I U C L I D

D a t a s e t

Existing Chemical Substance ID: 630-08-0
CAS No. 630-08-0
EINECS Name carbon monoxide
EINECS No. 211-128-3
Molecular Formula CO

Dataset created by: EUROPEAN COMMISSION - European Chemicals Bureau

This dossier is a compilation based on data reported by the European Chemicals Industry following 'Council Regulation (EEC) No. 793/93 on the Evaluation and Control of the Risks of Existing Substances'. All (non-confidential) information from the single datasets, submitted in the IUCLID/HEDSET format by individual companies, was integrated to create this document.

The data have not undergone any evaluation by the European Commission.

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1.0.1 OECD and Company Information

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1.0.2 Location of Production Site

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1.0.3 Identity of Recipients

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1.1 General Substance Information

Substance type: inorganic
Physical status: gaseous

Substance type: organic
Physical status: gaseous

Substance type:
Physical status: gaseous

1.1.1 Spectra

-

1.2 Synonyms

Carbon monooxide
Source: BASF AG Ludwigshafen
BASF Antwerpen N. V. Antwerpen 4
BASF AG Ludwigshafen
BASF Schwarzheide GmbH Schwarzheide

Carbon monoxide
Source: Bayer AG Leverkusen

Carbon monoxide (8CI, 9CI)
Source: BASF AG Ludwigshafen
BASF Antwerpen N. V. Antwerpen 4
BASF AG Ludwigshafen
BASF Schwarzheide GmbH Schwarzheide

Carbon monoxide, cryogenic liquid
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(1)

Carbon oxide
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(1)

Carbon oxide (CO)
Source: BASF AG Ludwigshafen
BASF Antwerpen N. V. Antwerpen 4
BASF AG Ludwigshafen
BASF Schwarzheide GmbH Schwarzheide

Carbonic oxide
Source: Bayer Hispania Barcelona

Carbonmonoxide
Source: Bayer Hispania Barcelona

Carbonoxide
Source: Bayer Hispania Barcelona

CO
Source: Bayer AG Leverkusen

Exhaust gas
Source: Bayer Hispania Barcelona

Exhaust gas
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(1)

Flue gas
Source: Bayer Hispania Barcelona

Flue gas
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(1)

Kohlenmonoxid
Source: BASF AG Ludwigshafen
BASF Antwerpen N. V. Antwerpen 4
Bayer Hispania Barcelona
Bayer AG Leverkusen
BASF AG Ludwigshafen
BASF Schwarzheide GmbH Schwarzheide

Kohlenoxid
Source: Bayer AG Leverkusen

Kohlenstoffmonoxid
Source: Bayer Hispania Barcelona
Bayer AG Leverkusen

1.3 Impurities

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1.4 Additives

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1.5 Quantity

Quantity more than 1 000 000 tonnes

1.6.1 Labelling

Labelling: as in Directive 67/548/EEC
Symbols: F+
T
Nota: E
E
Specific limits: no data
R-Phrases: (61) May cause harm to the unborn child
(12) Extremely flammable
(23) Toxic by inhalation
(48/23) Toxic: danger of serious damage to health by prolonged exposure through inhalation
S-Phrases: (53) Avoid exposure - obtain special instructions before use
(45) In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible)

1.6.2 Classification

Classification: as in Directive 67/548/EEC
Class of danger: extremely flammable
R-Phrases: (12) Extremely flammable

Classification: as in Directive 67/548/EEC
Class of danger: toxic
R-Phrases: (23) Toxic by inhalation
(48/23) Toxic: danger of serious damage to health by prolonged exposure through inhalation

Classification: as in Directive 67/548/EEC
Class of danger: toxic for reproduction, category 1
R-Phrases: (61) May cause harm to the unborn child

1.7 Use Pattern

Type: type
Category: Use in closed system

Type: industrial
Category: Basic industry: basic chemicals

Type: industrial
Category: Chemical industry: used in synthesis

Type: industrial
Category: Metal extraction, refining and processing of metals

Type: use
Category: Fuel

Type: use
Category: Intermediates

Type: use
Category: Reducing agents

1.7.1 Technology Production/Use

-

1.8 Occupational Exposure Limit Values

Type of limit: MAK (DE)
Limit value: 30 ml/m3
Short term expos.
Limit value: 60 ml/m3
Schedule: 30 minute(s)
Frequency: 4 times
Source: BASF AG Ludwigshafen
BASF Antwerpen N. V. Antwerpen 4
BASF AG Ludwigshafen
BASF Schwarzheide GmbH Schwarzheide

(2)

Type of limit: MAK (DE)
Limit value: 33 mg/m3
Source: BASF AG Ludwigshafen
BASF Antwerpen N. V. Antwerpen 4
BASF AG Ludwigshafen
BASF Schwarzheide GmbH Schwarzheide

(2)

Type of limit: MAK (DE)
Limit value:
Remark: fortpflanzungsgefaehrdend Gruppe B
Source: BASF AG Ludwigshafen
BASF Antwerpen N. V. Antwerpen 4
BASF AG Ludwigshafen
BASF Schwarzheide GmbH Schwarzheide

(3)

Type of limit: MAK (DE)
Limit value: 33 mg/m3
Short term expos.
Limit value: 66 mg/m3
Schedule: 30 minute(s)
Frequency: 4 times
Country: BRD 1993
Source: Bayer AG Leverkusen

Type of limit: TLV (US)
Limit value: 25 ml/m3
Source: Bayer Shell Isocyanates N.V. Antwerpen

Type of limit: TLV (US)
Limit value: 57 mg/m3
Remark: Limit value: 50 ppm. Changes for these values are proposed.
Source: BASF AG Ludwigshafen
BASF Antwerpen N. V. Antwerpen 4
BASF AG Ludwigshafen
BASF Schwarzheide GmbH Schwarzheide

(4)

Type of limit: TLV (US)
Limit value: 57 mg/m3
Short term expos.
Limit value: 458 mg/m3
Schedule: 15 minute(s)
Frequency: 4 times
Remark: Less than 40 ppm of CO in end-exhaled air is recommended at the end of work shift by BEI Committee.
The Biological Exposure Index should not be applied to samples collected in an emergency, during the first three hours of exposure, or later than 15 minutes after the end of exposure. Monitoring of exposure in tobacco smokers and commuters on congested highways requires special considerations.
Less than 8% of carboxyhemoglobin in blood (expressed as percentage of hemoglobin) is recommended at the end of work shift by BEI Committee.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro

(5)

Type of limit: other
Limit value: 34 mg/m3
Short term expos.
Limit value: 86 mg/m3
Remark: TLV (Finland): 34 mg/m3 (8h TVA)
Source: Outokumpu Chrome OY Tornio

1.9 Source of Exposure

Remark: Major industrial sources are the cupolas of iron foundries, catalytic cracking units in petroleum rafineries, lime kilns and kraft recovery furnaces in kraft paper mills, and the sintering of blast furnace feed in the sintering plants. Additional potential exposures occur: in manifacture and use of illuminating gas; in manifacture of sintetic methane or other organics from carbon monoxide; in carbide manufacture; in distillation of coal and wood; in operation near furnaces, ovens, stoves, forges and kilns; in controlled atmosphere heat-treating of metals; in fire fighting; in testing internal combustion engines. An unexpected source of carbon monoxide is methylene chloride, used as paint stripper, among other uses. Methylene chloride is metabolized to carbon monoxide, and a 3 hours exposure, even in a well ventilated room, can result in a carbon monoxide hemoglobin saturation of 16%.

Source: Terni Industrie Chimiche S.p.A. Nera Montoro

(6)

Remark: The carbonmonoxide is tranported in pipeline and used as fuel in ferrochromium production (smelting in arc furnace).

