DANTES

Executive Summary

Environmental costs and environmental impacts in a chemical industry

eLCC and LCA on two colorants

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Abstract

This study has focused on the production of two colorants. A surfactant (Berol 09) used in the older of these colorants contains nonyl phenol ethoxylate, a substance with potentially toxic properties. The newer colorant contains another surfactant (Bermodol SPS 2532) that was developed as an environmentally preferable alternative to the older surfactant. Both surfactants are manufactured at the Akzo Nobel plant in Stenungsund, Sweden. This substitution is studied and evaluated both from a traditional Life Cycle Assessment (LCA) perspective and from a perspective of costs caused by environmental work at the company and the environmental impacts of the studied products. These costs are referred to as environmental costs. An attempt is also made to develop a method that combines the environmental cost and the LCA perspectives. The aim of the study is to determine how these 'environmental costs' look for a chemical company.

From an LCA perspective the newer colorant seems to be the better alternative. The substitution of surfactant leads to other changes in the composition of the colorant, among other things the newer colorant contains more water than the older colorant, and this affects the LCA results significantly.

The environmental costs are higher for the newer colorant. A large part of the difference between the colorants lies in the development costs of the new surfactant.

The environmental costs were approximately 5% of the sales price for both surfactants. As new legislations and increased tax rates will lead to additional environmental costs, they seem to remain an important issue for chemical companies.

1. Introduction

The chemical industry's work with environmental issues is even more important than in other industries. Moreover, chemical products with environmentally hazardous properties are one of the main environmental concerns in the chemical industry. One way to improve the environmental properties of a product that contains a hazardous substance is to try to substitute the chemical with another chemical that can fill a similar function in the product without the hazardous properties of the first.

Two chemicals involved in such a substitution, Berol 09 and Bermodol SPS 2532, are produced at Akzo Nobel in Stenungsund, Sweden. They are used as surfactants in colorants in water based indoor paint. The surfactants are needed to keep the colorant; a mix of pigment, water and glycol as a homogenous solution.

Nonyl phenol ethoxylate, a major constituent of Berol 09, has been a topic of several years' discussions and studies of its environmental performance and possible estrogen-like activity. [Svennberg 1995] Discussions of the future legislation on nonyl phenol ethoxylate breached the subject of a possible ban on the use of nonyl phenol ethoxylate in several applications, among them paint. [Munk 2003]

Thus in 1991 Cellulosic Specialties began the work on an alternate surfactant for use in colorants for water based paint. One of the results of that work, Bermodol SPS 2532, was developed in association with the Colorant Manufacturer. Production of Bermodol SPS 2532 began in 1995.

2. Aim of the study

The aim of the project is to study the environmental impact and environmental costs of the colorants in a way that allows comparisons with environmental impact data from an LCA.

Since experience from studies on environmental costs is limited, the actual size of the environmental costs and the process of collecting environmental cost data are also valuable to the study.

3. Methods and concepts used

Environmental costs

The concept of environmental costs in this study is referring to monetary costs carried by the producing companies, in this case costs carried by Akzo Nobel exclusively. There is no global definition of what environmental costs are and where in a company they can be found. For this specific study, performed in a chemical industry, a few criteria for environmental costs have been set up. In the environmental costs concept the following costs have been included: costs related to the toxicity of a product, to harmful emissions caused by the product or its manufacturing process, overhead costs that relates to the company's environmental performance and finally, costs for investments and developments performed with the purpose to reduce the environmental impact of a product or a manufacturing process.

eLCC (environmental Life Cycle Costing)

