Nickel mixed oxides: Human health tier II assessment

25 November 2016

Chemicals in this assessment

Chemical Name in the Inventory	CAS Number
Silicic acid (H2SiO3), nickel(2+) salt (1:1)	21784-78-1
Nickel antimony, titanium yellow rutile	8007-18-9
Aluminium nickel oxide (Al2NiO4)	12004-35-2
Nickel titanium oxide (NiTiO3)	12035-39-1
Silicic acid, nickel salt	37321-15-6
Antimony nickel titanium oxide	54576-53-3
C.I. Pigment Black 25	68186-89-0
Nickel ferrite, brown spinel	68187-10-0
Olivine, nickel green	68515-84-4
C.I. Pigment Yellow 157	68610-24-2
Nickel niobium titanium, yellow rutile	68611-43-8

Chemical Name in the Inventory	CAS Number
Nickel iron chromite, black, spinel	71631-15-7

Preface

This assessment was carried out by staff of the National Industrial Chemicals Notification and Assessment Scheme (NICNAS) using the Inventory Multi-tiered Assessment and Prioritisation (IMAP) framework.

The IMAP framework addresses the human health and environmental impacts of previously unassessed industrial chemicals listed on the Australian Inventory of Chemical Substances (the Inventory).

The framework was developed with significant input from stakeholders and provides a more rapid, flexible and transparent approach for the assessment of chemicals listed on the Inventory.

Stage One of the implementation of this framework, which lasted four years from 1 July 2012, examined 3000 chemicals meeting characteristics identified by stakeholders as needing priority assessment. This included chemicals for which NICNAS already held exposure information, chemicals identified as a concern or for which regulatory action had been taken overseas, and chemicals detected in international studies analysing chemicals present in babies' umbilical cord blood.

Stage Two of IMAP began in July 2016. We are continuing to assess chemicals on the Inventory, including chemicals identified as a concern for which action has been taken overseas and chemicals that can be rapidly identified and assessed by using Stage One information. We are also continuing to publish information for chemicals on the Inventory that pose a low risk to human health or the environment or both. This work provides efficiencies and enables us to identify higher risk chemicals requiring assessment.

The IMAP framework is a science and risk-based model designed to align the assessment effort with the human health and environmental impacts of chemicals. It has three tiers of assessment, with the assessment effort increasing with each tier. The Tier I assessment is a high throughput approach using tabulated electronic data. The Tier II assessment is an evaluation of risk on a substance-by-substance or chemical category-by-category basis. Tier III assessments are conducted to address specific concerns that could not be resolved during the Tier II assessment.

These assessments are carried out by staff employed by the Australian Government Department of Health and the Australian Government Department of the Environment and Energy. The human health and environment risk assessments are conducted and published separately, using information available at the time, and may be undertaken at different tiers.

This chemical or group of chemicals are being assessed at Tier II because the Tier I assessment indicated that it needed further investigation.

For more detail on this program please visit:**www.nicnas.gov.au**

Disclaimer

ACRONYMS & ABBREVIATIONS

Grouping Rationale

The compounds in this group consist of mixed oxides and pigments of nickel, based on a range of oxyanions. The pigments in this group are produced through a calcining process above 1000 °C, resulting in chemically and thermally stable compounds with very low water solubility (CPMA, 2000). These compounds have been included in this group due to their similarity in complex structure and related end uses. While the individual oxyanions may vary in toxicological properties, in each case the Ni^{2+} ion is expected to dominate the toxicological profile.

Import, Manufacture and Use

Australian

The following Australian uses were reported under previous mandatory and/or voluntary calls for information.

C.I. Pigment Yellow 53 (CAS No. 8007-18-9) has reported commercial and site-limited use in paints and pigments.

International

The following international uses have been identified through European Union Registration, Evaluation, Authorisation and Restriction of Chemicals (EU REACH) dossiers; the Organisation for Economic Cooperation and Development Screening Information Dataset Initial Assessment Report (OECD SIAR); Galleria Chemica and the Substances and Preparations in the Nordic countries (SPIN) database.

The chemicals, C.I. Pigment Yellow 53 (CAS No. 8007-18-9), C.I. Pigment Black 25

(CAS No. 68186-89-0), C.I. Pigment Black 30 (CAS No. 71631-15-7), C.I. Pigment Yellow 157 (CAS No. 68610-24-2) and C.I. Pigment Yellow 161 (CAS No. 68611-43-8) have reported commercial use in paints, lacquers and varnishes.

