



**Conference of the Parties to the
Minamata Convention on Mercury
Sixth Meeting**

Geneva, 3–7 November 2025

Item 4 (b) (iii) of the provisional agenda*

**Matters for consideration or action by the Conference of the
Parties: mercury-added products and manufacturing
processes in which mercury or mercury compounds are used:
consideration of the feasibility of mercury-free alternatives for
manufacturing vinyl chloride monomer**

**Information on the economic and technical feasibility of
mercury-free catalyst in vinyl chloride monomer production****

Note by the secretariat

1. The Conference of the Parties, in decision MC-5/6, invited parties and relevant organizations to submit information to the secretariat on technically and economically feasible alternatives to the use of mercury and mercury compounds in vinyl chloride monomer production, and requested the secretariat to prepare a report for consideration by the Conference of the Parties at its sixth meeting.
2. Information was submitted by nine parties and three organizations. Submitted information, which was also posted on the Convention website, is set out in the annex to the present note, without formal editing.

* UNEP/MC/COP.6/1/Rev.1.

** This document has not been formally edited.

Submission by Brazil

I would like to recall **decision MC-5/6**, adopted at the fifth meeting of the Conference of the Parties to the Minamata Convention on Mercury. In this decision, **Parties and relevant organizations were invited to submit, by 31 March 2025, on a voluntary basis, information on technically and economically feasible alternatives to the use of mercury and mercury compounds in vinyl chloride monomer production**, in accordance with **Paragraph 8 of Article 5 and Paragraph 1 of Article 17 of the Convention**.

Brazil developed its **National Inventory of Mercury Releases and Emissions**, which did not identify any vinyl chloride monomer (VCM) production using mercury or mercury compounds in the country in 2019.

In this context, we submit information on the production process of VCM in Brazil, which does not involve the use of mercury and is based on the ethylene route, considered both technically and economically feasible.

The balanced process for producing **vinyl chloride monomer (VCM)** is based on two **interdependent production routes**, both of which rely on the same intermediate compound: **1,2-dichloroethane (EDC)**.

1. Direct Chlorination

In the first route, called **direct chlorination**, **ethylene reacts with chlorine** to produce EDC. This reaction is typically carried out in the **liquid phase** at temperatures between **50°C and 70°C** and under pressures of **4 to 5 atmospheres**. In **gas-phase processes**, the temperature ranges from **90°C to 130°C**, with pressures between **7 and 10 atmospheres**.

2. Oxychlorination

The second route, known as **oxychlorination**, involves the reaction of **ethylene with hydrogen chloride and oxygen** (usually from air). This reaction uses **copper chloride as a catalyst** and takes place at much **higher temperatures**, typically between **250°C and 350°C**. To improve efficiency, **pure oxygen** can be added to increase the partial pressure of oxygen in the reaction mixture.

3. Thermal Cracking of EDC

EDC produced from both routes is then sent to **cracking furnaces**, where it is heated to high temperatures—between **470°C and 540°C**—to decompose it into **VCM and hydrogen chloride**. The pressure in these furnaces can vary depending on the technology used: some systems operate at **high pressures (24–26 atm)**, while others operate at **lower pressures (7–10 atm)**.

The **yield** of this reaction typically ranges from **60% to 70%**. Since higher conversion rates reduce flow rates and may be less economical, industries often operate at moderate conversion levels and **recycle unreacted EDC** to improve overall efficiency.

The process is called "balanced" because it aims to **match the amount of hydrogen chloride generated in the cracking step with the amount needed in the oxychlorination step**. For every two molecules of hydrogen chloride consumed in oxychlorination, one is regenerated during cracking. To maintain this balance, the process is designed to use **approximately 50% EDC from direct chlorination and 50% EDC from oxychlorination**.

This balance ensures **efficient reuse of hydrogen chloride**, minimizing waste and the need for additional inputs, which makes the process both **economically and environmentally advantageous**.

Advantages of the Ethylene Route

- **Does not use mercury or mercury compounds**, making it safer for human health and the environment.

Submission by Burkina Faso

**MINISTRY OF THE ENVIRONMENT, WATER AND
SANITATION**

GENERAL SECRETARIAT

**GENERAL DIRECTORATE FOR ENVIRONMENTAL
PRESERVATION**

**DIRECTORATE FOR THE PREVENTION OF
POLLUTIONS AND ENVIRONMENTAL RISKS**

BURKINA FASO

Homeland or Death, We Will Win

Report on technically and economically feasible alternatives to the use of mercury and mercury compounds in the production of vinyl chloride monomer

April 2025

As part of the submission of information on technically and economically feasible alternatives to the use of mercury and mercury compounds in the production of vinyl chloride monomer.

In Burkina Faso, no vinyl chloride monomer production activity is carried out. However, initiatives are being taken to regulate its import and use in Burkina Faso. This is evidenced by Decree No. **2023 1337/PRES TRANS/PM/MEEA/MFPTPS/MATDS/MEFP/MARAH/MSHP/MDICAPM E/MEMC/MESRI/MUTMUSR of October 17, 2023, listing regulated chemical products or substances, which stipulates in Article 11 that:** mercury and its derivatives used in the manufacturing processes of products listed in Annex B of the Minamata Convention of October 10, 2013 on mercury are intended for elimination and are no longer authorized.

Information on Mercury-Free Production of Acetylene Based Vinyl Chloride Monomer Manufacturing Sector in China

I. Progress and achievements of acetylene based vinyl chloride monomer manufacturing sector in China in fulfilling its obligations under the Convention

The Chinese government attaches great importance to the implementation of the Minamata Convention on Mercury (hereinafter referred to as the Convention). Since the Convention came into force in China on August 16, 2017, a series of measures have been undertaken to promote the reduction of mercury use in the acetylene based vinyl chloride monomer (VCM) manufacturing sector.

(I) Sector-wide low-mercury catalyst alternatives to achieve Convention implementation targets

Since 2015, the acetylene based VCM manufacturing sector in China has fully replaced high-mercury catalysts (mercury chloride content of 6.5% or more) with low-mercury catalysts (mercury chloride content of 4-6.5%), reducing mercury use by thousands of tons; Mercury use per unit of product has been reduced to no more than 49.14 grams since 2020 for the entire sector, achieving the implementation target of Annex B to the Convention, keeping in a stable level and with gradual decrease.

(II) Release of national policies to ban the construction of new facilities

On August 15, 2017, seventeen ministries and commissions including the Ministry of Ecology and Environment and the Ministry of Industry and Information Technology jointly issued the *Notice on the Entry into Force of the Minamata Convention on Mercury*, which clearly stated that from August 16, 2017, the use of mercury in new VCM manufacturing processes would be prohibited, further reducing the use of mercury or mercury compounds from the source.

(III) Encouraging mercury-free trials and promoting the reduction of mercury in the industry

In 2019, the National Development and Reform Commission issued the *Catalogue for Guiding Industrial Structure Adjustment* to encourage the petrochemical industry to develop and produce new, efficient, environmentally friendly, mercury-free catalysts. The industry has been carrying out research and development and application evaluation and testing of mercury-free catalysts.

Since 2023, a few enterprises have made breakthroughs in mercury-free production technology and built mercury-free manufacturing facilities for acetylene based VCM with a production capacity of more than 100,000 tons with the help of policy guidance and financial support, which has served as an example.

II. R&D and application evaluation and testing of mercury-free catalysts in China

In general, the research and development of mercury-free catalysts in China mainly focuses on three categories: gold, copper and ruthenium mercury-free catalysts.