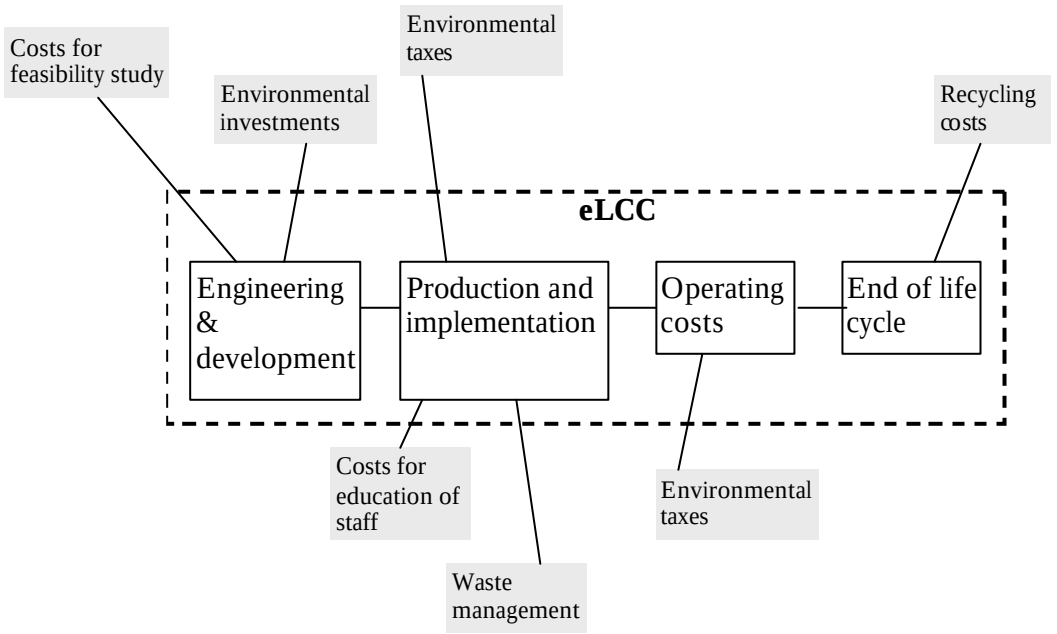

Figure 1 Example of costs that could be invluded in an eLCC

A regular LCC considers all costs that arise in the different life cycle phases of the product. [Woodward 1997] In this study only environmental costs included in the standard LCC are of interest. An environmental Life Cycle Costing (eLCC) has been developed for this study.

4. Boundaries

LCA

The LCA attempts to cover production of two colorants and their respective raw materials. The environmental impact is only considered for the actual processes and transports. Thus impacts related to the manufacturing of machines and industrial plants are omitted, and so are the environmental impacts caused by the work force and their transports.

The study spans from the cradle of the colorants, the extraction of necessary resources to the gate of the colorant manufacturer. The use of the colorant in paint and the waste management of paint are omitted from the study as the colorants are expected to have roughly the same environmental impacts in these steps.

eLCC

The environmental cost study takes place in Sweden and is mainly performed at Akzo Nobel in Stenungsund where raw materials to the colorant are produced. Environmental costs are only included for the raw materials produced at Akzo Nobel and for the production of the colorants at the Colorant Manufacturer.

In chapter 9 environmental costs for the rest of the raw materials are estimated to assist in the calculation of an estimate total environmental cost for the colorants.

5. Environmental costs

Using the criteria described in chapter 3 the following possible environmental costs were identified in chemical industries.

Environmental taxes

Three environmental taxes have been identified: energy tax, carbon dioxide tax and sulfur tax. [Naturvårdverket 2003]

Environmental permits or certificates

Costs for environmental permits, environmental reports and costs for environmental certificates such as ISO 14001 are all considered environmental costs. [Miljöbalken 1998]

Environmental fees

Several fees were identified. They are: an environmental protection fee [Svensk Författningssamling 1998], NO_X-fee [Naturvårdsverket 2003], registration fee [Kemikalieinspektionen 2004] and an environmental damage and clean-up insurance. [Miljöbalken 1998]

Environmental costs for tests in the development phase

When developing a new chemical substance a company is obliged to test it in several ways. [Miljöbalken 1998] The tests considered as environmental costs are not just the biodegradability tests and eco-toxicity test, but also tests related to human health such as tests for human toxicology.

Measuring and testing costs during production

The manufacture of some products causes emissions to water, ground and air. To keep track of the level of environmentally hazardous substances in the surrounding environment continuous testing of the outlet from the process and on the surroundings has to be performed.

