

## 4. CHEMICAL AND PHYSICAL INFORMATION

### 4.1 CHEMICAL IDENTITY

Information regarding the chemical identity of chromium is located in Table 4-1.

The synonyms, trade name, chemical formula, and identification numbers of chromium and selected salts are reported in Table 4-1.

### 4.2 PHYSICAL AND CHEMICAL PROPERTIES

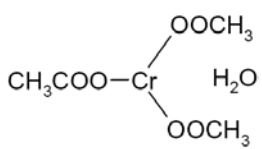
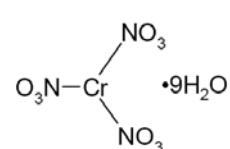
Information regarding the physical and chemical properties of chromium is located in Table 4-2.

Chromium is a metallic element with oxidation states ranging from chromium(-II) to chromium(+VI). The important valence states of chromium are II, III, and VI. Elemental chromium, chromium(0), does not occur naturally. The divalent state (II or chromous) is relatively unstable and is readily oxidized to the trivalent (III or chromic) state. Chromium compounds are stable in the trivalent state and occur in nature in this state in ores, such as ferrochromite ( $\text{FeCr}_2\text{O}_4$ ). The hexavalent (VI or chromate) is the second most stable state. However, hexavalent chromium rarely occurs naturally, but is produced from anthropogenic sources (Alimonti et al. 2000; Barceloux 1999; EPA 1984a; Johnson et al. 2006; Shanker et al. 2005). Chromium in the hexavalent state occurs naturally in the rare mineral crocoite ( $\text{PbCrO}_4$ ) (Hurlbut 1971; Papp and Lipin 2001).

The solubility of chromium compounds varies, depending primarily on the oxidation state. Trivalent chromium compounds, with the exception of acetate, hexahydrate of chloride, and nitrate salts, are generally insoluble in water (Table 4-2). The zinc and lead salts of chromic acid are practically insoluble in cold water (Table 4-2). The alkaline metal salts (e.g., calcium, strontium) of chromic acid are less soluble in water. Some hexavalent compounds, such as chromium(VI) oxide (or chromic acid), and the ammonium and alkali metal salts (e.g., sodium and potassium) of chromic acid are readily soluble in water. The hexavalent chromium compounds are reduced to the trivalent form in the presence of oxidizable organic matter. However, in natural waters where there is a low concentration of reducing materials, hexavalent chromium compounds are more stable (EPA 1984a; Loyaux-Lawniczak et al. 2001).

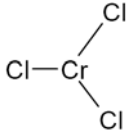
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**Table 4-1. Chemical Identity of Chromium and Compounds**

Characteristic	Information		
Chemical name	Chromium(0)	Chromium(III) acetate, monohydrate	Chromium(III) nitrate, nonahydrate
Synonym(s)	Chrome; Chrom (German); Chrome (French)	Acetic acid, chromium salt, hydrate; chromic acetate, hydrate	Nitric acid, chromium (III) salt, nonahydrate; chromium nitrate, nonahydrate
Registered trade name(s)	Chrome	No data	No data
Chemical formula	Cr	$\text{Cr}(\text{CH}_3\text{COO})_3 \cdot \text{H}_2\text{O}$	$\text{Cr}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}$
Chemical structure	Cr		
Identification numbers:			
CAS registry	7440-47-3	25013-82-5	7789-02-8
NIOSH RTECS	GB420000	AG3053333	GB6300000
EPA hazardous waste	D007	No data	No data
OHM/TADS	7216647	No data	No data
DOT/UN/NA/IMDG shipping	Not assigned	No data	No data
HSDB	910	No data	No data
NCI	Not assigned	No data	No data

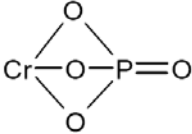
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**Table 4-1. Chemical Identity of Chromium and Compounds**