Source: Outokumpu Chrome OY Tornio

1.10.1 Recommendations/Precautionary Measures

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1.10.2 Emergency Measures

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1.11 Packaging

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1.12 Possib. of Rendering Subst. Harmless

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1.13 Statements Concerning Waste

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1.14.1 Water Pollution

Classified by: KBwS (DE)
Labelled by: KBwS (DE)
Class of danger: 0 (generally not water polluting)
Source: Bayer Shell Isocyanates N.V. Antwerpen
BASF AG Ludwigshafen
BASF Antwerpen N. V. Antwerpen 4
BASF AG Ludwigshafen
BASF Schwarzheide GmbH Schwarzheide

Classified by: KBwS (DE)
Labelled by:
Class of danger: 0 (generally not water polluting)
Source: Bayer AG Leverkusen

1.14.2 Major Accident Hazards

Legislation: Directive 82/502/EEC
Substance listed: yes
No. in Directive: Annex II, Part II, No 2 and 3, Annex III, No 124
Source: Bayer Shell Isocyanates N.V. Antwerpen

Legislation: Stoerfallverordnung (DE)
Substance listed: yes
Remark: Stoerfall-Stoff-Nr. 1 "brennbare Gase"
Source: BASF AG Ludwigshafen
BASF Antwerpen N. V. Antwerpen 4
BASF AG Ludwigshafen
BASF Schwarzheide GmbH Schwarzheide

(7)

Legislation: other: Stoerfallverordnung, 12. BImSchV
Substance listed: yes
Remark: Anhang II, Stoffnummer 1
20.September 1991
Source: Bayer AG Leverkusen

1.14.3 Air Pollution

Classified by: other: Real Dekret 833/1975 , Anlage IV
Labelled by:
Number:
Class of danger:
Remark: limit: 500 ppm
Source: Bayer Hispania Barcelona

1.15 Additional Remarks

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1.16 Last Literature Search

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1.17 Reviews

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1.18 Listings e.g. Chemical Inventories

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2.1 Melting Point

Value: = -205.1 degree C
Decomposition: no
Sublimation: no
Remark: Triple point temperature at 153.5 hPa.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(8)

2.2 Boiling Point

Value: = -191.5 degree C at 1013 hPa
Decomposition: no
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(9)

2.3 Density

Type: density
Value: = 1.2501 kg/m3 at 0 degree C
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(9)

Type: relative density
Value: = .968
Remark: Vapor density , relative to air (air=1)
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(10)

2.3.1 Granulometry

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2.4 Vapour Pressure

Value: = 30609 hPa at -143 degree C
Method: other (calculated)
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(11)

2.5 Partition Coefficient

log Pow:
Method:
Year:
Source: Terni Industrie Chimiche S.p.A. Nera Montoro

2.6.1 Water Solubility

Value: = .03537 vol% at 0 degree C
Qualitative: slightly soluble
Remark: Volume of gaseous CO at 1013.3 hPa absorbed by one volume of water.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(12)

Value: = .02319 vol% at 20 degree C
Qualitative: slightly soluble
Remark: Volume of gaseous CO at 1013.3 hPa absorbed by one volume of water.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(12)

Value: 41 g/l at 20 degree C
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(13)

Value: = 41 g/l at 20 degree C
Source: BASF AG Ludwigshafen
(14)

2.6.2 Surface Tension

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2.7 Flash Point

-

2.8 Auto Flammability

Value: 605 degree C
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(13)

Value: = 605 degree C
Source: BASF AG Ludwigshafen
(14)

Value: ca. 617 degree C
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(15)

2.9 Flammability

Result:
Remark: Flammability range in the air : 12.5- 74.2 vol%

flammability range in oxygen : 15.5- 93.9 vol%
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(15)

2.10 Explosive Properties

Result:
Method: other
Remark: Explosive limits in air: 12.5% - 74.2%
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(16)

2.11 Oxidizing Properties

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2.12 Additional Remarks

Remark: Solubility of carbon monoxide in various solvents at 20°C and 1013.3 hPa :

Solvent	Solubility vol% (a)
Methanol	0.1830
Ethanol	0.1901
Acetic Acid	0.1689
Acetone	0.2538
Toluene	0.1742
Chloroform	0.1897

(a) : volume of gaseous CO absorbed by one volume of solvent
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(17)

Remark: Chemical Reactivity

Carbon monoxide is an unsaturated molecule, it has reducing properties and it may combine with a large variety of molecules.
It is almost inert under mild condition, but it becomes very reactive when subjected to high pressure or elevated temperature or when it is activated by catalysis.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(18)

3.1.1 Photodegradation

Type: air
Method:
Year: **GLP:**
Test substance:
Remark: Carbon monoxide is degraded by photochemical reactions in the stratosphere (Newell et al.,1974; Pressman and Warneck, 1970) .
Ehhalt (1975), extimated that photolysis could remove as much as 3.9 millions tons of CO per year from the atmosphere
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(19)

3.1.2 Stability in Water

Type: biotic
Method:
Year: **GLP:**
Test substance:
Result: CO at trace concentrations (<=1nM) was utilized in ocean water, lake water and soils.
CO consumption followed Michaelis-Menten kinetics with Km-values of 7-9 nM CO.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(20)

3.1.3 Stability in Soil

Type: field trial **Radiolabel:** no
Concentration: .2 ppm
Soil classif.: other: eolian sand, loess loam, loess **Year:**
Cation exch. capac.
Microbial biomass:
Method:
Year: **GLP:**
Test substance:
Result: Measurements in 3 different types of soil, showed that CO was consumed by an apparent 1st-order reaction and produced by an apparent zero-order reaction. The CO consumption rate ranged between 0.13 and 1.03 nl/cm2 min, based on a CO mixing ratio of 0.2 nl/ml (or 0.2 ppm) as representative for continental air at the latitude of 50°N.
The CO production rate varied between 0.01 and 0.26 nl/cm2 min.The consumption rate as well as the production rate was apparently higher in summer than in winter.
Laboratory experiments on five different soil types showed that CO consumption was strongly inhibited by the presence of streptomicyn or cycloheximide or both. In contrast, CO production was stimulated by autoclaving, by UV irradiation, by fumigation with ammonia or chloroform, by treatment with

streptomycin or cycloheximide or both, by drying and rewetting procedure.
The consumption of atmospheric CO by soil is a microbial process, but the production of CO is apparently not a metabolic process.

Source: Terni Industrie Chimiche S.p.A. Nera Montoro

Test condition: The measurements were carried out by covering the soil surface with a glass box without removing the vegetation (grass and small plants) and determining the CO decrease with time inside the glass box.

(21)

Type: laboratory **Radiolabel:** no
Concentration:
Cation exch. capac.
Microbial biomass:
Method:
Year: **GLP:**
Test substance:
Result: 17 soils, collected from ecological situations different for climate, vegetation types and degree of atmospheric pollution, showed different ability to remove carbon monoxide from air containing 80 to 130 ppm of CO .
At 25°C, rate of CO uptake ranged between 2.16 and 16.99 mg/h per square meter of soil. Acidic soils with a high content of organic matter were generally the most active. This activity was ascribed to soil microorganisms. In fact, steam sterilization of the soil, the addition of antibiotics or 10% (by weight) saline solution , and anaerobic condition all prevented carbon monoxide uptake. A sterilized soil inoculated with a nonsteril soil acquired activity with time.

Source: Terni Industrie Chimiche S.p.A. Nera Montoro

(22)

Type: laboratory **Radiolabel:** yes
Concentration: 3 ppm
Cation exch. capac.
Microbial biomass:
Method:
Year: **GLP:**
Test substance:
Result: The ability of soil to remove carbon monoxide from air was examined at four temperatures (0°C, 10°C, 20°C, 30°C) for 20 different types of soil.
At 0°C , the rates ranged between 0.003 and 0.230 mg/h per square meter of soil, at 10°C between 0.030 and 0.480 mg/h per square meter, at 20 °C between 0.06 and 0.680 mg/h per square meter and at 30 °C between 0.09 and 850 mg/h per square meter . On the basis of CO consumption rates at 20°C, the global soil uptake of atmospheric carbon monoxide was calculated 410 Tg/year.