Environmental costs of transportation

Taxes and fees on the emissions from transports are considered environmental costs. If the cost of transport is higher due to the environmental hazardousness of the product the additional cost is also considered an environmental cost.

Education of employees

When additional education is needed for employees to handle toxic products or due to their environmentally hazardous properties the additional cost to educate employees is considered an environmental cost.

External information

For some companies and products external information is needed to inform the public about the environmental hazardousness of the product or production process.

Environmental investments

Investments in production equipment might be made in order to reduce environmentally hazardous emissions. Such investments are considered environmental costs. Most investments however are motivated by more than just environmental concerns. In this case only the part of the investments that is considered environmental is an environmental cost. [SCB 2001]

Cost for additional cleaning

Cleaning of process equipment is an environmental cost if additional cleaning is needed due to the environmental properties of a raw material or the final product.

Cost for waste management

Waste can be handled either by the producer or by external waste treatment companies. Either way handling of the waste causes environmental costs. The cost to transport waste is also considered an environmental cost.

Potential clean-up costs for shut-down of business

The clean-up cost that is related to the environmental hazardousness of the production at the site is an environmental cost.

Membership of special interest organizations

Membership in CEFIC and the Swedish Plastics and Chemicals Federation and costs for membership and for participating in activities related to environmental issues are considered environmental costs.

Staff

The cost for employees that work with environmental issues is an environmental cost. The cost is not just the wages but the total cost the company has for its employees. In addition to wages, these costs consist of, office space, software and computers.

6. Composition of colorants

Since the properties of the two surfactants are different several changes have to be made to the recipe of the colorant. It is not a simple substitution of 1 kg of Bermodol SPS 2532 for each 1 kg of Berol 09. In the studied colorant, in which iron oxide is used as pigment, the amounts of surfactant, water and glycol are altered significantly. The colorant containing Berol 09 will from here on be referred to as Old Colorant while the colorant containing Bermodol SPS 2532 will be referred to as New Colorant.

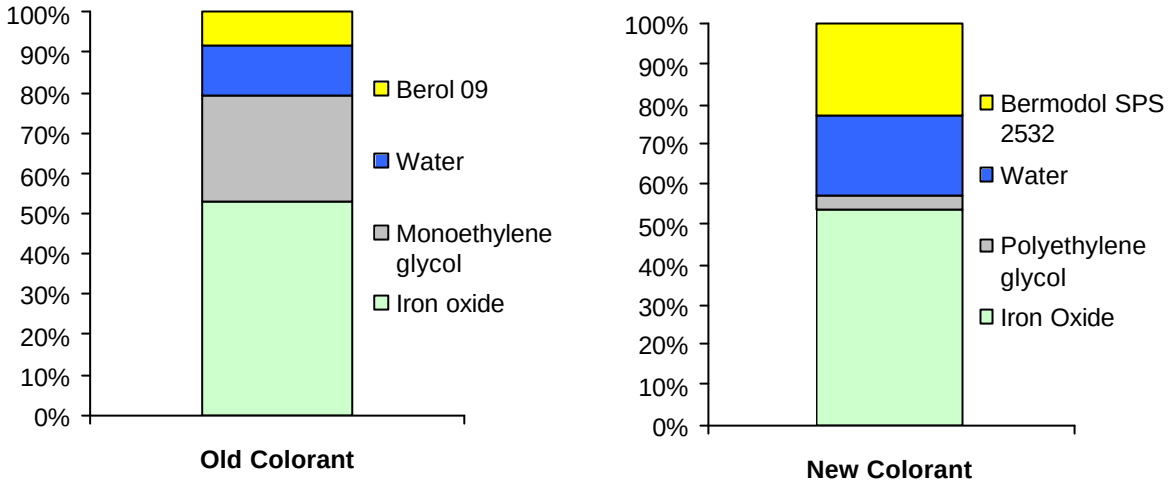

Figure 2 Approximate compositions of the iron oxide yellow colorants that are studied in the project. [Colorant Manufacturer 2003]

Berol 09, Bermodol SPS 2532 and monoethylene glycol is manufactured at Akzo Nobel Stenungsund, additionally data from the production of polyethylene glycol at Akzo Nobel is used instead of data from the actual supplier since that data was not available. Iron oxide is produced in Germany but Swedish data is used instead since no data from the production in Germany could be found.

