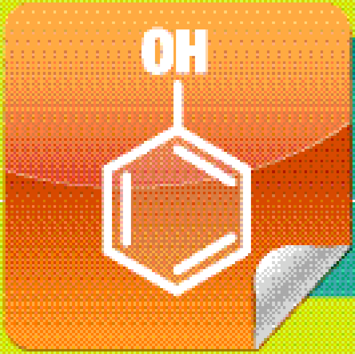

PRODUCT DOSSIER

PHENOL

CAS n° 108-85-2

MANAGEMENT OF CHEMICAL EYE AND SKIN SPLASHES

JANUARY 2008 EDITION

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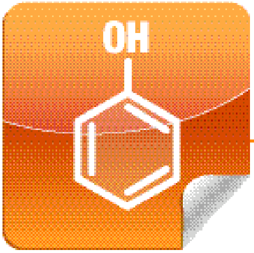
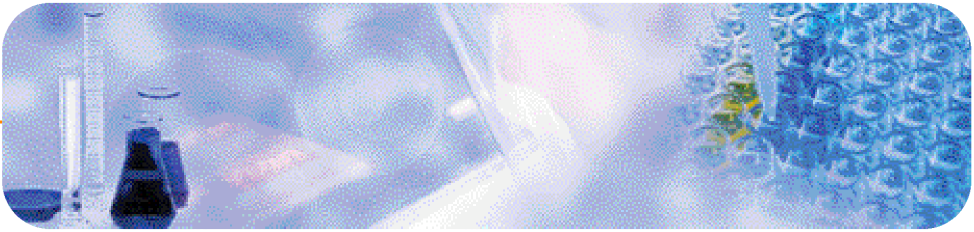


TABLE OF CONTENTS

PHENOL

MANAGEMENT OF CHEMICAL EYE AND SKIN SPLASHES



1. KEY POINTS

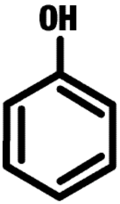
1.1. History

Discovered in its crude state in the 17th century by the distillation of coal oil tar, phenol, at the time, was described as: “a bright blood red oil that dries and cures all wet ulcers”. Isolated in the early 19th century, it was synthesized and produced in 1889 by the BASF firm. The currently most widespread manufacturing process is the Hock method from cumene.

1.2. Names and formula

Other names of phenol are:

- Hydroxybenzene
- Benzenol
- Phenic acid
- Carbolic acid
- Phenyl Alcohol
- Phenyl Hydroxide



PHENOL	
Molecular Formula	C_6H_5-OH
Molar Mass	94,11 g.mol^{-1}
CAS Number	108-95-2
EINECS Number	203-632-7
ICSC Number	0070
INRS[1]	FT n°15

Sources: INERIS[2], CSST[3] and INRS

1.3. Uses

Phenol is used as an intermediate chemical for the manufacture of plastics, pest control products, explosives, dyes, pharmaceutical drugs, industrial and household janitorial products and sometimes as a biocide.

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1 - Institut National de Recherche et de Sécurité (The French National Research and Safety Institute)

2 - Institut National de l'EnviRonnement industriel et des rISques (the French National Industrial Environment and Risks Institute)

3 - Commission de la Santé et de la Sécurité du Travail (the Occupational Health and Safety Committee of Quebec)

2. LABELLING

2.1. Danger level according to concentration

CE Classification (Product included in the 19th ATP[4] and updated in the 29th ATP).

PHENOL	HAZARD SYMBOL	RISK PHRASES
Pure	T Mut. Cat. 3	R23/24/25 R48/20/21/22 R34 R68
Preparation > or = to 10%	T Mut. Cat. 3	R23/24/25 R48/20/21/22 R34 R68
Preparation from 3 to 9.99%	C Xn Mut. Cat. 3	R20/21/22 R34 R68
Preparation from 2.99 to 1%	Xn Mut. Cat. 3	R36/38 R68
Preparation from 0 to 0.99%	-	-

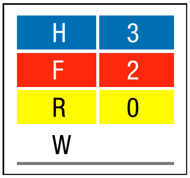
Risk phrase codes are given at the end of document