Similarly, the chemicals listed above have reported site-limited use including:

- as inorganic pigmentary colourants for paints and plastics;
- as colouring agents;
- as surface treatments;
- in paints, lacquers and varnishes;
- as additives in polymers; and
- in construction materials.

Restrictions

Australian

Nickel and its compounds are listed in Schedule 10 (prohibited carcinogens, restricted carcinogens and restricted hazardous chemicals) of the Work Health and Safety Regulations (WHS, 2014) for restricted use in abrasive blasting at a concentration of greater than 0.1 % of nickel.

International

REACH Regulations Annex XVII Section 27 on nickel and its compounds states:

'1. Shall not be used:

(a) in all post assemblies which are inserted into pierced ears and other pierced parts of the human body unless the rate of nickel release from such post assemblies is less than 0.2 μg/cm^2/week (migration limit);

(b) in articles intended to come into direct and prolonged contact with the skin such as:

- earrings,
- necklaces, bracelets and chains, anklets, finger rings,
- wrist-watch cases, watch straps and tighteners,
- rivet buttons, tighteners, rivets, zippers and metal marks, when these are used in garments,
- if the rate of nickel release from the parts of these articles coming into direct and prolonged contact with the skin is greater than 0.5 μg/cm^2/week;

(c) in articles such as those listed in point (b) where these have a non-nickel coating unless such coating is sufficient to ensure that the rate of nickel released from those parts of such articles coming into direct and prolonged contact with the skin will not exceed 0.5 μg/cm^2/week for a period of at least two years of normal use of the article.

2. Articles which are the subject of paragraph 1, shall not be placed on the market unless they conform to the requirements set out in those points.

3. The standards adopted by the European Committee for Standardisation (CEN) shall be used as the test methods for demonstrating the conformity of articles to paragraphs 1 and 2' (REACH Annex XVII, 2009).

Existing Worker Health and Safety Controls

Hazard Classification

The chemicals in this group are not listed on the Hazardous Substances Information System (HSIS) (Safe Work Australia).

Exposure Standards

Australian

No specific exposure standards are available.

International

No specific exposure standards are available.

Health Hazard Information

Limited data are available for the compounds in this group. Available data for C.I. Pigment Yellow 53 (CAS No. 8007-18-9) and aluminium nickel oxide (CAS No. 12004-35-2) are used as analogue data for other compounds in this group, as there is similarity in stability between the crystalline structures (spinel and rutile) of the compounds in this group. Also, it has been shown that the measured release of nickel from spinels and rutiles is significantly lower than from the naturally occurring nickel oxide–bunsenite (Hart, 2008). The data show that the Ni^{2+} ion is not biologically available in specific rutile and spinel compounds

containing nickel (Hart, 2008). Specifically, the OECD SIAR report (2002) for C.I. Pigment Yellow 53 (CAS No. 8007-18-9), which has a rutile crystalline structure, indicates that the Ni^{2+} ion is not biologically available after acute and/or repeated inhalation and oral exposure in rats. Consequently, this chemical and other specific rutile and spinel compounds containing nickel were excluded from hazard classification in the European Union (EU) (Hart, 2008).

The mixed oxides in this group are all expected to have lower bioavailability than nickel oxide, ranging up to the high measured stability of the spinel and rutile structures. Where information is available indicating that the compounds in this group have a spinel/rutile crystalline structure, and/or data indicate that the Ni^{2+} ion is not biologically available, the compounds will be excluded from classification. In the absence of such data, it is expected that the compounds in this group will have a hazard profile ranging between non-toxic to that of nickel oxide (NICNASa). Nickel oxides previously assessed by NICNAS are recommended for classification for carcinogenicity, skin sensitisation and repeated dose toxicity via inhalation. Based on the available data for different compounds in this group, a classification for some compounds may be necessary unless further information becomes available to demonstrate their safety (refer to **Recommendation** section).

Toxicokinetics

Toxicokinetic data are limited to C.I. Pigment Yellow 53 (CAS No. 8007-18-9). This chemical is a relatively inert and stable compound and contains approximately 4 % or 40000 ppm nickel in total. In an assessment of nickel release, 170 ppm Ni^{2+} was released under strong acidic conditions (pH = 1.5), with substantially less available at higher pH (pH = 7 or pH = 10) (CPMA, 2000). The nickel contained within the pigment is said to be 'incorporated in a mineral lattice, making it inert, with no toxicological significance' (CPMA, 2000).