Characteristic	Information		
Chemical name	Chromium(III) chloride	Chromium(III) chloride, hexahydrate	Ferrochromite (Chromium[III])
Synonym(s)	Chromium trichloride	Hexaaquachromium (III) chloride	Chromite
Registered trade name(s)	C177295	No data	No data
Chemical formula	CrCl <sub>3</sub>	Cr(Cl) <sub>3</sub> •6H <sub>2</sub> O	FeCr <sub>2</sub> O <sub>4</sub>
Chemical structure		Cr[Cl <sub>2</sub> (H <sub>2</sub> O) <sub>4</sub> ]Cl•2H <sub>2</sub> O	FeOCr <sub>2</sub> O <sub>3</sub>
Identification numbers:			
CAS registry	10025-73-7	10060-12-5	1308-31-2
NIOSH RTECS	GB5425000	GB5450000	GB4000000
EPA hazardous waste	No data	No data	D007
OHM/TADS	No data	No data	No data
DOT/UN/NA/IMDG shipping	No data	No data	No data
HSDB	No data	No data	2963
NCI	No data	No data	No data

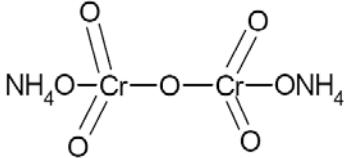
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**Table 4-1. Chemical Identity of Chromium and Compounds**

Characteristic	Information		
Chemical name	Chromium(III) oxide	Chromium(III) phosphate	Chromium(III) sulfate
Synonym(s)	Chromium sesquioxide; dichromium trioxide	Chromumorthophosphate; phosphoric acid, chromium (III) salt	Sulfuric acid, chromium (III) salt
Registered trade name(s)	No data	Amaudon's Green	Chromitan B
Chemical formula	Cr <sub>2</sub> O <sub>3</sub>	CrPO <sub>4</sub>	Cr <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>
Chemical structure	O=Cr—O—Cr=O		SO <sub>4</sub> =Cr—SO <sub>4</sub> —Cr=SO <sub>4</sub>
Identification numbers:			
CAS registry	1308-38-9	7789-04-0	10101-53-8
NIOSH RTECS	GB6475000	GB6840000	GB7200000
EPA hazardous waste	D007	No data	D0007
OHM/TADS	Not assigned	No data	7800052
DOT/UN/NA/IMDG shipping	Not assigned	No data	Not assigned
HSDB	1619	No data	2543
NCI	Not assigned	No data	Not assigned

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**Table 4-1. Chemical Identity of Chromium and Compounds**

Characteristic	Information		
Chemical name	Sodium chromite (Chromium[III])	Chromium(IV) oxide	Ammonium dichromate (Chromium[VI])
Synonym(s)	No data	Chromium dioxide	Chromic acid, diamonium salt
Registered trade name(s)	No data	No data	No data
Chemical formula	NaCrO <sub>2</sub>	CrO <sub>2</sub>	(NH <sub>4</sub> ) <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>
Chemical structure	NaO-Cr=O	O=Cr=O	
Identification numbers:			
CAS registry	12314-42-0	12018-01-8	7789-09-5
NIOSH RTECS	No data	GB6400000	HX7650000
EPA hazardous waste	No data	D007	Not assigned
OHM/TADS	No data	No data	7217321
DOT/UN/NA/IMDG shipping	No data	No data	UN1439; IM05.1
HSDB	No data	1620	481
NCI	No data	No data	No data

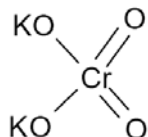
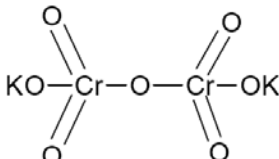
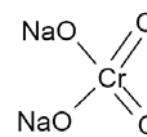
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**Table 4-1. Chemical Identity of Chromium and Compounds**

Characteristic	Information		
Chemical name	Calcium chromate (Chromium[VI])	Chromium(VI) trioxide	Lead chromate (Chromium[VI])
Synonym(s)	Chromic acid, calcium salt	Chromic acid, chromium anhydride	Chromic acid, lead salt
Registered trade name(s)	Calcium Chrome Yellow	No data	Chrome Yellow G
Chemical formula	CaCrO <sub>4</sub>	CrO <sub>3</sub>	PbCrO <sub>4</sub>
Chemical structure			
Identification numbers:			
CAS registry	13765-19-0	1333-82-0	7758-97-6
NIOSH RTECS	GB2750000	GB6650000	GB2975000
EPA hazardous waste	U032; D007	D007	D007; D008
OHM/TADS	7800051	Not assigned	Not assigned
DOT/UN/NA/IMDG shipping	NA9096	YB1463/UN15.1; IM05.1	Not assigned
HSDB	248	518; NA1463	1650
NCI	Not assigned	UN1463	Not assigned