7. Results

LCA

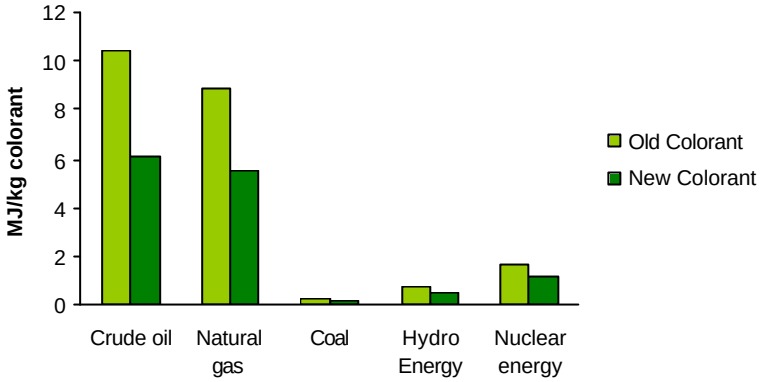

Figure 3. Use of energy resources caused by the production of 1kg of colorant.

Natural gas and oil are the two major resources used in the production of colorants. The production of the old colorant requires significantly more energy resources of all kinds than production of the new colorant.

eLCC

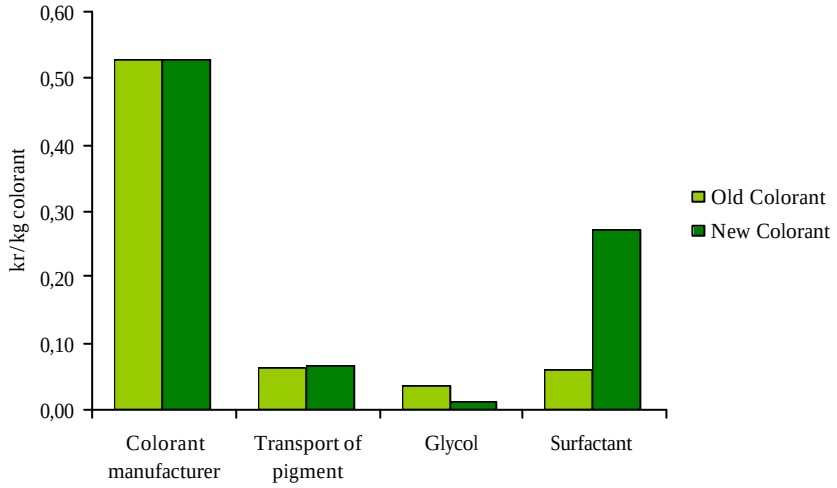

Figure 4 Contributions from the production of raw materials and manufacture of the colorants to the total environmental costs of the two colorants.

The main difference in environmental costs of the two colorants is caused by the difference in environmental costs of the two surfactants, Berol 09 and Bermodol SPS 2532.

