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A STUDY ON THE PLASMA AND IT'S LIFE CYCLE

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ABSTRACT

In the 21st century, treating textile materials in a way that is beneficial to the environment is of the utmost importance. The traditional processing of textile materials is a manufacturing process that uses up a significant amount of water, dyestuff, and energy. The use of energy, raw materials, and auxiliary components is significantly reduced thanks to the plasma treatment's much improved efficiency. As a result, research has been conducted in the field of plasma treatment of textile materials with the purpose of demonstrating its ability to reduce negative effects on the environment. Regarding this topic, a thorough LCA analysis has been carried out, and Sima Pro 7 was the supporting software application that was utilized. The findings of the research have demonstrated that textile materials treated with plasma nanotechnology have functional properties that are either equivalent to or even superior to those of textile materials treated with the traditional technique. According to the findings of the LCA study, the fabrics that were treated with plasma nanotechnology had a much smaller negative influence on the surrounding environment.

Keywords: *plasma, textile, cotton, LCA study*

INTRODUCTION

In comparison to the traditional treatment that is done as part of the preparatory process for finishing, the purpose of this article is to demonstrate that the plasma treatment applied to textile materials results in a more environmentally friendly product. This comparative LCA study was able to be carried out because the functional qualities that were produced as a result of the two different forms of treatment were very similar.

We planned to conduct research in the field of plasma treatment on textile materials as the overarching objective of the research activities. The purpose of these studies was to highlight the benefits of plasma treatment and to distribute the results to industrial multipliers in the shape of European textile SMEs. The ability of textile products made with plasma treatments to perform many functions confers a competitive advantage on European small and medium-sized enterprises (SMEs) and enables the production of goods with a high value-added content.

INCDTP – Bucharest has certified laboratories for the examination of textile materials (RENAR certified laboratories), and it also has a plasma treatment installation from Europlasma Belgium: the CD 400 Roll-to-roll low-pressure plasma installation (fig. 1) in its endowment. Both of these facilities are accredited by RENAR. In order to highlight the need for performing the comparative LCA analysis, we would like to offer an overall perspective of the research activities that have been carried out in the field of plasma treatments on textile materials, which are as follows:

- An in-depth research study in the field of plasma treatment on textiles was completed;
- As a consequence of plasma treatment, the functional qualities of textile materials were improved:

Fig. 1. Installacion de plasma para tratamiento

a functionality that repels water, a functionality that attracts water, and a functionality that fights microbes. The plasma installation was used to treat a large number of textile samples; the functionality of the samples was determined by the following characteristics of the plasma treatment:

- The Kind of Gas Used; the Kind of Frequency Generator; the Amount of Power; the Amount of Time Spent on Treatment; the Temperature; and the Pressure
- Anti-microbial research tests were carried out in accordance with the requirements of Standard ISO 20743:2007 in order to provide evidence of the anti-microbial properties possessed by medical products that had been treated with plasma [4]. After being treated with plasma, the fabrics were given a final coating of colloidal silver, chitosan, and thyme oil. Bandages, surgical gowns, and bed linen for operating rooms were all envisioned to round out the assortment of medical supplies.

The improvement of the qualities of textile materials through the use of plasma treatment with a variety of parameters represents a significant step forward in terms of the novelty degree of the research studies that have been carried out. As a result, we were able to achieve a hydrophobic effect on fabrics by treating them with hexafluoropropane gas plas- ma. With oxygen plasma treatment, we were also able to achieve a hydrophilic effect, also known as a wettability effect; this may be followed by the application of colloidal silver, chitosan, and thyme oil for an enhanced anti-microbial impact. The Turkish partner PLUS ELECTRONIC was successful in producing an industrial plasma treatment facility, which made it possible for the laboratory studies to be replicated on an industrial scale.

In spite of this, one of the final tasks consisted of providing evidence of the ecologically benign nature of the plastic treatment in comparison to the traditional treatment, and this is the topic that will be discussed in the following article.