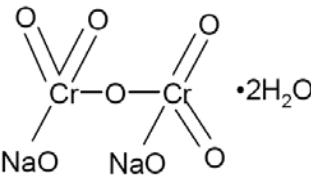
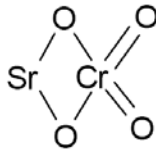
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**Table 4-1. Chemical Identity of Chromium and Compounds**

Characteristic	Information		
Chemical name	Potassium chromate (Chromium[VI])	Potassium dichromate (Chromium[VI])	Sodium chromate (Chromium[VI])
Synonym(s)	Chromic acid, dipotassium salt	Chromic acid, dipotassium salt	Chromic acid, disodium salt
Registered trade name(s)	No data	No data	Caswell No. 757
Chemical formula	$K_2CrO_4$	$K_2Cr_2O_7$	$Na_2CrO_4$
Chemical structure			
Identification numbers:			
CAS registry	7789-00-6	7778-50-9	7775-11-3
NIOSH RTECS	GB2940000	HX7680000	GB2955000
EPA hazardous waste	No data	No data	D007
OHM/TADS	7217277	7217278	7216891
DOT/UN/NA/IMDG shipping	NA9142	NA1479; IM09.0	No data
HSDB	1249	1238	2962
NCI	Not assigned	Not assigned	Not assigned

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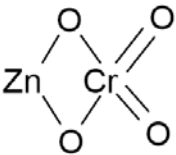
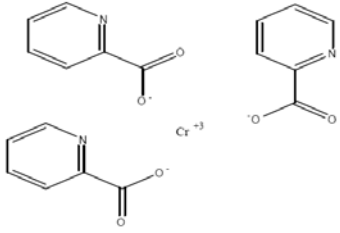
**Table 4-1. Chemical Identity of Chromium and Compounds**

Characteristic	Information	
Chemical name	Sodium dichromate, dihydrate (Chromium[VI])	Strontium chromate (Chromium[VI])
Synonym(s)	Chromic acid, disodium salt; dihydrate	Chromic acid, strontium salt
Registered trade name(s)	No data	No data
Chemical formula	$\text{NaCr}_2\text{O}_7 \cdot 2\text{H}_2\text{O}$	$\text{SrCrO}_4$
Chemical structure		
Identification numbers:		
CAS registry	7789-12-0	7789-06-2
NIOSH RTECS	HX7750000	GB3240000
EPA hazardous waste	No data	D007
OHM/TADS	No data	780058
DOT/UN/NA/IMDG shipping	No data	NA9149
HSDB	No data	2546
NCI	No data	Not assigned



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**Table 4-1. Chemical Identity of Chromium and Compounds**

Characteristic	Information	
Chemical name	Zinc chromate (Chromium[VI])	Chromium(III) picolinate
Synonym(s)	Chromic acid, zinc salt	CrPic; Chromium 2-pyridinecarboxylate; Chromium; tris(picolinato)-; Picolinic acid; chromium salt
Registered trade name(s)	CI Pigment Yellow	No data
Chemical formula	ZnCrO <sub>4</sub>	C <sub>18</sub> H <sub>12</sub> CrN <sub>3</sub> O <sub>6</sub>
Chemical structure		
Identification numbers:		
CAS registry	13530-65-9	14639-25-9
NIOSH RTECS	GB3290000	No data
EPA hazardous waste	D007	No data
OHM/TADS	7217401	No data
DOT/UN/NA/IMDG shipping	Not assigned	No data
HSDB	6188	No data
NCI	Not assigned	No data

