Chrometherm finishing process LCA report

Metaltex SpA

External report

12 January 2016

Contents

1. Metaltex

Metaltex develops, manufactures and distributes high quality products for everyday use in specific areas of the home.

Since 1945, when the company was established, Metaltex has followed on a path of constant growth and innovation that has led it to becoming a global, skilled, reliable and safe company in the household goods sector.

Metaltex currently offers a wide range of goods, divided into various product categories: home and kitchen utensils, space saving and organisational items, laundry care products.

Figure 1: Metaltex product.

Figure 2: Chrometherm treatment system.

A major aspect for Metaltex is innovation and the development of new items.

In 2016 Metaltex launched CHROMETHERM, a new surface finish treatment that guarantees products with a high corrosion resistance by using thermosetting paints.

The visual appearance of the CHROMETHERM finish draws from the characteristic features of shine and brilliance typical of decorative chrome plating, but the innovative process makes it possible to significantly reduce impact on the environment

2. Aim of the study

The purpose of this study is to ensure transparency on the environmental performance of the Chrometherm process and to provide scientific support for communication of the environmental characteristics of the process to the outside world.

In addition, assuming that the Chrometherm treatment has less impact on the environment than decorative chrome plating, we compared the two processes, with the aim of scientifically highlighting the different environmental performance levels.

The analysis is carried out with the LCA (Life Cycle Assessment) methodology.

The structure of the LCA can be summarised in four main phases:

- *aim and field of application*: preliminary phase in which the purposes of the study, the functional unit, the boundaries of the system studied, the data requirements and the assumptions are defined;
- *inventory analysis*: quantification of inflows and outflows for all LCA processes;
- *impact assessment*: phase that brings together the results of the inventory, with scientific models, in a number of potential environmental impacts;
- *interpretation of results*: phase in which the results of the LCA are interpreted, in order to draw conclusions and recommendations.

The study was carried out by Anna Atti, LCA expert and auditor for certification bodies, of **studio e3** - associated consulting firm, via G. Rossetti 40 - 25128 Brescia.www.ecubo.it

3. Field of application of the study

3.1 Chrometherm process

The Chrometherm process is a chrome effect finish that can be applied to metal surfaces.

The treatment is carried out within a dedicated production line: the paint is applied to the item by immersion in tanks (firstly base paint and secondly top coat) with drying in an oven powered by natural gas.

Before application, the item is welded to a metal hook, which is necessary to hang the item on the trolleys and allow a uniform application of the paint. At the end of the treatment, the hook is detached and handled as waste.

There are significant environmental benefits of the treatment:

- unlike decorative chrome plating, degreasing baths are not necessary before Chrometherm treatment;
- the process is entirely dry, with no consumption of water and production of wastewater.

The thickness of the coating is 250 µm and, according to the salt spray tests carried out by the ASA chemical laboratory (test report no. 3347F2015/3), it provides a corrosion resistance of at least 300 hours.

The process is proposed as an alternative to decorative chromium plating, which has been carried out to date on the same items, with a thickness of 12 µm of nickel + 1 µm of chromium.

3.2 Functional unit

The functional unit examined is 1 m^2 of surface coated with the Chrometherm process, with a thickness of 250 µm.

3.3 System boundaries

The boundaries of the system include all the phases of extraction and production of the input flows to the coating process (raw materials, energy), as well as the output flows with the relative treatment (waste, emissions into the atmosphere, water discharges).

In more detail, the end of life of the coating alone has also been considered, assuming that it is oxidised in the oven of a steel mill.

