17	CAS No.: 7439-98-7 (Molybdenum)	Substance: Molybdenum and its compounds

Chemical Substances Control Law Reference No.:

PRTR Law Cabinet Order No.*: 1-453 (molybdenum and its compounds)

Element Symbol: Mo

Atomic Weight: 95.94

Note: No. in Revised Cabinet Order enacted on October 1, 2009

1. General information

Molybdenum and molybdenum disulfide are insoluble in water. Ammonium molybdate and phosphomolybdic acid are soluble in water. The water solubility of molybdenum trioxide is 1.34×10^3 mg/1,000 g (20°C), the water solubility of sodium molybdate is 3.940×10^5 mg/1,000 g (25°C), the water solubility of calcium molybdate is 50 mg/1,000 g, and the water solubility of molybdic acid is 1.33×10^3 mg/L (18°C).

This substance is designated as a Class 1 Designated Chemical Substance under the Law Concerning Reporting, etc. of Releases to the Environment of Specific Chemical Substances and Promoting Improvements in Their Management (PRTR Law). The main uses of molybdenum are as a raw material for stainless steel and low-alloy steels, as a raw material for specialty steels used in automobiles and pipelines, as electronic materials, and as resistive elements. The main uses of molybdenum compounds are as petrochemical catalysts in the case of molybdenum trioxide, as catalysts in the case of molybdate ammonium, and as antifreeze raw materials, color couplers for pigments, dye mordants, metal surface treatment agents, and rust prevention agent raw materials in the case of sodium molybdate.

The production (shipments) and import quantity in FY 2007 was 10,000 to <100,000 t for molybdenum trioxide, 100 to < 1,000 t for sodium molybdate, ammonium molybdate and molybdenum disulfide, and 10 to <100 t for calcium molybdate. The production and import category under the PRTR Law for molybdenum and its compounds is more than 100 t.

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2. Exposure assessment

Total release to the environment in FY 2009 under the PRTR Law was approximately 160 t, of which approximately 67 t or 42% of overall releases were reported. The major destination of reported releases was public freshwater bodies. In addition, approximately 500 t was transferred to waste materials. Industry types with large reported releases were the chemical industry for the atmosphere, and the chemical industry and the steelmaking industry for public water bodies. The largest release among releases to the environment including unreported ones was to water bodies. Predicting distribution proportions by individual media was not considered appropriate because the chemical forms adopted by molybdenum in the environment vary considerably. Accordingly, a prediction of proportions of distribution of molybdenum into individual media was not carried out.

The predicted maximum exposure to humans via inhalation, based on general environmental atmospheric data, was around 0.0036 μg/m^3. Meanwhile, the annual mean value of atmospheric concentration estimated from reported releases to the atmosphere under the PRTR Law was a maximum of 0.56 μg/m^3. The predicted maximum oral exposure was estimated to be around 0.062 μg/kg/day based on calculations from data for drinking water and soil, and 1.2 μg/kg/day based on calculations from data for groundwater and soil. Further, the predicted maximum exposure via ingestion calculated from food data, together with data for drinking water and soil was 4.5 μg/kg/day, while that similarly calculated from data for groundwater and soil was 5.6 μg/kg/day. In both cases past data was employed and the area surveyed was limited.

The predicted environmental concentration (PEC), which indicates exposure to aquatic organisms, was 87 μg/L for public freshwater bodies and around 20 μg/L for seawater when set up from data with a high probability of human activity. The maximum river concentration was estimated to be 46 μg/L from reported releases to public freshwater bodies under the PRTR Law.

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3. Initial assessment of health risk

The aerosol of sodium molybdate is irritating to respiratory tract and eyes. When inhaled, it causes coughing and sore throat. When orally taken, it may cause abdominal pain, nausea, vomiting and diarrhea. Contact of skin and eyes to the substance makes them red. Calcium molybdate may cause mechanical irritations to eyes, skin and respiratory tract. When inhaled, it will cause coughing and sore throat. Contact of skin and eyes to the substance makes them red and cause pain to eyes.

As sufficient information was not available on carcinogenicity of the substance, an initial assessment was conducted on the basis of the information on its non-carcinogenic effects.

As for oral exposure to the substance, a NOAEL of 0.9 mg/kg/day for molybdenum (for prolonged estrus cycle and fetal growth retardation) obtained from its reproductive/developmental toxicity tests on rats would be its lowest reliable dose without any effect and was identified as its 'non-toxic level*'. As for its inhalation exposure, a LOAEL of 10 mg/m^3 for molybdenum trioxide (for degeneration of lung, throat and nasal tissue) was obtained from mid- and long-term toxicity tests on rats and mice. It was then adjusted to 1.8 mg/m^3 (equivalent to 1.2 mg/m^3 for molybdenum) against exposure conditions and was further divided by 10 as is always the case with LOAEL. Final outcome of 0.12 mg/m^3 was deemed to be the lowest reliable concentration of the substance without any effect, and this was identified as its 'non-toxic level*'.