Source: Terni Industrie Chimiche S.p.A. Nera Montoro

(23)

Type: laboratory **Radiolabel:** yes
Concentration:
Cation exch. capac.
Microbial biomass:
Method:
Year: **GLP:**
Test substance:
Result: The rate of CO depletion in the air over three different soils was concentration dependent and followed Michaelis -Menten kinetics. The rate constants Km and Vmax ranged from 18 to 51 nl CO/ml and from 0.58 to 4.35 mg C/ h per Kg of dry soil, respectively. No oxidation occurred when soils had been autoclaved.Incorporation of labelled-C in the soil was slight and was via CO2 rather then CO.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
Test condition: Gas exchange was measured using a flowing-gas system for the precise, non-destructive and simultaneous assay for labelled CO,CO2, COx. The measurements were made at 20°C within 30 hours of collection, using soil samples (equivalent to 100 g of oven-dry soil) at the moisture content as collected in the field and an initial atmospheric CO concentration of 100 nl /ml .

(24)

Type: laboratory **Radiolabel:**
Concentration:
Soil classif.: other: loess, eolian sand, chernozem **Year:**
Cation exch. capac.
Microbial biomass:
Method:
Year: **GLP:**
Test substance:
Result: The rate of CO consumption in the air over three natural soils followed Michaelis-Menten kinetics. The reaction was already saturated at CO mixing ratios below 100 nl CO/ ml. Vmax values ranged from 300 to 900 nl CO/ h per g of soil (dry weight), depending of type of soil.
Km values, from 5 to 8 nl CO/ ml, were two orders of magnitude lower than those (Km, 465 to 1110 nl CO /ml) observed in tests with suspensions of carboxydobacteria such as P.carboxydohydrogena, P.carboxydovorans, P.carboxydoflava. Considering the difference of the Km values and the observed Vmax values, according to the authors, carboxydobacteria cannot contribute significantly to the consumption of atmospheric CO.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro

(25)

3.2 Monitoring Data (Environment)

Type of measurement: background concentration
Medium: air
Remark: In the upper troposphere the CO–mixing rate decreases from 0.15 ppm at 50 °N to 0.05 ppm at 50 °S latitude. At the surface the difference between the hemispheres is larger decreasing from 0.2–0.24 to 0.05 ppm.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(26)

Type of measurement: background concentration
Medium: other: seawater
Result: Measurements of dissolved CO were carried out (1978–1980) in northern and southern Atlantic Ocean covering an area between 53° N and 35° S. The dissolved CO in surface water showed large variations, with maximum values of 4–5 ppm and minimum values of 0.07–0.10 ppm . The corresponding saturation factors varied between a value of 50, indicating high supersaturation of the ocean with respect to atmospheric CO, and a value of 1, indicating equilibrium between the ocean and atmosphere. The daily average CO saturation increased with average chlorophyll concentration and light intensity and decreased with wind speed. The dissolved CO showed strong diurnal variations with maximum values in the afternoon.
Based on average CO saturation factors of 30 +–20 in the surface water of the ocean, the total source strength for atmospheric CO is 10–180 Tg/yr.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(27)

Type of measurement: concentration at contaminated site
Medium: air
Remark: Air pollution by carbon monoxide is restricted almost entirely to urban and highly industrialized areas.
Levels above 100 mg/kg have been detected in urban areas.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(28)

3.3.1 Transport between Environmental Compartments

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3.3.2 Distribution

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3.4 Mode of Degradation in Actual Use

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3.5 Biodegradation

Type: aerobic
Inoculum: other: Agromyces,Microbispora, Mycobacterium
Method: other: modification of method of Pramer and Schimdt
Year: **GLP:** no data
Test substance:
Remark: Slight activity was found among species of Actinoplanes, Agromyces, Microbispora, Mycobacterium.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
Test condition: The microorganisms were incubated in sealed tubes containing about 0.050 ml of labelled CO per liter in the gas phase.
(29)

Type: aerobic
Inoculum: other: Nocardia species
Method: other: modification of method of Pramer and Schimdt
Year: **GLP:** no data
Test substance:
Remark: Species of Nocardia were capable of oxidizing CO to CO2, although the rate were quite different among species. Nocardia salmonicolor oxidized ca.10% of CO after 48 hours of incubation in nutrient broth.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
Test condition: The microorganisms were incubated in sealed tubes containing about 0.050 ml of labelled CO per liter in the gas phase.
(30)

Type: aerobic
Inoculum: other: bacteria, algae, fungi
Result: under test conditions no biodegradation observed
Method: other: modification of method of Pramer and Schimdt
Year: **GLP:** no data
Test substance:
Remark: No oxidation was detected in the following microorganisms: Anabaena flos–aquae 1444, Anacystis nidulans 625, Chlamydomonas reinhardtii 90, Chlorella pyrenoidosa 26, Scenedesmus quadricauda 76 incubated for 5 days in medium C; Saccaromyces fragilis, Penicillum sp., Zygorhynchus moelleri incubated for 72 hours in potato dextrose broth; Agrobacterium tumefaciens, Arthrobacter oxydans, Bacillus circulans, Corynebacterium fascians, Enterobacter aerogens, Pseudomonas auraginosa, Pseudomonas putida incubated for 48 or 72 hours in nutrient broth; C. aquaticum LL–B2252, C.equi LL–C101, Micromonospora chalcea ATCC 12452, Oerskovia xanthineolytica LL–G62, Streptomyces albus ATCC 618, and S.griseus LL–FR3 grown for 48–72 hours in Trypticase soy broth.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
Test condition: The microorganisms were incubated in sealed tubes containing about 0.050 ml of labelled CO per liter in the gas phase.
(29)

Type: aerobic
Inoculum: other bacteria: Pseudomonas carboxydohydrogena, P. carboxydovorans, P. carboxydoflava
Method:
Year: **GLP:**
Test substance:
Remark: CO consumption by suspensions of carboxydobacteria was measured at high CO mixing ratios (50%), as representative for CO autrophic colture conditions,and low mixing ratios (0.5 nl CO /ml), as representative for ambient air conditions. CO was only consumed when the bacteria were grown under CO-autrophic conditions, except for P.carboxydoflava which also consumed CO after heterotrophic growth on pyruvate.
The rates of CO consumption followed Michaelis-Menten kinetics. The calculations gave Km values of 465 to 557 nl CO /ml for CO-autrophically grown cells and of 1110 nl CO/ml for heterotrophically grown P. carboxydoflava.
CO consumption rates ranged from 148 to 959 nl/h per mg of protein at 0.5 nl CO /ml mixing ratio, and from 201,600 to 829,300 nl/h per mg of protein at 50% mixing ratio.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(25)

Type: aerobic
Inoculum: other: Nitrosomonas europea, Nitrosomonas 4W30, Nitrosococcus oceanus
Method:
Year: **GLP:**
Test substance:
Remark: Nitrosomonas europea, Nitrosomonas 4W30, Nitrosococcus oceanus were capable to oxidize significant amount of carbon monoxide over a wide range of temperatures and pH. Ammonium concentration of 1 mg NH4-N/l initially inhibited CO oxidation in all 3 organisms; however, after 48 hours, the presence of ammonium stimulated the CO-oxidizing ability of N. europea and Nitrosomonas 4W30, whereas N.oceanus remained inhibited. No C from CO was incorporated into cellular material in absence of ammonium ion, or in presence of alternate N sources or with ammonium concentration of 50 mg/l. The oxidation of ammonium ion by these organisms was inhibited by carbon monoxide.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(31)

Type: anaerobic
Inoculum: other bacteria: Clostridium pasterianum
Method:
Year: **GLP:**
Test substance:
Remark: Crowing cultures oxidized CO to CO2 at the maximum rate of ca.15 nmole /min mg of protein. The dependence of the rate CO concentration followed Michaelis-Menten kinetics. Half-maximum velocity was obtained with 3000 nM CO in the grown medium.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro

(32)

3.6 BOD5, COD or BOD5/COD Ratio

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3.7 Bioaccumulation

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3.8 Additional Remarks

Remark: Production of carbon monoxide from human activities accounts for 640 Tg/yr, 85% of which is in the northern hemisphere. Moreover, brushwood and forest fire, oxidation of hydrocarbons, release from the oceans and photochemical oxidation of methane by reaction with OH, account for 60, 60, 40 , and ca. 400 Tg/y respectively.
The sinks for CO, uptake by the soil, the stratosphere and oxidation by OH, account for 450, 110 and 600 Tg/y respectively.
The mean residence time of CO in the atmosphere is about 0.3 year.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro