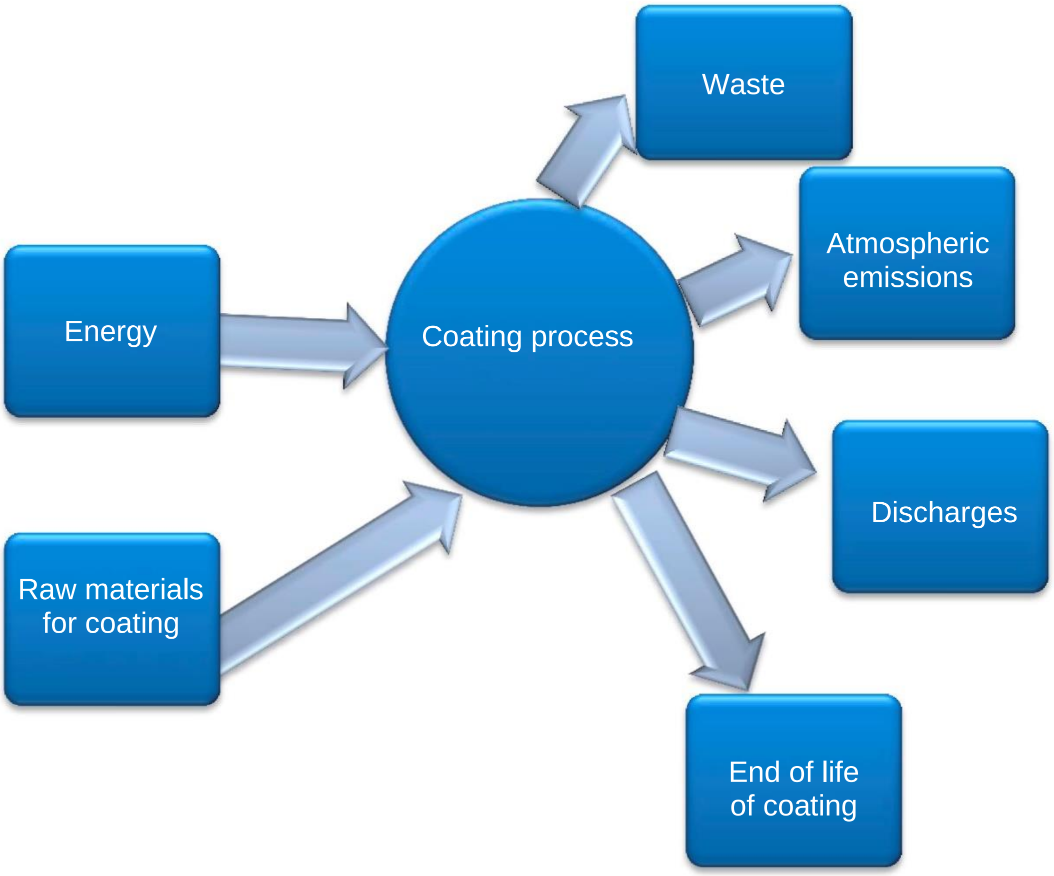

Figure 3: Chrometherm process LCA system boundaries.

Process	Chrometherm process
Raw materials for coating	The production phase of the powders used in the painting process has been considered. The relative packaging has also been included.
Energy	The gas and electricity consumption of the oven was considered, which also include the electricity consumption of the smoke abatement systems. The electricity consumption for the welding of the hooks and the compressed air were also considered.
Waste	The disposal of the waste powders from the painting process and the disposal and packaging of used raw materials were considered.
Atmospheric emissions	The mass flow of powders resulting from the painting process was considered.
Water discharges	The process is carried out dry, so there is no water consumption or production of water discharges.
Process yield	Considered
End of life of the coating (without item)	The combustion process of the coating at the end of its life in an electric arc oven was considered, assuming the recovery scenario of the metal item in a second melting steel plant. However, the end of life of the item was not considered, as it is independent of the treatment carried out.

The following are excluded from the system boundaries:

- transport of raw materials entering the process and the waste produced, in order to disconnect the analysis from the location of the production plant;
- construction and maintenance of the production plants;
- production and transport of the substrate material to be coated;
- end of life of the coated item (with the exclusion of the coating, which is the object of the study).

3.4 Exclusion criteria

The criterion chosen for the initial inclusion of the input and output elements is based on the definition of a cut-off level of 1%, in terms of environmental relevance. This means that a process has been neglected if it is responsible for less than 1% of the total impact.

In the case of the Chrometherm process, all available data have been considered, even if their contribution is less than 1%.

3.5 Time boundaries

Data	Chrometherm process
Primary data	The primary data come from production tests carried out in November 2015 at the Metaltex plant in Maslianico.
Secondary data	The secondary data comes from the ecoinvent v3.1 database, published in 2014.