Application evaluation and testing of different scales were carried out for their respective reaction models, catalyst active components, catalyst carriers, loading methods, etc. The application evaluation and testing of gold-based mercury-free catalysts is the most active after comparison, with three enterprises conducting large-scale (100,000 tons and above) industrial application evaluation and testing; The application evaluation and testing scale of copper-based mercury-free catalysts is concentrated at the thousand-ton or ten-thousand-ton level, although enterprises tried industrial application evaluation and testing in the early stage, it failed due to poor test results; The application evaluation and testing of ruthenium-based mercury-free catalysts only remains at the pilot scale, and application evaluation and testing of thousand-ton level and above have not been carried out.

Mercury-free catalysts should be evaluated for application throughout their entire life cycle, including production, use, and recycling. However, at present, all three catalysts lack full life cycle application evaluation and testing, and they focused on the production and use stages, with insufficient research and data on the recovery stage. Most of the gold-based catalysts of the three enterprises mentioned above are still in use, and large-scale recovery has not been carried out, while copper-based and ruthenium-based catalysts have never been evaluated for full life cycle application, including production, use, and recovery.

(I) Evaluation and testing on the application of gold-based mercury-free catalysts

1. Technical feasibility assessment

The technical feasibility is uncertain and still faces challenges, which is mainly reflected in:

First, poor adaptability. Compared with existing processes and facilities, gold-based mercury-free catalysts require further reduction of water content in the feed gas and increase of reaction temperature, which are not compatible with existing process and facilities and require further technical renovation.

Second, low representativeness. Currently, three Chinese enterprises (Enterprises A, B and C) are conducting industrial application evaluation and testing of gold-based mercury-free catalyst VCM production, with annual production capacities of 400,000 tons, 600,000 tons and 100,000 tons respectively. All three enterprises have carried out major technical renovations, which are quite different from the existing mainstream processes and facilities. More application samples and data verification for the industrial application in the full life cycle (production, use, and recovery) are needed for determining whether this technology can be scaled up in the entire industry.

Third, lacking standards. For gold-based mercury-free catalysts, there is a lack of standards for the full life cycle management, such as product standards, gold content determination methods, application operations, and recovery standards. Notably, there's no standard for adaptive technical renovation of processes and facilities.

Fourth, a lack of recovery data. Recovery is an important part of the entire life cycle, especially for precious metal catalysts. Most of the gold-based mercury-free catalysts of the above three enterprises are still in use. Although a small number of gold-based mercury-free catalysts have been replaced, while waste gold-catalysts have not been recovered and disposed. It will take at least one to two years to start carrying out large-scale gold recovery and identify the data of loss during the recovery.

2. Economic feasibility assessment

The application of gold-based mercury-free catalysts is not economically feasible, which is mainly reflected in:

First, the high cost of processes renovation. Based on the analysis of the industrial application of the three enterprises, in order to adapt to the gold-based mercury-free catalyst, the existing processes, facilities and operation control need to be optimized and technically renovated. Assuming that the entire industry uses gold-based mercury-free catalysts, the total investment in technical renovation will exceed 10 billion yuan only on technical renovation of hot water reactors and feed gas dehydration based on the analysis and calculation. In addition, the costs of other adaptation processes technology renovations such as one-time loss provisions for existing facilities, upstream and downstream processes adjustments, automation control, and pipeline adjustments are still unclear, and the investment cannot be calculated.

Second, the high application cost. According to the comparative analysis of the measured data provided by Enterprise A, the production and recovery costs of gold-based mercury-free catalysts are high. First, the price of gold is much higher than that of mercury (the current price of refined mercury is about 1.45 million yuan/ton, and the price of gold is about 750 million yuan/ton), and the manufacturing processes of mercury-free catalysts is more complicated, resulting in increased processing fees; Second, gold is difficult to recover due to its extremely stable physical and chemical properties, and its special financial attributes require higher recycling technology, so the corresponding costs are higher.

Third, the unclear recovery cost. As most of the gold-based mercury-free catalysts are still under application evaluation and testing, a stable operation of the processes technology cannot be guaranteed. In addition, the gold loss rate and the calculation of gold recovery products are still unclear. The greater the gold loss, the higher the production cost. Although data show that the gold loss rate of gold-based mercury-free catalysts over the entire life cycle may range from 15% to 20%, more samples and full life cycle management data are needed for determining whether the loss rate is representative and how to prevent and control gold loss in the manufacturing processes.

3. Availability assessment

In general, gold-based mercury-free catalysts are available, but the price of gold, as a precious metal, has shown a significant upward trend in recent years, which has put great pressure on the economic applicability of gold-based mercury-free catalysts,

thereby reducing its promotion and application.

4. Environmental and health assessment

Environmental and health risks are still unclear, which is mainly reflected in:

First, the catalyst components are difficult to obtain because the manufacturers' formulas are confidential. If aqua regia is used in the production of gold-based mercury-free catalysts, the NO_x pollutants produced will have an impact on the environment. In addition, gold-based mercury-free catalysts mostly use organic complexes containing gold (gold complexing compound), but the environmental risks of this organic gold complex are unknown, and organic solvents are required in its preparation processes. The environmental protection facilities required for industrial production organization and its impact on the environment are still unclear.

Second, since the industrial application evaluation and testing has just begun, it is still unknown which substances need to be monitored in waste gas and wastewater emissions and what monitoring methods should be used.

Third, it remains to be clarified whether the mercury-free catalyst recovery processes produces waste gas and wastewater, whether any substances harmful to the environment and health are produced, and whether there are targeted solutions and disposal measures.

(II) Evaluation and testing on the application of copper-based mercury-free catalysts

First, the technical feasibility is low. Under the same operating conditions, compared with low-mercury catalysts, the service life does not meet the industrial operation requirement of 8,000 hours. The low air velocity leads to low production capacity of a single converter, the increase in by-products makes the disposal complicated, and the active components in the catalyst are easy to lose and clog the pipeline. **Second, the economic feasibility cannot be demonstrated now.** Because there are still many problems in the technical application of copper-based mercury-free catalysts, and there is no capacity to complete the full life cycle management, it is impossible to demonstrate the economic feasibility. **Third, it is relatively easy to obtain.** From the perspective of resource reserves and global trade volume, copper reserves and trade volumes are large and is relatively easy to obtain. **Fourth, there are certain environmental safety hazards.** Catalysts are prone to spontaneous combustion during overturning and unloading, causing safety accidents.

(III) Evaluation and testing on the application of ruthenium-based mercury-free catalysts

First, the technical feasibility is low. The activity of the catalyst is greatly affected by temperature. When the operating parameter changes in the initial stage of operation, the reactor temperature is prone to rise sharply, namely, the "temperature runaway". Under the same operating conditions, the catalytic activity decreases rapidly and the service life is short. The air velocity is low and cannot meet the production requirements. **Second, it's highly unavailable.** In terms of resource reserves and global trade volume, the annual commodity volume of ruthenium is only

about 30 tons, and the global reserves is only about 5,000 tons. The supply cannot meet the needs of the entire industry, so it's highly unavailable.

3. Conclusion

In summary, China has actively promoted the reduction of mercury in the industry through policy guidance and practical actions, and achieved the implementation target of reducing the use of mercury in terms of per unit production by 50 percent in the VCM production sector. At the same time, China has actively carried out research and development of mercury-free catalysts and achieved certain breakthroughs. Three enterprises are currently carrying out large-scale industrial production of gold-based mercury-free catalysts for VCM production, which has played a demonstration and leading role in the entire industry to eliminate mercury. Related reports also demonstrate China's positive attitude and initial results in promoting mercury-free alternatives in the acetylene based VCM manufacturing sector.