In a 90-day repeated dose oral study performed similarly to OECD Test Guideline (TG) 408, male and female Wistar rats were administered C.I. Pigment Yellow 53 (0, 0.45, 45 or 450 mg/kg bw/day) in feed for 90 days. Trace amounts of antimony were detected in the liver and kidneys of male and female rats exposed to the highest dose (450 mg/kg bw/day). There was no nickel detected in the liver or kidney at any exposure concentration (REACHa; OECD, 2002).

In an inhalation study, 50 male Wistar rats were exposed to C.I. Pigment Yellow 53 (60 mg/m^3) for five days (six hours a day) and then followed up for varying periods of time (0–60 days). Immediately post exposure, the concentrations of nickel and antimony were 79 and 202 μg/lung (corresponding to approximately 2 mg of pigment/lung). Based on elimination patterns across 60 days, the half-life of C.I. Pigment Yellow 53 was estimated to be 50 days in the lungs. In the kidneys and liver, nickel was below the quantification threshold of 10 ng/g and 25 ng/g, respectively. Antimony was detected in the liver of the post exposure group up to 4-fold greater when compared with unexposed animals. These levels were reported to fall to pre-exposure levels by day 10. In the kidneys, antimony was only quantifiable in the three-day exposure group (5.6 ng/g) (OECD, 2002).

Acute Toxicity

Oral

The chemicals, C.I. Pigment Yellow 53 (CAS No. 8007-18-9) and aluminium nickel oxide (CAS No. 12004-35-2) had low acute toxicity based on results in animal tests following oral exposure. The median lethal dose (LD50) in rats was greater than 2000 mg/kg bw. There were no observed sub-lethal effects.

In a study conducted according to OECD TG 401, male and female rats (strain:Crj; CD(SD)) were given a single dose of 2000 mg/kg bw C.I. Pigment Yellow 53 (CAS No. 8007-18-9) and observed for 14 days. No adverse clinical effects were reported (REACHa). Additional studies have not been described in detail and have reported LD50 values ranging from 2500–10000 mg/kg bw (OECD, 2002).

In a study conducted according to OECD TG 423, female Sprague Dawley (SD) rats were given a single dose of 2000 mg/kg bw of aluminium nickel oxide (CAS No. 12004-35-2) and observed for 14 days. The median LD50 in female SD rats was greater than 2000 mg/kg bw. One of the six animals tested displayed abnormal behaviour 30 minutes after exposure, but recovered within an hour of aluminium nickel oxide administration (REACHb).

Dermal

No data are available.

Inhalation

Data available from a non-guideline study reported that no mortality was observed in 12 rats (unspecified strain or sex) exposed to an unspecified dose of C.I. Pigment Yellow 53 (CAS No. 8007-18-9) for seven hours via inhalation (REACHa).

Corrosion / Irritation

Skin Irritation

C.I. Pigment Yellow 53 (CAS No. 8007-18-9) produced no skin irritation in reported studies (OECD, 2002). Similarly, aluminium nickel oxide (CAS No. 12004-35-2) was not irritating in an in vitro human skin model test conducted according to OECD TG 431 (REACHb).

Six New Zealand White rabbits were exposed to C.I. Pigment Yellow 53 (0.5 g, undiluted) for 24 hours to intact and abraded skin under occlusive conditions and monitored for eight days. Evaluation of erythema in animals with intact skin was not possible due to the colouring effect of the pigment on the skin, although no erythema was observed after 72 hours and no oedema was reported. In animals with abraded skin, slight erythema was reported in three animals. Scaling was reported in four animals after eight days (REACHa; OECD, 2002).

In an in vitro human skin test, 15 mg of aluminium nickel oxide (CAS No. 12004-35-2) was assessed as non-irritating (REACHb).

Eye Irritation

C.I. Pigment Yellow 53 (CAS No. 8007-18-9), was reported to be a slight eye irritant in animal studies as a result of mechanical irritation. Effects were not sufficient to warrant a hazard classification (OECD, 2002). Aluminium nickel oxide (CAS No. 12004-35-2) was assessed as not irritating to eyes according to the Hen's Egg Test–Chorioallantoic Membrane (HET-CAM) test method (REACHb).