(33)

AQUATIC ORGANISMS

4.1 Acute/Prolonged Toxicity to Fish

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4.2 Acute Toxicity to Aquatic Invertebrates

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4.3 Toxicity to Aquatic Plants e.g. Algae

Species: other algae: Chlorella
Endpoint:
Exposure period:
Unit: **Analytical monitoring:**
Method:
Year: **GLP:**
Test substance:
Remark: At concentrations of 28–350 mg/l in the air and a light intensity of 18 klux , carbon monoxide had no effect on growth of Chlorella cultures. However, at 4.5 klux, the lowest concentration of CO inhibited the algal growth rate.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(34)

4.4 Toxicity to Microorganisms e.g. Bacteria

Type: other: airborne bacteria
Species: other bacteria: Bacillus subtilis var niger
Exposure period:
Unit: **Analytical monitoring:**
Method:
Year: **GLP:**
Test substance:
Remark: At levels of 85 ppm , carbon monoxide decreased the decay rates of Bacillus subtilis spores.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(35)

Type: other: airborne bacteria
Species: other bacteria: Serratia marcescens 8UK
Exposure period:
Unit: **Analytical monitoring:**
Method:
Year: **GLP:**
Test substance:
Remark: At levels of 85 ppm and low relative humidity, carbon monoxide decreased the survival of airborne Serratia marcescens 8UK but protected the cells at high relative humidity.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(36)

Type: other: airborne bacteria
Species: other bacteria: sarcina lutea
Exposure period:
Unit: **Analytical monitoring:**
Method:
Year: **GLP:**
Test substance:
Remark: At levels of 85 ppm carbon monoxide stabilized Sarcina lutea during the first hour of exposition, but the death rate increased up to 30-fold in subsequent 5 hours.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro

(35)

4.5 Chronic Toxicity to Aquatic Organisms

4.5.1 Chronic Toxicity to Fish

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4.5.2 Chronic Toxicity to Aquatic Invertebrates

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TERRESTRIAL ORGANISMS

4.6.1 Toxicity to Soil Dwelling Organisms

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4.6.2 Toxicity to Terrestrial Plants

-

4.6.3 Toxicity to other Non-Mamm. Terrestrial Species

Species: other: Wild bird species
Endpoint: mortality
Expos. period:
Unit: ppm
LD50 : = 1344
Method:
Year: **GLP:**
Test substance:
Source: Terni Industrie Chimiche S.p.A. Nera Montoro

(37)

Species: other: ladybird and stick insect
Endpoint: mortality
Expos. period:
Unit:
Method:
Year: **GLP:**
Test substance:
Remark: Ladybirds and stick insects exposed to high levels of carbon monoxide (80% CO, 20% O) for <10 days, all survived. When exposed for >10 days, they died.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(38)

Species: other: Embryonated chicken eggs
Endpoint: other: 18th day of incubation
Expos. period: 18 day
Unit:
Method:
Year: **GLP:**
Test substance:
Remark: When embryonated chicken eggs were exposed continuously to various CO concentrations (100, 425, 650, 800, 1000 ppm) during the first 18 incubation days, hatchability and viability were inversely related to CO concentrations.
The 8th to 14th incubation days constituded the critical period, beginning with the 425 ppm level. Macroscopic observations on embryos revealed "compensatory hypertrophy" of extra–embryonic blood vessels and amnionic vesiculation. A "quasi–taliped" condition appeared in hatched chicks exposed to 650 ppm.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(39)

Species: other: forest litter invertebrates
Endpoint:
Expos. period:
Unit:
Method:
Year: **GLP:**
Test substance:
Remark: At levels of 100 ppm– 50%, CO had negligible effects on the behaviour of Enchytraeus species, Arion fasciatus, Tracheoniscus rathkei, Diploiulus species, Liobunum calcar and several other forest litter invertebrates. Also, it had no effect on the health and biological functions of the various organisms.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(40)

4.7 Biological Effects Monitoring

–

4.8 Biotransformation and Kinetics

Type: plant
Result: Leaves of 35 species of temperate and tropical plants absorbed CO in light from air containing 6 ppm CO at an average rate of 190 nl/h g of fresh weight.
CO uptake by 9 species, having widely different rates of absorption, was proportional to CO concentration in the range 0 to 100 ppm.
Absorbed CO was metabolized either by oxidation to carbon dioxide and fixation as such or by reduction and incorporation into serine .
CO had various effects on the photosynthesis of leaves of different species, acting like an inhibitory, at concentration as low as 65 ppm, or exerting no influence or even permitting an increase in net CO2 fixation at 99% CO because of the absence of oxygen.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(41)

Type: plant
Result: Reyegrass incubated 3 hours in 0.1% labelled CO in the light yielded labelled sucrose (79% of the total radioactivity of the low–molecular–weight substances), labelled fructose (13.5%), glucose (6%), succinic acid (4.7%), alanine (0.4%) and raffinose(0.2%). Similar results were obtained with corn. Perennials such as maple, privet, aspen, alder were also capable to metabolize CO.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(42)

4.9 Additional Remarks

-

5.1 Acute Toxicity

5.1.1 Acute Oral Toxicity

–

5.1.2 Acute Inhalation Toxicity

Type: LC50
Species: rat
Sex:
Number of Animals:
Vehicle:
Exposure time: 4 hour(s)
Value: = 1807 ppm
Method:
Year: **GLP:**
Test substance:
Remark: Central nervous system effects, blood effects
Source: Terni Industrie Chimiche S.p.A. Nera Montoro

(43)

Type: LC50
Species: rat
Sex:
Number of Animals:
Vehicle:
Exposure time: 30 minute(s)
Value: 4600 – 5000 ppm
Method:
Year: **GLP:**
Test substance:
Remark: The addition of nonlethal concentrations of CO2 (1.7–17.3%) to sublethal concentrations of CO (2500–4000 ppm) caused death of the exposed rats both during and following (up to 24 hours) a 30 minutes exposure. The most toxic combination of these two gases (2500 ppm CO + 5% CO2) increased the rate of carboxyhemoglobin formation 1.5 times that found in rats exposed to 2500 ppm of CO alone.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro

(44)

Type: LC50
Species: mouse
Sex:
Number of Animals:
Vehicle:
Exposure time: 4 hour(s)
Value: = 2444 ppm
Method:
Year: **GLP:**
Test substance:
Source: Terni Industrie Chimiche S.p.A. Nera Montoro

(45)

Type: LCLo
Species: human
Sex:
Number of Animals:
Vehicle:
Exposure time: 30 minute(s)
Value: = 4000 ppm
Method:
Year: **GLP:**
Test substance:
Source: Terni Industrie Chimiche S.p.A. Nera Montoro

(46)

Type: other: TCLo
Species: human
Sex:
Number of Animals:
Vehicle:
Exposure time: 45 minute(s)
Value: = 650 ppm
Method:
Year: **GLP:**
Test substance:
Source: Terni Industrie Chimiche S.p.A. Nera Montoro

(47)

Type: other
Species: monkey
Sex:
Number of Animals:
Vehicle:
Exposure time: 30 minute(s)
Value: = 900 ppm
Method:
Year: **GLP:**
Test substance:
Remark: Monkeys (macaca fascicularis) were seriously affected after 20-30 minutes of exposure, achieving carboxyhemoglobin levels of 25-30 % .The tests were as sensitive as tests in man for detecting psycomotor deficits induced by CO. Apparently a man exposed to 1000 ppm CO while engaged in light activity (e.g. walking) could be seriously affected within 30 minuts.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro

(48)

Type: LC50
Species: other: ICR mouse
Sex:
Number of Animals:
Vehicle:
Exposure time: 30 minute(s)
Value: ca. 8000 ppm
Method:
Year: **GLP:**
Test substance:
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(49)