Sources: HSDB 2008; NIOSH 2005

CAS = Chemical Abstracts Services; DOT/UN/NA/IMCO = Department of Transportation/United Nations/North America/International Maritime Dangerous Goods Code; EPA = Environmental Protection Agency; HSDB = Hazardous Substances Data Bank; NCI = National Cancer Institute; NIOSH = National Institute for Occupational Safety and Health; OHM/TADS = Oil and Hazardous Materials/Technical Assistance Data System; RTECS = Registry of Toxic Effects of Chemical Substances

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**Table 4-2. Physical and Chemical Properties of Chromium and Compounds**

Property	Chromium	Chromium(III) acetate, monohydrate	Chromium(III) nitrate, nonahydrate	Chromium(III) chloride
Molecular weight	51.996	229.13	400.15	158.35
Color	Steel-gray	Gray-green or bluish-green	Purple or violet	Violet or purple
Physical state	Solid	Solid	Solid	Solid
Melting point	1,90±10 °C	No data	60 °C	≈1,150 °C
Boiling point	2,642 °C	No data	Decomposes at 100 °C	Decomposes at 1,300 °C
Density at 20 °C	7.14 (28 °C) <sup>a</sup>	No data	No data	2.87 (25 °C) <sup>a</sup>
Odor	odorless	No data	No data	No data
Odor threshold:				
Water	No data	No data	No data	No data
Air	No data	No data	No data	No data
Solubility:				
Water at 20 °C	Insoluble	Soluble	Soluble	Slightly soluble in hot water
Organic solvents	Insoluble in common organic solvents	45.4 g/L in methanol (15 °C); 2 g/L in acetone (15 °C)	Soluble in ethanol and acetone	Insoluble in cold water, acetone, methanol, and ether
Partition coefficients:				
Log K <sub>ow</sub>	Not applicable	Not applicable	Not applicable	Not applicable
Log K <sub>oc</sub>	Not applicable	Not applicable	Not applicable	Not applicable
Vapor pressure at 20 °C	1 mmHg (1,616 °C)	No data	No data	No data
Henry's law constant at 25 °C	Not applicable	Not applicable	Not applicable	Not applicable
Autoignition temperature	No data	No data	No data	No data
Flashpoint	No data	No data	No data	No data
Flammability limits	No data	No data	No data	No data
Conversion factors	No data	No data	No data	No data
Explosive limits	No data	No data	No data	No data

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**Table 4-2. Physical and Chemical Properties of Chromium and Compounds**

Property	Chromium(III) chloride, hexahydrate	Ferrocromite (Chromium[III])	Chromium(III) oxide	Chromium(III) phosphate
Molecular weight	266.45	223.84	151.99	146.97
Color	Violet	Brown-black	Green	Gray-brown to black <sup>d</sup>
Physical state	Solid	Solid	Solid	Solid
Melting point	83 °C	No data	2,435 °C	>1,800 °C
Boiling point	No data	No data	3,000 °C	No data
Density at 20 °C	1.76 <sup>b</sup>	4.97 (20 °C)	5.22 (25 °C) <sup>b</sup>	2.94 (32.5 °C) <sup>a,c</sup>
Odor	No data	No data	No data	No data
Odor threshold:				
Water	No data	No data	No data	No data
Air	No data	No data	No data	No data
Solubility:				
Water at 20 °C	58.5 g/100 cc at 25 °C	Insoluble	Insoluble	Insoluble <sup>c</sup>
Organic solvents	Soluble in ethanol	No data	Insoluble in ethanol	Insoluble in alcohol, acetone
Partition coefficients:				
Log K <sub>ow</sub>	No data	Not applicable	Not applicable	Not applicable
Log K <sub>oc</sub>	No data	Not applicable	Not applicable	Not applicable
Vapor pressure at 20 °C	No data	No data	No data	No data
Henry's law constant at 25 °C	No data	Not applicable	Not applicable	Not applicable
Autoignition temperature	No data	No data	No data	No data
Flashpoint	No data	No data	No data	No data
Flammability limits	No data	No data	No data	No data
Conversion factors	No data	No data	No data	No data
Explosive limits	No data	No data	No data	No data