The left eye of six New Zealand White rabbits was instilled with C.I Pigment Yellow 53 (100 mg) for 15 seconds. Three out of the six animals had their exposed eyes flushed with physiological saline solution. Animals were monitored for seven days after exposure. One rabbit (flushed group) was reported to have slight conjunctivitis after 24 hours, but not at any other observation time point. No further adverse effects were reported (OECD, 2002; REACHa).

Sensitisation

Skin Sensitisation

No data are available for this endpoint. However, considering that the Ni^{2+} ion was not biologically available following repeated inhalation and oral exposure to C.I. Pigment Yellow 53 (CAS No. 8007-18-9), this chemical is not likely to produce sensitisation (Hart, 2008).

With respect to other chemicals in this group, in the absence of structural data indicating a spinel/rutile crystalline structure, or data showing evidence that the Ni^{2+} ion is not biologically available, these chemicals should be classified for skin sensitisation similar to nickel oxide (refer to **Regulatory control—Work health and safety**).

Repeated Dose Toxicity

Oral

The chemicals in this group are not expected to cause serious health damage from prolonged exposure if swallowed. Furthermore, data from the nickel sulfate NICNAS assessment (NICNASb), indicate it is more bioavailable than chemicals in this group through the oral route, which suggests that classification is not warranted.

In a 90-day oral gavage study in rats (strain Crj; CD(SD)), an estimated no observed adverse effect level (NOAEL) of ≥450 mg/kg bw/day was reported for C.I Pigment Yellow 53 (CAS No. 8007-18-9). No adverse effects were observed at any concentration in the study. In a second study conducted according to OECD TG 422, male (46 days) and female (41–45 days) Wistar rats were administered C.I. Pigment Yellow 53 (0, 250, 500, 1000 mg/kg bw/day) for up to 46 days. No adverse effects were reported at any tested dose and the NOAEL was estimated to be the highest dose in the study (≥1000 mg/kg bw/day) (REACHa).

Dermal

No data are available. However, considering the ionic nature of nickel salts, dermal absorption is expected to be poor. Therefore, hazard classification is not warranted for the chemicals in this group.

Inhalation

In a five-day repeated dose inhalation toxicity study in male Wistar rats, exposure to C.I Pigment Yellow 53 (CAS No. 8007-18-9) (60 mg/m^3) for six hours a day for five days did not result in any clinical adverse effects. There were no reported effects on body weight, body weight gain or mortality (OECD, 2002). No further data are available.

With respect to other chemicals in this group, in the absence of structural data showing a spinel/rutile crystalline structure or data showing evidence that the Ni^{2+} ion is not biologically available, these chemicals should be classified for repeated exposure through inhalation similar to nickel oxide (refer to **Regulatory control—Work health and safety**).

Genotoxicity

C.I. Pigment Yellow 53 (CAS No. 8007-18-9), tested negative in two in vitro genotoxicity assays (Ames test and mammalian chromosome aberration test) with and without metabolic activation. There are no in vivo data available (REACHa). Aluminium nickel oxide (CAS No. 12004-35-2) also tested negative in the Ames test with and without metabolic activation (REACHb).

In a study conducted according to OECD TG 471, C.I Pigment Yellow 53 was incubated with various strains of *Salmonella typhimurium* up to a maximum concentration of 5000 μg/plate. No cytotoxicity or genotoxicity, with or without metabolic activation, was reported in the study (REACHa).

In a further study conducted according to OECD TG 473, Chinese hamster lung (CHL/IU) cells were exposed to concentrations of C.I Pigment Yellow 53 up to 1250 μg/mL. Cytotoxicity was observed at ≥39.1 μg/mL and ≥19.5 μg/mL with and without metabolic activation, respectively. No genotoxicity (chromosome aberrations) was reported with or without metabolic activation (REACHa).

A study was conducted according to OECD TG 471 with various strains of *S. typhimurium* exposed to aluminium nickel oxide (CAS No. 12004-35-2) up to a maximum concentration of 5001 μg/plate with and without metabolic activation. No mutagenic activity was observed with or without metabolic activation (REACHb).

Carcinogenicity

There are no specific carcinogenicity studies conducted on chemicals in this group.