Type: LC50
Species: other: Swiss albino mouse
Sex:
Number of Animals:
Vehicle:
Exposure time: 30 minute(s)
Value: = 3570 ppm
Method:
Year: **GLP:**
Test substance:
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(49)

5.1.3 Acute Dermal Toxicity

-

5.1.4 Acute Toxicity, other Routes

-

5.2 Corrosiveness and Irritation

5.2.1 Skin Irritation

-

5.2.2 Eye Irritation

-

5.3 Sensitization

-

5.4 Repeated Dose Toxicity

Species: rat **Sex:** male/female
Strain: Fischer 344
Route of admin.: inhalation
Exposure period: 13 weeks
Frequency of treatment: 6 h/day, 5 d/week
Post. obs. period:
Doses: 135 ppm
Control Group: no data specified
Method:
Year: **GLP:**
Test substance:
Result: Blood carboxyhemoglobin achieved the level of 10%. No deleterious effects were observed.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro

(50)

Species: rat **Sex:** male
Strain:
Route of admin.: inhalation
Exposure period: 62 days
Frequency of treatment:
Post. obs. period:
Doses: 500 ppm
Control Group:
Method:
Year: **GLP:**
Test substance:
Result: Blood carboxyhemoglobin achieved the level of 40%. Ventricular hypertrophy was induced.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro

(51)

Species: monkey **Sex:** female
Strain: Macaca Fascicularis
Route of admin.: inhalation
Exposure period: 8 months
Frequency of treatment: intermittently
Post. obs. period:
Doses:
Control Group: yes
Method:
Year: **GLP:**
Test substance:
Result: Cardiorespiratory data obtained on 4 adult female monkeys were compared with data obtained from the same animals after 5 weeks of recovery. Due to CO exposure the arteriovenous oxygen concentration difference and oxygen consumption decreased and blood oxygen affinity increased. However, there was no significant change in cardiac output and mixed venous oxygen partial pressure. The monkeys adapted to chronic CO exposure by reducing their metabolic rate.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro

(52)

Species: monkey **Sex:**
Strain: other: Macaca irus
Route of admin.: inhalation
Exposure period: 2 years
Frequency of treatment: 22 h/day, 7 d/week
Post. obs. period:
Doses: 20 or 65 ppm
Control Group: yes
Method:
Year: **GLP:**
Test substance:
Result: Blood carboxyhemoglobin values ranged from 2.0 to 5.5% and 4.8 to 10.2% for low and high carbon monoxide ambient concentration, respectively.
These levels of carboxyhemoglobin for two years did not lead to any biologically significant changes in the monkeys.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro

(53)

Species: monkey **Sex:**
Strain:
Route of admin.: inhalation
Exposure period: 24 weeks
Frequency of treatment:
Post. obs. period:
Doses: 120 ppm
Control Group: yes
Method:
Year: **GLP:**
Test substance:
Result: The average carboxyhemoglobin level of 12.4% resulted in a polycythaemia with an increase in haematocrit from 35 to 50% All animals developed symptoms which suggested non specific myocardial stress rather than ischaemia.
Animals, in which an experimental myocardial infarction was produced prior to exposure to carbon monoxide, had more marked electrocardiographic changes than animals breathing room air.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(54)

5.5 Genetic Toxicity 'in Vitro'

Type:
System of testing:
Concentration:
Metabolic activation:
Result:
Method:
Year: **GLP:**
Test substance:
Remark: No evidence is available on mutagenicity in relation to exposure to carbon monoxide.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(55)

5.6 Genetic Toxicity 'in Vivo'

-

5.7 Carcinogenicity

Species: **Sex:**
Strain:
Route of admin.:
Exposure period:
Frequency of treatment:
Post. obs. period:
Doses:
Result:
Control Group:
Method:
Year: **GLP:**
Test substance:
Remark: No evidence is available on carcinogenicity in relation to exposure to carbon monoxide.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(55)

5.8 Toxicity to Reproduction

-

5.9 Developmental Toxicity/Teratogenicity

Species: rat **Sex:** female
Strain: Long–Evans
Route of admin.: inhalation
Exposure period: all gestation
Frequency of treatment: 24 hours daily
Duration of test: litters were removed within 12 hours after birth
Doses: 150 ppm
Control Group: yes, concurrent no treatment
Method:
Year: **GLP:**
Test substance:
Remark: Rats prenatally exposed to a low concentration of carbon monoxide capable to produce carboxyhemoglobin levels in the blood equivalent to those founded in cigarette smokers, showed reduced birth weight and decreased weight gain. Neurobehavioral and biochemical testing of offspring revealed lower behavioral activity levels through the preweaning period, altered central catecholamine activity and reduction in total brain protein at birth.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(56)

Species: rat **Sex:** female
Strain:
Route of admin.: inhalation
Exposure period: pregnancy
Frequency of treatment:
Duration of test:
Doses: 150 ppm
Control Group: yes
Method:
Year: **GLP:**
Test substance:
Result: Exposure of pregnant rats produced only a minor reduction in the birth weights of the pups and gave no evidence of overt teratogenesis. However, behavioral evaluation of learning and memory processes suggested a functional deficit in central nervous system of the exposed offspring.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(57)

Species: mouse **Sex:** female
Strain: no data
Route of admin.: inhalation
Exposure period: 6–15 d
Frequency of treatment: 7 or 24 h daily
Duration of test: 10 days
Doses: 250 ppm
Control Group: yes
Method:
Year: **GLP:**
Test substance:
Result: CO was not teratogenic. However a significant increase in the incidence of some minor skeletal variants was observed.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(58)

Species: mouse **Sex:** female
Strain: CD–1
Route of admin.: inhalation
Exposure period: 7 to 18 d
Frequency of treatment: 24 h daily
Duration of test: 12 days
Doses: 65, 125, 250 and 500 ppm
Control Group: yes
Method:
Year: **GLP:**
Test substance:
Remark: Exposure of pregnant animals to CO failed to produce apparent signs of maternal toxicity, but effects were seen in the offspring. The mean percent fetal mortality per litter from mothers exposed to CO at 0, 65, 125, 250 or 500 ppm was 4.52, 5.89, 12.50, 15.50 and 55.30 respectively. The mean number of dead or desorbed fetuses per litter in the high–dose group was significantly greater than the control value. Weights of fetuses from 125. 250 and 500 ppm CO–exposed mothers were significantly decreased when compared to weights of control. Fetal weight was not significantly influenced by 65 ppm CO exposure.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(59)

Species: other: miniature and domestic pig **Sex:** female
Strain: no data
Route of admin.: inhalation
Exposure period: 108–110 days of gestation
Frequency of treatment: 24 hours daily
Duration of test: 48–96 hours
Doses: 200, 250, 300, 350 ppm
Control Group:
Method:
Year: **GLP:**
Test substance:
Result: In sown exposed to CO concentration of 200, 250, 300, 350 ppm ,stillbirth rates were 6.7,34.8 42.3 and 80.0% respectively. The frequency of stillbirth increased significantly when maternal carboxyhemoglobin concentration exceeded 23% saturation of hemoglobin. The carboxyhemoglobin concentrations in new–delivered pigs were greater than maternal ones. Common gross lesions in stillborn pigs were cherry red discoloration of the subcutaneous tissues, muscles and viscera and accumulation of a large volume of serosanguineous pleural effusion.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(60)

5.10 Other Relevant Information

Type: other
Remark: Review
The recent as well as few older CO animal studies are examinated. The toxicology, physiology and pathology of acute carbon monoxide poisoning are discussed.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(61)

Type: other
Remark: Rat, acute inhalation to 3600 to 4767 ppm CO for 30 minutes: COHb-complex dissociated in a first kinetics, the halftime is 12.6 minutes.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(62)