3.6 Geographical representativeness

Data	Chrometherm process
Primary data	The Metaltex production site where the coating with paints is carried out is located in the municipality of Maslianico, in the province of Como. The management of the waste produced is specific to the plant.
Electricity mix	The energy mix used in the analysis is Italian.

3.7 Boundaries with the environment and with other systems

Air emissions, wastewater treatment and waste from the production process were included in the LCA.

3.8 Allocation rules

No allocation was carried out in the study.

No allocation is made for waste subject to recycling. Outputs subject to recycling are considered inputs for the subsequent life cycle.

3.9 Method used

The methodology chosen to evaluate the potential environmental impacts used in this study is the CML-IA baseline V3.03 method, developed by the Center of Environmental Science (CML) of Leiden University – The Netherlands.

More information is available at http://cml.leiden.edu/software/data-cmlia.html

The impact categories considered by the method are as follows:

Global warming

Global warming refers to the phenomenon of increase in the average temperatures of the Earth's surface which are not attributable to natural causes. This change is largely attributed to the emissions into the atmosphere of increasing amounts of greenhouse gases (mainly carbon dioxide, methane, nitrous oxide and refrigerant gases).

The characterisation model is developed according to the Intergovernmental Panel on Climate Change (IPCC). The emission factors are expressed as Global Warming Potential for a time horizon of 100 years (GWP100), in kg CO2 equivalent/kg emission.

Water eutrophication

Eutrophication is the excessive growth of plant organisms that occurs as a result of the presence in the aquatic ecosystem of excessively high doses of nutrients such as nitrogen, phosphorus or sulphur, coming from natural or anthropogenic sources (such as fertilizers, some types of detergent, civil or industrial discharges) and the consequent degradation of the environment that has become asphyxiating. The accumulation of elements such as nitrogen and phosphorus causes the proliferation of microscopic algae which, in turn, as it is not disposed of by primary consumers, results in greater bacterial activity; thus the global consumption of oxygen increases and the lack of the latter eventually causes the death of fish.

The eutrophication potentials developed by Heijungs et al expressed in kg PO4 equivalent /kg emission are used in the CML model.

Acidification of the atmosphere (acid rain)

The emissions of compounds resulting from the combustion of fossil fuels, in particular sulphur oxides and nitrogen oxides, are mainly responsible for the phenomenon of acid rain, which causes the lowering of the pH of lakes, forests and soil, with serious consequences for living organisms, ecosystems and materials.

In the CML model, the acidification potentials developed by Huijbregts and expressed in kg SO2 equivalent /kg emission are used.

Photochemical oxidation:

Photochemical smog, which is a characteristic phenomenon of the daylight hours of large urban areas in the summer, is a complex mixture of air pollutants composed of ozone and other oxidizing chemicals, nitrogen dioxide (NO2) and fine dust. The most important component is ozone, due to its consequences on human health and natural ecosystems. Ozone is not emitted directly, but is formed in the troposphere, under the influence of solar radiation, as a result of a series of photochemical reactions involving volatile organic compounds (VOCs) and nitrogen oxides (NOx).

The photochemical oxidation potentials developed by Jenkin&Hayman and Derwent and expressed in kg ethylene equivalent/kg emission are used in the CML model.

Abiotic resource consumption

Two impact categories are considered: the consumption of minerals (elements, ultimate reserves) and the consumption of fossil fuels (e.g. oil, coal), linked to the use of raw materials and energy of the analysed process.

The Abiotic Depletion Factor (ADF) is determined for each mineral extraction (expressed in kg antimony equivalents /kg extraction) on the basis of available reserves.

The abiotic depletion of fossil fuels is related to the PCI expressed in MJ per unit of fuel.

Destruction of the ozone layer

The reduction of the stratospheric ozone layer, which is much more marked in the polar regions, is a mechanism linked to the halogens emitted by human activities, mainly chlorine and bromine, which catalyse ozone-destructive reactions.

The ozone layer is a critical screen for the interception of radiation lethal to life on earth.

The characterisation model is developed by the World Meteorological Organisation (WMO) and the emission factors are expressed in kg CFC-11 equivalent/ kg emission.