Nickel oxide (CAS No. 1313-99-1) is classified as hazardous—Category 1 carcinogenic substance—with the risk phrase 'May cause cancer by inhalation' (T; R49) in HSIS (Safe Work Australia). The International Agency for Research on Cancer (IARC) has classified nickel compounds as 'Carcinogenic to humans' (Group 1). Therefore, in the absence of structural data showing a spinel/rutile crystalline structure or data showing that the Ni^{2+} ion is not biologically available, chemicals in this group should be classified in the HSIS as a Category 1 carcinogenic substance via the inhalation route of exposure, similarly to nickel oxide (refer to **Regulatory control–Work health and safety**).

Reproductive and Developmental Toxicity

Based on the limited information available, C.I. Pigment Yellow 53 (CAS No. 8007-18-9) does not show specific reproductive or developmental toxicity (REACHa; OECD, 2002). Considering that nickel oxide is not classified as hazardous for reproductive and developmental toxicity, no classification is warranted for this group of chemicals.

In a study conducted according to OECD TG 422, male and female rats (strain Crj; CD(SD)) were exposed to C.I. Pigment Yellow 53 via oral gavage (0, 250, 500 or 1000 mg/kg bw/day) for 46 days (including 14-day pre-mating exposure period). There were no reproductive effects noted in parental animals, nor any developmental effects in the first generation (F1) of offspring (REACHa). In a further study conducted similarly to OECD TG 408, male and female Wistar rats were exposed to C.I. Pigment Yellow 53 (0, 0.45, 45 or 450 mg/kg) incorporated into their food for 90 days. There were no reported adverse effects on reproductive organs (REACHa).

Risk Characterisation

Critical Health Effects

The critical health effects for the compounds in this group are dependent on the biological availability of the Ni^{2+} ion.

Compounds in this group with spinel or rutile crystalline structures are not expected to release the Ni^{2+} ion as it is incorporated within a mineral lattice, making it inert, and therefore having no toxicological significance (CPMA, 2000; Hart, 2008). Where data on the biological availability of the Ni^{2+} ion are not available, the critical health effects may approach those of nickel oxide (NICNASa). These include local long-term effects (carcinogenicity), local acute effects (skin sensitisation) and chronic lung inflammation and alveolar hyperplasia following repeated exposure through inhalation (NICNASa).

Public Risk Characterisation

C.I. Pigment Yellow 53 (CAS No. 8007-18-9) has commercial and site-limited uses in Australia. Overseas, several of the compounds in this group have commercial and site-limited uses. Although the public may come into contact with articles or coated surfaces containing these chemicals, it is expected that the chemicals will be bound within the article or coated surface and hence will not be bioavailable. Therefore the risk to the public is not considered to be unreasonable.

Occupational Risk Characterisation

During use of these chemicals, dermal and inhalation exposure of workers to the chemicals may occur, particularly where manual or open processes are used. These may include transfer and blending activities, quality control analysis, and cleaning and maintenance of equipment. Worker exposure to the chemicals at lower concentrations may also occur while using formulated products containing the chemicals. The level and route of exposure will vary depending on the method of application and work practices employed.

Given that the critical local long-term and local acute health effects of these chemicals may approach those of nickel oxide, these chemicals may pose an unreasonable risk to workers unless adequate control measures to minimise dermal, ocular and

inhalation exposure to the chemicals are implemented. These chemicals should be appropriately classified and labelled to ensure that a person conducting a business or undertaking (PCBU) at a workplace (such as an employer) has adequate information to determine appropriate controls.

NICNAS Recommendation

Assessment of the compounds in this group is considered to be sufficient, provided that the recommended amendment to the classification is adopted, and labelling and all other requirements are met under workplace health and safety and poisons legislation as adopted by the relevant state or territory.

Regulatory Control

Work Health and Safety

The chemical in this group are recommended for classification and labelling under the current approved criteria and adopted GHS as below. This assessment does not consider classification of physical hazards and environmental hazards.

The classifications are to be applied to all compounds in this group except for C.I. Pigment Yellow 53 (CAS No. 8007-18-9), C.I. Pigment Black 30 (CAS No. 71631-15-7), C.I. Pigment Brown 34 (CAS No. 68187-10-0), antimony nickel titanium oxide (CAS No. 54576-53-3) and nickel niobium titanium yellow (CAS No. 68611-43-8) as it has been demonstrated that the biological availability of Ni^{2+} ions from these rutile and spinel compounds is negligible (CPMA 2000; Hart, 2008). With respect to other compounds in this group, if it can be demonstrated that the Ni^{2+} ions are incorporated in a highly stable mineral lattice, making them inert, not biologically available and therefore of no toxicological significance, then the classification need not apply.

