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SELENIUM AND TELLURIUM

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14 Selenium and Tellurium

Selenium and tellurium metals are recovered as by-products during copper, lead-zinc, gold and platinum ore processing. The principal sources of selenium are sulphide deposits and anode mud or slime obtained during electrolytic refining of copper. Tellurium is found mostly in tellurides associated with metals, such as, bismuth, lead, gold and silver. It is found with selenium in the anode slime from electrolytic copper refineries.

EXTRACTION

Selenium and tellurium metals were being recovered as allied products at Ghatsila Copper Smelter of HCL in Jharkhand, where the annual installed capacity to produce selenium was 14,600 kg. HCL has not reported production of selenium since 2006-07 and that of tellurium since 2004-05. Hindalco Industries Ltd reported 73,870 kg production of selenium from imported copper concentrates at its Dahej Smelter in Gujarat during 2010-11 and thereafter no production data is available.

USES

Selenium

In glass manufacturing, selenium powder in traces is used as a decolourant for removing the green tint caused by iron impurities in container glass and other soda-lime silica glasses. Approximately, 1 kg selenium is used for about 150 tonnes of glass production. It is also used in architectural plate glass to reduce solar heat transmission. High-purity selenium compounds were used principally as photoreceptors on the drums of older plain paper copiers which are gradually being replaced by newer models that do not use selenium in the reproduction process. Dietary supplement for livestock is the largest agricultural usage of selenium. Also, selenium is known to be added to fertilizer to enrich selenium-poor soils.

Selenium is added to steel, copper and lead alloys to improve machinability which enables faster production with better surface finish and casting properties. Selenium is added to low antimony-lead alloys used in the support grids of lead acid storage batteries. The addition of 0.02% selenium by weight as a grain refiner improves the casting and mechanical properties of alloy. Metallurgical applications of selenium also include its use in the production of electrolytic manganese metal (EMM), wherein about 2 kg of SeO_2 is required per tonne of electrolytic manganese metal produced.

Chemical uses of selenium are in industrial and pharmaceutical applications. The principal pharmaceutical use of selenium is in anti-dandruff hair shampoos. Selenium is also used as a human dietary supplement. Miscellaneous industrial chemical uses are as lubricant, rubber compounding catalysts and as a promoter in the reformation of naptha.

In pigment applications, selenium is used to produce colour changes in cadmium sulphide-based pigments. Sulphoselenide pigments have good heat stability highly resistant to light and chemical attack and hence are used in ceramics, plastics, paints, inks and enamels. Selenium is used in catalysts to enhance selective oxidation and in plating solutions to improve appearance and durability. It is also used in blasting caps and gun bluing.

The use of selenium in glass has increased due to higher colourless glass production. The use of selenium in fertilizer and supplements in the plant-animal human chain and as human vitamin supplements increased as its health benefits were documented. The use of selenium in copper-indium-gallium-diselenide (CIGD) solar cell has increased.

Selenium is recovered from used electronic and photocopier components and recycled. The estimated global use of selenium was in metallurgy (40%), glass (25%), agriculture, chemicals & pigments, electronic (10% each) and other industries (5%).

Tellurium

Tellurium is used principally as an alloying element in the production of free-machining low carbon steel, where additions up to 0.1% tellurium greatly improves machinability. It is also used as a minor additive in copper alloys to improve machinability without reducing conductivity. Tellurium catalysts are used chiefly for the oxidation of organic compounds and also in hydrogenation and halogenation reactions. Tellurium chemicals are used as vulcanising and accelerating agents in processing of rubber compounds. It finds use as a component of catalysts for synthetic fibre production that is increasingly used in cadmium-tellurium-based solar cells. In plain paper copiers and in thermoelectric and photoelectric devices, tellurium is used along with selenium. Mercury-cadmium telluride is used as a sensing material for thermal imaging devices. Tellurium is also used as an ingredient in blasting caps and as a pigment to produce colours in glass and ceramics. High purity tellurium is used in alloys for electronic applications.

SUBSTITUTES

High-purity silicon has replaced selenium in high-voltage rectifiers and is the major substitute for selenium in low and medium voltage rectifiers and solar photovoltaic cells. Other inorganic semiconductor materials, such as, silicon, cadmium, tellurium, gallium and arsenic as well as organic photoconductors are the substitutes for selenium in photoelectric applications. Cerium oxide is substitute of selenium as either a colorant or decolorant in glass. Amorphous silicon and organic photoreceptors are substitutes of selenium in plain paper photocopiers. Sulphur dioxide can be used as a replacement for selenium dioxide in the production of electrolytic manganese metal.