## 4. CHEMICAL AND PHYSICAL INFORMATION

**Table 4-2. Physical and Chemical Properties of Chromium and Compounds**

Property	Chromium(III) sulfate	Sodium chromite (Chromium[III])	Chromium(IV) oxide	Ammonium dichromate (Chromium[IV])
Molecular weight	392.18	106.98	83.99	252.07
Color	Violet, red, peach	No data	Brown-black	Orange
Physical state	Solid	No data	Solid	Solid
Melting point	No data	No data	Decomposes at 300 °C	Decomposes at 180 °C
Boiling point	No data	No data	Not applicable	Not applicable
Density at 20 °C	3.012	No data	No data	2.15 (25 °C) <sup>a</sup>
Odor	No data	No data	No data	odorless
Odor threshold:				
Water	No data	No data	No data	No data
Air	No data	No data	No data	No data
Solubility:				
Water at 20 °C	Insoluble	No data	Insoluble	In water (wt/wt): 15.5% (0 °C); 26.67% (20 °C); 36.99% (40 °C); 46.14% (60 °C); 54.20% (80 °C)
Organic solvents	soluble in alcohols	No data	No data	Soluble in alcohols, insoluble in acetone
Partition coefficients:				
Log K <sub>ow</sub>	Not applicable	Not applicable	Not applicable	Not applicable
Log K <sub>oc</sub>	Not applicable	Not applicable	Not applicable	Not applicable
Vapor pressure at 20 °C	No data	No data	No data	No data
Henry's law constant at 25 °C	Not applicable	Not applicable	Not applicable	Not applicable
Autoignition temperature	No data	No data	No data	No data
Flashpoint	No data	No data	No data	No data
Flammability limits	No data	No data	No data	No data
Conversion factors	No data	No data	No data	No data
Explosive limits	No data	No data	No data	No data

## 4. CHEMICAL AND PHYSICAL INFORMATION

**Table 4-2. Physical and Chemical Properties of Chromium and Compounds**

Property	Calcium chromate (Chromium[VI])	Chromium(VI) trioxide	Lead chromate (Chromium[VI])	Potassium chromate (Chromium[VI])
Molecular weight	156.07	99.99	323.19	194.19
Color	Yellow	Red	Yellow	Yellow
Physical state	Solid	Solid	Solid	Solid
Melting point	No data	197 °C	844 °C	975 °C
Boiling point	No data	Decomposes	Decomposes	No data
Density at 20 °C	2.89 <sup>b</sup>	2.70 (25 °C)	6.12 (15 °C)	2.732 (18 °C)
Odor	No data	Odorless	No data	Odorless
Odor threshold:				
Water	No data	No data	No data	No data
Air	No data	No data	No data	No data
Solubility:				
Water at 20 °C	2.23 g/100 mL	61.7 g/100 cc at 0 °C	5.8 µg/100 mL	62.9 g/100 at 20 °C
Organic solvents	No data	Soluble in ethanol, ethyl ether, sulfuric and nitric acids	Soluble 0.2 mg/l water	62.9 G/100 cc water (20 °C)
		Soluble 61.7 g/100 cc water (0 °C)	Insoluble in acetic acid; soluble in dilute nitric acid and in solution of fixed alkali hydroxides	79.2 g/100 cc water (100 °C)
		67.45 g/100 cc water (100 °C)	Soluble in acid, insoluble in ammonia	Insoluble in alcohol
		167.299 lb/100 lb water (70 °F)		
		Soluble in acetic acid and acetone		
Partition coefficients:				
Log K <sub>ow</sub>	Not applicable	Not applicable	Not applicable	Not applicable
Log K <sub>oc</sub>	Not applicable	Not applicable	Not applicable	Not applicable
Vapor pressure at 20 °C	No data	No data	No data	0
Henry's law constant at 25 °C	Not applicable	Not applicable	Not applicable	Not applicable
Autoignition temperature	No data	No data	No data	No data
Flashpoint	No data	No data	No data	No data
Flammability limits	No data	No data	No data	No data
Conversion factors	No data	No data	No data	No data
Explosive limits	No data	No data	No data	No data

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**Table 4-2. Physical and Chemical Properties of Chromium and Compounds**

