SODIUM CHLORITE

1. Chemical and Physical Data

1.1 Synonyms and molecular formulae and weights

Sodium chlorite

Chem. Abstr. Services Reg. No: 7758-19-2
Synonym: Chlorous acid, sodium salt
Molecular formula: $NaClO_2$
Molecular weight: 90.44

Sodium chlorite trihydrate

Chem. Abstr. Services Reg. No.: 49658-21-1
Synonym: Chlorous acid, sodium salt, trihydrate
Molecular formula: $NaClO_2 \cdot 3H_2O$
Molecular weight: 144.49

1.2 Chemical and physical properties of the pure substance

From Weast (1989) unless otherwise specified

Sodium chlorite

(*a*) *Description*: White, hygroscopic crystals
(*b*) *Melting-point*: Decomposes at 180-200°C
(*c*) *Solubility*: Soluble in water (g/l): 390 at 17°C, 550 at 60°C
(*d*) *Stability*: Stable in the absence of oxidizable organic matter (Budavari, 1989)
(*e*) *Reactivity*: Oxidizes many organic and inorganic substances; can explode in response to physical shock or heat when mixed with combustibles (Canadian Centre for Occupational Health and Safety, 1989). In aqueous

alkaline solutions, chlorite ion is very stable, even at 100°C; in acid solutions, chlorite forms chlorous acid ($HClO_2$), which rapidly disproportionates to chlorine dioxide, chlorate and chloride (Aieta & Roberts, 1985).

Sodium chlorite, trihydrate

(*a*) *Description*: Triclinic leaflets

(*b*) *Stability*: Becomes anhydrous at 38°C or in a dessicator over potassium hydroxide at room temperature (Budavari, 1989)

1.3 Technical products and impurities

Trade names: Neo Silox D; Textone

Sodium chlorite is the only chlorite salt marketed and used in commercially significant quantities. The technical-grade usually contains approximately 80% sodium chlorite (Noack & Doerr, 1979). Products are available in dry form or as aqueous solutions containing 25-80% sodium chlorite (Olin Corporation, 1989). A small amount of sodium hydroxide is usually retained to stabilize the product, and sodium chloride is usually added to reduce the sodium chlorite content to a maximum of about 80%; this is necessary to ensure safety and minimize reactivity (Noack & Doerr, 1979).

2. Production, Use, Occurrence and Analysis

2.1 Production and use

(*a*) *Production*

Sodium chlorite was described in 1843 by N. Milan; it was first produced in the USA by the Mathieson Company in 1937. In 1948, Degussa AG became the first German producer (Eul, 1989).

The commercial manufacture of sodium chlorite depends entirely on chlorine dioxide made from sodium chlorate. Generally, chlorine dioxide is absorbed in caustic soda containing hydrogen peroxide as a reducing agent to produce sodium chlorite. An excess of hydrogen peroxide is important to prevent disproportionation, which yields sodium chlorate. Sodium chloride may be added to decrease the sodium chlorite content to 80% of dry product weight (Noack & Doerr, 1979).

Commercially significant quantities of sodium chlorite are produced mainly in Japan, the European Economic Community and the USA. Accurate production

statistics are not available. The Japanese Ministry of International Trade and Industry reported production of 6200 tonnes in 1973 and 5400 tonnes in 1974, although it is unclear whether these statistics refer strictly to sodium chlorite (Noack & Doerr, 1979). Japanese production of sodium chlorite (100%) was 4000 tonnes in 1984, 3815 tonnes in 1985, 3634 tonnes in 1986, 3811 tonnes in 1987 and 3503 tonnes in 1988 (Anon., 1985; Ministry of International Trade and Industry, 1989).

Sodium chlorite is produced by one company each in Belgium, Brazil, France, Italy, Spain and the UK, by two companies in Germany and the USA, and by five companies in Japan (Chemical Information Services Ltd, 1988).