However, the industrial application of existing gold-based, copper-based and other mercury-free catalysts still faces problems and challenges such as uncertainty in technical feasibility, lack of economic feasibility, and unclear environmental risks of mercury-free alternatives. It will take significant time and considerable effort to promote them on a large scale across the industry. China will take actions to gradually improve the full life cycle management system and the renovation of adaptive processes and facilities based on more application evaluation and testing samples, so as to further clarify the specific timetable and roadmap for mercury-free alternatives.

Submission by Mozambique



REPUBLIC OF MOZAMBIQUE
MINISTRY OF AGRICULTURE, ENVIRONMENT AND FISHERIES
NATIONAL DIRECTORATE FOR THE ENVIRONMENT

To: Minamata Convention Secretariat

Att: Ms. Monica Stankieewick, Executive Secretary
Geneva Switzerland

OurRef **MAAP/68/DINAB/GDN/ / 25** **Maputo, 28th of April 2025**

Subject: Extension of the Deadline for Submission of Information on the Use of Mercury and its components

Dear Sirs;

We acknowledge receipt of Your Excellency's communication, addressed to the Government of Mozambique through the Ministry of Foreign Affairs and Cooperation with Reference 1876/MINEC/DRM/995 of 15 April requesting information on the Use of Mercury and its components.

We would like to inform you that the implementation of the Minamata Convention in Mozambique is still at an early stage, despite some important steps having already been taken through the Minamata Initial Assessment (MIA) and the preparation of the National Action Plan (NAP) which led us to the ratification of the Minamata Convention on Mercury by the Council of Ministers through Resolution Nr. 36/2023, of the Minamata Convention on Mercury of 21 September.

The government has been implementing the following projects with the aim of minimizing and eliminating the use of mercury and its components:

- Dissemination of Techniques and Technologies for Gold Mining Extraction and Processing with Mercury alternatives use in the central and northern regions of Mozambique, namely in the provinces of: Manica, Tete, Zambezia, Cabo Delgado and Niassa;
- Conduction of Survey on mercury concentrations in artisanal gold mining areas;

- Formalization of Mining Associations in Cooperatives;
- Conduction of Artisanal Minerals Census in 2021;
- Geological and technological characterization in support of artisanal mining;
- Mining Technology Laboratory to Support Artisanal Mining The Mining National Institute (INAMI) has a Mining Technology Laboratory dedicated to the development of technical solutions to support artisanal mining, focusing on the technological characterization of various minerals and the optimization of mineral processing flowsheets. Through physical-chemical analyses and processing tests, the laboratory aims to maximize recovery rates, increase production efficiency and implement sustainable practices;
- Technological Innovation in the area of Mining Processing a strategic project was initiated, at INAMI in coordination with National Directorate of Mining DNGM, aimed at the design and development of improved and sustainable equipment for mineral processing, with an emphasis on eliminating dependence on toxic substances, such as mercury. After technical validation, the solutions will be transferred to artisanal mining communities through training programs and on-site demonstrations, aiming at the dissemination of practices aligned with environmental and occupational safety parameters; and
- Phytoremediation trials for Decontamination of Mercury Impacted Areas are ongoing in laboratory scale tests to evaluate the effectiveness of phytoremediation plant species in the decontamination of soils and water bodies affected by mercury. The study includes the selection of hyperaccumulator plants, the analysis of their capacity to absorb and fix the contaminant, and the optimization of cultivation protocols. The initiative seeks to validate low-cost biotechnological solutions to mitigate environmental impacts resulting from Artisanal Small Scale Mining (ASM) activity, contributing to the recovery of degraded ecosystems and the reduction of risks to public health.

And the health sector, it has been working on the following initiatives:

- Elimination of the use of medical devices containing mercury in the sector (e.g. thermometers, sphygmomanometers etc.);and
- Removal of dental amalgam containing mercury from the consumables needs list.

Finally, we would like to highlight that additional information related to the different activities listed by the partners above can be provided in case of need.

Yours Sincerely

p/ 
Guilhermina Amurane
National Director



Submission by Norway

Norway wants to submit information on technically and economically feasible alternatives to the use of mercury and mercury compounds in vinyl chloride monomer production.

Mercury have never been used in VCM production in Norway, all VMC is based om ethylene.

Please see this report for documentation:

THE MERCURY PROBLEM: Reducing and eliminating mercury pollution in Norway
(<http://www.mercury.org.cn/zcfg/gj/202107/P020210715338600571869.pdf>)

Submission by Senegal

Nous accusons bonne réception de votre correspondance en date du 17 avril 2025, relative à la prorogation du délai de soumission d'informations sur les alternatives techniquement et économiquement réalisables à l'utilisation du mercure dans la production de chlorure de vinyle monomère, conformément aux dispositions de la Convention de Minamata sur le mercure.

Après examen attentif, nous vous informons que **le Sénégal ne dispose pas d'installations industrielles utilisant du mercure ou des composés du mercure dans la production de chlorure de vinyle monomère**. De ce fait, notre pays **n'est pas concerné par l'objet spécifique de votre demande de soumission d'informations**.

Nous restons cependant engagés dans le cadre de la mise en œuvre de la Convention de Minamata, notamment en ce qui concerne les autres produits contenant du mercure ajouté et les usages pertinents identifiés dans notre Plan d'action national. Nous vous remercions également du support agissant de la convention notamment pour l'appui au spécifique international programme dont nous soumettrons bientôt la stratégie régionale d'élimination des produits contenant du mercure ajouté et souhaitons que vous ou toute autre autorité pertinente puisse la préfacer.

Enfin, je voudrais profiter de ce courriel pour vous informer que le courrier qui m'est adressé je ne l'ai pas reçu d'où ce retard dans la réponse.

Submission by Switzerland

Submission by Switzerland of information on technically and economically feasible alternatives for the use of mercury and mercury compounds in the production of vinyl chloride monomer (VCM)

In the decade since the Minamata Convention on Mercury (2013) was adopted, the field of mercury-free catalysis for VCM production from acetylene has advanced significantly. The number of scientific publications and patents in this area has increased tenfold, driven by environmental and health concerns and technological opportunities.¹ Alternatives based on gold and copper catalysts were the first alternative technologies to be demonstrated in pilot and full-scale operations.²⁻⁴ **Today, mercury-free VCM production is technically feasible and economically competitive.** In China, the world's leading producer of acetylene-based VCM, with 88 plants and a combined capacity of over 22 million t/year, several facilities have transitioned away from mercury. For instance, Erdos Electric Power Metallurgy Group (400 kt/year) and Jintai Chlor Alkali Shenmu Chemical (2 × 300 kt/year) completed their switch by the end of 2023, and Adani Group has announced four new 500 kt/year mercury-free plants.⁴ Several manufacturers, including Johnson Matthey (UK) and Kaili Catalyst (China) now supply commercial quantities of Au- and Cu-based catalysts.⁴

Recent developments have also introduced a new generation of mercury-free catalysts based on platinum. Pioneering research at ETH Zurich has demonstrated the efficacy of Pt single-atom catalysts with low metal content, offering exceptional stability and promising kinetic profiles.⁵ Detailed characterization has enabled a precise understanding of their structure-performance relationships. Importantly, Pt is roughly three times cheaper than Au and has already been scaled up in technical form,⁶ holding great potential to further lower costs and environmental impact. Taken together with the already proven gold- and copper-based technologies, this body of work provides strong evidence that technically sound, mercury-free routes to VCM are not only available but advancing rapidly.