Hazard	Approved Criteria (HSIS)[a]	GHS Classification (HCIS)[b]
Sensitisation	May cause sensitisation by skin contact (Xi; R43)	May cause an allergic skin reaction - Cat. 1 (H317)
Repeat Dose Toxicity	Toxic: danger of serious damage to health by prolonged exposure through inhalation (T; R48/23)	Causes damage to organs through prolonged or repeated exposure through inhalation - Cat. 1 (H372)
Carcinogenicity	Carc. Cat 1 - May cause cancer by inhalation (T; R49)	May cause cancer - Cat. 1A (H350i)

[a] Approved Criteria for Classifying Hazardous Substances [NOHSC:1008(2004)].

[b] Globally Harmonized System of Classification and Labelling of Chemicals (GHS) United Nations, 2009. Third Edition.

[*] Existing Hazard Classification. No change recommended to this classification

Advice for industry

Control measures

Control measures to minimise the risk from dermal and inhalation exposure to the chemicals should be implemented in accordance with the hierarchy of controls. Approaches to minimise risk include substitution, isolation and engineering controls. Measures required to eliminate or minimise risk arising from storing, handling and using a hazardous chemical depend on the

physical form and the manner in which the chemical is used. Examples of control measures which may minimise the risk include, but are not limited to:

- using closed systems or isolating operations;
- using local exhaust ventilation to prevent the chemical from entering the breathing zone of any worker;
- health monitoring for any worker who is at risk of exposure to the chemical if valid techniques are available to monitor the effect on the worker's health;
- minimising manual processes and work tasks through automating processes;
- work procedures that minimise splashes and spills;
- regularly cleaning equipment and work areas; and
- using protective equipment that is designed, constructed, and operated to ensure that the worker does not come into contact with the chemical.

Guidance on managing risks from hazardous chemicals are provided in the *Managing risks of hazardous chemicals in the workplace—Code of practice* available on the Safe Work Australia website.

Personal protective equipment should not solely be relied upon to control risk and should only be used when all other reasonably practicable control measures do not eliminate or sufficiently minimise risk. Guidance in selecting personal protective equipment can be obtained from Australian, Australian/New Zealand or other approved standards.

Obligations under workplace health and safety legislation

Information in this report should be taken into account to assist with meeting obligations under workplace health and safety legislation as adopted by the relevant state or territory. This includes, but is not limited to:

- ensuring that hazardous chemicals are correctly classified and labelled;
- ensuring that (material) safety data sheets ((m)SDS) containing accurate information about the hazards (relating to both health hazards and physicochemical (physical) hazards) of the chemical are prepared; and
- managing risks arising from storing, handling and using a hazardous chemical.

Your work health and safety regulator should be contacted for information on the work health and safety laws in your jurisdiction.

Information on how to prepare an (m)SDS and how to label containers of hazardous chemicals are provided in relevant codes of practice such as the *Preparation of safety data sheets for hazardous chemicals— Code of practice* and *Labelling of workplace hazardous chemicals—Code of practice*, respectively. These codes of practice are available from the Safe Work Australia website.

A review of the physical hazards of the chemicals has not been undertaken as part of this assessment.

References

Approved Criteria for Classifying Hazardous Substances [NOHSC: 1008(2004)] Third edition. Accessed January 2014 at **http://www.safeworkaustralia.gov.au/sites/swa/about/publications/pages/ns2004criteriaforclassifyinghazardous**