(b) Use

Most of the sodium chlorite used in the USA is in the production of aqueous chlorine dioxide solutions at the site of use. This conversion can be carried out by the disproportionation of chlorous acid formed from chlorite in aqueous hydrochloric acid solution, but is more commonly achieved by the oxidation of chlorite by chlorine or hypochlorous acid (Aieta & Roberts, 1985; White, 1986). Chlorine dioxide is generated to bleach and strip textiles, to bleach wood pulp in paper processing, to eliminate tastes and odours in potable water, to reduce loads of adsorbable organic halogenated compound in industrial effluents, to control microbiological growth in paper mills, oil wells and petroleum systems and food processing plant flume water, to bleach (upgrade) fats and oils, to disinfect sewage, to treat factory wastes, where it converts simple phenolic compounds, simple cyanides and sulfides, to bleach natural foliage and to control algae in industrial cooling towers. Sodium chlorite is also used in the electronics industry for etching printed circuits because it oxidizes copper metal to copper[II] directly (Olin Corporation, 1984, 1989). The compound is used for the same processes in Europe and Asia, but more sodium chlorite is used to bleach textiles (Noack & Doerr, 1979).

2.2 Occurrence

(a) Natural occurrence

Sodium chlorite is not known to occur naturally.

(b) Occupational exposure

Industrial processes in which workers may be exposed to sodium chlorite include generation of chlorine dioxide in aqueous solutions at pulp and textile mills and the treatment of drinking-water; however, no data on occupational exposures were available to the Working Group. No regulatory standards or guidelines have been published for exposures to sodium chlorite.

2.3 Analysis

A method for the quantitative analysis of chlorite in water, which distinguishes chlorite from other oxychlorine species, has been reported (White, 1986).

3. Biological Data Relevant to the Evaluation of Carcinogenic Risk to Humans

3.1 Carcinogenicity studies in animals (Table 1)

(*a*) *Oral administration*

Mouse: Groups of 50 male and 50 female B6C3F$_1$ mice, six weeks old, were given 0.0, 0.025 or 0.05% sodium chlorite (82-87% pure [impurities unspecified]) in the drinking-water for 80 weeks. Survival at 85 weeks was: males—control, 35/50; low-dose, 47/50; high-dose, 43/50; females—control, 47/50; low-dose, 50/50; high-dose, 50/50. Hyperplastic nodules in the liver occurred in 6/35 control, 14/47 low-dose and 11/43 high-dose males, and hepatocellular carcinomas occurred in 4/35 control, 8/47 low-dose and 6/43 high-dose males; these differences are not significant. The incidences of liver tumours in control and treated females were similar. Adenomas of the lung occurred in 0/35 control, 2/47 low-dose and 5/43 high-dose male mice ($p < 0.05$, chi-square test), and adenocarcinomas occurred in 0/35 control, 1/47 low-dose and 2/43 high-dose males; the incidences of lung tumours were similar in control and treated females. The proportion of high-dose female mice with malignant lymphoma/leukaemia was significantly smaller than that in controls (control, 7/47; low-dose, 5/50; high-dose, 1/50; $p < 0.05$, chi-square test) (Yokose *et al.*, 1987). [The Working Group noted that survival-adjusted statistical analyses were not reported.]

Rat: Groups of 50 male and 50 female Fischer 344 rats, six weeks old, were given 0.0, 0.03 or 0.06% sodium chlorite [purity unspecified] in the drinking-water for 85 weeks. The study was terminated early because of pneumonia associated with Sendai virus infection. Survival at 85 weeks was: males—control, 34/50; low-dose, 30/50; high-dose, 43/50; females—control, 47/50; low-dose, 44/50; high-dose, 50/50. The proportions of low- and high-dose rats with tumours were not significantly greater than that of controls. Hyperplastic foci of the liver occurred in 0/34 control, 0/30 low-dose and 4/43 high-dose male rats (Shimoyama *et al.*, 1985).

(*b*) *Skin application*

Mouse: A group of 20 female Sencar mice, six weeks old, was given 0.2-ml topical applications of sodium chlorite [purity unspecified] at 20 mg/ml in acetone

(4 mg per mouse) twice a week for 51 weeks. A group of 15 female mice given topical applications of acetone was used as controls. All mice survived to the end of the study; no skin tumour was observed in the treated or control groups (Kurokawa *et al.*, 1984). [The Working Group noted the small number of animals used.]