Toxicity

There are 4 impact categories linked to the toxicity in the method, depending on the effects of toxic substances in the environment:

- human toxicity
- freshwater ecotoxicity
- marine ecotoxicity
- soil ecotoxicity

The characterisation factors are calculated with the USES-LCA method, describing the fate, exposure and effects of toxic substances over an infinite time horizon. For each toxic substance they are expressed as 1.4-dichlorobenzene equivalent/ kg emission.

The study was limited to the characterisation phase, without normalization.

4. Inventory analysis

The collection of the data used for the inventory of the Chrometherm process was carried out as indicated in the table:

Data	Data collection mode
Base paint with relative packaging (plastic and cardboard bag)	The consumption of paints used in the coating process is specific per m^2 of treated surface and was obtained from weights taken before and after coating.
Top coat with its packaging (plastic and cardboard bag)	As above.
Iron hook	There is a welded hook for each treated piece
Natural gas consumption	The consumption of the production oven was monitored for an entire production day and compared to the weight of treated items, so as to have specific consumption. In this way, the oven start-up and shutdown transients were also counted
Electricity consumption	The consumption of the production oven, including the suction, compressed air and welding systems were monitored for a whole production day and compared to the weight of treated items, so as to have the specific consumption.
Atmospheric emissions	Analyses were carried out on the 4 chimneys of the oven during production
Waste	The amount of dust captured by the filters of the abatement plant and the quantity of other waste produced for disposal (plastic) was weighed. The iron hooks and the cardboard packaging are sent, on the other hand, for recycling.
Process yield	Obtained by considering the parts discarded due to defects
End of life of coating	Oxidation in an electric oven was assimilated to the oxidation in an incinerator.

5. Impact assessment

During the evaluation of the impacts of the process, the information obtained from the inventory analysis is combined according to the effects related to the various environmental issues, using the SIMA Pro 8.1 software.

Chrometherm process

The environmental indicators represent the environmental impact of the life cycle of 1 m^2 of treatment carried out on an item, divided into the various phases.

Impact category		Total
Abiotic depletion	kg Sb eq	0.00000297
Abiotic depletion (fossil fuels)	MJ	75.4
Global warming (GWP100a)	kg CO2 eq	5.22
Ozone layer depletion (ODP)	kg CFC-11 eq	0.000000179
Human toxicity	kg 1.4-DB eq	1.3
Freshwater aquatic ecotoxicity.	kg 1.4-DB eq	0.782
Marine aquatic ecotoxicity	kg 1.4-DB eq	1790
Terrestrial ecotoxicity	kg 1.4-DB eq	0.0102
Photochemical oxidation	kg C2H4 eq	0.000981
Acidification	kg SO2 eq	0.0194
Eutrophication	kg PO4--- eq	0.00289

The contribution of the various phases of the process, for each impact category, is shown in the following diagram and strongly depends on the impact categories analysed.