1. Lazaridou et al. Recognizing the best catalyst for a reaction. [Nat. Rev. Chem. 2023, 7, 287-295.](#)
2. Johnston et al. Discovery, development, and commercialization of gold catalysts for acetylene hydrochlorination. [J. Am. Chem. Soc. 2015, 137, 46, 14548-14557.](#)
3. Malta et al. Identification of single-site gold catalysis in acetylene hydrochlorination. [Science 2017, 355, 1399-1403.](#)
4. Smit et al. VCM from acetylene can be made without mercury. COP 5 presentation, Johnson Matthey, **2023.**
5. Kaiser et al. Nanostructuring unlocks high performance of platinum single-atom catalysts for stable vinyl chloride production. [Nat. Catal. 2020, 3, 376-385.](#)
6. Giulimondi et al. Convergent active site evolution in platinum single atom catalysts for acetylene hydrochlorination and implications for toxicity minimization. [ACS Catal. 2024, 14, 13652-13664.](#)

Submission by Uganda2nd April 2025**Alternatives to vinyl-chloride-monomer production with mercury-dichloride (HgCl₂) as catalyst, that are currently under use in Uganda**

The Minamata Initial Assessment studies carried out in Uganda between 2016 and 2016 revealed that, there was no VCM (vinyl-chloride-monomer) production with mercury-dichloride (HgCl₂) as catalyst.

Follow up sectoral consultations carried out in April 2025 on the application of alternative mercury free catalysts for the production of Vinyl-Chloride-Monomer (VCM), revealed that: VCM production is typically a large-scale chemical industrial process, requiring high technological capacity, which may still be limited in Uganda.

Whereas there are small-scale uses of VCM or its derivatives in Uganda for instance in the production of PVC, as well as export of polymers of vinyl chloride (finished products) from Uganda to Kenya and other countries within the region, there's no domestic production of VCM.

Based on the above, there is no profiling of mercury free catalysts for the production of Vinyl-Chloride-Monomer in use within Uganda.

Alternatives to HgCl₂ as catalyst for Vinyl Chloride Monomer production in other countries

- i. Gold-Based Catalysts in VCM Manufacture
- ii. Copper based catalyst as vinyl chloride monomer (VCM) manufacture
- iii. Palladium 10IL/AC Catalyst
- iv. Metal-based catalysts including Ruthenium (Ru), palladium (Pd), and platinum (Pt) are all platinum group metals (PGMs)
- v. Alternative Production Methods including Direct Chlorination of Ethylene
- vi. PVC Alternatives

Submission by the United States of America**2025 Submission from the United States of America
in Response to Decision MC-5/6****Information on the Technical and Economic Feasibility of Mercury-Free
Production of Vinyl Chloride Monomers****April 2025**

Decision MC-5/6 of the Conference of the Parties to the Minamata Convention on Mercury (Convention) invites Parties and relevant organizations to submit, by 31 March 2025, on a voluntary basis, information to the secretariat on technically and economically feasible alternatives to the use of mercury and mercury compounds in vinyl chloride monomer production, in accordance with paragraph 8 of article 5 and paragraph 1 of article 17 of the Convention.

Technical Feasibility

The United States is of the view that two key factors demonstrate that the use of alternatives to mercury and mercury compounds in global vinyl chloride monomer (VCM) production is technically feasible. The first factor is the adoption of alternative feedstocks in the global VCM industry, namely in ethylene-based production processes that do not use mercury or mercury compounds. This captures the experience of the United States, the EU, and most of the world. The second factor is technological advancement in acetylene-based processes which enables the use of alternatives to mercury-based catalysts. Alternatives to mercury-based catalysts include single metallic catalysts (gold, palladium, copper, or other metallics), ionic liquids, carbon-based catalysts, multi-metallic catalysts, and liquid-phase non-mercury catalysts using cupric chloride and cuprous chloride.¹

The United States began production of VCM in the 1920s using acetylene-based processes with mercury catalysts but fully phased out the use of such catalysts in domestic plants in 2001.² The United States began its conversion away from acetylene-based VCM production and moved to commercial-scale ethylene-based VCM production in the 1950s; ethylene became the primary feedstock by the 1980s.³ In ethylene-based VCM production processes, mercury is not used as a catalyst. Rather, ethylene reacts with chlorine to make ethylene dichloride (EDC), which is then thermally cracked to make VCM. There are two common routes used to make EDC: direct chlorination (using pure chlorine and ethylene) or oxychlorination (in which the ethylene reacts with chlorine in hydrogen chloride). The hydrogen chloride byproduct can be recycled to an oxychlorination plant to make more EDC.

In 2019, the United States produced approximately 8.8 MMT of VCM using non-mercury and non-mercury compound-based production processes, yielding 7.4 million metric tons (MMT) of PVC.⁴ Most production of ethylene dichloride, VCM, and PVC is vertically integrated,⁵ with several facilities located in the Gulf Coast region of the United States. Benefits of the ethylene process in the United States include heightened energy efficiency, and greater overall process reliability, in addition to improved environmental performance, resulting in ethylene-based technologies being the preferred choice for large-scale VCM production in the United States.⁶

Production of VCM in the European Union (EU) has followed a similar trajectory as the United States by transitioning to ethylene-based VCM processes; the last mercury-using facility was phased out before 2022 to comply with EU regulations on mercury.⁷ The significant shift towards the use of ethylene-based technologies in the United States and the EU has also occurred at the global level, amplifying its technical availability and feasibility. Apart from approximately 90 plants in China, one plant in India, and one plant in Uzbekistan, the remaining global production of VCM relies on ethylene feedstocks.⁸ Around 2006, 95% of global VCM production occurred via the ethylene feedstock, demonstrating the technical feasibility of mercury-free VCM production.⁹

For those plants employing acetylene-based VCM production technology, not all rely on mercury-based catalysts. At present, roughly 70% of China's VCM production requires the use of mercury in its acetylene hydrochlorination process.¹⁰ While new acetylene capacity in China has substantially increased¹¹ and capacity and total production from the acetylene-based process are projected to continue growing,¹² which might suggest a parallel increase in the usage of mercury, recent acetylene-based production capacity has included alternatives to mercury catalysts at several new and existing plants in the country.

Gold-based catalysts for the acetylene hydrochlorination process offer a particularly viable mercury-free alternative as it has been deployed in both pilot and commercial production facilities, including in China, where 1.5 MMT of VCM capacity per year is supported by gold-based catalysts – equivalent to about 7% of China and India's acetylene VCM capacity.¹³ Additionally, the gold catalyst process yields a higher conversion rate than the mercuric chloride process, potentially making it an even more attractive alternative.¹⁴ Reports indicate initial acetylene conversion rates of over 90%, which decline gradually to around 70% after 18 months of operating time in a commercial-scale setting; this compares favorably to the 60% conversion rate of mercuric chloride after 7 months of production.¹⁵

In summary, switching feedstock away from acetylene to ethylene is a proven, longstanding, and widely adopted mechanism for decoupling VCM production from mercury usage. More recently, technological advancement providing an avenue for continuing the use of acetylene as a feedstock for VCM production, but with different catalysts that are not mercury-based, has forged a second, emerging pathway to decoupling VCM production from mercury.