In an initiation-promotion study, a group of 20 female Sencar mice, six weeks old, was given a single topical application of 20 nmol (5.1 μg) 7,12-dimethylbenz[*a*]anthracene in acetone followed by 0.2-ml applications of sodium chlorite [purity unspecified] at 20 mg/ml in acetone twice a week for 51 weeks. A group of 15 female mice given a single application of 7,12-dimethylbenz[*a*]anthracene followed by applications of acetone was used as controls. The effective number of mice was 20 [number of survivors not given]. Squamous-cell carcinomas of the skin were seen in 5/20 treated mice and no control (Kurokawa *et al.*, 1984).

3.2 Other relevant data

(*a*) *Experimental systems*

(i) *Absorption, distribution, metabolism and excretion*

Radiolabel (^{36}Cl) derived from sodium chlorite given to rats by gavage (0.15 mg/kg bw) was absorbed and appeared in serum at a rate constant of 0.2/h relative to an absorption constant of 0.04/h for sodium chloride also given by gavage. The radiolabel was eliminated from blood with a half-time of 35 h, compared to 52 h for sodium chloride. The authors reported that 32% of the original dose of sodium chlorite was eliminated as chloride in the urine, while 6% was eliminated as chlorite within 72 h. Of the recovered dose, 83% was found in urine and 13% in faeces. After periods ranging from 72 to 120 h, the highest concentration of radiolabel derived from sodium chlorite appeared in blood (Abdel-Rahman *et al.*, 1982; Suh & Abdel-Rahman, 1983; Abdel-Rahman *et al.*, 1984; Abdel-Rahman, 1985).

Haem catalysed the chlorination of monochlorodimedone (a model substrate for myeloperoxidase) by sodium chlorite *in vitro* (Wilson *et al.*, 1983).

(ii) *Toxic effects*

The toxicological effects of chlorite have been reviewed (National Academy of Sciences, 1980, 1987).

Sodium chlorite induced haemolysis, decreased haemoglobin concentrations and loss of packed cell volume in the blood of male Sprague-Dawley rats treated for 30 and 60 days with 100-500 mg/l chlorite in drinking-water but did not induce methaemoglobinaemia at concentrations up to 500 mg/l chlorite. After 90 days of treatment, red blood cell counts and haemoglobin concentrations returned to normal; however, red blood cell glutathione concentrations remained significantly

Table 1. Summary of carcinogenicity studies of sodium chlorite in experimental animals

Reference	Species/ strain	Sex	Dose schedule	Experimental parameter/ observation	Group				Significance	Comments
					0	1	2	3		
Yokose *et al.* (1987)	Mouse $B6C3F_1$	M	Ad-lib. drinking-water, 80 weeks	Dose (%)	0	0.025	0.05	-		
				Survival (85 weeks)	35/50	47/50	43/50			
				Liver						
				Hyperplastic nodule	6/35	14/47	11/43			
				Carcinoma	4/35	8/47	6/43			
				Lung						
				Adenoma	0/35	2/47	5/43		$p < 0.05$	Increase
				Adenocarcinoma	0/35	1/47	2/43			
		F		Dose (%)	0	0.025	0.05	-		
				Survival (85 weeks)	47/50	50/50	50/50		$p < 0.05$	Decrease
				Lymphoma/leukaemia	7/47	5/50	1/50			
Kurokawa *et al.* (1984)	Mouse Sencar	F	2 d/week skin appl. acetone, 51 weeks	Dose (mg/mouse)	0	4	-	-		No skin tumour
				Survival (51 weeks)	15/15	20/20				
Shimoyama *et al.* (1985)	Rat	M	Ad-lib drinking-water, 85 weeks	Dose (%)	0	0.03	0.06	-		
				Survival (85 weeks)	34/50	30/50	43/50			
				Hepatic hyperplasia	0/34	0/30	4/43			
		F		Dose (%)	0	0.03	0.06			
				Survival (85 weeks)	47/50	44/50	50/50			

depressed and 2,3-diphosphoglycerate levels elevated in animals treated with concentrations of chlorite as low as 50 mg/l (Heffernan *et al.*, 1979). Similar haematological effects have been observed in cats, rats, mice and monkeys exposed to similar concentrations (Heffernan *et al.*, 1979a; Abdel-Rahman *et al.*, 1980; Moore & Calabrese, 1980; Bercz *et al.*, 1982). Bercz *et al.* (1982) saw no effect on thyroid function in monkeys exposed to sodium chlorite for 30-60 days in drinking-water at doses up to 60 mg/kg per day.