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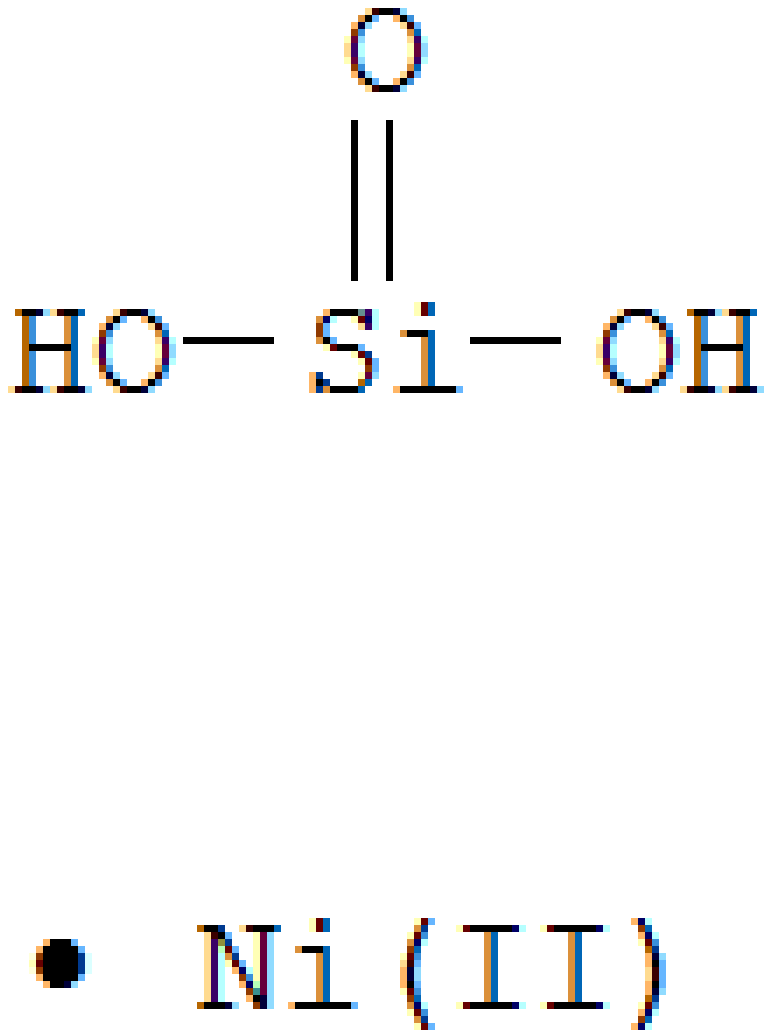
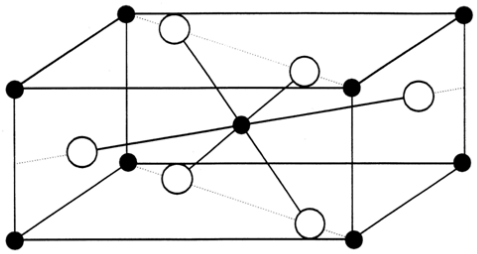
Last Update 25 November 2016

Chemical Identities

Chemical Name in the Inventory and Synonyms	**Silicic acid (H2SiO3), nickel(2+) salt (1:1)** Nickel silicate Nickel silicon oxide Nickel (2+) metasilicate
CAS Number	21784-78-1
Structural Formula	

	
Molecular Formula	H2O3Si.Ni
Molecular Weight	134.7

Chemical Name in the Inventory and Synonyms	**Nickel antimony, titanium yellow rutile** C.I. Pigment Yellow 53 C.I. 77788 Cerdec Yellow 10401 Antimony nickel titanium oxide yellow
CAS Number	8007-18-9
Structural Formula	



$0,05 \leq x \leq 0,1$

$$NiCO_3 + Sb_2O_3 + TiO_2 \xrightarrow[O_2]{\triangle T} Ni_{\frac{x}{3}}Sb_{\frac{2x}{3}}Ti_{1-x}O_2$$

$$Cr_2O_3 \qquad Cr_{\frac{x}{2}}Sb_{\frac{x}{2}}Ti_{1-x}O_2$$

$$MnO_2 \qquad Mn_{\frac{x}{3}}Sb_{\frac{2x}{3}}Ti_{1-x}O_2$$

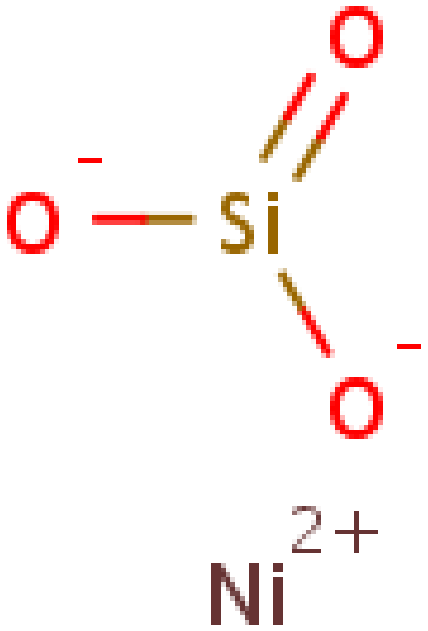
Molecular Formula	Unspecified
Molecular Weight	Unspecified