Property	Potassium dichromate (Chromium[VI])	Sodium chromate (Chromium[VI])	Sodium dichromate, dihydrate (Chromium[VI])
Molecular weight	294.18	161.97	298.00
Color	Red	Yellow	Red
Physical state	Solid	Solid	Solid
Melting point	398 °C	792 °C	356.7 °C
Boiling point	Decomposes at 500 °C	No data	Decomposes at 400 °C
Density at 20 °C	2.676 (25 °C)	2.710–2.736 <sup>b</sup>	2.52 (13 °C)
Odor	No data	No data	No data
Odor threshold:			
Water	No data	No data	No data
Air	No data	No data	No data
Solubility:			
Water at 20 °C	4.9 g/100 cc at 0 °C	87.3 g/100 cc at 30 °C	230 g/100 cc at 0 °C
Organic solvents	Insoluble in ethanol and acetone	Soluble in methanol	Insoluble in ethanol
Partition coefficients:			
Log K <sub>ow</sub>	Not applicable	Not applicable	Not applicable
Log K <sub>oc</sub>	Not applicable	Not applicable	Not applicable
Vapor pressure at 20 °C	No data	No data	No data
Henry's law constant at 25 °C	Not applicable	Not applicable	Not applicable
Autoignition temperature	No data	No data	No data
Flashpoint	No data	No data	No data
Flammability limits	No data	No data	No data
Conversion factors	No data	No data	No data
Explosive limits	No data	No data	No data

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**Table 4-2. Physical and Chemical Properties of Chromium and Compounds**

Property	Strontium chromate (Chromium[VI])	Zinc chromate (Chromium[VI])	Chromium(III) picolinate
Molecular weight	203.61	181.97	418.3 <sup>c</sup>
Color	Yellow	Lemon-yellow	Ruby red <sup>d</sup>
Physical state	Solid	Solid	Crystal <sup>d</sup>
Melting point	No data	No data	No data
Boiling point	No data	No data	No data
Density at 20 °C	3.895 (15 °C)	3.40 <sup>b</sup>	No data
Odor	No data	Odorless	No data
Odor threshold:			
Water	No data	No data	No data
Air	No data	No data	No data
Solubility:			
Water at 20 °C	0.12 g/100 cc at 15 °C	Insoluble	1 ppm at 25 °C <sup>d</sup>
Organic solvents	Soluble in acetyl acetone	Insoluble in acetone	>6 g/L (DMSO) <sup>d</sup>
Partition coefficients:			
Log K <sub>ow</sub>	Not applicable	Not applicable	1.753 <sup>e</sup>
Log K <sub>oc</sub>	Not applicable	Not applicable	No data
Vapor pressure at 20 °C	No data	No data	No data
Henry's law constant at 25 °C	Not applicable	Not applicable	No data
Autoignition temperature	No data	No data	No data
Flashpoint	No data	No data	No data
Flammability limits	No data	No data	No data
Conversion factors	No data	No data	No data
Explosive limits	No data	No data	No data

<sup>a</sup>Temperature at which the densities were measured has been given only when such data are available

<sup>b</sup>Temperature at which density was measured was not specified.

<sup>c</sup>O'Neil et al. 2006

<sup>d</sup>Broadhurst et al. 1997

<sup>e</sup>Chakov et al. 1999

DMSO=dimethylsulfoxide

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In humans, chromium(III) is an essential nutrient that may play a role in glucose, fat, and protein metabolism possibly by potentiating the action of insulin. However, there is some emerging controversy whether chromium(III) is essential and more work has been suggested to elucidate its mechanism of action. Chromium picolinate, a trivalent form of chromium complexed with picolinic acid, is used as a dietary supplement, because it is claimed to speed metabolism and may have anti-diabetic effects (Broadhurst et al. 1997). However, there still remains controversy over the use of chromium(III) in diabetes, and several researchers claim no demonstrated effects of chromium(III) on diabetes or insulin resistance (Althuis et al. 2002). Currently, the mechanism of transport and absorption of chromium picolinate has not been determined, although spectroscopic analysis has shown that chromium picolinate is a very stable complex in the body and its absorption properties may be due to its ability to cross membranes (Chakov et al. 1999).