Intraperitoneal injection of sodium chlorite at doses of 10 mg/kg and above produced methaemoglobinaemia in rats (Musil *et al.*, 1964; Heffernan *et al.*, 1979).

(iii) *Effects on reproduction and prenatal toxicity*

Reproductive effects: Female A/J mice were given sodium chlorite (100 mg/l) in distilled drinking-water throughout gestation and through 28 days of lactation (Moore *et al.*, 1980). Control mice received distilled drinking-water without sodium chlorite. The proportion of mice that became pregnant was smaller among treated than control mice. There was no change in litter size, weight at birth or neonatal survival through lactation, but pups in the sodium chlorite group had a significant reduction in weight gain.

Male and female Long-Evans rats were given 0, 1, 10 or 100 mg/l sodium chlorite in deionized drinking-water (Carlton *et al.*, 1987). Males were treated for 56 days before mating and during 10 days of mating; females were treated for 14 days before mating, throughout the mating period and gestation and through to day 21 of lactation. Additional males were given 0, 10, 100 or 500 mg/l sodium chlorite in drinking-water for 72-76 days to confirm the observed changes in sperm count, morphology and movement. There was no significant effect on the body weight of adults or offspring, but water consumption was decreased at the 500 mg/l dose level. There was no effect on fertility, litter size or survival of neonates or on the weight of the testis, epididymis or cauda epididymis. On histological examination of organs of the male and female reproductive tract, no chemically induced toxicity was seen. With 100 and 500 mg/l sodium chlorite, there was a subtle but reproducible increase in the number of abnormal sperm and a decrease in progressive sperm motility, as observed by videomicrography. Adverse effects in neonates were limited to a significant decrease in the levels of the thyroid hormones triiodothyronine and thyroxine in the serum on postnatal days 21 and 40.

Developmental toxicity: Groups of 4-10 Sprague-Dawley rats were treated with sodium chlorite as 0.1, 0.5 or 2% in drinking-water or by daily intraperitoneal injections of 10, 20 or 50 mg/kg bw, or by gavage at 200 mg/kg bw, on gestation days 8-15. Toxicity, including high mortality in some groups, was observed in groups receiving sodium chlorite by intraperitoneal injection at 20 or 50 mg/kg bw or by gavage, but not in the groups given sodium chlorite in the drinking-water or at 10

mg/kg bw intraperitoneally. The group receiving 0.1% in the drinking-water had a significant increase in body weight compared to controls, whereas significant decreases were observed in groups that received higher doses in the drinking-water and in the group receiving 20 mg/kg sodium chlorite intraperitoneally. There was no evidence of a teratogenic effect, and there was no effect on litter size, postnatal growth or survival (Couri *et al.*, 1982). [The Working Group noted the small group sizes.]

Female Sprague-Dawley rats were given sodium chlorite in the drinking-water at 0, 1 or 10 mg/l for 2.5 months and were then mated with untreated males. Treatment of the mated females continued through to gestation day 20. There were six to nine pregnant females per group. No apparent maternal toxicity and no change in litter size or weight was seen, but a dose-related increase in variants of the sternum and an increase in crown-rump length of fetuses occurred at the high-dose level (Suh *et al.*, 1983). [The Working Group noted the small group sizes.]

(iv) *Genetic and related effects* (Table 2)

Positive responses were reported with sodium chlorite in a *Salmonella typhimurium* reverse mutation assay, in a chromosomal aberration test with the Chinese hamster CHL cell line and in a micronucleus test in mice after a single intraperitoneal treatment. In mouse bone-marrow micronucleus tests, a weak response was observed following a single oral treatment, while no effect was observed after multiple oral or intraperitoneal administration. In mice, multiple oral treatments did not induce chromosomal aberration or aneuploidy in bone marrow or abnormal sperm morphology. [The Working Group noted that the conflicting findings obtained in tests for micronucleus induction in mice reflect differences in dose.]