Chemical Name in the Inventory and Synonyms	**Aluminium nickel oxide (Al2NiO4)** Nickel aluminate Dialuminum nickel tetraoxide Nickel alumine Nickel aluminum spinel
CAS Number	12004-35-2
Structural Formula	

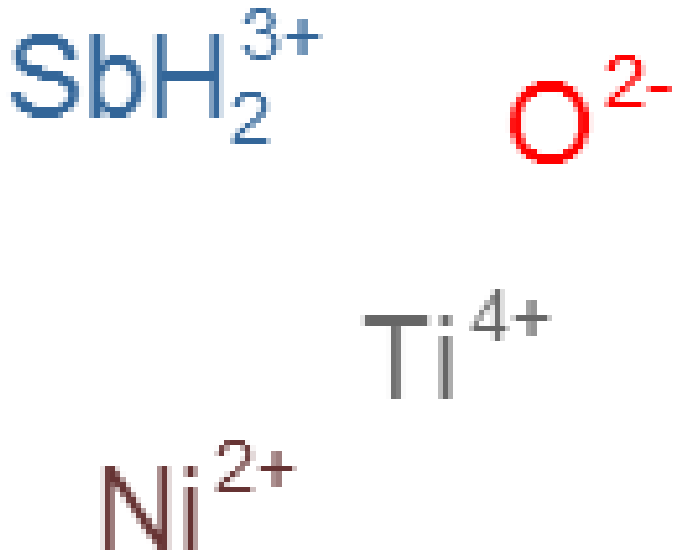
Molecular Formula	Al2NiO4
Molecular Weight	176.7

Chemical Name in the Inventory and Synonyms	**Nickel titanium oxide (NiTiO3)** Nickel titanate Nickel titanate (IV)
CAS Number	12035-39-1
Structural Formula	**No Structural Diagram Available**
Molecular Formula	Ni.O.Ti
Molecular Weight	Unspecified

Chemical Name in the Inventory and Synonyms	**Silicic acid, nickel salt** Nickel silicate Nickel silica Nickel silicon oxide
CAS Number	37321-15-6
Structural Formula	

	
Molecular Formula	Unspecified
Molecular Weight	134.8

Chemical Name in the Inventory and Synonyms	**Antimony nickel titanium oxide** Titanium yellow
CAS Number	54576-53-3
Structural Formula	

	
Molecular Formula	Unspecified
Molecular Weight	244.3

Chemical Name in the Inventory and Synonyms	**C.I. Pigment Black 25** Cobalt nickel grey periclase C.I. 77332
CAS Number	68186-89-0
Structural Formula	

	No Structural Diagram Available
Molecular Formula	Unspecified
Molecular Weight	Unspecified

Chemical Name in the Inventory and Synonyms	**Nickel ferrite, brown spinel** C.I. Pigment Brown 34 C.I. 77497
CAS Number	68187-10-0
Structural Formula	No Structural Diagram Available
Molecular Formula	Unspecified
Molecular Weight	

Chemical Name in the	**Olivine, nickel green**

Inventory and Synonyms	Nickel silicate green olivine
CAS Number	68515-84-4
Structural Formula	**No Structural Diagram Available**
Molecular Formula	Unspecified
Molecular Weight	Unspecified

Chemical Name in the Inventory and Synonyms	**C.I. Pigment Yellow 157** Nickel barium titanium priderite C.I. 77900 Daipyroxide Yellow 9110
CAS Number	68610-24-2
Structural Formula	

	No Structural Diagram Available
Molecular Formula	Unspecified
Molecular Weight	Unspecified

Chemical Name in the Inventory and Synonyms	**Nickel niobium titanium, yellow rutile** C.I. Pigment Yellow 161 C.I. 77895 Ferro Yellow PK 6066
CAS Number	68611-43-8
Structural Formula	**No Structural Diagram Available**
Molecular Formula	Unspecified
Molecular Weight	Unspecified

Chemical Name in the Inventory and Synonyms	**Nickel iron chromite, black, spinel** C.I. Pigment Black 30 C.I. 77504
CAS Number	71631-15-7
Structural Formula	**No Structural Diagram Available**
Molecular Formula	Unspecified
Molecular Weight	

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