Removal and Control of Mercury Vapor in Coal Power Plants with Metallic Nanoparticles

Mercury removal and control is important in the generation of electricity from coal, especially if a future materializes where our nation leverages its vast coal reserves for clean coal baseload power generation. Controlling mercury vapor is important in ensuring environmental quality is preserved as energy production increases to meet ever-growing demand.

Mercury is present in all coal, and the vaporization of mercury from coal combustion poses significant biological risks. Methyl Mercury, a chemical created as a by-product of coal combustion, bioaccumulates and biomagnifies in multicelled organisms. Methyl Mercury causes has been shown to have cardiovascular effects, raising blood pressure and decreasing heart rate variability in children. In adults, those exposed to methyl mercury can experience the delayed and persistent onset of neurological disorders, heart palpitations, and a general accelerated aging process. Methyl Mercury also wreaks havoc on the reproductive system. Methyl Mercury exposure can cause low sperm counts, increase the risk for miscarriage or stillbirth and cause fetal malformations. For all of these reasons, reducing mercury emissions from coal is an area of great research and concern.

In the last decade, researchers have been studying ways to capture and control vaporized mercury via metallic nanoparticle filters. Filters comprised of iron oxide and palladium nanoparticles on carbon and ceramic substrates have proven efficient at trapping mercury vapor and other harmful gases in filter medium through absorption and catalysis. The mercury can then be removed through thermal desorption methods, essentially melting the mercury out of the filter medium, thus regenerating the filters in the process. The chemically stable and regenerative properties of the filter medium makes them suitable for repackaging and reduces the cost of mercury filtration, while reducing the negative impacts of coal generation. The filter medium is currently under commercial development by the University of Montana and E2RT LLC.
Product Name:

- Technology Licensed to E2RT llc [13]

Development Stage:

- Commercial [14]

Key Words:

- Nanoparticle [2]
- Palladium [6]
- Clean Coal [15]
- Iron Oxide [5]
- Ceramic Filters [16]
- Mercury Filtration [12]

Mechanism:

- Passive Nanostructure [17]

Summary:

The purpose of this technology is to create cost effective emissions control devices to prevent the harmful release and provide for the sequestration of heavy metals, particularly mercury.

Function:

- Emissions Control [18]
- Enhanced Energy Production [19]

Source:

Mercury Capture from Flue Gas Using Palladium Nanoparticle-Decorated Substrates as Injected Sorbent [20]
Material:

- Carbon [21]
- Iron [22]
- Oxygen [23]
- Palladium [24]

Source:

Mercury Capture from Flue Gas Using Palladium Nanoparticle-Decorated Substrates as Injected Sorbent [20]

Control of Elemental Mercury Vapor in Combustion systems using Fe2O3 nanoparticles [25]

Development and Commercialization of Metallic Nanoparticle Mercury Control Device. [Presentation] [26]

Benefit Summary:

This technology has the potential to significantly reduce the emissions of mercury in coal. The mercury that is trapped can be collected and marketed or sequestered. Additionally, the filter medium can be re-used reducing the overall cost of emissions control in coal fired power plants.

Benefit:

- Improved Environmental Quality [27]

Risk Summary:

Since the Nanoparticles [7] are embedded in the ceramic substrate and the substrates are reusable, there is very little risk of release of nanoparticles into the environment. Any risk originates from the fabrication process and manufacturing of the nanoparticles, and is inherently dependent on the formulation of the filter medium. If carbon nanotubes [28] are used as a substrate, they have been proven potentially carcinogenic due to their ability to pierce cell walls. Additionally, CNTs [29] are one of the strongest nanomaterials and do not readily biodegrade. Free small aspect nanoparticles, such as palladium nanoparticles [7], may pose biological health risks. During the manufacturing of the palladium nanoparticles, disposal of nanoparticle containers, and embedding of the palladium nanoparticles in the ceramic substrate there is a potential for human, ecological, and environmental health risks. Palladium [6] is a heavy metal from the platinum group, and platinum group nanoparticles have been shown to be potentially toxic. Studies have shown that Platinum group nanoparticles transfer to
animal tissues and are recycling in organic synthesis? they can be passed through animal faeces and to offspring. Platinum group nanoparticles however have not been shown to be bio-accumulating.

Risk Characterization:

- Complex [33]
- Simple [34]

Risk Assessment:

- Ecological Risks [35]
- Health Risks [36]

Source:

Platinum group elements in raptor eggs, faeces, blood, liver and kidney [37] Nanoparticles: Their potential toxicity, waste and environmental management [38]

Facility:

- Energy Systems [39]

Activity:

- Emissions Control: Coal Generation [40]

Substitute:

- Existing Method [41]

Challenge Area:

- Air Pollution [42]
CNS-ASU research, education, and outreach activities are supported by the National Science Foundation under cooperative agreement #0937591.

Terms and Conditions

Source URL: https://nice.asu.edu/nano/removal-and-control-mercury-vapor-coal-power-plants-metallic-nanoparticles

Links:
[2] https://nice.asu.edu/keywords/nanoparticle
[3] https://nice.asu.edu/keywords/methyl-mercury
[4] https://nice.asu.edu/keywords/emissions
[5] https://nice.asu.edu/keywords/iron-oxide
[6] https://nice.asu.edu/keywords/palladium
[7] https://nice.asu.edu/keywords/nanoparticles
[8] https://nice.asu.edu/keywords/carbon
[9] https://nice.asu.edu/keywords/ceramic
[10] https://nice.asu.edu/keywords/absorption
[12] https://nice.asu.edu/keywords/mercury-filtration
[14] https://nice.asu.edu/development-stage/commercial
[16] https://nice.asu.edu/keywords/ceramic-filters
[17] https://nice.asu.edu/mechanism/passive-nanostructure
[18] https://nice.asu.edu/function/emissions-control
[19] https://nice.asu.edu/function/enhanced-energy-production
[21] https://nice.asu.edu/material/carbon
[22] https://nice.asu.edu/material/iron
[23] https://nice.asu.edu/material/oxygen
[24] https://nice.asu.edu/material/palladium
[27] https://nice.asu.edu/benefit/improved-environmental-quality
[28] https://nice.asu.edu/keywords/carbon-nanotubes
[29] https://nice.asu.edu/keywords/cnts
[30] https://nice.asu.edu/keywords/health
[31] https://nice.asu.edu/keywords/heavy-metal
[32] https://nice.asu.edu/keywords/organic
[33] https://nice.asu.edu/risk-characterization/complex
[34] https://nice.asu.edu/risk-characterization/simple
[36] https://nice.asu.edu/risk-assessment/health-risks
[38] https://nice.asu.edu/biblio/nanoparticles-their-potential-toxicity-waste-and-environmental-m
[39] https://nice.asu.edu/facility/energy-systems
[40] https://nice.asu.edu/activity/emissions-control-coal-generation
[41] https://nice.asu.edu/substitute/existing-method
[42] https://nice.asu.edu/challenges/air-pollution