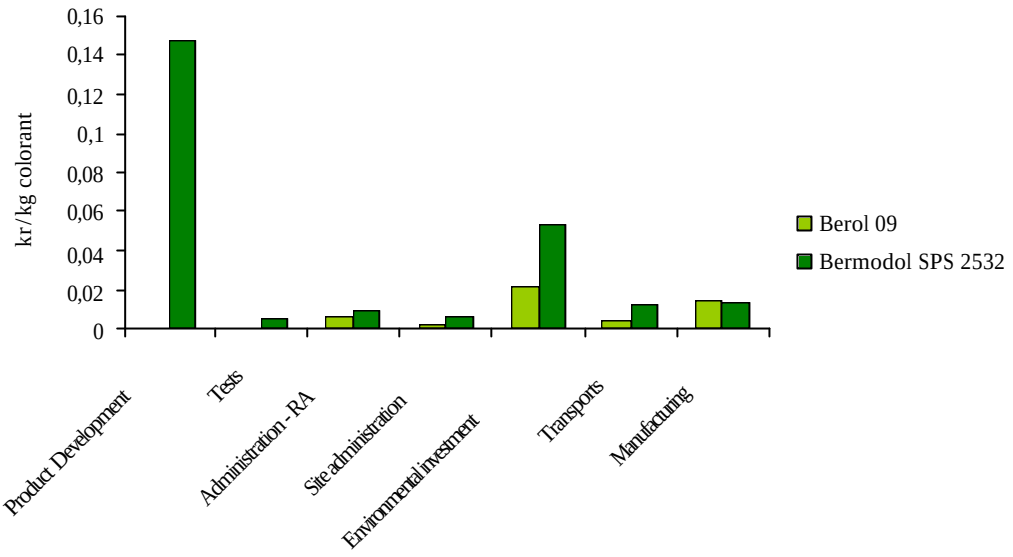

Figure 5 Environmental costs caused by the surfactants Berol 09 and Bermodol SPS 2532. Contributions from different activities in the life cycle of the surfactants are described.

In Figure 5 the environmental costs of the surfactants used in the two colorants are compared. The comparison is made on amount of surfactants used in one kg of colorant. The different amount of surfactant used in the two colorants is the main reason for the difference of their environmental cost per kg colorant.

The product development cost consists almost entirely of costs for the personnel in the development team. Administration and site administration costs consist of costs for personnel and different environmental fees. The manufacturing costs consist of taxes caused by the use of oil and natural gas in the production and costs for measurements performed during production The other costs in the figure are already described in chapter 5.

The development cost of Bermodol SPS 2532 is a significant environmental cost for the new colorant. Since Bermodol SPS 2532 was developed as an environmentally favorable alternative to Berol 09, the development cost is clearly an environmental cost. It is not obvious that this cost should be allocated to Bermodol SPS 2532 and the new colorant; this is discussed further in chapter 9.

The environmental costs that Akzo Nobel carries for the two surfactants have been compared to these products' sales price to get an idea whether environmental costs are important for the studied products. The results of the comparison shows that the environmental costs are approximately 6,3% of the sales price for Berol 09 and 4,8% of the sales price for Bermodol SPS 2532. It is worth to note that the sales price of Bermodol SPS 2532 is higher than that of Berol 09.

8. Comparison of LCA and eLCC

Since the scope of the LCA and the eLCC differs significantly, a model that includes the environmental costs of raw materials produced outside Akzo Nobel is developed. The model is based on the assumption that the relative sizes of different costs are similar for all raw materials in the supply chain. The size of the environmental costs for raw materials produced outside Akzo Nobel is assumed to be 5% of their sales price.

The result of the LCA is aggregated to one common unit using the EPS method. The EPS method measures environmental impact in ELU, a unit that is an estimate of society's willingness to pay (in EUR) to avoid the damages caused by the environmental impacts that the LCA study measures [Steen 1999].