2.2. Other classifications

UN Hazard Class: 6.1

In the United States[5] :

NFPA Code :



H	3
F	2
R	0
W	

GHS[6] labelling example:

3.1/3 - Toxic by inhalation, contact with skin and if swallowed

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[4] - Adaptations to Technical Progress appendix 1 of 1981 text - source ECB

[5] - According to International Chemical Safety Cards WHO IPSC ILO

[6] - Globally Harmonized System of Classification and Labelling of Chemicals

3.2 - Causes severe skin burns and ocular lesions

3.5/2 - Likely to induce genetic anomalies
3.9/1 - Proven serious risks of damage to blood, kidneys, central nervous system in the case of repeated or prolonged exposure by inhalation, contact with skin or if swallowed

3. CHEMICAL CHARACTERISTICS

In its pure chemical form, phenol is a crystalline solid in the form of needles.

It is an aromatic alcoholic compound whose chemical characteristics can harm the skin, the eyes or mucous membranes.

Molar mass	94,11 $g.mol^{-1}$
Boiling point	181,8° C
Melting point	40,9° C
Vapor pressure	28,7 Pa at 20° C
VME[7]	7,8 mg/m^3 (VME)
PEL (TWA)[8]	19 mg/m^3
STEL (TWA)[9]	60 mg/m^3
Density	1,071 g/cm^3 at 20° C

4. CORROSIVITY OF PHENOL

Four chemical reactions are involved when tissues (eye or skin) come into contact with phenol:

- 1 - solvent effect on fats because of apolar properties of the aromatic ring
- 2 - solubility in water due to its alcohol function

And above all

- 3 - its dissociation (property of a weak acid - pK = 9.95) which liberates a proton H^+, responsible for corrosivity
- 4 - plus a phenolate ion (also liberated during the dissociation of phenol), responsible for its systemic toxicity.

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[7] - Mean Exposure Value
[8] - Permissible Exposure Limit (for an 8 hour day as defined by the Occupational Safety Health Administration)
[9] - Short-Term Exposure Limit (15 minutes, OSHA)

The mechanism of phenol burns works as follows:

1 Depending on its concentration, phenol acidity causes more or less severe burns. Indeed, it is the hydrogen ion released during the phenol dissociation in contact with mucous membranes or the tears which can cause acid burns by protein coagulation.

2 Its solvation properties (phenol dissolves lipids contained in the membrane) lead to cell necrosis which aggravates the lesions caused directly by the acid burn.

The chemical burn due to phenol is manifested by a whitish discoloration of the involved tissues (above all in cases of cutaneous contact from keratin coagulation and/or keratinolysis by interstitial or membrane protein coagulation) (Jelenko: J of Trauma, 1974). The sensation of pain appears after a pain-free interval because of the local anesthetic properties of phenol which last a little less than one-half hour.
Two types of injuries: local or generalised (systemic).

4.1 - Local effects

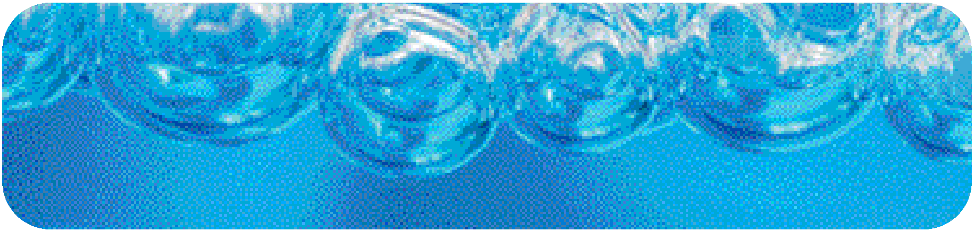
The seriousness of the burn depends on three key factors: solution concentration, surface area contaminated and duration of exposure.

4.1.1 - With skin splashes

- Simple irritation,
- A more or less deep burn, immediate or slightly delayed,
- Chronic dermatitis in the event of repeated exposure,
- Possible subsequent depigmentation (related to a direct effect on the melanocytes as skin cells produce melanine, the brown pigmentation of the skin).