Economic Feasibility

With respect to the economic feasibility of alternatives to the use of mercury and mercury compounds in VCM production, the United States has found the commercial ethylene application of this process to be economically feasible domestically. The process has proven economically feasible in many other countries as well, including those without abundant domestic petroleum or natural gas resources such as Republic of Korea;¹⁶ in both China and India, substantial portions of VCM production came from ethylene processes at the time of Minamata Convention on Mercury's entry into force¹⁷ and the ethylene process currently accounts for the majority of global VCM production, including all production outside of Asia.¹⁸ Additionally, the use of ethylene is relatively more attractive than the acetylene process as it is considered to be most suitable for high-end PVC products.¹⁹ The production of ethylene from petroleum or natural gas also yields several valuable co-products, such as propylene, butadiene, and benzene, bolstering the economic viability of transitioning to ethylene-based processes.²⁰ The ethylene route is also substantially less energy intensive than acetylene routes, and therefore is more attractive when energy is particularly expensive or scarce.²¹

The United States notes that there is an active body of research on non-mercury catalyst alternatives for acetylene-based VCM production. To date, gold-based catalysts have proven most viable. The upfront cost of gold needed for mercury-free catalyst for a 400,000 metric ton VCM plant is \$10-12 million (USD), or \$25-30 (USD) per metric ton of VCM capacity, varying with the market price of gold.^{22,23} Barium salt catalysts have also exhibited successful commercial scale VCM production via the acetylene route.²⁴ Dezhou Shihua Chemical Co. successfully scaled up its pilot-tested mercury-free catalyst process, with expected annual VCM production capacity of 200,000 tons.²⁵ Researchers associated with the project have reported strong results on conversion rates and VCM yield.²⁶

Epidemiological evidence has demonstrated an association between mercury exposure and IQ losses in children,²⁷ which has been linked to decrements in lifetime earnings.²⁸ Therefore, reducing the use of mercury in VCM and its resulting emissions is expected to generate substantial economic benefits in the form of increased labor productivity, lower health risks, and ecological benefits. Economically feasible mercury-free VCM production can be achieved through a combination of approaches, including construction of new ethylene capacity, construction or retrofit of mercury-free acetylene capacity, and increased PVC production from existing ethylene capacity. The additional gold and/or petroleum that would be required to support this increased production represents a relatively small fraction of the current consumption of these resources. Importantly, should gold-based catalysts prove the most cost-effective transition away from mercury in VCM production, efforts should be made to ensure increased gold demand does not result in upstream mercury use in artisanal gold mining operations, which could partially offset the downstream environmental and health benefits.

Citations

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- ⁵ Brown and Whitfield 2022. <https://cesp.gmu.edu/wp-content/uploads/2022/09/Appendix-3-Industry-Structure-and-Technology-for-PVC-Production-GMU-PVC-decarb-2050.pdf>
- ⁶ <https://cdn.intratec.us/docs/reports/previews/vcm-e41a-b.pdf>, pg. 6
- ⁷ Submission from the EU on mercury-added products and manufacturing processes using mercury or mercury compounds, https://minamataconvention.org/sites/default/files/documents/submission_from_government/EU_AnnexAB.pdf
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- ¹¹ CNCIC 2019, https://scic.sg/images/2017/2_Shiyao_Wang.pdf
- ¹² Zhou, <https://www.sciencedirect.com/science/article/pii/S2468823118301706>
- ¹³ Johnson Matthey, <https://matthey.com/products-and-markets/chemicals/process-licensing/vinyl-chloride-monomer-production>
- ¹⁴ Other substances have been proposed as alternative catalysts for acetylene based VCM production, including copper, platinum, and ruthenium. To our knowledge, these alternative catalysts have not been demonstrated or commercialized. UNIDO/GEF reported financing a pilot project using a copper catalyst, but preliminary reports suggest gold is the more promising alternative catalyst. (2024 Project Implementation Report <https://www.thegef.org/projects-operations/projects/6921>)
- ¹⁵ Andersson and Smith 2023 <https://minamataconvention.org/sites/default/files/inline-files/Ready%201031B-NRDC.pdf>
- ¹⁶ ICIS https://www.icis.com/subscriber/icb/chemicalprofile?commodityId=10197®ionId=10007#_
- ¹⁷ UN Environment [global_mercury.pdf](https://www.un.org/development/desa/pubs/2019/04/global-mercury.pdf)
- ¹⁸ https://www.icis.com/subscriber/icb/chemicalprofile?commodityId=10197®ionId=10007#_
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- ²⁰ ICIS 2019 <https://s3-eu-west-1.amazonaws.com/cjp-rbi-icis-compliance/wp-content/uploads/2019/04/30062040/Ethylene-US-Margin-Analytics-Methodology-17-April-2019.pdf>
- ²¹ Asian Development Bank 2015, <https://www.adb.org/sites/default/files/linked-documents/47051-002-sd-01.pdf>
- ²² Andersson and Smith 2023: (<https://minamataconvention.org/sites/default/files/inline-files/Ready%201031B-NRDC.pdf>)
- ²³ Hutchins 2021: <https://results2021.ref.ac.uk/impact/ec7deea3-b89f-4c2e-a6c5-385d28d70271/pdf>
1 kg of catalyst is needed per 3 metric tons of VCM, and catalyst contains 0.1% gold. The inflation-adjusted price of gold has risen roughly 60% since the Minamata Convention entered into force, from about \$1700 per troy ounce (\$54,700 per kg) in August 2017 to \$2700 per troy ounce (\$86,800 per kg) in January 2025.
- ²⁴ CNCIC 2019, https://scic.sg/images/2017/2_Shiyao_Wang.pdf
- ²⁵ Asian Development Bank 2022, <https://www.adb.org/sites/default/files/project-documents/47051/47051-002-pcr-en.pdf>

²⁶ WANG Liangliang et al (2023). "Operation summary of production plant for vinyl chloride synthesis by mercury-free catalyzed reaction between acetylene and dichloroethane," *Polyvinyl Chloride*, 51(8).

²⁷ E.g., Grandjean et al. 1997 <https://pubmed.ncbi.nlm.nih.gov/9392777/>

²⁸ E.g., Griffiths, McGartland, and Miller 2007 <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1892144/>

**Submission by the Natural Resources
Defense Council**



March 31, 2025

Transmitted Electronically

UNEP Secretariat, Minamata Convention on Mercury
Geneva, Switzerland

Re: Comments on the Technical and Economic Feasibility of Mercury-Free VCM
Production in China and Elsewhere

The Natural Resources Defense Council (NRDC) hereby submits these comments on the technical and economic feasibility of mercury-free catalysts to produce VCM, and ultimately PVC. Globally, the vast majority of VCM is produced from ethylene using a mercury free technology. The use of a mercury catalyst in an acetylene-based process to produce VCM is largely limited to China and one plant in India.¹ For these countries, the issue is whether a non-mercury catalyst is technically and economically feasible, where ethylene is difficult to access.²

In the case of India, two new large VCM plants are under construction in India, using in part the acetylene process and a mercury-free catalyst. Operations are expected to begin in late 2026,³ demonstrating the feasibility of using mercury free catalysis in India.

In the case of China, almost half of new VCM production capacity added in 2024 was ethylene-based, and an estimated 1.8 million tons of ethylene-based PVC is expected to be added in 2025. The new ethylene-based capacity is concentrated in the eastern part of China where access to ethylene is more easily secured. This new capacity demonstrates the increasing importance of ethylene production, and that conversion to the dominant global method of producing VCM using ethylene is technically and economically feasible for much of eastern China.

¹ See https://minamataconvention.org/sites/default/files/documents/2024-09/CombinedPresentations_240911_Processes.pdf, slide 21.

² Under Part II of Annex B, the feasibility finding is “based upon existing processes” when the Minamata Convention entered into force. Since both ethylene and acetylene-based processes were employed in China and elsewhere when the Convention entered into force, the feasibility finding should take into account the availability of both technologies.

³ See <https://economictimes.indiatimes.com/industry/indl-goods/svs/petrochem/adani-group-to-commission-4-billion-petchem-project-by-next-year/articleshow/112076091.cms?from=mdr>.