EXPERIMENTAL

The plasma treatment study operations on textile materials yielded positive findings across the board in every one of the planned research premises. These findings were discussed in a number of studies published in the past. In light of the preliminary finishing procedure for cotton woven fabrics, the purpose of this article is to compare and contrast the environmentally friendly qualities of fabrics that have been treated with plasma and those that have been treated using traditional methods. In order to carry out the comparative life cycle assessment (LCA), the piece of software known as Sima Pro 7 was utilized. A life cycle assessment (LCA) will typically consist of four stages (fig. 2), as outlined by Standards 14040 and 14044.

GOAL AND OBJECTIVES

The completion of a comparative research between two different types of therapies was the primary goal of the LCA study that was carried out:

- The cloth that is woven from cotton (189 g/m^2) use the traditional approach;
- The cloth that is woven from cotton (189 g/m^2) with the use of plasma therapy;

The life cycle assessment (LCA) is a cradle-to-gate study that investigates the two approaches to processing woven cotton fabrics, in the context of a laboratory setting, at the manufacturing stage. The treatments' practical capabilities in relation to both fabrics

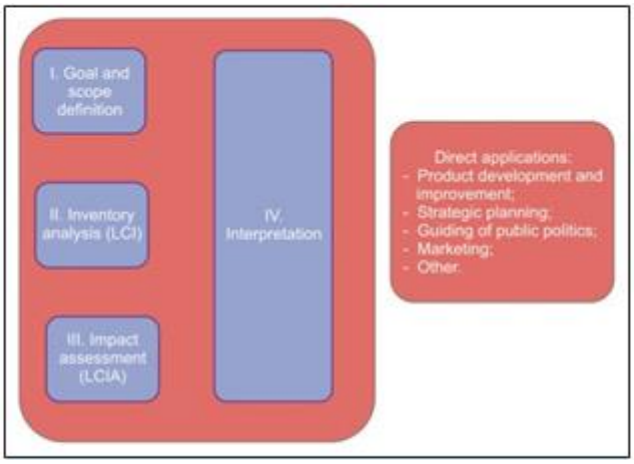

Fig. 2. The four stages of a life-cycle assessment (LCA) research in accordance with Standard 14040

In accordance with the findings of the research, the procedures are comparable as follows: a treatment with oxygen gas plasma was carried out in order to clean the surface of the fabric; this method substitutes the preliminary classical finishing that was previously performed on the cotton fabric. As a result, it was possible to conduct a comparative LCA research on the two different treatment techniques. The comparison will be made using one kilogram of completed woven cotton fabric as the functional unit. The purpose of this life cycle assessment (LCA) is to provide evidence of the eco-friendly nature of the plasma treatment that is performed on textile materials.

The shortcomings of the system were:

A. It was introduced in calculation:

a. The utilization of unprocessed materials;

b. The use up of the earth's natural resources;

c. The use of items that are supplementary to chemical production;

d. The amount of energy that is used by the treatment installations to run on electrical power.

B. It was excluded from calculation:

a. The amount of power consumed for heating (gas or coal), which is seen as being comparable in both approaches;

b. The transportation of the materials, which is disregarded as being of any importance in this scenario.

The LCA approach that was utilized for this particular investigation was Eco-indicator 99 (E) version 2.08.

This LCA study intends to disseminate its findings to the research and academic environments, in addition to the industry environments, which are represented by the small and medium-sized textile businesses (SMEs) in Romania and Europe.

RESULTS

Both treatment techniques' inventory data have been registered within the scope of the LCI investigation. In this study, we only compared the results of the two different approaches to find out which one was better. This indicates that the data for making the raw cotton woven fabric were not paid enough attention to.

The transformation of the total quantity of woven fabric that has been processed into linear meters serves as the basis for the model that is used to calculate the amount of electrical energy that is consumed by the installations that are utilized in the traditional processing of cotton woven fabric. With the width of the fabric being 1.50 meters and the specific weight being 189 grams per square meter, the result is 283.5 grams per linear meter. 100 kilograms of cotton fabric is equal to 352,7 linear meters, and 1 lm is equal to 0.2835 kilograms.