(*b*) *Humans*

(i) *Absorption, distribution, excretion and metabolism*

No data were available to the Working Group.

(ii) *Toxic effects*

Michael *et al.* (1981) took blood samples from the population of a village in which the water disinfectant system was changed to chlorine dioxide as a disinfectant during the summer months to avoid taste and odour problems produced by chlorine. A population of 197 individuals was screened and compared with 112 unexposed individuals. Chlorine dioxide concentrations ranged from 0.33 to 1.11 mg/l, chlorite levels from 3.19 to 6.96 mg/l and chlorate levels from 0.34 to 1.82 mg/l; total available chlorine (chlorine was used to generate the chlorine dioxide from chlorite) ranged from 8.79 to 20.83 mg/l. No significant difference was

Table 2. Genetic and related effects of sodium chlorite

Test system	Result		Dose LED/HID	Reference
	Without exogenous metabolic system	With exogenous metabolic system		
SA0, *Salmonella typhimurium* TA100, reverse mutation	+	+	100.000	Ishidate *et al.* (1984)
CIC, Chromosomal aberrations, Chinese hamster CHL fibroblasts	+	0	20.000	Ishidate (1987)
MVM, Micronucleus test, CD-1 mice *in vivo*	-	0	30.000	Meier *et al.* (1985)
MVM, Micronucleus test, ddY mice	+	0	15.000	Hayashi *et al.* (1988)
MVM, Micronucleus test, ddY mice	-	0	15.000	Hayashi *et al.* (1988)
MVM, Micronucleus test, ddY mice	(+)	0	150.000	Hayashi *et al.* (1988)
CBA, Chromosomal aberrations, bone-marrow cells of CD-1 mice *in vivo*	-	0	30.000	Meier *et al.* (1985)
AVA, Aneuploidy, bone-marrow cells of CD-1 mice *in vivo*	-	0	30.000	Meier *et al.* (1985)
SPM, Sperm morphology, B6C3F$_1$ mice *in vivo*	-	0	30.000	Meier *et al.* (1985)

observed in haematocrit, haemoglobin, red blood cell count, white cell count, reticulocyte count, mean corpuscular volume, methaemoglobin, blood urea nitrogen, serum creatinine or total bilirubin 70 days after chlorine dioxide treatment was initiated. A single glucose-6-phosphate dehydrogenase-deficient male identified in the population displayed a reduction of haemoglobin concentrations from 14.7 to 12.9 g/dl, of haematocrit from 46 to 40% and of red blood cell count from 4.78 to 4.11 $\times$ 10^6 ml. [The Working Group noted that the last observed effect was mild and that a causal association with chlorite could not be established.]

A clinical study of the effects of chlorite, chlorate and chlorine dioxide was conducted in three parts; tolerance to a rising dose by normal male volunteers (Lubbers & Bianchine, 1984), a 12-week study (Lubbers *et al.*, 1984a) and a study in three glucose-6-phosphate dehydrogenase-deficient male volunteers (Lubbers *et al.*, 1984b). In the study of rising doses, the maximal concentrations of chlorite and chlorate were 2.4 mg/l and that of chlorine dioxide, 24 mg/l; each treatment involved drinking two 500-ml portions. The authors concluded that although there were some significant trends, no physiological importance could be attached to the changes (Lubbers & Bianchine, 1984). The 12-week study required subjects to drink 500 ml of water containing 5 mg/l chlorine dioxide, chlorite or chlorate within a 15-min period each day. Again, there were significant, but small trends in certain parameters. No physiological significance could be attributed to any of these changes (Lubbers *et al.*, 1984a). The study of the three glucose-6-phosphate dehydrogenase-deficient individuals was conducted under circumstances similar to those outlined above, and they were followed for an additional eight weeks after treatment. No clinically significant treatment-related change was identified (Lubbers *et al.*, 1984b).

