

Environmentally problematic substance used in the chrome plating industry can be substituted

An important Danish investigation concerning replacement of the harmful substance PFOS that is used as a chemical aid in the hard chrome plating industry all over the world is now finished. PFOS is harmful to both the environment and health. The results show that it is possible to replace PFOS as mist suppressant within non-decorative hard chrome plating. The investigation, which was financed by the subsidy scheme "Eco-efficient technology" by the Danish EPA, was managed by FORCE Technology in cooperation with IPU, DTU Mechanical Engineering, and the surface treatment company a.h. nichro Haardchrom A/S that was assisted by the development company SurfCoat A/S.

Approach and results

First, different alternatives to PFOS were tested in laboratory scale. Secondly, the best of the alternatives was tested in larger scale at the surface treatment company a.h. nichro Haardchrom A/S situated in Hvidovre, Denmark. Both a fluorinated (but non-PFOS) and a non-fluorinated alternative were tested in laboratory scale. Both alternatives worked effectively as mist suppressant and reduced the chromium emissions to 0.7% and 1.2% (of the reference value without mist suppressant) respectively. However, the non-fluorinated alternative was not chosen for testing on larger scale as this alternative requires continuously addition. Continuously automatic dosing of mist suppressant requires on-line measurements of the mist suppressant concentration in the chrome bath, as the consumption of mist suppressant varies a lot due to the inhomogeneous production that an electroplater has. As no satisfactory on-line measurement method exists, it is not directly possible to use continuously automatic dosing.

The testing and the results of the chromium emission measurements of the fluorinated alternative at a.h. nichro Haardchrom A/S showed that the alternative works as effectively as PFOS in reducing the chromium emissions from the chrome bath. Furthermore, the durability of the fluorinated alternative seems to be similar to that of PFOS. Substitution of PFOS with the fluorinated alternative which is a fluortelomer compound is not as large an environmental improvement as substituting with e.g. a non-fluorinated alternative perhaps could be. However, using the fluortelomer alternative instead of PFOS is still an environmental improvement as the fluortelomer alternative is less persistent, less bioaccumulative, and less toxic than PFOS. Economically, a change from PFOS to the fluortelomer alternative only results in minor differences.

Other positive results from the investigation were that no or reduced ventilation seems to reduce the emission of chromium from the chrome bath significantly. This indicates that it may be worth investigating further if mechanical methods that reduce the airflow around the chrome bath also could be an alternative to PFOS. Furthermore, it will be interesting – both commercially and environmentally – to clarify the interaction between ventilation of the chrome bath and emission of aerosols, as the consumption of energy for operation of ventilation systems in galvanic companies is quite huge.

Background

A general restriction on the use of PFOS (perfluorooctanesulphonate) and other PFOS-based chemicals became effective in Denmark and the rest of the EU in June 2008 due to the fact that PFOS is persistent, bioaccumulative, and an endocrine disruptor that is concentrated in animals and humans and affects our fertility. PFOS is listed on the POP (Persistent Organic Pollutants) list of the Stockholm Convention of especially environmentally dangerous chemicals.

PFOS and other PFOS-based chemicals are surface active chemicals which are contained in mist suppressing agents (mist suppressants) that are used within non-decorative hard chrome plating. However, this specific use is exempted from the EU restriction as no suitable alternatives were available at the time of adoption of the legislation. Without the use of PFOS as mist suppressant in the hard chrome plating process, droplets (aerosols) of chromium acid are emitted into the surrounding air of the chrome bath. Chromium acid is a hexavalent chromium compound which is carcinogenic, allergenic, and harmful to the environment. Therefore, the use of PFOS together with exhaust devices is eliminating a potentially working environmental problem in the industry.

The current annual use of PFOS in Denmark as mist suppressant for chrome plating is not large – a maximum of 30 kg. However, on a worldwide basis, the use is more than 30 tons PFOS annually. In Denmark, PFOS is disposed of together with the used process baths that are handled as chemical waste.

Experiments with non-PFOS-based mist suppressant

The authorities consider PFOS to be an environmentally dangerous substance and therefore the substance must be prohibited and phased out; cf. POP¹-Regulation No. 850/2004. PFOS is a surface active substance and is contained in commercially available mist suppressants used among others within non-decorative hard chrome plating. The amount of PFOS in mist suppressants is typically 5-10%. Until now, the use of PFOS within non-decorative hard chrome plating has been exempted from the EU restriction, as mist suppressants without PFOS have not been available. However, this has now changed.

FORCE Technology, IPU & DTU Mechanical Engineering has for the Danish EPA funding investigated several alternatives to PFOS-containing mist suppressants in consultation with a.h. nichro Haardchrom A/S that kindly has participated in the project and carried out experiments in pilot scale. The project showed that mist suppressants without PFOS are applicable. The project also showed that release of aerosols can be prevented by mechanical solutions that completely eliminate the need for mist suppressant chemicals. Experiments without ventilation showed that the air flow just over the surface of the chrome bath is critical for the amount of aerosols that are removed with the exhaust device.

It will be interesting – both commercially and environmentally – to clarify the interaction between ventilation of the chrome bath and emission of aerosols as the consumption of energy for operation of ventilation systems in galvanic companies is quite huge.

¹ POP = Persistent Organic Pollutants