As for its oral exposure, its mean exposure would be about 0.020 μg/kg/day and its predicted maximum exposure would be around 0.062 μg/kg/day, respectively, if its intakes through drinking water and soil were assumed. The MOE would be 1,500 when calculated from its 'non-toxic level*' of 0.9 mg/kg/day and the predicted maximum exposure, and further divided by 10 for conversion of the 'non-toxic level*' from animal experiments to an equivalent dose for humans. In addition, if intakes through groundwater and soil were assumed, its mean exposure would be no less than around 0.0029 μg/kg/day but less than 1.6 μg/kg/day and its predicted maximum exposure would be 1.2 μg/kg/day, to provide the MOE of 75. For information, its maximum exposure through food intakes was reported to be 4.4 μg/kg/day for some location in 2000. When its predicted maximum exposure through intakes of drinking water and soil is combined with this, its combined exposure would be 4.5 μg/kg/day to provide MOE of 20. When its predicted maximum exposure through intakes of groundwater and soil is combined with this, its combined exposure would be 5.6 μg/kg/day to provide MOE of 16. Therefore, collection of information would be required to assess health risk from oral exposure to this substance.

As for its inhalation exposure, its mean exposure would be about 0.0024 $\mu g/m^3$ and its predicted maximum exposure would be less than around 0.0036 $\mu g/m^3$ respectively, when its concentrations in the ambient air are considered. The MOE would be 3,300 when calculated from the 'non-toxic level*' of 0.12 mg/m^3 and the predicted maximum exposure, and divided by 10 for conversion of the 'non-toxic level*' from animal experiments to an equivalent dose for humans. On the other hand, its releases to the ambient air reported in FY2009 under the PRTR Law suggests that its maximum annual mean concentration in the ambient air around its major sources of emissions would be 0.56 $\mu g/m^3$ and associated MOE would be 21. Therefore, collection of information would be required to assess health risk from inhalation exposure to this substance in the ambient air. As a part of such effort, it is desirable to measure its concentrations in the ambient air around its major sources of emissions.

Toxicity				Exposure assessment			Result of risk assessment			Judgment
Exposure Path	Criteria for risk assessment	Animal	Criteria for diagnoses (endpoint)	Exposure medium	Predicted maximum exposure dose and concentration					
Oral	Non-toxic level * ' 0.9 mg/kg/day	Rats	Prolonged estrus cycle, fetal growth retardation	Drinking water/soil	0.062	μg/kg/day	MOE	1,500	○	▲
				Groundwater/soil	1.2	μg/kg/day	MOE	75	▲	
Inhalation	Non-toxic level * ' 0.12 mg/m^3	Rats Mice	Degeneration of lung, throat, and nasal tissues	Ambient air	0.0036	$\mu g/m^3$	MOE	3,300	○	(▲)
				Indoor air	—	$\mu g/m^3$	MOE	—	×	×

Non-toxic level *

・When a LOAEL is available, it is divided by 10 to obtain a level equivalent to NOAEL.

・When an adverse effect level for the short-term exposure is available, it is divided by 10 to obtain a level equivalent to an adverse effect level for the long-term exposure.

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4. Initial assessment of ecological risk

With regard to acute toxicity, the following reliable data were obtained: a 96-h LC_{50} of 180,000 μg Mo/L for the crustacean *Americamysis bahia*; and a 96-h LC_{50} of 800,000 μg Mo/L for the fish *Oncorhynchus mykiss* (rainbow trout). Also obtained was a 96-h LC_{50} of 4,563 μg Mo/L for the sludge worm *Tubifex tubifex*. No data for algae was obtained that could be used, but applying an assessment factor of 100, a predicted no effect concentration (PNEC) of 1,800 μg Mo/L was obtained.

With regard to chronic toxicity, the following reliable data were obtained: a 21-d NOEC 49,900 μg Mo/L for reproductive inhibition in the crustacean *Daphnia magna*; and a 1-y NOEC of more than 17,000 μg Mo/L for growth inhibition or mortality in the fish *Oncorhynchus mykiss* (rainbow trout). Also obtained was a 7-d NOEC of 24,700 μg Mo/L for growth inhibition in the duckweed *Lemna minor*. No data for algae was obtained that could be used but applying an assessment factor of 10, a predicted no effect concentration (PNEC) of more than 1,700 μg Mo/L was obtained. This more than 1,700 μg Mo/L obtained from the fish chronic toxicity was used as the PNEC for this substance.

The PEC/PNEC ratio was less than 0.05 for freshwater bodies and less than 0.01 for seawater, and no further work is considered necessary at this point in time judging from the toxicity values of the three organism groups (algae, crustacea, and fish). However, ecological risk assessment for organism groups other than the three already studied is considered necessary for these substances because the PEC/PNEC ratio is 1.9 for freshwater bodies and 0.4 for seawater when using PNEC for other organisms.

Hazard assessment (basis for PNEC)			Assessment factor	Predicted no effect concentration PNEC (μg/L)	Exposure assessment		PEC/PNEC ratio	Judgment based on PEC/PNEC ratio	Assessment result
Species	Acute/ chronic	Endpoint			Water body	Predicted environmental concentration PEC (μg/L)			
Fish (rainbow trout)	Chronic	NOEC mortality/growth inhibition	10	≧1,700	Freshwater	87	≦0.05	○	▲
					Seawater	20	≦0.01		

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5. Conclusions

	Conclusions		Judgment
Health risk	Oral exposure	Requiring information collection.	▲
	Inhalation exposure	Further information collection would be required for risk characterization.	(▲)
Ecological risk	Ecological risk assessment for organism groups other than the three (algae, crustacea, and fish) already studied considered necessary.		▲

［Risk judgments］ ○: No need for further work ▲: Requiring information collection

■: Candidates for further work ×: Impossibility of risk characterization

(○) : Though a risk characterization cannot be determined, there would be little necessity of collecting information.

(▲) : Further information collection would be required for risk characterization.