(iii) *Effects on reproduction and prenatal toxicity*

In a retrospective epidemiological study, Tuthill *et al.* (1982) compared neonatal morbidity and mortality in two communities in the USA, one of which employed chloride dioxide for water disinfection in 1945 and the other, chlorination (see also the monograph on chlorination of drinking-water, p. 106). Exposure was estimated from the amount of chlorite added to the water; the monthly average was 0.32 mg/l (high, 0.56 mg/l), which gave rise to an average concentration of residual chlorine species in excess of 0.3 mg/l. In subsequent years, the mean level of sodium chlorite added to the water declined to 0.16 mg/l. The number of infants that were judged by the attending physician to be premature or to have greater weight loss after birth was significantly greater in the community utilizing chlorine dioxide compared with the community utilizing chlorination. The rates of jaundice, birth defects and neonatal mortality did not differ between the communities. [The

Working Group noted the difficulties associated with establishing prematurity and poor weight gain after birth, especially in a retrospective study, and that confounding factors were not controlled for.]

(iv) *Genetic and related effects*

No data were available to the Working Group.

3.3 Case reports and epidemiological studies of carcinogenicity to humans

No data were available to the Working Group.

4. Summary of Data Reported and Evaluation

4.1 Exposure data

Sodium chlorite is the only chlorite salt produced commercially in significant quantities. It is used mainly for the generation of chlorine dioxide *in situ* for bleaching textiles, in pulp and paper processing, and for disinfection. Sodium chlorite is used in a small number of water treatment plants to generate chlorine dioxide; this may result in low residual concentrations of chlorite in drinking-water.

No information was available on occupational exposures to sodium chlorite.

4.2 Experimental carcinogenicity data

Sodium chlorite was tested for carcinogenicity in male and female B6C3F$_1$ mice and Fischer 344 rats by oral administration in the drinking-water and in a limited study by skin application in female Sencar mice. It was further tested for promoting effects in female Sencar mice by skin application following a single application of 7,12-dimethylbenz[*a*]anthracene. Oral administration of sodium chlorite to mice was associated with a marginal increase in the incidence of lung tumours in treated males. In the study in rats, no significant increase in tumour incidence at any site was seen in treated animals. Skin tumours did not occur in Sencar mice following skin application of sodium chlorite. In the initiation/promotion study, sodium chlorite had a marginal promoting effect.

4.3 Human carcinogenicity data

No data were available to the Working Group.

4.4 Other relevant data

Sodium chlorite has been shown to produce haemolytic anaemia in several animal species at concentrations in drinking-water of 100 mg/l or higher. No sign of such effects was seen in humans at much lower doses.

Minimal adverse reproductive effects were observed in rats and mice given sodium chlorite in the drinking-water at concentrations of 100 mg/l or higher.

Single studies indicated that sodium chlorite induced mutations in bacteria and chromosomal aberrations in cultured mammalian cells. In mice treated *in vivo*, conflicting results were obtained with regard to the induction of micronuclei, while a single study showed no induction of aneuploidy, chromosomal aberrations or abnormal sperm morphology.

4.5 Evaluation[1]

There is *inadequate evidence* for the carcinogenicity of sodium chlorite in experimental animals.

No data were available from studies in humans on the carcinogenicity of sodium chlorite.

Overall evaluation

Sodium chlorite *is not classifiable as to its carcinogenicity to humans (Group 3).*

5. References

Abdel-Rahman, M.S. (1985) Pharmacokinetics of chlorine obtained from chlorine dioxide, chlorine, chloramine, and chloride. In: Jolley, R.L., Bull, R.J., Davis, W.P., Katz, S., Roberts, M.H., Jr & Jacobs, V.A., eds, *Water Chlorination: Chemistry, Environmental Impact and Health Effects*, Vol. 5, Ann Arbor, MI, Lewis Publishers, pp. 281-293

Abdel-Rahman, M.S., Couri, D. & Bull, R.J. (1980) Kinetics of ClO_2 and effects of ClO_2, ClO_2^-, and ClO_3^- in drinking water on blood glutathione and hemolysis in rat and chicken. *J. environ. Pathol. Toxicol.*, *3*, 431-449

Abdel-Rahman, M.S., Couri, D. & Bull, R.J. (1982) Metabolism and pharmacokinetics of alternative drinking water disinfectants. *Environ. Health Perspect.*, *46*, 19-23

Abdel-Rahman, M.S., Couri, D. & Bull, R.J. (1984) The kinetics of chlorite and chlorate in the rat. *J. Am. Coll. Toxicol.*, *3*, 261-267

Aieta, E.M. & Roberts, P.V. (1985) The chemistry of oxo-chlorine compounds relevant to chlorine dioxide generation. In: Jolley, R.L., Bull, R.J., Davis, W.P., Katz, S., Roberts, M.H., Jr & Jacobs, V.A., eds, *Water Chlorination: Chemistry, Environmental Impact and Health Effects*, Vol. 5, Ann Arbor, MI, Lewis Publishers, pp. 783-794

---

[1]For definition of the italicized terms, see Preamble, pp. 30-33.