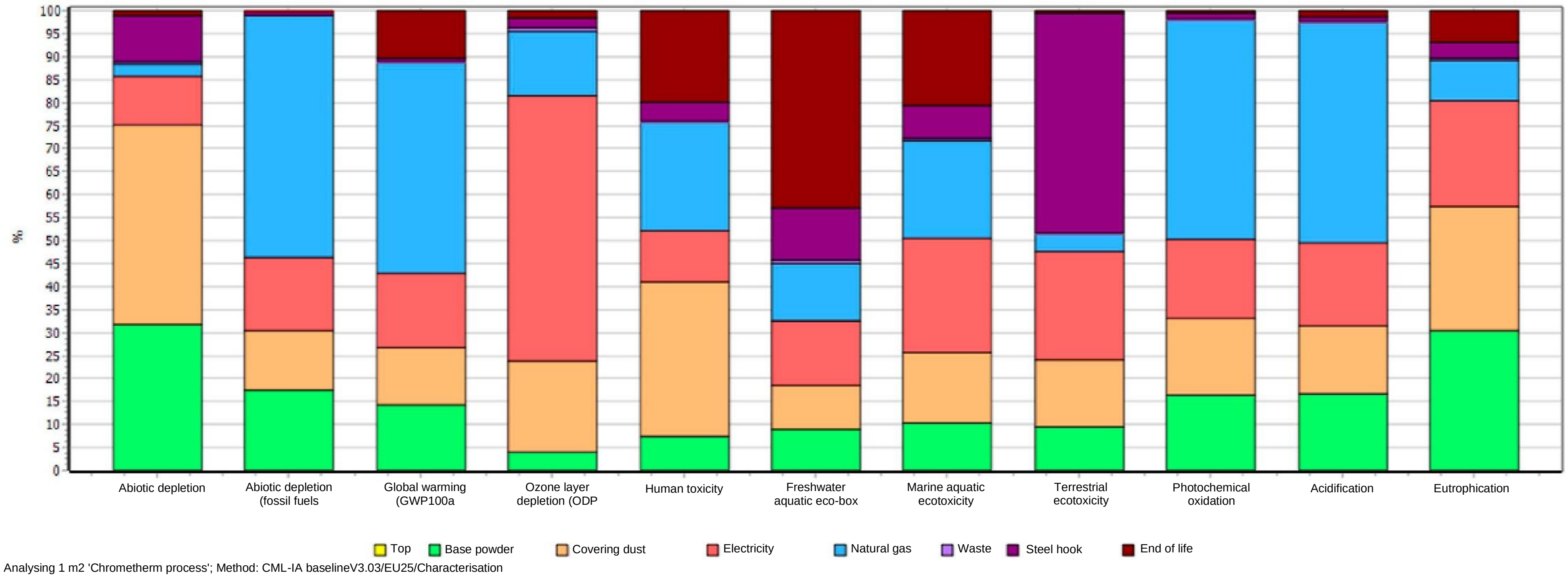

Figure 4: Impacts of the various phases of Chrometherm treatment

6. Interpretation of results

The LCA study made it possible to calculate the environmental impact of the Chrometherm process.

The contributions of the various processes change significantly depending on the impact category analysed:

- consumption of abiotic resources: 75% of the contribution is linked to the use of powders;
- consumption of abiotic resources (fossil fuels) and global warming: over 50% of the impact is linked to the consumption of natural gas by the oven, and almost 20% to the consumption of electricity;
- destruction of the ozone layer: about 60% of the contribution is linked to the consumption of electricity;
- human toxicity: the greatest contribution is linked to the use of powders, from the production to the end of life;
- freshwater ecotoxicity: the greatest contribution is linked to the end-of-life of powders in oxidation in an electric steel oven;
- marine ecotoxicity: the largest contribution, equal to about 25%, is due to the use of electricity;
- terrestrial ecotoxicity: the greatest contribution is linked to the production of the steel necessary for the production of the hook;
- photochemical oxidation and acidification: about 50% of the contribution is due to the use of natural gas;
- eutrophication: about 55% of the contribution is linked to the production of the powders.

6.1 Comparison with the decorative chrome plating process

The environmental impacts of the Chrometherm coating process were compared with those of decorative chromium plating, which is currently the most widely used technology for coating the same items.

LCA study with literature data on decorative chrome plating

An LCA study was carried out with the CML-IA baseline V3.03 method using consumption data on decorative chrome plating collected in the literature.

Functional unit

For the analysis of decorative chromium plating, the functional unit is 1 m^2 of coated surface, with a thickness of 12 μm of nickel + 1 μm of chromium.

It should be noted that according to the tests carried out, the corrosion resistance of Chrometherm is considerably higher than that of chromium plating.