Several materials can replace tellurium in most of its uses, but usually with loss in production efficiency or product characteristics. Bismuth, calcium, lead, phosphorus, selenium and sulphur can be used in place of tellurium in many free-machining steels. Several of the chemical process reactions catalysed by tellurium can be carried out with other catalysts or by means of non-catalytic processes. The chief substitutes for tellurium were selenium and sulphur in rubber compound applications and selenium, germanium and organic compounds in electronic applications.

WORLD REVIEW

Selenium

The world reserves of selenium at 1,20,000 tonnes only cover the estimated contents of economic copper deposits. Selenium was obtained as a by-product with copper. Substantial resources also exist in association with other metals, coal deposits and in uneconomic copper deposits (Table - 1).

In 2014, the production of selenium metal in respect of the world countries for which data is available was estimated at 2,813 tonnes. The chief producers were Japan (28%), Germany (25%), Russia (8%), Belgium (7%), Canada, Mexico, Kazakhstan, Sweden and Finland (4% each) (Table - 2).

Global selenium and tellurium output cannot be determined easily because not all companies or countries report production and because trade in scrap and semi-refined products may be included with refined metal trade data.

Table – 1 : World Reserves of Selenium (By Principal Countries)

(In tonnes of Selenium content)

Country	Reserves
World: Total (Rounded off)	**120000**
Canada	6000
Chile	25000
China	26000
Peru	13000
Poland	3000
Russia	20000
USA	10000
Other countries	21000

Source: *Mineral Commodity Summaries, 2016.*

Table – 2 : World Production of Selenium Metal (By Principal Countries)

(In tonnes)

Country	2012	2013	2014
World total	**2691**	**2708**	**2813**
Belgium[e]	200	200	200
Canada	144	159	154
China[e]	65	65	65
Finland	93	72	94
Germany[e]	650	700	700
Japan	820	739	782
Kazakhstan[e]	130	130	130
Mexico	95	132	120
Poland	90	80	90
Peru	42	50	40[e]
Philippines[e]	70	70	70
Russia[e]	172	155	212
Sweden[e]	70	100	100
Uzbekistan[e]	20	20	20
Other countries	30	36	36

Source: *World Mineral Production, 2010-2014.*

Tellurium

The world reserves of tellurium were at 25,000 tonnes contained in copper resources. Concentration of tellurium could also be found in lead and gold deposits. The quantities of tellurium in deposits of coal, copper and other metals that are of sub-economic grade are several times the amount of tellurium contained in identified economic copper deposits (Table-3).

Table – 3 : World Reserves of Tellurium (By Principal Countries)

(In tonnes of Tellurium content)

Country	Reserves
World: Total (Rounded off)	**25000**
Canada	800
Peru	3600
Sweden	700
USA	3500
Other countries	16000

Source: *Mineral Commodity Summaries, 2016.*

More than 90% of tellurium is produced from anode slimes collected from electrolytic copper refining and the remainder is derived from skimmings at lead refineries and from flue dust and gases generated during the smelting of bismuth, copper and lead ores. The anode slimes of copper and lead refineries normally contain about 3% tellurium. The chief producers of refined tellurium in the world in 2014 were USA, Japan, Sweden, Russia and Canada contributing an estimated 152 tonnes to the world production compared to 147 tonnes produced in 2013 (Table-4).

Table – 4 : World Production of Tellurium Metal (By Principal Countries)

(In tonnes)

Country	2012	2013	2014
Canada	11	12	9
Japan	43	31	32
Russia	30	30(e)	30(e)
Sweden	7	24	31
USAe	50	50	50

Source: *World Mineral Production, 2010-2014.*

China

In 2014, China's rare metals Fanya Metal Exchange began listing and trading selenium and tellurium. On April 21,2014, it began trading 99.99% tellurium and 99.9% selenium powder with reported stocks of 20 tonnes of tellurium and 30 tonnes of selenium. By October, Fanya warehouses reportedly held 205 tonnes of selenium and 135 tonnes of tellurium.

Peru

Corporacion Nacional del Cobre de Chile (Codelco) and LS Nikko Copper Inc. established a joint venture in Chile to recover precious and minor metals from copper slimes. Construction of the plant in Mejillones started in late 2014, Projected output estimates included 20 metric tonnes per year of tellurium, 200 tonnes/year of selenium, 5 tonnes/year of gold, 550 tonnes/year of silver, 140 kilograms per year of palladium, and 7 kilograms/year of platinum.