Type: other: Adsorption, Metabolic pathways and biochemical interactions, Elimination
Remark: Carbon monoxide is absorbed via the lungs . It readily diffuses across capillary and placental membranes. Approximately 80% to 90% of the absorbed amount of carbon monoxide binds with hemoglobin, forming carboxyhemoglobin (COHb) which results in reduction of the oxygen-carrying capacity of the blood. The affinity of hemoglobin for carbon monoxide is 200-250 times that for oxygen. COHb shifts the oxyhemoglobin dissociation curve to the left, thus interfering with the delivery of oxygen to tissues. Carbon monoxide also binds reversibly to other heme proteins such as myoglobin, cytochrome oxidase, cytochrome P-450 and hydroperoxidase. Another site of toxicity may be the binding of carbon monoxide to cytochrome a3 oxidase, whih results in inhibition of mitochondrial respiration and impairment of oxygen diffusion into mitochondria.
CO is eliminated unchanged via the lungs. The rate of elimination depends on the rate of its release from heme proteins, alveolar ventilation, duration of exposure, inspired oxygen concentration and carboxyhemoglobin saturation.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(5) (63)

5.11 Experience with Human Exposure

Remark: Carbon monoxide is particularly dangerous because it cannot be detected by the natural senses of the body It is toxic because it competes successfully with the oxygen for the binding sites of hemoglobin (Hb). The affinity of hemoglobin for CO is 200-300 times higher than the affinity for the oxygen. Rarely physiological effects are observed when carboxyhemoglobin is below 10% in blood (for smokers, COHb levels is frequently 4-5%). The first toxic symptoms are a slight headache and sortness of breath; usually they appear at about 20% COHb. Above 40% COHb, severe headache, weakness on exertion, dizziness, hearing and vision troubles, nausea and eventual collapse are observed in conjunction with a cherry-red coloration of the skin. Unconsciousness and possibly death can occur for a carboxyhemoglobin levels of 60-70%. Above 80-90% COHb, death occurs within minutes.

Source: Terni Industrie Chimiche S.p.A. Nera Montoro

(64)

Remark: Physiological Effects of Carbon Monoxide

Conc (ppm)	Effects
0-200	slight headache in some cases
200-400	after 5-6 hours, mild headache,nausea,vertigo mental symptoms
400-700	after 4-5 hours, severe headache, muscolar incoordination, weakness,vomiting,collapse
700-1100	after 3-5 hours, severe headache, weakness, vomiting, collapse
1100-1600	after 1.5-3 hours, coma, breathing still fairly good unless poisoning has been prolonged
1600-2000	after 1-1.5 hours, possibily death
5000-10000	after 2-15 minutes, death

Source: Terni Industrie Chimiche S.p.A. Nera Montoro

(65)

Remark: In almost all cases, acute and severe poisoning results either death or complete recovery. In few cases in which prolonged coma occurred, residual neurologic symptoms and signs appeared. These are been extremely varied, ranging from memory lapses to various palsies and to nearly complete loss of cerebral function. It is impossible to predict the ultimate disability when a person has been in hipoxic coma for several hours. Some make amazing recoveries. Neurologic textbooks usually state that carbon monoxide poisoning is a cause of the Parkinson syndrome.

Source: Terni Industrie Chimiche S.p.A. Nera Montoro

(6)

Remark: In sedentary humans volunteers, there were no signs of illness during a 24-hours period after exposure to an atmosphere containing 25, 50 or 100 ppm of CO. Blood chemistry remained within normal limits and there were no changes in the performance tests.

At 200 ppm, three subjects exposed for 4 hours reported mild "sinus headache" after the third hour; blood chemistry remained normal.

At 500 ppm, one subject reported light headedness; a 10% increase in the heart rate during slight exertion and mild frontal headache occurred after 60 and 90 minutes, respectively. Headache and nausea reached a peak 3.5 hours after exposition.

Exposure to 1000 ppm of CO for 30 minutes caused incapacitating headache 6 hours after exposure, which was still noticeable after a night’s sleep.

Source: Terni Industrie Chimiche S.p.A. Nera Montoro

(66)

Remark: In 39 patients, the severity of poisoning determined by clinical examination did not correlate with carboxyhemoglobin (COHb) content in blood but depended to a large extent on the duration of exposure.
A correlation was observed between the severity of poisoning and pyruvate and lactate blood concentration.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(67)

Remark: Cardiovascular effects summarized by ACGIH :

In normal volunteers, carboxyhemoglobin (COHb) increments less than 5% resulted in acute reduction in exercise tolerance (Horvath et al. 1975; Drinkwater et al. 1974), reduction in arterial and mixed venous oxygen tensions (Ayers et al. 1970), and a reduction in the length of time to the onset of angina in the men with stable angina pectoris (Anderson et al. 1973). Although these findings have not always been reproduced (Sheps et al. 1987) , two recent studies confirm these findings in patients with coronary artery disease.
Elevation of carboxyhemoglobin levels from 0.6% to 2% and 3.9% in 63 men caused a decrease in time to myocardial ischemia and angina (Allred et al. 1989), and average COHb levels of 2.9% resulted in significantly exercise tolerance with onset of angina (Kleinman et al. 1989).
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(68)

Remark: Neurologic/ psycomotory effects summarized by ACGIH:

Anoxia produced by carbon monoxide poisoning may produce acute neurological deficits as well as severe, and often delayed, neurological sequelae. Absorption of carbon monoxide sufficient to cause a COHb level above 10% may be noticed by symptoms such as headache. A number of studies report on the effects of low-level CO exposure (resulting in 2%-5% COHb) on performance psycomotor tasks. Decrements in psycomotor function are observed at 3%-4% COHb, although conflicting results have been reported (Shephard, 1980).
One explanation for inconsistent findings is that positive results have usually been observed only when the psycomotor tasks were of long duration (Insogna and Warren, 1984).
A 3.4% increase in COHb resulted in highly significant deficit in " careful driving skills" (Wraight et al.,1973), 2% or 4% COHb were associated with reduced video game performance (Insogna and Warren, 1984), and 5% COHb caused decrements in vigilance tests (Benignus et al.,1987).
Other behavioral tests on subjects exposed to carbon monoxide sufficient to produce 5% COHb had minimal effects on motor performance only for difficult "dual-task " tests (Mihevic et al. 1983). A report indicates that minimal effects on cognitive performance at 7% are reliably observed and are exacerbated after physical work (Bunnell and Horvath,1988).
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(69)

Remark: Effects in pregnancy summarized by ACGIH: In pregnant workers, oxygen consumption is 15%-25% higher than normal. However, the mother's oxygen capacity may decreased 20%-30% because of the lowered hemoglobin levels (Kindwal and Zenz 1980) , and endogenous production of CO is elevated threefold (Longo 1977). The fetus is unable to increase cardiac output in response to carbon monoxide exposure above endogenous levels and it is normally close to the critical level for tissue oxygenation.
While the carboxyhemoglobin (COHb) levels of the fetus lag behind changes in maternal COHb, at the steady-state, fetal COHb levels are 10%-15% higher than maternal levels, partly because fetal hemoglobin has higher affinity for CO. For example, continous exposure to 30 ppm carbon monoxide, resulting in approximately 5% COHb in mother, will produce 6% in the fetus. A well-established and probably causal relation exists between maternal smoking (resulting in COHb levels of 2%-5% in the fetus) and low birth weight (Longo 1977). There also appears to be a dose-related increase in perinatal deaths with maternal smoking. There may also be a retardation of mental abilities in infants born to smoking mothers (Shephard 1980). Carbon monoxide is likely to be one of the primary etiological agents responsible for these effects.

Source: Terni Industrie Chimiche S.p.A. Nera Montoro

(70)

Remark: In a recent review sixty case reports of carbon monoxide exposures involving pregnant women have been evaluated. The circumstances under which CO exposures adversely affected pregnancy and the types of effects seen have been examined. Carbon monoxide appears to have teratogenic and embryotoxic potential when exposures are sufficient to cause significant increase in maternal carboxyhemoglobin levels and/or moderate to severe toxicity. There are no reports of adverse outcome of pregnancy as a result of carbon monoxide exposures in the workplace.