Bibliography used

The following bibliographical sources were used to collect data on the decorative chromium plating process:

a. Linee Guida per le Migliori Tecniche Disponibili nei Trattamenti di superficie dei metalli - IPCC - gruppo tecnico ristretto istituito dal Ministero dell'Ambiente - gennaio 2008 (*Guidelines for the Best Available Techniques in the Surface Treatment of Metals - IPCC - restricted technical group established by the Ministry of the Environment - January 2008*)
b. Metodologie per l'analisi ambientale dei cicli produttivi e casi applicativi - Isprambiente - galvanico - 2008 - http://www.isprambiente.gov.it/public files/cicli produttivi/Rubinetterie/CAP6RUBI.pdf (*Methodologies for the environmental analysis of production cycles and application cases - Isprambiente - galvanic - 2008)*
c. LCA comparative analysis of different technologies for surface functionalization - Gabriela Benveniste, Gian Luca Baldo, Massimo Perucca, Bernardo Ruggeri - 2007
d. Nickel, Cobalt and their alloys - Joseph R. Davis - ASM International – 2000

System boundaries

Process	**Decorative chrome plating**
Raw materials for coating	The production of the nickel, chromium and sulfuric acid compounds used in the galvanic process was considered. As certain data was not available, upstream processes, such as degreasing baths before the nickel plating bath, were not included.
Energy	Gas and electricity consumption of the degreasing plant, galvanic treatment and all related auxiliaries (abatement plants, etc.) were considered.
Waste	Not considered
Atmospheric emissions	Not considered
Water discharges	The treatment of the galvanic baths used in the nickel plating - chromium plating process was considered.
Process yield	Considered
End of life of coating	The end of life of the steel oven lining has been considered, in the scenario that the steel item is sent for recycling.

Time boundaries

Data	**Decorative chrome plating**
Primary data	No primary data available. Data refer to publications that refer to the period 2000-2008
Secondary data	The secondary data comes from the ecoinvent v3.1 database, published in 2014.

Geographical boundaries

Data	**Decorative chrome plating**
Primary data	The data refer to publications that refer to Italian or EU production companies.
Energy mix	The energy mix used in the analysis is Italian.

Allocation

Process	**Decorative chrome plating**
Energy consumption	Allocation on a mass basis, based on the nickel used in the production process.

Inventory

Data	Data source *
Quantity of nickel needed for a 12 μm layer	(d). Data also verified by calculation starting from the density
Nickel plating process yield	(a)
Actual nickel consumption	Combining the two previous items
Nickel consumption divided into various forms	(b)
Quantity of chromium required for a 1 μm layer	Calculation starting from the density
Chrome plating process yield	(a)
Actual chromic acid consumption	Combining the two previous items + molecular weight
Sulphuric acid consumption	Assumed proportional to the concentration in the chromium plating bath (1/100); in reality, consumption is significantly higher, as the consumption of sulfuric acid in the bath is higher than chromium
Electricity consumption	(b). The sum of electricity and natural gas consumption is also in line with the consumption indicated in (c)
Natural gas consumption	(b)
Wastewater to treatment	(b)
End of life of coating	(d)

* see texts cited in the previous "bibliography" section

The results of the comparative analysis are as follows:

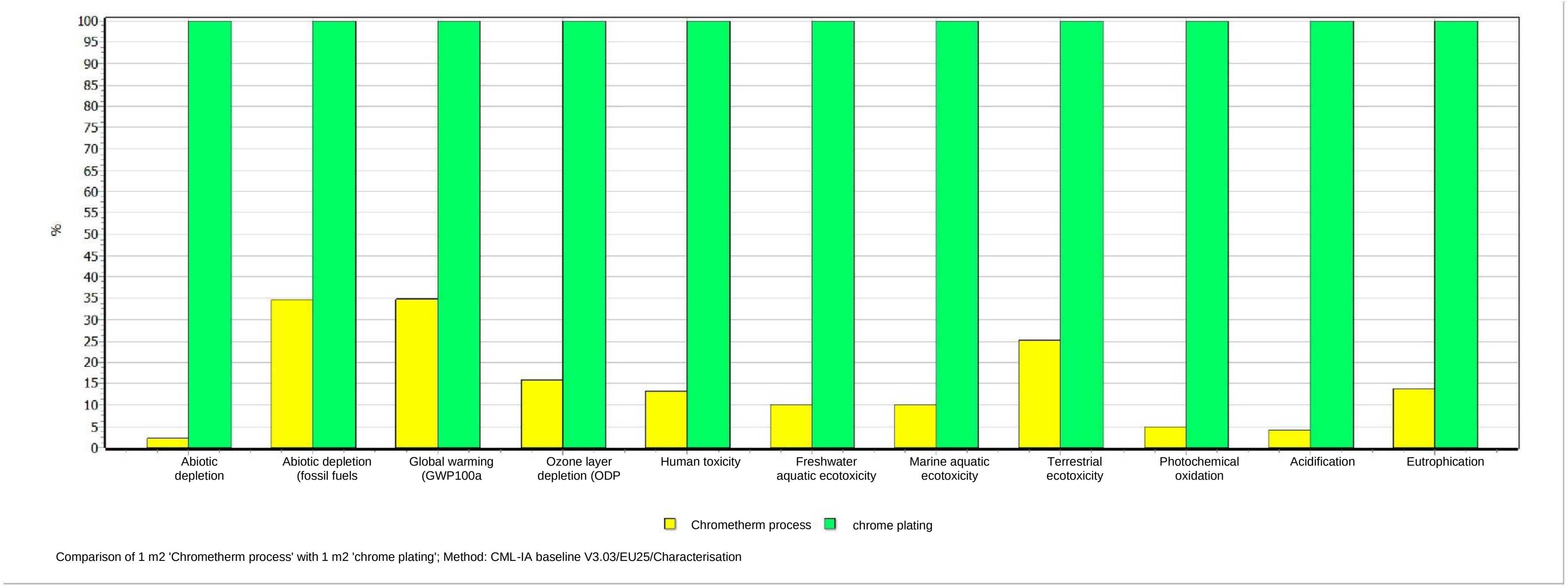

Figure 5: Result of the comparative analysis between the Chrometherm treatment and the decorative chrome plating

The impacts of the Chrometherm process are significantly lower than those of traditional decorative chromium plating for each impact category analysed.

7. Conclusions

The study allowed examination of the entire life cycle of the Chrometherm treatment, according to the CML-IA baseline V3.03 method.

Depending on the impact category analysed, the processes with the most impact were found to be different. These include:

- dust consumption;
- natural gas consumption;
- electricity consumption.

The environmental impacts obtained were compared with those of the decorative chromium plating, both by carrying out a specific LCA study and by using an LCA study available in the literature.

In both cases, the environmental impacts of the Chrometherm process were found to be lower than those of decorative chromium plating.

The following figures compare the environmental impacts of the Chrometherm process with those obtained from the LCA study carried out on the decorative chromium plating.

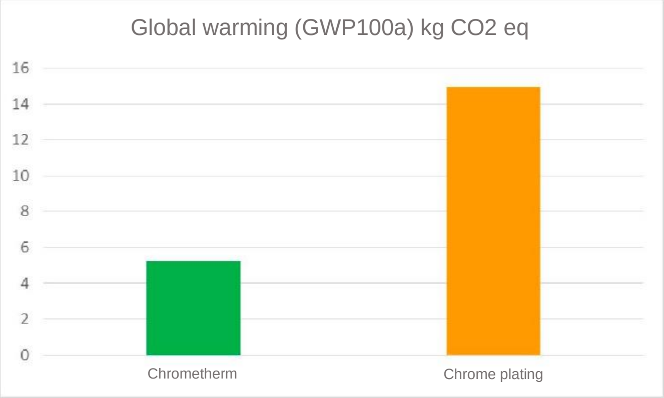

Figure 6: Global warming: comparative analysis between Chrometherm treatment and decorative chrome plating

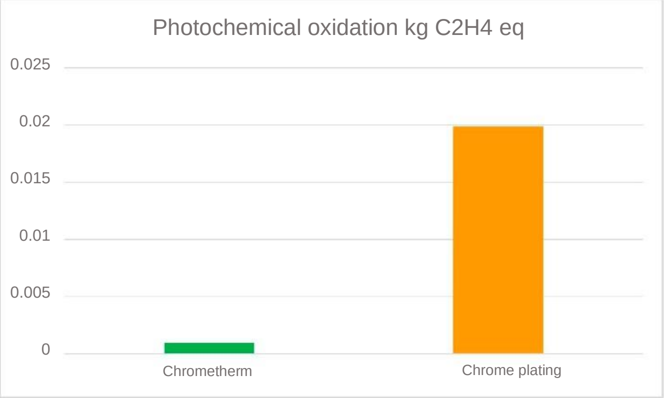

Figure 7: Photochemical smog: comparative analysis between Chrometherm treatment and decorative chrome plating