Table 1

ELECTRICAL ENERGY CONSOMPTION FOR THE CLASSICAL TREATMENT METHOD						
Operation	Time duration (min.)	Time duration (h)	Power (kW)	Electrical energy consume (kWh)	Electrical energy Consume kWh/m1)	Electrical energy consume (kWh/kg fabric)
A. Preliminary preparation Degreasing	45	0.75				
Alkaline cleaning	120	2				
Hot washing	30	0.5				
Warm washing	30	0.5				

Cold washing	30	0.5				
Neutralizing	30	0.5				
Cold washing	30	0.5				
Total preparation	315	5,25	15	78.75	0.223	0.7875
B. Dyeing	90	1.5	15	22.5	0.0637	0.225
Total dyeing	90	1.5	15	22.5	0.0637	0.225
C.Superior finishing a. Fireproofing Drying stenter /min: speed: 10 lm b. Hydrophobic effect: Drying stenterspeed:10 ml/min	35.3 35.3	0.59 0.59				
Total superior finishing	70.6	1.18	58	68.44	0.1940	0.6844
TOTAL general	475.6	7.93		169.69	0.4807	1.6969

The calculation that was done was as follows: L = P t, where L is the amount of electrical energy that was consumed, P is the amount of power that was installed, and t is the amount of time that was spent on treatment. It has now been possible to retrieve the subsequent table of consumes (see table 1).

The calculations for the exhaust treatment method make up the model for the consumption of chemical compounds during the preliminary treatment of cotton fabric. The model includes the following components: According to the research, the exhaust ratio is 1:3. This indicates that 300 liters of exhaust bath are needed to clean 100 kilograms of cotton woven fabric. During the preliminary treatment, a concentration of 0.5 g of Kemapon per liter is utilized for degreasing the material. It produces an exhaust bath with a volume of 300 l as a result: 0,5 g/l □ 300 l = 150 g Kemapon. We utilize 150 grams of Kemapon per 100 kilograms of cotton, which equals 1.5 grams of Kemapon every kilogram of final cotton fabric. This model is applicable to the Preliminary preparation (A) and Dyeing procedures (B), but for padding in the event of Superior finishing (C), we utilize a different calculating model.

The model for calculating the amount of plasma needed for the installation treatment needs to take into account the plasma treatment's parameters, which are as follows:

- Gas consisting of oxygen; the generator's frequency is kHz; the generator's power is 50 watts; the treatment lasts for 120 seconds; the pressure is 20 millitorr; and the temperature is 19.8 degrees Celsius.

At a total weight of 106 g O2, an estimation of the amount of oxygen gas was made using the law of ideal gases, which states that p V = n R T. In order to calculate the amount of electrical energy that is consumed, we have the formula L = P t, where P is equal to 32 kW (based on the data from the machine), and t is equal to 120 seconds. As a consequence, an electrical energy usage of L1 = 1.06 kWh is produced. The consequence of this is the table3, which contains data on comparative life cycle inventories.

Table 2

RECIPE FOR THE TECHNOLOGY PROCESS OFPRELIMINARY PREPARATION	
A. Preliminarypreparation	**Recipe/Parameters**

1. Degreasing –washing	Temperature = 50 ^{O}C; Duration: 45 min Recipe: Kemapon PC/LF : 0,5 g/l
2. Alkaline classicalfinishing	Temperature = 98 ^{O}C; Duration: 120 min Recipe: NaOH: 8–20 g/l / Na_2CO_3:1/3 from NaOH Kemapon PC/LF : 0,5 g/lKemapon SR 40: 0.5 g/l (Concentration reducer: 1 – 2 g/l)
3. Hot washing	Temperature = 90 ^{O}C; Duration: 30 min
4. Warm washing	Temperature = 70 ^{O}C; Duration: 30 min
5. Cold washing	Temperature = 30 ^{O}C; Duration: 30 min
6. Neutralizing	Temperature = 40 ^{O}C; Duration: 30 min Acetic acid = 0.5g/l
7. Cold washing	Temperature = 30 ^{O}C; Duration: 30 min