Where access to ethylene remains problematic, mercury-free catalysts are currently in use and demonstrated to be technically and economically feasible, according to published news reports and associated website postings on three plants as described below.

First, on February 17, 2023, the Erdos Electric Power Metallurgy Group hosted a press conference announcing it has accomplished “comprehensive and stable mercury-free production operation” of the first large-scale mercury-free PVC production using the acetylene process. The production capacity is 400,000 tons/year, and began operation in August 2022. The technology was evaluated and approved by the Ministry of the Environment. In approving the technology, MOE stated –

“The Heavy Metal Management Technology Department of our center has studied and analyzed the characteristics of the mercury-free catalytic process in detail based on the actual situation of my country's calcium carbide-based polyvinyl chloride production process, and constructed a set of scientific, complete and operational "Calcium Carbide-based Polyvinyl Chloride Mercury-Free Catalytic Process Application Evaluation Method" (hereinafter referred to as the evaluation method). In 2022, the 400,000-ton annual polyvinyl chloride and caustic soda project of Inner Mongolia Ordos Electric Power Metallurgical Group Co., Ltd., based on the evaluation method established by our center, took the lead in completing the evaluation and acceptance of the first calcium carbide-based polyvinyl chloride mercury-free catalytic process in China, and obtained the first pollutant discharge permit for mercury-free discharge of calcium carbide-based polyvinyl chloride process.

The establishment of the evaluation method has laid a solid foundation for the evaluation of mercury-free application in the calcium carbide polyvinyl chloride industry, and provided evaluation technical guarantee for promoting the smooth implementation of mercury-free alternative processes by calcium carbide polyvinyl chloride production enterprises.”⁴

This press conference was widely covered by the media , including [News.cn](#), [Sina](#), [Sohu.com](#), and [CCTV News](#). In the Sina news report, the Company is reported to indicate –

“Up to now, the green mercury-free production line of calcium carbide-based PVC produced by Dianye Group has been operating safely and stably, with excellent product quality and showing a good usage trend.”

The plant is also referenced on a provincial government website, specifically the [Inner Mongolia Department of Science and Technology](#). The success of this project

⁴ See https://www.meesc.cn/zhxx/zxyw/202301/t20230131_1014251.shtml.

is further noted by the national [Ministry of Science and Technology of the PRC](#) (2023).

During the following year, The [Inner Mongolia News \(2024\)](#) reported -

“Ordos Electric Power and Metallurgical Group has also achieved major breakthroughs in the mercury-free production technology of calcium carbide-based polyvinyl chloride. Its annual production capacity of 400,000 tons of polyvinyl chloride project has been fully loaded with mercury-free catalysts, fully realizing mercury-free production, filling the industry gap in mercury-free production of calcium carbide-based polyvinyl chloride, and creating the world's first large-scale industrial production demonstration plant for mercury-free calcium carbide-based PVC. It is known as a key milestone in the compliance of the global parties to the Minamata Convention on Mercury.”

Most recently, in 2025, the head of the company continued to tout the success of the mercury free technology, as indicated in this [Interview from the Owner WANG Zhen](#) during the National People’s Congress (NPC) meeting (2025).

Second, in advance of testing on a mercury-free VCM production line (10,000 tons capacity) Zhongtai Chemical Co., Ltd. prepared an Environmental Impact Report in August 2020.⁵ In describing the direct economics of the project, Zhongtai stated –

“The total investment in the project is 15 million yuan. By replacing low-mercury catalysts with mercury-free catalysts, the project reduces heavy metal mercury emissions and lowers wastewater treatment costs, resulting in significant economic benefits. After calculation, the project is expected to achieve an average annual total profit of 2.7764 million yuan and an average annual net profit of 2.0823 million yuan. The total investment return rate is 18.51%, indicating strong profitability.

From this, it can be concluded that the proposed project will yield favorable economic benefits.”⁶

Third, Shaanxi Jintai chemical Technology Group Co., Ltd. started operating a large-scale mercury-free production facility using the acetylene process in April 2024. According to the press report, [Sina news](#):

“There are two 300,000 tons/year production lines for polyvinyl chloride, the largest single production line in the world, and the equipment includes three processes: acetylene, vinyl chloride equipment and polymerization. The

⁵ See

<https://sthjt.xinjiang.gov.cn/xjepd/hjyxpjst/202008/754f7596c1474dd88fd1688ded991d5e/files/%E4%B8%87%E5%90%A8%E6%97%A0%E6%B1%9E%E8%A7%A6%E5%AA%92%E6%8A%80%E6%94%B9%E9%A1%B9%E7%9B%AE%EF%BC%88%E5%85%AC%E7%A4%BA%E7%89%88%EF%BC%89.pdf>

⁶ Id., Chapter 8.1.

acetylene unit has the largest single production line in the industry. It adopts the industry's first fully automatic slag removal technology independently developed, consumes 900,000 tons of calcium carbide annually, and produces 330,000 tons of acetylene gas.

The vinyl chloride process adopts the mercury-free catalytic technology with all application intellectual property rights owned by the company. The polymerization process introduces the advanced polymerization process of France's KEM ONE and the drying technology of Germany's ANDRITZ. It has the largest 143m³ polymerization kettle in China and produces 600,000 tons of polyvinyl chloride annually. After the 600,000 tons/year high-performance resin project reaches full production, it can achieve annual sales revenue of 6.3 billion yuan and an average total profit of about 1.201 billion yuan.

The completion of the entire process of the 600,000 tons/year high-performance resin project is another important milestone in the development of the green chemical sector of Shaanxi Investment Group.”

The facility passed applicable safety testing inspections in [Jan 2025](#).

These projects, particularly the two operating large-scale production facilities, demonstrate the technical and economic feasibility of mercury-free catalysts in China. Its already used by three significant PVC producers, two at commercial scale.

We note that there is a GEF project covering mercury-free catalysts in VCM production, but no relevant results are available.⁷ Further evidence of feasibility may be obtained by access to technical data produced under that project, when the data are peer reviewed by international experts.⁸

⁷ <https://www.thegef.org/projects-operations/projects/6921>. See STAP Review, p. 3 and GEF 6 Request for Project Endorsement, pp. 60-61.

⁸ The latest progress report on this project notes testing of the mercury-free catalyst at four facilities, and “a comprehensive evaluation” of this testing that was already conducted. However, no testing data or evaluation are yet publicly available to the best of our knowledge from UNIDO, GEF, or the project participants. See 2024 Project Implementation Report, Output 2.3, pp. 6, 10. No consultation is taking place regarding mercury free catalyst development outside of the Chinese industry, FECO, and its chosen experts. *Id.* at p. 15.

Donor: GEF (ID: 6921) | Duration: 2018 – 2025

GEF Financing: USD 16.2M | Co-financing: USD 100.4M

Implementing Agency: United Nations Industrial Development Organization (UNIDO)

Executing Agency: Foreign Economic Cooperation Office (FECO) of the Ministry of Environmental Protection of China (MEE)

Reporting date: 22 May 2025

Key project results (as of April 2025)

1) Component 1: Institution capacity strengthened

- 9 regulations and policies revised and issued.
- Supervision and inspection carried out on the application of low-mercury catalyst and phase out of high-mercury at the state level.
- About 4,700 officers at central and local levels trained to coordinate and monitor the VCM production (2020-2022).
- About 4,000 people attended the National Trainings on Chemical & Environmental Management and Convention Implementation (2021-2023).

2) Component 2: Promote BAT/BEP technology transfer & investment

Low-mercury catalyst demonstration results:

- The technology verification and demonstration of low mercury catalyst in four coal-based VCM plants, achieving the mercury use of below 43g/t PVC and 359.5 tons of mercury reduction by mid-term evaluation.