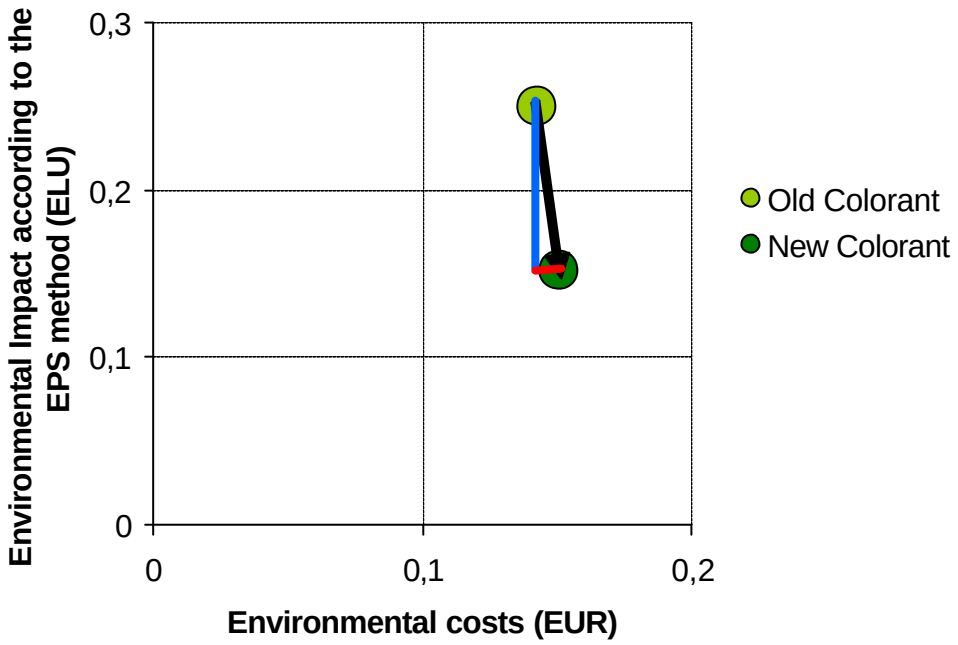

Figure 6. A comparison of environmental impact, using the EPS method to aggregate environmental impact data to one unit, and the total environmental cost of the colorants, including the estimated costs of raw materials produced outside Akzo Nobel.

Figure 6 implies that the substitution has lead to a decrease in the environmental impacts and an increase in the environmental costs of the colorants. The increased environmental costs can be considered as a "payment" to decrease the environmental impact of colorants.

The change in environmental impact divided by the change in environmental costs can be considered an estimate of the environmental costs effect. This concept, the Environmental cost efficiency, describes the value of the environmental improvement per environmental cost unit (EUR).

9. Discussion & Conclusions

Environmental costs

The environmental cost of the studied surfactants was found to be approximately 5% of their sales price. This is a significant cost especially since upcoming legislations are likely to ensure that environmental costs remain a big issue in chemical industries.

The environmental cost of the New Colorant is higher than the environmental cost of the Old Colorant, mainly because of the relatively large impact of the development cost of Bermodol SPS 2532. However, it could be argued that the development cost should be allocated to Berol 09, the product that Bermodol SPS 2532 was developed to replace. This highlights one of the main problems with the environmental costs study: Assembling data for the eLCC study has been more difficult than was first expected. One of the problems was that there is no global definition of environmental costs and the meaning of the concept environmental costs differs from person to person. A large part of the environmental cost data is based on interviews with persons familiar with the products. These persons have made estimations of the environmental costs where no specific data was found. The uncertainty of these estimates could affect the results of the study. Data is collected from different persons with different ideas on environmental costs; this should also be taken into consideration.

Finding the data on environmental costs at Akzo Nobel proved to be a time-consuming task. The idea to view costs and investments as environmental or not environmental is not widespread and the type of costs that are thought of as environmental differs a lot between employees.

Environmental impacts

Results from the LCA study show that the environmental impacts caused by the production of the New Colorant are lower than the environmental impacts caused by the Old Colorant.

The study has not considered the potential toxicity of the colorants or their raw materials and the health and environmental hazards that it can lead to. Environmental impacts considered are mainly air emissions and resource use in the production of the colorants and their raw materials. However, during the development of Bermodol SPS 2532 the focus was mainly on toxicity. It can be concluded that the substitution performed to avoid a toxic raw material lead to the added benefit of lower air emissions and resource use for the production of the colorant.

Combined LCA & eLCC studies

A combination of LCA and eLCC studies could be useful to evaluate the efficiency of environmental investments and can assist in the decision-making process when different environmental improvements are considered.
Reliable environmental cost data is difficult to come by for raw materials to the studied products. If the raw materials are neglected in the eLCC while they are still included in the LCA the two studies (LCA and eLCC) do not describe the same system. This could be solved by estimates of the environmental costs of raw material suppliers but these estimates will lead to added uncertainties in the results. When performing comparisons between alternatives with significant differences in the supply chain this problem should be kept in mind. For the time

being, maybe LCA & eLCC studies are best suited for evaluating alternatives where a majority of the important raw materials is produced by the company performing the study.

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