]. Standardization of spirometry—1987 update. American Thoracic Society. Am Rev Respir Dis 136:1285-1296.

Clayton G, Clayton F [1981]. Patty's industrial hygiene and toxicology. 3rd rev. ed. New York, NY: John Wiley & Sons.

CFR. Code of Federal regulations. Washington, DC: U.S. Government Printing Office, Office of the Federal Register.

Flickinger CW [1976]. The benzenediols: catechol, resorcinol, and hydroquinone a review of the industrial toxicology and current industrial exposure limits. Am Ind Hyg Assoc J 37:596-606.

Flint OP, Maclean M [1988]. Teratogenicity of polyphenols assessed in vitro. Teratology 37(5):456-457.

Grant WM [1986]. Toxicology of the eye. 3rd ed. Springfield, IL: Charles C. Thomas.

IARC [1977]. IARC monographs on the evaluation of the carcinogenic risk of chemicals to man: some fumigants, the herbicides 2,4-D and 2,4,5-T, chlorinated dibenzodioxins and miscellaneous industrial chemicals. Vol. 15. Lyon, France: World Health Organization, International Agency for Research on Cancer, pp. 167-171.

Kavlock RJ [1990]. Structure-activity relationships in the developmental toxicity of substituted phenols: in vivo effects. Teratology 41(1):43-59.

NIOSH [1987a]. NIOSH guide to industrial respiratory protection. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 87-116.

NIOSH [1987b]. NIOSH respirator decision logic. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 87-108.

NIOSH [1992a]. NIOSH recommendations for occupational safety and health: compendium of policy documents and statements. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 92-100.

NIOSH [1992b]. Registry of toxic effects of chemical substances database: catechol. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, Division of Standards Development and Technology Transfer, Technical Information Branch.

OSHA [1989]. OSHA laboratory in-house methods file. Salt Lake City, UT: U.S. Department of Labor, Occupational Safety and Health Administration, OSHA Analytical Laboratory.