4.1.2 – With eye splashes

- Simple irritation and watering of the eyes in the simplest cases,
- corneal and/or conjonctival oedema with conjunctivitis in moderate injuries,
- corrosive lesions with white cornea, corneal hypoesthesia and risk of severe ulceration;



4.2 - Systemic effects

Regardless of the route of exposure (skin, digestive or respiratory tract) there are two main groups of effects:

4.2.1 - Solvent effects on the fatty tissues

- Solvent effects on the fatty tissues of the central nervous system, an effect shared by all solvents, with inebriation-narcotics like symptoms : vertigo, hearing and sight disorders, drowsiness that can lead to coma or death.

4.2.2 - Specific signs of toxicity due to the phenolate ion

- blood disorders like hemolysis (destruction of circulating red blood cells) and methemoglobinemia (blockage of the oxygen-binding site on hemoglobin);
- cardiovascular disorders (bradycardia, excitability disorders that can result in cardiovascular collapse);
- neuromuscular disorders (in particular a sensation of muscular weakness);
- and damage to the liver and kidneys.

In the workplace setting, poisonings are mainly by skin exposure because phenol easily penetrates through the stratum corneum. Poisonings by ingestion are rare as are poisonings by inhalation which are usually of little significance because the volatility of phenol is weak. (OSHA guideline[10])

On the other hand, inhalation of aerosols or dust containing high concentrations of phenol (pure phenol consists of needle-shaped crystals) can cause acute lung oedema which may be more or less delayed.

The oral LD_{50} values for rats are approximately 400 mg/kg and 850 mg/kg with skin exposure in the rabbits (source INRS).

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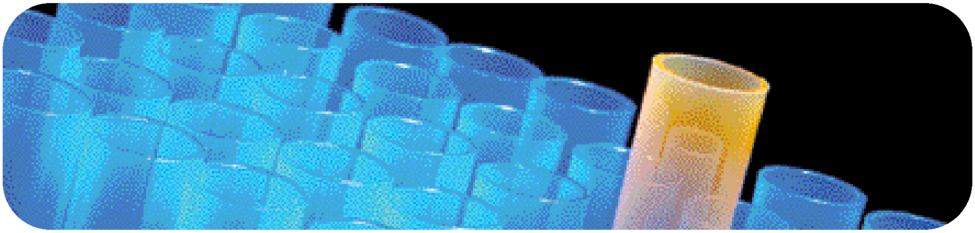
[10] - *Occupational Safety & Health Administration*



5. MANAGING ASSOCIATED RISKS

Collective and Personal Protection[11]

GROUP PROTECTION	• Worker in an enclosed space • In the absence of a better means, provide an exhaust system at the source • In all cases, anticipate periodic monitoring of the breathing atmosphere ***Secondary prevention:*** • Make the means of efficacious decontamination available
PERSONAL PROTECTION	• Protective clothing, • gloves (polychloroprene, neoprene, polyethylene or multi-layer) • face shields or protective goggles

6. EMERGENCY RESPONSE TO CHEMICAL SPLASHES

6.1. Evaluation of decontamination methods

One of the known decontamination methods is PEG 400 or polyethylene glycol with a 400 g/mol molecular weight (formulation $H(OCH_2CH_2)_nOH$). PEG 300 is also reported in the literature. Polyethylene glycol is a viscous substance that can be only used for skin decontamination. Its use does not resolve at all the question of ocular splashes. PEG is applied either directly, or after initial rinsing with water, or mixed with an alcoholic solvent (Monteiro-Riviere, Toxicol Ind Health, 2001).

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[11] - See full description in INRS Toxicological Data Sheet n°15 and OSHA guideline

It should be noted that the application of a polyethylene glycol cream (63% PEG 300, 32% PEG 4000, 5% PEG 1000) on the skin of 3 persons with thermal burns lead to their deaths (Bruns & al. – Burns 1982). This was explained by PEG absorption and PEG hydrolysis into ethylene glycol, which was discovered in the three patients. These findings are to be correlated to those obtained on PEG toxicity (carbowax) used as a topical application in rabbits.