Mercury-free catalyst demonstration results:

- The technical evaluation of gold-based and copper-based mercury-free catalysts was conducted in six test units from four PVC plants from June 2023. Two of these plants are in the top 20 largest PVC producers in Asia. Operating hours of each test unit are 8,000-10,000 hours. Production capacity of each test unit ranges from 10,000 to 30,000 tons/year. The co-financing amount leveraged from the four PVC demonstration plants is: RMB 219,560,000, around USD 31,366,000 (compared to the project's investment of RMB 16,000,000, around USD 2,286,000). The results of the demonstration runs highlights the following:
 - Both gold-based and copper-based mercury-free catalysts continue to face unresolved technical and economic uncertainties compared to low-mercury catalysts. These challenges hinder their large-scale industrial application, despite extensive R&D efforts from both the government of China and the private sector.
 - Further research, pilot testing, technological optimizations, comprehensive data collection, and time are necessary to address these challenges before a conclusion can be reached.

Preliminary results of demonstration runs with mercury-free catalysts :

Technical feasibility:

- **Gold-based catalyst:** high selectivity with by-product content of around 600 ppm; stable acetylene content below 5%-6% during operation, the space velocity is around 20 h⁻¹-30h⁻¹, lower than low-mercury catalyst. Some technical issues include: operates under high-pressure conditions, cavitation of heptane pump, converter corrosion and leakage, catalyst agglomeration, melting of pipes at high temperature, severe agglomeration of catalyst, and requires very strict drying protocols
- **Copper-based catalyst:** poor selectivity with by-product content around 2900 ppm; rapid performance decay, shorter operational life, and reduced conversion rates; operates under atmospheric pressure.
- Insufficient data prevents a conclusive assessment of the catalyst performance and waste recycling processes; technological differences among PVC producers means a generalization or consensus is hard to reach.

Technical Availability

- **Gold-based catalyst:** requires new equipment (e.g., high-pressure reactor) and careful process control for temperature and load; with insufficient research and data on the recovery stage.
- **Copper-based catalyst:** atmospheric-pressure reactor makes it easier to integrate; requires passivation techniques to prevent combustion.
- Issues on technical differences among PVC producers and between catalyst producers and PVC plants compounded by a lack of collaboration or communication.

Environmental and Health Risks and Benefits

- **Gold-based catalyst:** fewer by-products than copper-based catalyst; requires improved recovery processes to minimize gold loss and waste generation.
- **Copper-based catalyst:** increased by-product levels and inefficient waste handling; have risks of spontaneous combustion during overturning and unloading, causing safety accidents.
- Incomplete data on wastewater, waste gas, and other environmental and health parameters

Economic Feasibility

- **Gold-based catalyst:** very high operating costs due to special activated carbon, gold material, processing, and volatile gold prices; extremely high investment into new equipment and plant renovation.
- **Copper-based catalyst:** initially lower costs but less economical due to short lifespan and poor performance; higher risks and inefficiencies increase overall costs over time.
- Performance data remains incomplete, limiting a clear economic evaluation.

3) Component 3: Promote mercury waste recovery in VCM production

- Cleaner production audit in PVC plants is completed.
- The Pollutant Release and Transfer Register (PRTR) guidelines were developed to conduct inventory in all PVC plants and implemented in catalyst manufacturing and recycling plants in 2022.

4) Component 4: Develop strategy to identify & assess Hg-contaminated sites

- The inventory of mercury-contaminated sites was conducted in nearly 99 plants of the VCM sector (97 plants are in production).
- The screening of typical mercury-contaminated site already finished and selected two sites to do the preliminary risk assessment.

5) Component 5: Awareness raising on mercury waste management

- Over 9300 people have been participated in trainings, awareness-raising events in 2019-2024 on various topics related to mercury, mercury-free alternatives, mercury-contaminated waste management, pollutant management and treatment
 - Information is available on the sites: www.fecomee.org.cn and www.mercury.org.cn.

Key remaining activities:

- The cleaner production audit and technical modification in two waste catalyst recycling plants are ongoing.
- PRTR system is being piloted in one province as a model for further nationwide implementation.
- After completing the preliminary risk assessment of the contaminated sites, a remediation strategy will be developed.
- Project closing event
- Terminal evaluation

Submission by the Zero Mercury Working Group

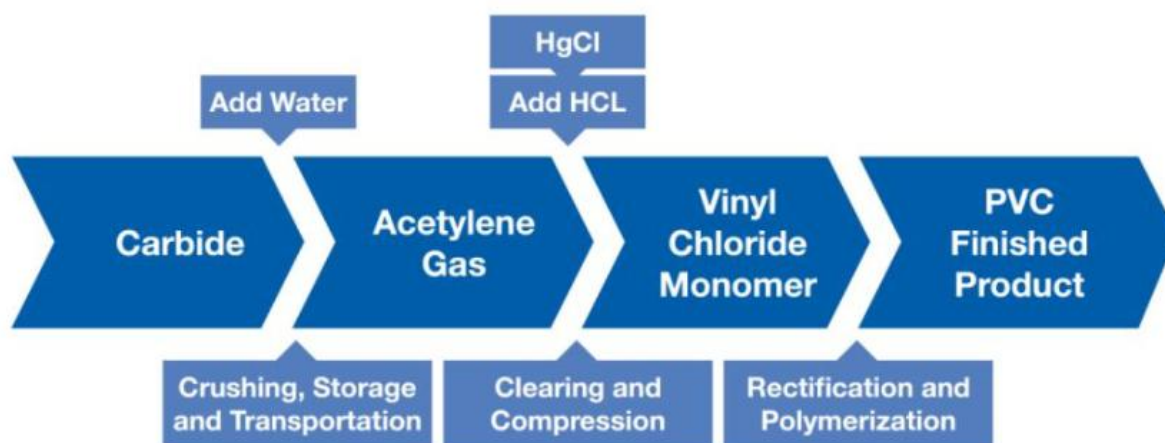
ZMWG Comments to the Minamata Secretariat on Mercury-free Alternative Processes to VCM

31 March 2025

The Zero Mercury Working Group appreciates the opportunity to provide information on technically and economically feasible alternatives to the use of mercury and mercury compounds in vinyl chloride monomer (VCM) production, in accordance with Paragraph 8 of Article 5 and Paragraph 1 of Article 17 of the Convention.

Based on the latest research, it's clear that the mercury-free alternative processes are available, affordable and effective. There are mercury-free catalysts that perform better than mercury-based ones and are commercially available, as already reported at the last COP in 2023.¹

The production of vinyl chloride monomer (VCM) is a manufacturing process that uses a catalyst containing high concentrations of mercury. However, a significant proportion of the mercury on the catalyst can be lost via evaporation, either during VCM production or during reprocessing of the used catalyst. VCM is the building block of polyvinyl chloride, or PVC, which is a type of plastic that is used for everything from water and sewer pipes to plastic toys and clothing.



As a result, there is a significant demand for plastic, with over 40 million tonnes of PVC produced annually. The majority of VCM (around 90%) is used in PVC manufacture.²

Most manufacturing of PVC around the world uses natural gas or petroleum as the “feedstock” or raw material from which the plastic is manufactured. However, there are a few countries that continue to produce vinyl chloride monomer using an older process that starts with coal as the feedstock. This is due to the relative abundance of coal as a resource. About 95% of these plants are in China. The Chinese PVC industry is effectively the world’s largest consumer of mercury, responsible for roughly a quarter of global consumption and an annual consumption of mercury in VCM of 670 to 790 metric tons (during 2019-2020), as per the last trade report³.