Sweden

Boliden Group announced that the expansion of the Garpenberg zinc mine was slightly ahead of schedule and within budget. The expansion was expected to produce more tellurium once the expansion was completed. In the second quarter of 2014, Boliden produced 30,900 kg of tellurium, up from 24,500 kg in the same quarter of 2013.

FOREIGN TRADE

Exports of selenium decreased to 124 tonnes in 2014-15 from 143 tonnes in the previous year. Exports were mainly to China (65%), UK (17%), Hong Kong (14%),Canada (2%), Iran and Malaysia (1% each). In 2014-15, exports of tellurium was neglible as compared to previous year. Exports were from USA & Saudi Arabia (Tables-5 & 6). Imports of selenium slightly decreased to 263 tonnes in 2014-15 as compared to 264 tonnes in the previous year. Imports were mainly from Japan (32%), Korea Rep. of (24%), Belgium (24%),Germany (9%) and UK (6%). In 2014-15, imports of tellurium increased and imports were mainly from UK and China (33% each) (Tables-7 & 8).

Table – 5 : Exports of Selenium (By Countries)

Country	2013-14 Qty (t)	2013-14 Value (₹'000)	2014-15 (P) Qty (t)	2014-15 (P) Value (₹'000)
All Countries	**143**	**440707**	**124**	**350157**
China	99	279682	81	221052
UK	20	64085	21	59898
Hong Kong	11	46273	17	54177
Canada	2	6338	2	7513
Iran	++	1090	1	3720
Malaysia	++	104	1	697
Sweden	-	-	++	597
USA	3	11693	++	573
Thailand	1	3762	++	554
Poland	++	30	++	369
Other countries	7	27650	1	1007

Table – 6 : Exports of Tellurium (By Countries)

Country	2013-14 Qty (t)	2013-14 Value (₹'000)	2014-15 (P) Qty (t)	2014-15 (P) Value (₹'000)
All Countries	**24**	**6979**	**++**	**93**
USA	-	-	++	62
Saudi Arabia	-	-	++	31
Other countries	24	6979	-	-

Table – 7 : Imports of Selenium (By Countries)

Country	2013-14 Qty (t)	2013-14 Value (₹'000)	2014-15 (P) Qty (t)	2014-15 (P) Value (₹'000)
All Countries	**264**	**1078360**	**263**	**867525**
Japan	87	349850	83	271399
Belgium	51	204131	62	207373
Korea, Rep. of	71	295127	63	199789
Germany	25	108816	23	81971
UK	14	57577	16	53626
China	7	25568	9	29844
Poland	2	8367	2	5407
Hong Kong	1	3293	5	15517
USA	1	2757	++	1059
UAE	1	2502	++	1015
Other countries	4	20372	++	525

Table – 8 : Imports of Tellurium (By Countries)

Country	2013-14 Qty (t)	2013-14 Value (₹'000)	2014-15 (P) Qty (t)	2014-15 (P) Value (₹'000)
All Countries	**2**	**27583**	**6**	**42663**
UK	++	1887	2	14581
China	1	11599	2	12727
Japan	++	3038	1	7029
Belgium	1	5469	++	788
Hong Kong	-	-	1	6650
USA	++	1890	++	466
Canada	++	2669	++	351
Netherlands	-	-	++	48
Germany	++	302	++	23
Other countries	++	729	-	-

FUTURE OUTLOOK

The supply of selenium and tellurium is directly affected by the production of the principal product from which it is derived i.e.copper and to a lesser extent, by the production of gold, lead, nickel or zinc produced from sulfide ores. Increased recovery rates at copper refineries could increase selenium and tellurium supply and long term investments in gold-telluride deposits and other sources of tellurium could boost the global rate of growth for tellurium production above the rate of growth in copper concentrate production. Although increased environmental regulation and prices have encouraged the recycling of electronic scrap, recovery of selenium and tellurium has been declining during the past several years due to the reduction in available scrapped selenium and tellurium-based copier drums. However, many high-grade tellurium producers and users were recovering much of the manufacturing scrap from the production of consumable goods. Also, solar-cell recycling plants have been built in the United States of America and around.

Demand for tellurium, particularly as the global carbon footprint is reduced and solar energy technology becomes more widespread, are predicted to increase steadily in the near future. Consumption for metallurgical alloying and chemicals was expected to decrease, assuming the price of tellurium continues to remain volatile; producers of low-value products were expected to find substitutes.