6.2. Experimental Data

In the table below are shown the different experimental results obtained at the PREVOR Laboratory. Parameters observed are temperature increase and pH, phenol being acidic.

MIXTURE TESTS	TEMPERATURE (°C)[12]	pH
1g phenol + 10 ml water	24 °C	5.38
1 g phenol + 10 ml Diphoterine®	24 °C (no heating)	7.35
1 g phenol + 10 ml PEG 400	24 °C (no heating)	8.64
1 g phenol + 10 ml water + 10 ml Diphoterine®[13]	24 °C (no heating)	7.33
13 g phenol + 10 ml PEG 400 + 10 ml water	35 °C (heating /cloudy)	6.50
1 g phenol + 10 ml water + 10 ml PEG 400	34 °C (heating/cloudy)	5.99

When 1g of phenol is rinsed with PEG and then with water, or inversely after rinsing with water and then applying PEG, the pH returns to normal physiological levels. But there was also a marked increase in temperature as well as a cloudy appearance caused by the formation of a high number of hydrogen bonds between polyol and water. When PEG400 is used alone as a first line response, the phenol is solubilized and washed off without being absorbed by the skin.

When phenol is mixed with water or Diphoterine®, directly, there is no increase in temperature in either case but the pH of the final mixture stands at 5.38 and 7.35 respectively. This shows the effect of Diphoterine® on the acid active site of phenol.

The above experiments show that the emergency response to phenol skin or eye splashes can be simplified by using Diphoterine® as the first and primary response, allowing a rapid and safe return to a neutral pH level.

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[12] - Ambiant temperature = 24°C

[13] - Diphotérine® batch number = D570908B

6.3. Experiential data

6.3.1 - Utilisation of water and PEG 400

Four cases of phenol splashes, washed immediately with water for at least 30 minutes followed by an application of PEG 400, were recently published in Burns by Lin & al (2006).

The rapid initial management limited consequences but did not prevent the development of burns with associated ocular damage. The injured tissues, treated with a local sulfadiazine, started to heal only 10 to 14 days later with occurrences of hypo- or hyper-pigmentation and slightly hypertrophic scar tissue. Hospitalization lasted 7 to 14 days, with an average of 10.3 days.

6.3.2 – Utilisation of Diphoterine®

Two industrial[14] accidents managed with Diphoterine® have been reported to us.

The first accident involved a truck driver who transported phenol. After filling the tank truck, the driver droped the cover. Several phenol droplets were squirted forth and burned the driver's face. The driver was **immediately washed with Diphoterine®** and **did not develop any burn injuries.** One could observe only a slight erythema (redness) which resolved over two days.

The second accident involved a splash of a heated glaze containing 40% cresol (a phenol derivative) on a large surface area of the thigh of a production worker. He was **immediately decontaminated with a mixture of PEG and alcohol. Previn®** (a Prevor solution sold in Germany and equivalent to Diphoterine®) was utilized as a **secondary decontamination**, and then the victim underwent **a third washing with PEG and water. Treatment** was continued with a cortisone-based ointment. **No damage and no after effects** were subsequently observed.

When rinsing, while most of the phenol is mechanically washed off the skin or tissue by whatever solution is used, it is the efficacy of the solution and rapidity of decontamination that will help limit or attenuate the development of chemical burns as shown by the two accidents above.

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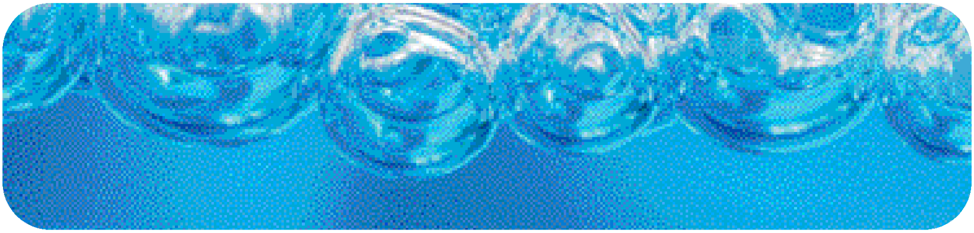
[14] *Testimonials can be consulted on the Prevor web site www.prevor.com*



7. RECOMMENDATIONS FOR WASHING WITH DIPHOTERINE®

Diphoterine® is an emergency washing solution for ocular and cutaneous chemical splashes. It acts directly on the potentially irritating or corrosive nature of the chemical thanks to its amphoteric properties. Its hyper-osmolarity stops any in-depth tissue penetration by the chemical. This maximizes the effectiveness of the solution avoiding or limiting corrosive lesions and the development of potential systemic effects.

