IPA

INTERNATIONAL PLATINUM GROUP METALS ASSOCIATION

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SOURCES OF EXPOSURE TO PLATINUM GROUP METALS

CONTENTS

SUMMARY

- Industrial processing has the potential for a variety of potential occupational exposures to PGMs. Non-occupational exposures are more limited.

- Industrial processing of PGMs typically involves materials handling, dissolution of PGM concentrates, separation and refining processes, manufacture of supported catalysts, PGM salts and powders, plus a large number of manufacturing processes for smaller scale products, including production of biologically active substances such as the platins, which are used for some cancer treatments (see Chapter 6).

- The main health effect of concern for certain forms of platinum in industrial settings is respiratory sensitisation, often referred to as “platinum salt sensitivity”, or PSS, and particularly relates to where complex halogenated platinum salts (CHPS) are formed or used. Workers in refining operations in particular are potentially exposed to PGMs and their chemical derivatives, as hydrometallurgical separation processes are invariably based on chloride chemistries and hence use chloroplatinates (the most common forms of CHPS).

- Depending on the production process, exposure may be through contact with PGM solutions, solids, aerosols, particulates or fume. The route of exposure for individuals can be by inhalation, ingestion or dermal contact.

- Non-occupational exposure may occur from both natural and man-made sources of PGMs (see also Chapter 5). Natural sources include geological deposits, and trace levels in soils, water and foodstuffs. In terms of man-made sources, PGMs may be released from some fabricated products, including dental materials and vehicle catalytic converters.

4.1

OCCUPATIONAL SOURCES OF EXPOSURE

For the sake of brevity, the following descriptions of platinum group metal industry operations inevitably contain generalisations and it is recognised that some organisations use alternative processes and production flows.

Industrial processing of PGMs typically involves materials handling, dissolution of PGM concentrates (invariably in acid chloride media), separation and refining processes, manufacture of supported catalysts and PGM salts, powder production, and a large number of manufacturing processes for smaller scale products. The latter includes the production of biologically active substances such as the “platins” (*e.g.*, cisplatin), which are used for cancer treatment. There are also generic cleaning, stocktaking, maintenance and packaging activities in many individual processes. Occupational exposure may occur in any of these scenarios.

The main health effect of concern for certain forms of platinum in industrial settings is respiratory sensitisation, often referred to as “platinum salt sensitivity” or PSS. Only platinum compounds that possess labile leaving groups have been shown to be respiratory sensitisers and these require stringent workplace control standards (see Chapters 6 - 10). Species that are respiratory sensitisers in industrial settings are largely confined to complex halogenated platinum salts (CHPS). Examples of industrial processes and activities where the most common forms of CHPS may be encountered viz., chloroplatinates, are covered in Table 4-1.

In particular, workers in primary and secondary PGM refining operations are potentially exposed to platinum group metals and their chemical derivatives used in hydrometallurgical separation. These are invariably based on chloride chemistries; and hence utilise chloroplatinate solutions.

4.1 OCCUPATIONAL SOURCES OF EXPOSURE

For most primary producers the final products of refining are usually the pure PGM metals, either in the form of powders or fabricated into massive metal. For secondary refiners and those companies otherwise involved in product manufacture, the most common route is to produce PGM solutions, some of which are converted into metal powders with the remainder used as intermediates in the manufacture of supported catalysts and other chemical products. Lateral to these mainstream activities is the production of alloys and other metallic forms of the PGMs and a large number of smaller scale products.

Downstream manufacturing uses include metal plating/coatings, medical products, further chemicals manufacture, jewellery, electronics, laboratory and furnace-ware and the use of supported or metallic catalysts in end-use industries, such as for petroleum refining and nitric acid production; amongst others described in Chapter 3.

The physical forms of exposure to PGMs vary according to the refining or manufacturing process as further modified by the exposure controls used in a facility. Exposure to particulate (dust), fume, liquid aerosols, and contact with solutions and solids may all occur. The route of exposure for individuals can therefore be by inhalation, ingestion (*e.g.*, via hand to mouth transference) or skin contact.

Some manufacturers have noted that while routine day-to-day exposure measurements can frequently be low in many plant areas over extended periods of time, these measurements can undergo excursions to higher values during non-routine activities such as stock-taking, equipment clean-down and maintenance activities.