Source: Terni Industrie Chimiche S.p.A. Nera Montoro

(71)

Remark: Carboxyhemoglobin levels in occupationally unexposed to CO populations:
- Endogenous production: 0.4%-0.7%, increasing up to 2.6% during pregnancy, and 4%-6% in patients with hemolytic anemia.
- Urban population: 1% - 2%.
- Commuters on urban highways: 5% or more.
- Tobacco smokers: cigarettes, one pack per day, average 5%-6% ; two to three packs per day, average 7%-9%; cigars, up to 20%.
- Methylene chloride exposure: at 50 ppm for 8 hours, 1.5%-2.5% of carboxyhemoglobin is formed (CO is a metabolite of methylene chloride).

Source: Terni Industrie Chimiche S.p.A. Nera Montoro

(72)

Remark: In normal subjects exposed to elevated environmental temperature (35-50°C) plus CO or toluene (300 mg/m3), changes in heart rate, body temperature, short-term memory, lactate dehydrogenase of blood serum and blood carboxyhemoglobin were larger than the sum of changes induced by the individual factors.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(73)

Remark: Male volunteers exposed to a gaseous mixture containing CO at levels of 600 mg/m3 or 800 mg/m3, after a 10 minutes exposure showed some mild intoxication symptoms which disappeared 24 hours following the effect.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(74)

Remark: The toxic effects of carbon monoxide on animals and men are been critically examinated and discussed.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(75)

Remark: Since 1967-1988, nine hospitalizations happened for CO inhalation. People showed symptoms such as headache, vertigo, vomiting and faint. Carboxyhemoglobin levels between 25%-35% were found.
Source: Terni Industrie Chimiche S.p.A. Nera Montoro
(76)

Remark: Von 1967-1988 wurden insgesamt 9 Faelle nach Kohlenmonoxid-Inhalation zur weiteren Behandlung in die Klinik eingewiesen. Es tarten Kopfschmerzen, Schwindel, Erbrechen, Benommenheit und Bewusstlosigkeit auf. Es wurden CO-Hb-Werte von 25 und 35 % gemessen.
Source: BASF AG Ludwigshafen
(77)

(1) Sax,N.I. ; Dangerous Properties of Industrial Materials, 7th, ed., Van Nostrand Reinhold Comp., New York 1989, p.713

(2) TRGS 900 (1993)

(3) TRGS 500 (1993)

(4) ACGIH (1991–1992)

(5) Documentation of the Threshold Limit Values and Biological Exposure Indicies ; 6th Ed. , American Conference of Governmental Industrial Hygienists,Inc., Cincinnati, Ohio, 1991

(6) Patty,F.A.; Patty's Industrial Hygiene and Toxicology, Vol 2C, 4114–4124, 3nd rev. ed., Interscience Publishers John Wiley and Sons, New York (1981)

(7) Stoerfall–Verordnung vom 20.09.1991

(8) Ledon, H.; Ullmanns's Encyclopedia of Industrial Chemistry, 5th ed., VCH, Weinhim 1989 Vol. A5, p 203–216

(9) Ledon, H.; Ullmann's Encyclopedia of Industrial Chemistry, 5th ed., VCH, Weinhim 1989, Vol.A5 p 203–216

(10) The Merck Index,11th ed,, Merck & Co.,Inc., Rahway,N.J. 1989

(11) ¿Ledon, H.; Ullmann's Encylopedia of Industrial Chemistry, 5th ed., VCH, Weinhim, 1989, Vol. A5 p 203–216 ¿

(12) Ledon, H.; Ullmann's Encyclopedia of Industrial Chemistry, 5th ed., VCH, Weinhim, 1989, Vol.A5 p 203–216

(13) BASF AG, Sicherheitsdatenblatt Kohlenmonoxid (getrocknet) (03/87)

(14) BASF AG, Sicherheitsdatenblatt Kohlenmonoxid (getrocknet) (03/87)

(15) Ledon,H.; Ullmann's Encyclopedia of Industrial Chemistry, 5th ed., VCH, Weinhim, Vol.A5 p 203–216

(16) N.I.Sax : Dangerous Properties of Industrial Materials, 7th, ed., Van Nostrand Reinhold Comp., New York 1989, p.713

(17) Ledon,H.; Ullmann's Encyclopedia of Industrial Chemistry, 5th ed., VCH, Weinhem, Vol. A5, 203–217

(18) Ledon, H.; Ullmann's Encyclopedia of Industrial Chemistry, 5th ed., VCH, Weinhim, Vol. A5, 203–216

(19) Newell, R.E.; Boer, G.J.; Kidson, J.W.; 1974, Tellus, 26, p 103–107 cited by Kim, Y.M.and Hegeman,G.D.1983, Int. Rev. Cyt., 81, p 1–32

Pressman, J. and Warneck, P.; 1970, J.Atmos.Sci.,27, 155–163 cited by Kim, Y.M. and Hegeman, G.D. 1983, Int. Rev. Cyt., 81, p 1–32

Ehhalt, D.H.; 1975, in "Microbial Production and Utilization of Gases", H.G. Schlegel et al. eds, Goltz, Gottingen, 13–21 cited by Kim, Y.M. and Hegemam, G.D., 1983, Int.Rev.Cyt., 81, p 1–32

(20) Conrad,R. and Seiler, W.; Arch. Microbiol. 1982, 132(1), 41–46 reviewed by Chem. Abst. 97 : 88463q

(21) Conrad,R. and Seiler,W.; App. Environ. Microbiol. 1980, 40(3), 437–445

(22) Inman, R.E., Ingersoll R.B.; Levy E.A. ; Science 1971, 172, 1229–1231

(23) Bartholomew, G.W. and Alexander, M.; Science 1981, 212, 1389–1391

(24) Duggin, A.J. and Cataldo D.A. ; Soil Biol. Biochem. 1985, 17(4), 469–474

(25) Conrad, R.; Meyer, O.; Seiler, W.; App. Environ. Microbiol. 1981, 42(2), 211–215

(26) Seiler, W.; Int. Conf. Environ. Sensing Assess. (Proc.) 1975 (Pub. 1976) 2, 87, IEEE: New York, N.Y. reviewed by Chem. Abst. 86: 77846p

(27) Seiler, C.R.;Bunse, G.; Giehl, H.; J. Geophys. Res. (Sect.)C 1982, 87(C11), 8839–8852

(28) Ledon, H.; Ullmann’s Encyclopedia of Industrial Chemistry, 5th ed., VCH, Weinhim, 1989 , Vol.A5 p 203–216

(29) Bartholomew,G.W. and Alexander, M:; Appl.Environ. Microbiol. 1979, 37(5), 932–937

(30) Bartholomew, G.W. and Alexander,M.; Appl.Environ.Microbiol. 1979, 37(5), 932–937

(31) Jones, R.D. and Morita R.Y.; Can. J. Microbiol. 1984, 30(7), 894–899

(32) Fuchs,G.; Schnitker, U.; Thauer, R.K.; Eur.J.Biochem. 1974, 49(1), 111–115

(33) Seiler, W.; Int. Conf. Environ. Sensing Assess. (Proc.) 1975 (Pub. 1976) 2, 87, IEEE: New York, N.Y. reviewed by Chem. Abst. 86: 77846p

(34) Maslennikova, V.G.; Al'bitskaya, O.N.; Mater. Vses.Rab. Soveshch. Vop. Krugovorota Veshchestv Zamknutoi Sist.Osn. Zhiznedeyatel. Nizshikh Organizmov, 7th, Rubenchik,L.I. Naukova Dumka ed.,Kiev 1971 reviewed by Chem. Abst. 78: 93055v

(35) Lighthart, B.; Appl. Microbiol. 1973, 25(1), 86-91

(36) Lighthart, B., Appl. Microbiol. 1973, 25(1), 86-91

(37) Archiv Environ. Cont. Toxicol. 1983, 12, p 355 cited in N.I. Sax: Dangerous Properties of Industrial Materials, 7th ed., 1989 , 713

(38) Baker, G.M. and Wright, E.A.; Bull. Environ. Contam. Toxicol. 1977, 17(1), 98-104 reviewed by Chem. Abst. 86 : 151194t

(39) Baker F.D. and Tumasonis, C.F.; Arch. Environ. Health 1972, 24, 53-61

(40) Kenyon, P. E. and Edgar, A. L. ; Bios 1971, 43(2), 139-143 reviewed by Chem Abst. 76 : 21655b