¹ <https://minamataconvention.org/sites/default/files/inline-files/Ready%201031B-NRDC.pdf>

² <https://www.sciencedirect.com/science/article/abs/pii/S1872206716624828>

³ <https://minamataconvention.org/en/documents/first-effectiveness-evaluation-minamata-convention-mercury-draft-report-mercury-trade>

In the coal-based process (technically, the hydrochlorination of acetylene process), mercury chloride is the catalyst that sparks the main chemical reaction. Some of the mercury used in this process is lost and must be continually replenished. Even after years of research, it is poorly understood exactly how some of this mercury is lost and where the lost mercury ends up. For example, a mass balance study in a Chinese PVC plant "...found that the total input and out mass of Hg is not balanced."⁴ As a result, it appears there is approximately 30% of mercury that is lost in the process with unknown destination.⁵ Furthermore, during the recycling of the mercury chloride catalyst, even more mercury is lost.

As the PVC industry represents one of the most significant uses of mercury in the world today, these mercury losses add unnecessarily to the deterioration of human health and the environment, also due to the potential for occupational exposure to mercury and mercury vapors. Given mercury's well-known toxicity, ability to travel long distances and its possibility to bioaccumulate and biomagnify, the potential risk of exposure can be substantial.

Based on research carried out over the last ten years, the following references explain why the VCM industry can now bring itself in line with the objectives of the Convention:

GEF 6921 - Demonstration of Mercury Reduction and Minimization in the Production of Vinyl Chloride Monomer in China , Project Implementation Report (1 July 2023- 30 June 2024),

<https://www.thegef.org/projects-operations/projects/6921>

The project has already achieved 359.5 tons of mercury reduction which was verified by the mid-term review in 2021. In 2020, China reduced the mercury by 50% compared to 2010 through the technology demonstration, BAT/BEP replication, and capacity building activities. FECO and the Government of China commit to further strengthening efforts in mercury reduction.

The evaluation of mercury-free technologies is progressing well. Preliminary results from participating companies are now available, following a successful phase of laboratory, pilot, and industrial tests. This data provides a strong foundation for the final results and the 10,000 ton-demonstration planned for 2025.

Progress in mercury-free catalysts for acetylene hydrochlorination

<https://pubs.rsc.org/en/content/articlelanding/2024/cy/d4cy00549j>

This 2024 review systematically summarizes the recent achievements in mercury-free catalysts including noble/non-noble metal-based catalysts and metal-free catalysts in acetylene hydrochlorination with the focus on catalyst design, catalytic performance and the reaction mechanism. Moreover, the advantages and drawbacks of diverse mercury-free catalysts are comprehensively discussed. Eventually, the current challenges and opportunities for the exploration and application of mercury-free catalysts in industrial VCM production are presented.

Vinyl Chloride Monomer Production From Acetylene

<https://matthey.com/products-and-markets/chemicals/process-licensing/vinyl-chloride-monomer-production>

The Johnson Matthey high yield, long-lasting vinyl chloride monomer production process with JM's PRICAT™ mercury-free catalyst (MFC) is presented. PRICAT MFC is a highly selective gold catalyst that is three times more productive than mercury-based alternatives and achieves high acetylene-to-VCM conversion for significantly longer. The catalyst's long life means high uptime and fewer changeovers to keep OPEX low, while the elimination of mercury from the process enables safer maintenance. 95% of the gold in PRICAT MFC can also be recovered and reused in fresh catalysts. This helps keep gold use low and improves the environmental impact of the overall VCM technology.

⁴ Ren, W.; Duan, L.; Zhu, Z.; Du, W.; An, Z.; Xu, L.; Zhang, C.; Zhuo, Y.; Chen, C., Mercury Transformation and Distribution Across a Polyvinyl Chloride (PVC) Production Line in China. Environmental Science & Technology 2014, 48, (4), 2321-2327.

⁵ https://minamataconvention.org/sites/default/files/documents/submission_from_government/compilation_10_processes.pdf

Transform Materials and Johnson Matthey Collaborate

<https://www.prnewswire.com/news-releases/transform-materials-and-johnson-matthey-collaborate-to-enable-lower-carbon-and-mercury-free-alternative-routes-for-pvc-manufacturing-302170248.html>

In June 2024, **Transform Materials**, a leader in the development of clean and sustainable chemical technologies, has joined forces with **Johnson Matthey**, a global leader in sustainable technologies. Scientists and engineers at both companies are applying their combined expertise with the aim of revolutionizing VCM production through a novel, lower-carbon-emission, mercury-free process.

[November 2023] VCM without Hg - Johnson-Matthey

<https://minamataconvention.org/sites/default/files/inline-files/Ready%201031B-NRDC.pdf>

[November 2022] Environmentally friendly high-efficient metal-free catalyst

<https://www.sciencedirect.com/science/article/abs/pii/S2468823122006058>

Mercuric-free catalysts, especially metal-free catalysts, are quite intriguing in the industrial production of acetylene hydrochlorination. In this work, nitrogen-doped biochar is prepared as green metal-free catalyst for acetylene hydrochlorination with natural walnut shells as starting material, in which the condensation product of dicyandiamide or dicyandiamide-formaldehyde is applied as nitrogen source.

Progress and Challenges of Mercury-Free Catalysis for Acetylene Hydrochlorination

<https://www.semanticscholar.org/paper/Progress-and-Challenges-of-Mercury-Free-Catalysis-Liu-Zhao/14531f86198c9044b05cea073eb11b78c0eb398f>

This 2020 review summarizes research progress on the design and development of mercury-free catalysts for acetylene hydrochlorination. Three types of catalysts for acetylene hydrochlorination in the chlor-alkali chemical industry are discussed. These catalysts are a noble metal catalyst, non-noble metal catalyst, and non-metallic catalyst. This review serves as a guide in terms of the catalyst design, properties, and catalytic mechanism of mercury-free catalyst for the acetylene hydrochlorination of VCM. The key problems and issues are discussed, and future trends are envisioned.

[April 2022] Facile synthesis of precious-metal single-site catalysts using organic solvents

<https://www.nature.com/articles/s41557-020-0446-z>

Single-site Au/C catalysts have previously been validated commercially to produce vinyl chloride, and here they show that this facile synthesis method can produce effective catalysts for acetylene hydrochlorination in the absence of the highly oxidizing acidic solvents previously used.

[2018] High Performance Non-Mercury Catalysts for VCM Production

<https://proceedings.aiche.org/conferences/aiche-annual-meeting/2018/proceeding/paper/31f-high-performance-non-mercury-catalysts-vcm-production-theoretical-study-industrialization>

Gold is widely considered as the most active metal for acetylene hydrochlorination reaction and copper is the most common metal with cost-effective advantage. The combination of two metals shows the best potential as the active component for environmentally friendly non-mercury catalysts. In this study, the performance of Au/Cu catalyst was enhanced dramatically by the introduction of organic ion ligands. Several ligands including trichloroisocyanuric acid (TCCA), cyanuric acid (CA) and melamine (M) were studied and TCCA was proved to be the best ligand for preventing Au³⁺ from reduction by acetylene, leading to longer catalyst lifetime. The findings were successfully verified by over 18000 hours industrial plant-trial evaluation, and the VCM productivity reached about 4.2 times comparing to industrial mercury catalyst.

The Convention enabled Parties to continue to produce PVC, but required the use of a mercury free process as soon as possible. In summary and as per above, mercury-free alternatives are readily available. Therefore, the COP has sufficient evidence to establish that mercury-free catalysts based on existing processes have become technically and economically feasible, requesting the phase out of this process in the next five years.