TYPE OF EXPOSURE					
Processes / Activities	Contact with solutions	Airborne Aerosols	Contact with solids	Airborne Particulate	Fume
Materials receipt	1 or 2		1, 2 or 3	1, 2 or 3	
PGM concentrate dissolving	1	1	1 or 2	1, 2 or 3	
Separation and refining	1 or 2	1 or 2	1 or 2		
Salts production	1 or 2	1 or 2	1 or 2	1, 2 or 3	
Supported catalyst production	1 or 2	1 or 2	1 or 2	2 or 3	
Massive metal & alloy production			3	3	3
Packaging	1 or 2	1 or 2	1, 2 or 3	1, 2 or 3	
Cleaning	1, 2 or 3	1, 2 or 3	1, 2 or 3	1, 2 or 3	
Maintenance	1, 2 or 3	1, 2 or 3	1, 2 or 3	1, 2 or 3	

1 Often chloroplatinate-containing
2 Often non-chloroplatinate substances
3 Powders and massive metal

Table 4-1: Examples of processes and potential exposures

NON-OCCUPATIONAL SOURCES OF EXPOSURE

Non-occupational exposure is more limited than occupational exposure, and occurs mainly due to the natural environmental load of PGMs, supplemented by discharges from processing and manufacturing facilities and the release of PGM containing materials from some end-uses.

The general public may be exposed to the platinum group metals and their compounds. A non-exclusive list of potential exposure sources includes the following three categories:

1. Ambient exposures from:
   a. Naturally occurring PGMs
   b. Local emissions from PGM processing facilities (primary and secondary)
   c. Groundwater
   d. Diet
   e. Emissions from vehicle exhausts
   f. Jewellery
2. Dental treatment with PGM-based implants, or other medical implants involving PGM materials.
3. Drug therapy for certain types of cancers (typically involving a class of Pt-based drugs known as "platins").

The last two categories involve the deliberate introduction of PGMs into the human body for the purposes of medical treatment. As the focus of this Guide is on workplace contexts, these scenarios are not further considered. However, Chapters 6 to 10 do cover aspects relevant to healthcare workers (HCWs) who are occupationally exposed to platins.

Platinum occurs naturally, but sparsely, in the environment with an estimated abundance of 0.001 part per million (ppm)[1]. The other PGMs are even less abundant by up to an order of magnitude. This concentration is of course greater closer to geological deposits of PGMs, such as those discussed in Chapter 3 and, potentially, near to PGM processing facilities. An ore seam itself may be 1-10 ppm Pt; this compares to a common element such as for example aluminium, which has a worldwide abundance estimated at 82,000 ppm.

The ultra-low levels of platinum detected in samples taken from ambient environmental media pose analytical difficulties that generally prevent the chemical form of the platinum from being determined. As a result, it is the total platinum concentrations in these samples which are generally reported. Speciation data are not available to determine the percentage represented by halogenated or other platinum salts; although, in most cases, these may reasonably be expected to be a low proportion of the total platinum.

Although exposure to platinum and other PGMs does occur during the handling of jewellery or coins/bars, the extent of exposure in these instances is limited because of their massive form (Chapter 2).

As PGMs can enter the food chain, due for example to low-level contamination of agricultural land, there is an expectation that exposure can also occur through the diet. Chapter 5 provides further information on background levels detected in non-occupationally exposed populations.

Probably the most common source of public exposure occurs from attritional loss of PGMs from automobile catalytic converters. The design of catalytic converters and the combinations of individual PGMs used in them have changed considerably since emissions legislation was first introduced in the mid-1970s. Early converters used pellets, which were subject to greater attritional losses. But these were soon superseded by gas-flowed monolith catalysts,

[1] http://nature.berkeley.edu/classes/eps2/wisc/pt.html

4.2

NON-OCCUPATIONAL SOURCES OF EXPOSURE

which are still in use today[2, 3]. Platinum (mainly) and palladium were the original key catalyst components. However as technologies and legislation have evolved, the mix has expanded to include rhodium, while palladium usage has grown to be double that of platinum.

Interest in the nature and volume of PGMs released from catalytic converters has generated a number of studies of variable quality, possibly due to the difficulties of analysing PGMs. Nevertheless, typical levels of platinum released into the environment by automotive catalysts can be illustrated by a recent study by the University of Wisconsin, USA (2017). This significant body of work was carried out in six European cities using state-of-the-art airborne particulate collection and analytical techniques. The anionic concentrations of platinum collected on PM3 filters (<3 µm; the dominant size fraction observed) were found to average from 0.02 picograms/m^3 at rural background sites to 0.06 picograms/m^3 in roadside and canyon sites in ultrapure water extracts, and from 0.1 picograms/m^3 at rural background sites to 0.4 picograms/m^3 in roadside and urban 'street canyon' sites, when extracted in surrogate lung fluid solutions. Anionic platinum concentrations represent an upper boundary limit on potential chloroplatinate levels.

2 www.aecc.eu/technology
3 www.meca.org/technology

REFERENCES

Association for Emissions Control by Catalyst (AECC); www.aecc.eu

Manufacturers of Emission Controls Association (MECA); www.meca.org

University of Wisconsin (2017)
Manuscripts in preparation.