(41) Bidwell, R. G. S. and Bebee, Gail P.; Can. J. Bot. 1974, 52(8), 1841-7

(42) Durmishidze, S.H.; Ugrekhelidze, D.Sh.; Beriashvili, T.V.; Dokl. Akad. Nauk SSSr 1978, 238(3), 730-732 reviewed by Chem. Abst. 88: 101656r

(43) Tox. Applied Pharmacol., 1970, Vol.17, 752 cited in N.I. Sax : Dangerous Properties of Industrial Materials, 7th ed., Van Nostrand Reinhold Comp., New York 1989, 713

(44) Levin,B.C.; Paabo, M.; Gurman, J.L.; Harris,S.E.; Braun,E.; Toxicology 1987, 47(1-2), 135-164

(45) Tox. Applied Pharmacol., 1970, Vol.17 , 752 cited in N.I. Sax : Dangerous Properties of Industrial Materials, 7th ed., Van Nostrand Reinhold Comp., New York 1989, 713

(46) "Pratical Toxicology of plastics" R. Lefaux, Cleveland, Ohio, Chemical Rubber Company , 1968 cited in N.I.Sax : Dangerous Properties of Industrial Materials, 7th, ed., Van Nostrand Reinhold Comp., New York 1989, 713

(47) Am. Ind. Hyg. Ass. J. 1973, Vol.34, 212 cited in N.I. Sax: Dangerous Properties of Industrial Materials, 7th, ed., Van Nostrand Reinhold Comp., New York 1989, 713

(48) Purser, D.A. and Berrill, K.; Arch. Environ. Health 1983, 38(5), 308-315

(49) J. Combust. Toxicol., 1977, 4(4), p 523-532 reviewed by Chem. Abst. 88: 115965c

(50) Mattsson, J.L.; Albee, R.R.; Eisenbrandt, D.L.; Pharmacol. Biochem. Behav. 1990, 36(3), 671-81 reviewed by Chem. Abst. 113: 72722m

(51) Bambach, G.A.; Penney, D.G.; Negendank, W.G.; J. Appl. Toxicol. 1991, 11(1), 43-49 reviewed by Chem. Abst. 114: 116574s

(52) Dhindsa, D.S. and Ochsner, A.J. ; J. Med. Primatol. 1981, 10 (4-5), 255-262 reviewed by Chem. Abst. 96 : 194719s

(53) Eckardt, R.E.; MacFarland, H.N.; Alarie, Y.C.E.; Busey,W.M.; Arch. Environ. Health 1972, 25(6), 381-387

(54) De Bias, D.A.;Banerjee, C.M.; Birkhead,N.C.; Harrer,W.V.; Kazal,L.A.; Arch. Environ. Health 1973 , 27, 161-167

(55) Environmental Health Criteria 13 (Carbon monoxide), WHO,1989

(56) Fechter,L.D. and Annau Z., Science 1977, 197(4304), 680-682

(57) Mactutus C.F. and Fechter, L.D:; Science 1984, 223 (4634) , 409-411

(58) Schwetz, B.A.; Smith,F.A.; Leong, B.K.J.; Teratology 1979, 19(3), 385-91

(59) Singh J. and Scott L.H.,Teratology 1984(30), 253-7

(60) Dominick, M.A. and Carson, T.L.; Am. J. Vet. Res. 1983, 44(1), 35-40 reviewed by Chem. Abst. 98: 48276v

(61) Penney, D.G.; Toxicology 1990, 62, 123-160

(62) Bayer AG data, Report No. 12647 (F), April 26 (1984).

(63) Environmental Health Criteria 13 (Carbon monoxide), WHO, Geneve 1979

(64) Ledon,H.; Ullmann's Encyclopedia of Industrial Chemistry, 5th ed., VCH, Weinhim, 1989, Vol.A5, 203-216

(65) Kirk-Othmer; Encyclopedia of Chemical Thecnology, 2th ed., John Wiley & Sons,

(66) Stewart, R.D.;Peyerson, J.E.; Baretta, E.D.; Bachand,R.T.; Hosko, M.J.; Hermann, A.A.; Arch. Environ. Health 1970, 21 (2), 154-64 reviewed by Chem. Abst. 73 : 85965y

(67) Sokal, Jerzy A.; Stud. Mater. Monogr.- Inst.Med. Pr. 1986, 24, 5-25 reviewed by Chem. Abst. 107: 128717j

(68) Horvath,S.M. et al.; J.Appl.Physiol. 1975, 38, 300-303 cited in ACGIH Documentation (1991)

Drinkwater, B.L.; Raven, P.D.; Horvath, S.M.; et al.; Arch. Environ. Health 1974, 28, 177-181 cited in ACGHI Documentation (1991)

Ayers,S.M. Gianelli, S.J.; Mueller, H.S.; Ann. N.Y. Acad. Sci. 1970, 174(1), 268-293 cited in ACGIH Documentation (1991)

Anderson,E.W. et al.; Ann. Intern. Med. 1973, 79, 46-50 cited in ACGIH Documentation (1991)

Sheps,D.S.; Adams Jr, K.F.; Bromberg, P.A.; et al. ; Arch. Environ. Health 1987, 42, 108-116 cited in ACGIH Documentation (1991)

Allred,E.N ; Bleecker, E.R.; Chaitman, B.R.;et al. ; N. Engl. J. Med. 1989, 321, 1426-1432 cited in ACGIH Documentation (1991)

Kleinman, M.T., Davidson, D.M.; Vandagiff, R.B.; Arch. Environ. Health 1989, 44, 361-369 cited in ACGIH Documentation (1991)

(69) Shephard,R.J.; Carbon Monoxide-The Silent Killer Charles C.Thomas, Springfied.(1980) cited in ACGIH Documentation (1991)

Insogna,S. and Warren,C.A.; The Effects of Carbon Monoxide on Psycomotor Function In: Trends in Ergonomics/Human Factors I.A. Mital, Ed.Esevier, north-Holland (1984) cited in ACGIH Documentation (1991)

Wright,G.; Randell, P.; Shephard, R.J.; Arch. Environ. Healt 1973, 27, 349-354 cited in ACGIH Documentation (1991)

Benignus,V.A.; Muller, K.E.; Barton,C.N.; Prah, J.D.; Neurotoxicol.Teratol. 1987, 9, 227-234 CIted in ACGIH Documentation (1991)

Mihevic,P.M.; Gliner,J.A.; Horvath,S.M.; Int. Arch. Occup. Environ. Health 1983, 51, 355-363 cited in ACGIH Documentation (1991)

Bunnell, D.E. and Horvath, S.M.; Aviat. Space Environ. Med. 1988, 59, 1133-1138 cited in ACGIH Documentation (1991)

(70) Kindwal,E.P. and Zenz,C.; Developments in Occupational Medicine, pp. 85-92 C.Zenz, Ed. Yearbook Medical Publishers, (1980) cited in ACGIH Documentation (1991)

(71) Norman, C.A. and Halton, D.M.; Ann. Occup. Hyg. 1990, 34(4), 335-347

(72) Documentation of the Threshold Limit Values and Biological Exposure Indicies; 6th Ed., American Conference of Governmental Industrial Hygienists, Inc., Cincinnati, Ohio, 1991

(73) Sedov, A.V.; Kustov, V.V.; Surovtsev, N.A.; Lukicheva, T.A.; Akinshin, A.V.; Nazarov,L.Yu; Gig. Tr. Prof. Zabol. 1990, (8), 11-14 reviewed by Chem. Abst. 113: 167125h

(74) Kustov, V.V.; Yastrebov, V.E.; Razinkin, S.M.; Gig.Tr.Prof. Zabol. 1987, (4), 34-6 reviewed by Chem Abst. 107: 34498m

(75) Environmental Health Criteria 13 (Carbon Monoxide), WHO, Geneve 1979

(76) BASF AG, Werksaerztlicher Dienst, unveroeffentlichte Mitteilung, (1994)

(77) BASF AG, Werksaerztlicher Dienst, unveroeffentlichte Mitteilung, (1994)

7.1 Risk Assessment

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