

Title:

In vivo and in vitro toxicity of a stainless-steel aerosol generated during thermal spray coating (Dataset)

Introduction:

Thermal spray coating is an industrial process where molten metal is sprayed onto a surface as a protective coat at high velocity. Using acellular, in vitro, and in vivo models, the toxicity of these aerosols was evaluated. An automated electric arc wire thermal spray coating aerosol generator and inhalation exposure system were developed to simulate an occupational exposure in an experimental model. Using the inhalation system, male Sprague-Dawley rats were exposed to stainless steel PMET720 aerosols at 25 mg/m³ x 4 hr/d x 9 d. Lung injury, inflammation, and cytokine alteration were determined. Resolution of the response was assessed by evaluating these parameters at 1, 7, 14 and 28 days after exposure. The aerosols generated were also collected and characterized. Macrophages were exposed to 0 – 200 µg/ml of the collected particles to determine cytotoxicity and screened for known mechanisms of toxicity. Other metal particles similar in composition and morphology, gas metal arc (GMA-SS) and manual metal arc (MMA-SS) stainless steel, were used as particle controls. The influence of pressure used during the process on the toxicity profile of the generated aerosols also was assessed and found to be minimal. The PMET720 thermal spray coating particles exhibited in vitro cytotoxicity and membrane damage only at the highest dose tested. Electron paramagnetic resonance spectroscopy (EPR) showed the PMET720 particles to have oxidative stress potential and caused a dose-dependent increase in intracellular oxidative stress. There also was a dose-dependent increase in NF-κB/AP-1 activity. Treatment with uptake inhibitors showed that the PMET720 particles were internalized via clathrin- and caveolar-mediated endocytosis as well as actin-dependent pinocytosis/phagocytosis. In most of the cell assays, the two welding fume control particles generated a greater response compared to the PMET720 particles. In vivo, lung damage, inflammation and alteration in cytokines were observed 1 day after inhalation exposure, and this response returned to air control exposure levels by day 7. Alveolar macrophages retained the particulate even after 28 days after exposure. The results suggest that compared to stainless steel welding fumes, the PMET 720 aerosols were less potent, and the animals recovered from the acute pulmonary toxicity induced after 7 days.

Methods Collection

- In vivo, male Sprague-Dawley rats were exposed to PMET720-60 psi aerosols at 25 mg/m³ x 4 hr/d x 9 d.
- Animals were sacrificed at 1, 7, 14 and 28 d after the final exposure. Bronchoalveolar lavage (BAL) was performed to assess lung injury and inflammation.
- Acellular reactivity of the aerosols was determined by electron paramagnetic resonance spectroscopy (EPR) by reacting them with H₂O₂ and spin trapping using DMPO.
- In vitro, monocyte/macrophage cell line RAW 264.7 and NF-κB reporter cell line RAW-Blue™ cells were used to evaluate mechanism of toxicity and compare potency with stainless steel welding fumes. Cytotoxicity and membrane damage were evaluated by exposing the cells to 0, 0.78, 1.56, 3.12, 6.25, 12.5, 25, 50, 100 µg/ml of the particulate for 24 hrs.
- Reactive oxygen species was determined by exposing cells to 0, 6.25, 25 and 100 µg/ml of the particulate for 24 hrs.

- NF- κ B activation was evaluated by exposing RAW-Blue™ cells to 0, 1.56, 3.125, 6.25 and 12.5 μ g/ml for 16 hours.
- The mechanism of uptake of the welding fume spray particulate was evaluated in RAW 264.7 cells by challenging them with 15 μ M chlorpromazine (Invitrogen, Waltham, MA), 3 μ M filipin III (Cayman Chemical Company, Ann Arbor, MI) or 8 μ M cytochalasin B (Sigma-Aldrich, St. Louis, MO). These pharmaceuticals inhibited clathrin-mediated endocytosis, caveolin-mediated endocytosis and actin-dependent pinocytosis/phagocytosis respectively.

Citations

Kodali V, Afshari A, Meighan T, McKinney W, Mazumder MHH, Majumder N, Cumpston JL, Leonard HD, Cumpston JB, Friend S, Leonard SS, Erdely A, Zeidler-Erdely PC, Hussain S, Lee EG, Antonini JM. In vivo and in vitro toxicity of a stainless-steel aerosol generated during thermal spray coating. Arch Toxicol. 2022 Aug 19. doi: 10.1007/s00204-022-03362-7. Epub ahead of print. PMID: 35984461.

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