TABLE 3

COMPARATIVE LIFE CYCLE INVENTORY DATA							
-. Functional unit = 1 kg finished woven fabric							
Classic treatment:				**Plasma treatment:**			
Process	Substances	Consum	Consume energy	Process	Substances	Consume substanc	Consume energy
Preliminary preparation Exhaust rate 1:3	Kemapon PC/LF	15g	0,7875 KWH	Treatment in Oxygen plasma	Oxygen	=>106 g O_2	32 KWHx 2 min = 1.06 KWH
Alkaline cleaning: Exhaust rate 1:3	NaOH= 8-20 g/l	30g					
	Na2CO3= NaOH 1/3 from	10g					
	Kemapon PC/LF	1.5g					
Neutralizing: Exhaust rate 1:3	Acid acetic:	1.5g					

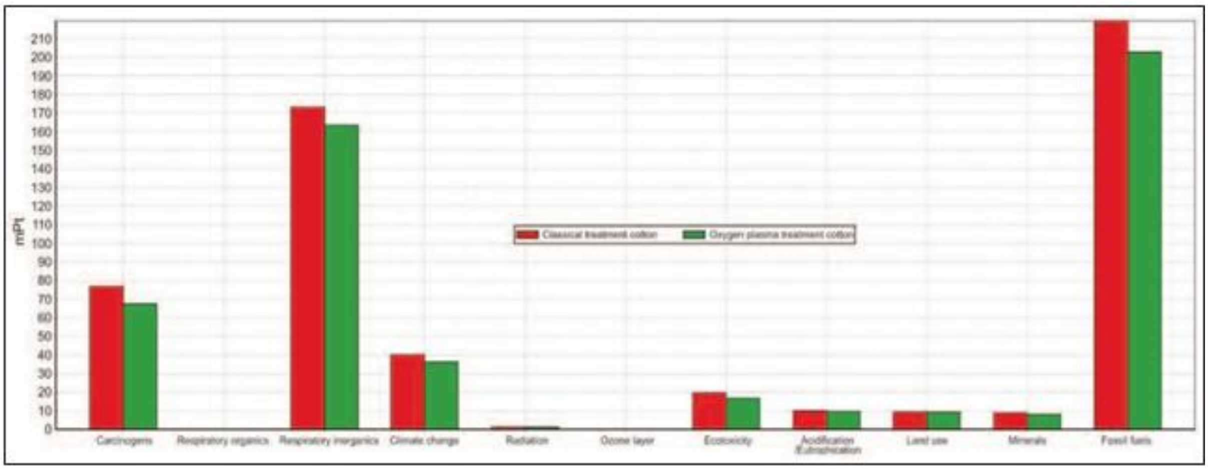

Fig. 3. Evaluation of environmental impacts through weighted comparisons

DISCUSSION

Results from processing LCI data with Sima Pro 7 are shown in the Life Cycle Inventory Assessment research.

As a summary, we will present a weighted comparison diagram (figure 3).

- A red cotton woven cloth that has been given a traditional treatment;
- Plasma-processed cotton woven fabric (in green).

Figure 3 displays the Eco-indicator 99 (E) assessment method's impact categories. Toxins, radiation, ozone depletion, acidification, eutrophication, land usage, minerals, and fossil fuels are all examples of environmental impacts. This graphic's weighting factor representation is calculated by multiplying each impact category by a weighting factor proportional to the category's global environmental impact.

In terms of carcinogens, respiratory inorganics, climate change, and fossil fuel use, the graphics show that plasma treatment is less harmful to the environment than traditional treatment.

CONCLUSIONS

The meaning of the LCA can be derived from the information presented in figure 3. According to the LCA method's Eco-indicator 99 (E), the traditional treatment method has a greater negative impact on the environment than any of the other impact categories. As a result, we are able to draw the conclusion that the plasma treatment approach is a treatment method that is friendlier to the environment. The plasma treatment of textile materials is an effective and contemporary technology for the finishing of textile materials. This method, which has the potential to be used on a wide scale in the textile enterprises of Europe, has a number of potential benefits. In light of the findings of this study, there is a compelling argument to be made for the introduction of plasma treatment installations on an industrial scale. This treatment method for textile materials is kind to the environment while also offering specialized functions and increased productivity.

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