The risk of acute lung oedema (ARDS - Acute Respiratory Distress Syndrome) must be emphasized, understanding that respiratory/inhalation exposure requires systematic medical follow-up during the initial 24 hours following the accident because of the potential delayed characteristics of clinical respiratory signs. Our rinsing solutions do not claim to treat this kind of complication and must not be recommended for this indication.

Comparatively, rinsing with water will only dilute and carry away the chemical but will not prevent reactions to the chemical and does not stop the evolution of the lesions.

In the case of ocular or cutaneous splash with phenol, we recommend rapid and prolonged washing with Diphoterine®. Diphoterine® stops the corrosiveness of this product.

For eye splashes with phenol and a contact time of less than 10 seconds, use one 50ml LIS.

For a contact time of less than one minute, use a 500 ml container and continue rinsing with a 250 ml container of Afterwash II®.

For skin splashes with phenol (hands, forearm, neck etc.) and a contact time of less than one minute, use a 100ml Micro DAP.

For an extensive body splash and a contact time of less than one minute, use a 5 litres Portable Autonomous Shower (DAP).

For a contact time greater than one minute with the corrosive substance, depending on the nature of the chemical, the burn may already have developed. Diphoterine® proves to be effective even with delayed used (after one minute). Washing, including rinsing of a visible burn, will facilitate subsequent secondary care.

- **In the case of ocular burns,** after the initial rinsing with 500ml Diphoterine®, we recommend to continue washing, ideally for 5 minutes, with a second container of Diphoterine®
- **In the case of skin burns,** after the initial rinsing with Diphoterine®, we recommend to continue washing with a second rinsing lasting 3 to 5 times the time of exposure to the chemical.

Please note that the French National Institute for Research and Safety (INRS) stresses the importance of prolonged washing in all cases. Pain relief does not indicate that washing should be stopped. The entire container must be used.

8. DOCUMENTS AND REFERENCES

Internet Document Sources :

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  http://www.reptox.csst.qc.ca/Produit.asp?no_produit=1982&nom=ACIDE+CARBOLIQUE+(PHENOL)&incr=0
- European chemical Substances Information System (ESIS database) from the European Chemical Bureau (ECB) http://ecb.jrc.it/esis/
- INERIS Toxicological Data Sheet for phenol - DRC-01-25590-01DR021.doc, Version N°2-1-May 05
- INRS France Toxicological Data Sheet 15 - 1997 - http://www.inrs.fr/htm/phenol.html
- PROMETRA database access on http://www.prevor.com
- OSHA, health guideline - http://www.osha.gov/SLTC/healthguidelines/phenol/recognition.html

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- Monteiro-Riviere NA, Imman AO, Jackson H, Dunn B, Dimond S, Efficacy of topical phenol decontamination strategies on severity of acute phenol chemical burns and dermal absorption: in vitro and in vivo studies in pig skin; Toxicol. Ind Health, 2001, 17(4), 95-104
- Moody RP, Maibach HI, Skin decontamination: importance of the wash-in effect; Food Chem Toxicol., 2006 Nov, 44 (11), 1783-1788

Risk phrase codes (EC classification)

R23/24/25	Toxic by inhalation, in contact with skin and if swallowed.
R48/20/21/22	Harmful: danger of serious damage to health by prolonged exposure, by inhalation, in contact with skin and if swallowed.
R34	Causes burns.
R68	Possible risk of irreversible effects.
R20/21/22	Harmful by inhalation, in contact with skin and if swallowed.