Anon. (1985) Chemical industry trends in 1984. In: Japan Chemical Week, ed., *Japan Chemical Annual 1985*, Tokyo, The Chemical Daily Co., pp. 14-18

Bercz, J.P., Jones, L., Garner, L., Murray, D., Ludwig, D.A. & Boston, J. (1982) Subchronic toxicity of chlorine dioxide and related compounds in drinking water in the nonhuman primate. *Environ. Health Perspect.*, *46*, 47-55

Budavari, S., ed. (1989) *The Merck Index*, 11th ed., Rahway, NJ, Merck & Co., pp. 1359-1360

Canadian Centre for Occupational Health and Safety (1989) *Cheminfo Database Summary, Sodium Chlorite*, Hamilton, Ontario, pp. 1-15

Carlton, B.D., Habash, D.L., Basaran, A.H., George, E.L. & Smith, M.K. (1987) Sodium chlorite administration in Long-Evans rats: reproductive and endocrine effects. *Environ. Res.*, *42*, 238-245

Chemical Information Services Ltd (1988) *Directory of World Chemical Producers—1989/1990 Edition*, Oceanside, NY, p. 519

Couri, D., Miller, C.H., Jr, Bull, R.J., Delphia, J.M. & Ammar, E.M. (1982) Assessment of maternal toxicity, embryotoxicity and teratogenic potential of sodium chlorite in Sprague-Dawley rats. *Environ. Health Perspect.*, *46*, 25-29

Eul, W.L. (1989) Applications of chlorine dioxide produced from sodium chlorite in Europe. In: *Chlorine Dioxide: Scientific, Regulatory and Application Issues, Denver, 1-2 November 1989*, Denver, CO, American Water Works Association, pp. 45-58

Hayashi, M., Kishi, M., Sofuni, T. & Ishidate, M., Jr (1988) Micronucleus tests in mice on 39 food additives and eight miscellaneous chemicals. *Food chem. Toxicol.*, *26*, 487-500

Heffernan, W.P., Guion, C. & Bull, R.J. (1979) Oxidative damage to the erythrocyte induced by sodium chlorite, *in vivo*. *J. environ. Pathol. Toxicol.*, *2*, 1487-1499

Ishidate, M., Jr (1987) *Data Book of Chromosomal Aberration Test* In Vitro, rev. ed., Tokyo, Life Science Information Center, p. 376

Ishidate, M., Jr, Sofuni, T., Yoshikawa, K., Hayashi, M., Nohmi, T., Sawada, M. & Matsuoka, A. (1984) Primary mutagenicity screening of food additives currently used in Japan. *Food chem. Toxicol.*, *22*, 623-636

Kurokawa, Y., Takamura, N., Matsushima, Y., Imazawa, T. & Hayashi, Y. (1984) Studies on the promoting and complete carcinogenic activities of some oxidizing chemicals in skin carcinogenesis. *Cancer Lett.*, *24*, 299-304

Lubbers, J.R. & Bianchine, J.R. (1984) Effects of the acute rising dose administration of chlorine dioxide, chlorate and chlorite to normal healthy adult male volunteers. *J. environ. Pathol. Toxicol. Oncol.*, *5*, 215-228

Lubbers, J.R., Chauhan, S., Miller, J.K. & Bianchine, J.R. (1984a) The effects of chronic administration of chlorine dioxide, chlorite and chlorate to normal healthy adult male volunteers. *J. environ. Pathol. Toxicol. Oncol.*, *5*, 229-238

Lubbers, J.R., Chauhan, S., Miller, J.K. & Bianchine, J.R. (1984b) The effects of chronic administration of chlorite to glucose-6-phosphate dehydrogenase deficient healthy adult male volunteers. *J. environ. Pathol. Toxicol. Oncol.*, *5*, 239-242