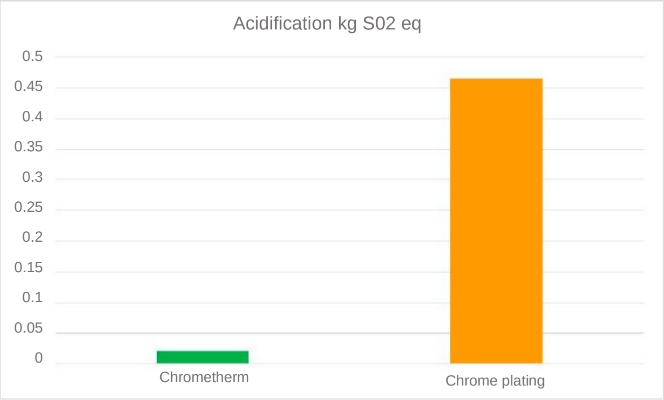

Figure 8: Acidification: comparative analysis between Chrometherm treatment and decorative chrome plating

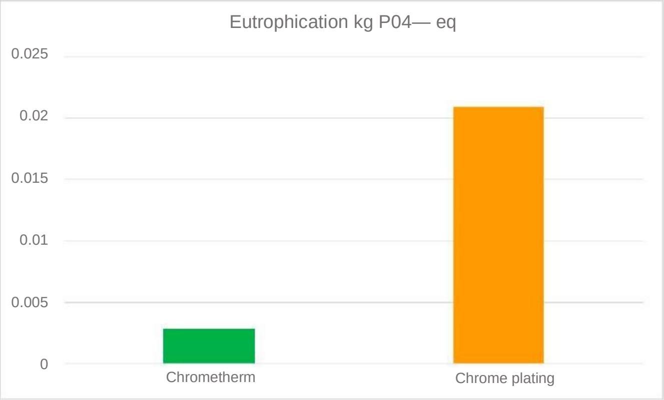

Figure 9: Eutrophication: comparative analysis between Chrometherm treatment and decorative chrome plating

Finally, it should be considered that by applying the Chrometherm finish, which guarantees a longer service life of the products than that for the chromium plating thanks to the improved corrosion resistance, the environmental impacts resulting from each production cycle are further reduced.

8. References

[1] Ecoinvent, 2014. Swiss Centre for Life Cycle Assessment, v 3.1 (www.ecoinvent.ch).

[2] CML-IA baseline V3.03- Center of Environmental Science (CML) - Leiden University - Olanda (http://cml.leiden.edu/software/data-cmlia.html)

[3] Linee Guida per le Migliori Tecniche Disponibili nei Trattamenti di superficie dei metalli - IPCC - gruppo tecnico ristretto istituito dal Ministero dell'Ambiente - gennaio 2008 (*Guidelines for the Best Available Techniques in the Surface Treatment of Metals - IPCC - restricted technical group established by the Ministry of the Environment - January 2008*)

[4] Metodologie per l'analisi ambientale dei cicli produttivi e casi applicativi - Isprambiente - galvanico - 2008 - http://www.isprambiente.gov.it/public files/cicli produttivi/Rubinetterie/CAP6RUBI.pdf (*Methodologies for the environmental analysis of production cycles and application cases - Isprambiente - galvanic - 2008)*

[5] LCA comparative analysis of different technologies for surface functionalization - Gabriela Benveniste, Gian Luca Baldo, Massimo Perucca, Bernardo Ruggeri - 2007

[6] Nickel, Cobalt and their alloys - Joseph R. Davis - ASM International – 2000

[7] Progetto LIFE 00 ENV/IT/000213 - Sviluppo di una tecnologia di rivestimento "pulita" PVD per applicazioni decorative su componenti metallici di grandi serie in sostituzione delle tecnologie di rivestimento tradizionali (galvaniche). *(LIFE project 00 ENV/IT/000213 - Development of a "clean" PVD coating technology for decorative applications on large series metal components replacing traditional (galvanic) coating technologies)*