Replacement of Toxic Hexavalent Chromium in the Plating Process

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Environmental Problem

Chromium in its hexavalent form (Cr^{+6}) is a hazardous chemical regulated under the Clean Air Act and designated by EPA as 1 of 17 "high priority" toxic chemicals. It is a known human carcinogen and emits a toxic mist at elevated temperatures. Chrome plating is used in a variety of heavy industrial applications to increase resistance to wear and corrosion on products such as cars and cutting tools, but Cr^{+6} plating produces hazardous air emissions. New installations of Cr^{+6} platers are banned in some states (including California), and existing Cr^{+6} platers have strict monitoring and control requirements and must report to the EPA.

SBIR Technology Solution

With support from EPA's SBIR Program, Faraday Technology, Inc., has developed a safer, cost-competitive method of chromium plating, using trivalent rather than hexavalent chromium. In its trivalent form, chromium is not only a benign chemical, but an essential element of the human diet. Faraday Technology's functional Cr^{+3} plating process is intended to replace entirely the toxic Cr^{+6} process. The pilot-scale technology is validating Faraday Technology's electrically mediated Cr^{+3} plating process (the Faradayic™ Process) as a "drop-in" replacement for the use of Cr^{+6} plating. This manufacturing process validation is being executed with a large manufacturer of industrial pumps and the Naval Air Depot (NADEP) at Cherry Point, North Carolina.

Faraday Technology's process uses pulse reverse-current electrolysis in conjunction with a reduced-cost Cr^{+3} plating chemistry and results in a reduced-cost, performance-based, functional Cr^{+3} plating process to replace conventional Cr^{+6} chromium plating. The process incorporates Faraday Technology's EXCHANGE™ In-Process Recycling System (also developed under EPA SBIR Program funding) for effluent waste management—plating bath chemistry and rinse water. A controlled "alpha" test of the Faradayic™ Process was completed in a pilot-scale manufacturing cell designed and built by Faraday Technology. This test was conducted using strut rods provided by a Tier 1 automotive supplier.

Faraday Technology's functional Cr^{+3} plating process demonstrates equivalent or superior plating rate, hardness, and current efficiency; will replace the conventional Cr^{+6} plating process; and will result in a more environmentally friendly and worker-safe plating process. The Faradayic™ Process demonstrates a thickness of 10 mils (250 μm), a plating rate of 1.44-2.25 μm/min, and a bath cost of $5.53 per pound of chromium; whereas conventional Cr^{+6} plating processes demonstrate a thickness of 6-10 mils (150-250 μm), a plating rate of 0.76-1.27 μm/min, and a bath cost of $4.81 per pound of chromium.

Commercialization Information

To date, Faraday Technology has secured $381,940 in commercial revenue to support this pilot-scale activity. Additionally, the company is preparing samples for external evaluation by Concurrent Technologies Corporation and NADEP Cherry Point. Faraday Technology has a successful track record of technology commercialization, with numerous strategic technology alliances currently under contract and 60% of its annual sales coming from commercial sources. Faraday Technology has filed a patent application covering the unique use of electric field process control based on this SBIR-funded project.

A pilot-scale plating Cr^{+3} line is being operated at the Faraday Technology facility in Clayton, Ohio. This plating line is a small-scale version of a shop-floor full-scale line.

The Faradayic™ Process is being widely implemented by large private and publicly owned companies as well as various components of the U.S. Department of Defense with the following applications:

- Faradayic™ Industrial Coatings—such as functional chromium from a trivalent chromium bath.
- Faradayic™ Edge and Surface Finishing—for advanced engineering alloys, such as stainless steel, aluminum, nickel, titanium, and the like without toxic, exotic electrolytes.
- Faradayic™ Leveling—metallization without leveler-brightener additives for advanced electronics applications.
- Faradayic™ Environmental Countermeasures—electrically mediated systems for in-process recycling of rinse waters and plating bath chemistry.

The functional Cr^{+3} plating process supports the Faradayic™ Process technologies listed above by providing environmentally conscientious reclamation and reuse of process solutions.

Company History and Awards

Faraday Technology, Inc., is an electrochemical process technology development company focused on enhancing and commercializing the Faradayic™ Process, its platform electrochemical manufacturing technology. Founded in 1991, Faraday is located in Clayton, Ohio, and has established itself as a noteworthy applied research and development company with approximately 80 publications and more than 50 patents/patents pending. The company has been recognized with a number of awards, including: the U.S. Small Business Administration-sponsored Small Business/Enterprise Spirit Award, the State of Ohio Governor's Thomas Edison Emerging Technology Award, the Affiliate's Society Council of Dayton Outstanding Technology Leadership Award, the Abner Brenner Silver Medal Award for a paper published in Plating & Surface Finishing, and the Ernst & Young Entrepreneur of the Year Award (High Technology Finalist for 2001).

SBIR Impact

- Hexavalent chromium (Cr^{+6}) plating produces hazardous air emissions, and EPA has identified Cr^{+6} as 1 of 17 "high-priority" toxic chemicals and as a known human carcinogen.
- Faraday Technology developed a cost-competitive, environmentally beneficial trivalent chromium (Cr^{+3}) plating process to replace Cr^{+6} plating.
- Faraday Technology's functional Cr^{+3} plating process demonstrates equivalent or superior plating rate, hardness, and current efficiency compared with Cr^{+6} plating.
- Faraday Technology has secured $381,940 in commercial revenue to support commercialization of this technology.