Meier, J.R., Bull, R.J., Stober, J.A. & Cimino, M.C. (1985) Evaluation of chemicals used for drinking water disinfection for production of chromosomal damage and sperm-head abnormalities in mice. *Environ. Mutagenesis*, *7*, 201-211

Michael, G.E., Miday, R.K., Bercz, J.P., Miller, R.G., Greathouse, D.G., Kraemer, D.F. & Lucas, J.B. (1981) Chlorine dioxide water disinfection: a prospective epidemiology study. *Arch. environ. Health, 36*, 20-27

Ministry of International Trade and Industry (1989) *Yearbook of Chemical Industries Statistics 1988*, Tokyo, International Trade and Industry Association

Moore, G.S. & Calabrese, E.J. (1980) The effects of chlorine dioxide and sodium chlorite on erythrocytes of A/J and C57L/J mice. *J. environ. Pathol. Toxicol., 4*, 513-524

Moore, G.S., Calabrese, E.J. & Leonard, D.A. (1980) Effects of chlorite exposure on conception rate and litters of A/J strain mice. *Bull. environ. Contam. Toxicol., 25*, 689-696

Musil, J., Knotek, Z., Chalupa, J. & Schmidt, P. (1964) Toxicologic aspects of chlorine dioxide application for the treatment of water containing phenols. *Technol. Water, 8*, 327-346

National Academy of Sciences (1980) *Toxicity of Selected Drinking Water Contaminants*, Vol. 3, *Chlorite*, Washington DC, pp. 197-200

National Academy of Sciences (1987) *Chemistry and Toxicity of Selected Disinfectants and By-products*, Vol. 7, *Chlorite, Chlorate*, Washington DC, pp. 99-111

Noack, M.G. & Doerr, R.L. (1979) Chlorine oxygen acids and salts. Chlorine dioxide, chlorous acid, and chlorites. In: Mark, H.F., Othmer, D.F., Overberger, C.G., Seaborg, G.T. & Grayson, M., eds, *Kirk-Othmer Encyclopedia of Chemical Technology*, 3rd ed., Vol. 5, New York, John Wiley & Sons, pp. 612-632

Olin Corporation (1984) *Product Data Sheet, Textone® Sodium Chlorite*, Stamford, CT

Olin Corporation (1989) *Product Data Sheet, Technical Sodium Chlorite for Chlorine Dioxide Generation*, Stamford, CT

Shimoyama, T., Hiasa, Y., Kitahori, Y., Konishi, N. & Murata, Y. (1985) Absence of carcinogenic effect of sodium chlorite in rats. *J. Nara med. Assoc., 36*, 710-718

Suh, D.H. & Abdel-Rahman, M.S. (1983) Kinetics study of chloride in rat. *J. Toxicol. environ. Health, 12*, 467-473

Suh, D.H., Abdel-Rahman, M.S. & Bull, R.J. (1983) Effect of chlorine dioxide and its metabolites in drinking water on fetal development in rats. *J. appl. Toxicol., 3*, 75-79

Tuthill, R.W., Giusti, R.A., Moore, G.S. & Calabrese, E.J. (1982) Health effects among newborns after prenatal exposure to ClO_2-disinfected drinking water. *Environ. Health Perspect., 46*, 39-45

Weast, R.C., ed. (1989) *CRC Handbook of Chemistry and Physics*, 70th ed., Boca Raton, FL, CRC Press, pp. 13-130

White, G.C. (1986) *The Handbook of Chlorination*, 2nd ed., New York, Van Nostrand Reinhold

Wilson, I., Bretscher, K.R., Chea, C.K. & Kelly, H.C. (1983) Heme models of peroxidase enzymes: deuteroferriheme-catalyzed chlorination of monochlorodimedone by sodium chlorite. *J. inorg. Biochem., 19*, 345-357

Yokose, Y., Uchida, K., Nakae, D., Shiraiwa, K., Yamamoto, K. & Konishi, Y. (1987) Studies of carcinogenicity of sodium chlorite in B6C3F_1 mice. *Environ. Health Perspect., 76*, 205-210