BISCOL Project

BIoprocessing for Sustainable production of COLoured textiles

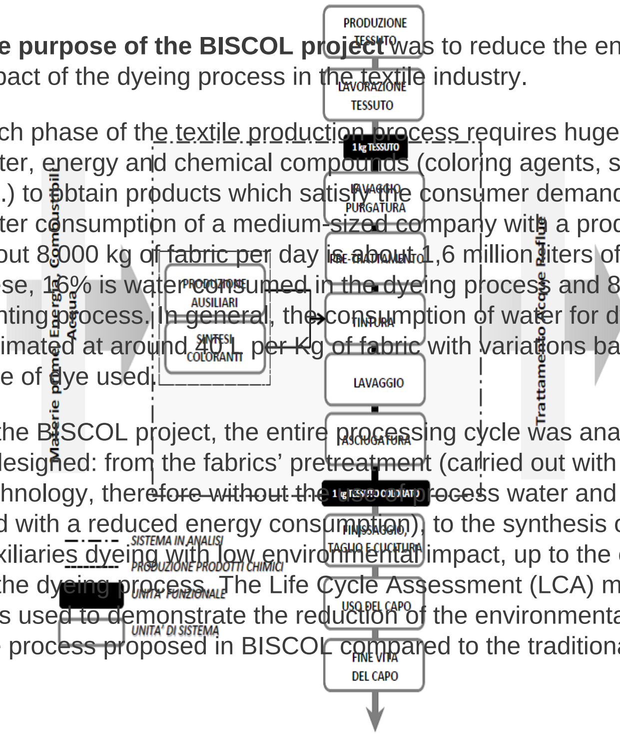
ecodesign | eco-innovation | circular economy | Life-Cycle assessment | production process | reduced environmental impact | eco-friendly products

PROJECT DESCRIPTION

The purpose of the BISCOL project was to reduce the environmental impact of the dyeing process in the textile industry.

Each phase of the textile production process requires huge quantities of water, energy and chemical compounds (coloring agents, surfactants etc.) to obtain products which satisfy the consumer demand. The daily water consumption of a medium-sized company with a production of about 8,000 kg of fabric per day is about 1,6 million liters of water. Of these, 16% is water consumed in the dyeing process and 8% in the printing process. In general, the consumption of water for dyeing is estimated at around 40 L per Kg of fabric with variations based on the type of dye used.

In the BISCOL project, the entire processing cycle was analyzed and redesigned: from the fabrics' pretreatment (carried out with plasma technology, therefore without the use of process water and chemicals and with a reduced energy consumption), to the synthesis of dyes and auxiliaries dyeing with low environmental impact, up to the optimization of the dyeing process. The Life Cycle Assessment (LCA) methodology was used to demonstrate the reduction of the environmental impact of the process proposed in BISCOL compared to the traditional one. Fig. 1



PROJECT PHASES

The BISCOL project developed a **new textile dyeing process** based on the optimization of the entire process, from raw materials to the finished product, with particular attention to saving energy and reducing water and chemical uses, notably:

- **Fabric pre-treatment**: in the dyeing process, the fabric pre-treatment phase is essential to remove impurities and modify the fibers to obtain a finished product that has the required aesthetic and functional characteristics. The hydrophobic nature of the wool cuticle and the high density of the outermost surface fibers creates a barrier that affects the absorption properties thus influencing the subsequent dyeing and printing processes. Conventionally the modification of the surface fibers is carried out mainly through **wet chemical processes** using special auxiliaries that attack the outermost layer of the wool fibers. Chemical products such as hypochlorites and anti-felt products are used. In this project, the phase concerning the fiber **pre-treatment** was carried out with a **Plasma device** (Homogeneous Dielectrical Barrier Discharge – HDBD; European Patent, EP 1993330) operating on a semi-industrial scale that works continuously using non-polluting gases (nitrogen and helium) to facilitate surface activation in woolen fabrics. In general, the surface of the fabric treated with **plasma technology** has advantages over conventional treatments since it is a **dry technology** (water saving) characterized by **reduced energy consumption**, in which **no chemicals** (chlorinated compounds and anti-felt) **are used and the fibers are not damaged**.

- **Synthesis of new auxiliaries**: according to the fiber-dye system, various chemical auxiliaries are used in the dye bath to foster interaction and facilitate the homogeneous fixing of the dye on the fiber. The main role of the auxiliaries is to modify the dye's fixing capacity on a given fiber. **Traditional auxiliaries** can be inorganic (electrolytes, oxidizing/ reducing agents etc.) or organic compounds (surfactant type) which are partially consumed during the dyeing process, while a large part remains in the dye bath. **New auxiliaries** (a mixture of ethoxylated stearyl alcohol with ethoxylated stereic amine and another mixture of ethoxylated polyaryl phenol with low molecular weight alcohol) have been **specifically developed and used** in this project **to increase the efficiency** of the dyeing process reducing the quantity of non-aromatic compounds required to obtain a quality product.

- **Synthesis of bio-dyes: new acid dyes** have been bio-synthesized **enzymatically**. Biocatalysis allows the development of low environmental impact synthesis processes. Acid dyes for fabrics have been synthesized in BISCOL using **oxidative enzymes**. For this purpose, a **bioreactor** has been created containing the laccase enzyme for industrial scale up. Since the synthesis of the dye is carried out in **water solution**, a **reverse osmosis** process was used to obtain the **optimal dye concentration**. The market for traditional liquid dyes is growing as an alternative to powder dyes. This solution also has advantages over the consumption of energy and resources since in this way the phases of drying and re-dissolution of the product are avoided with consequent benefits also for workers.
- **Optimization of the dyeing process**: the fundamental step of the entire dyeing process is the application of the dye to the fabrics in water. Conventionally, high temperatures and pressures are used. A **specific protocol** has been defined within BISCOL which optimizes the process with particular attention to **reducing the temperature and dyeing times.**
- **Monitoring of the various project phases**: approach based on the use of the ***Life Cycle Assessment (LCA)*** procedure. This method allowed to compare, step by step, the conventional process with that proposed within the project monitoring the following environmental aspects: **consumption of raw materials or resources** measured as consumption of abiotic material (ADP), **impact on the atmosphere** in terms of acidification potential (AP), global warming (GWP), photochemical ozone creation (POCP), **impact on water resources** in terms of eutrophication (EP), **impact on toxicity** as ecotoxicity of fresh water (FAETP), human toxicity (HTP), marine (MAETP) and terrestrial (TETP) ecotoxicity. In addition, an **energy analysis** was conducted based on the demand for non-renewable cumulative fossil energy (CED).

PROJECT RESULTS

The results based on the primary data obtained by the project consortium clearly show that significant environmental benefits can be achieved with the proposed new dyeing protocol:

- The use of irradiation procedures for the pre-treatment of the fabrics allows a **saving of about 70% of direct energy** (about 150kJ for plasma treatment against 540 kJ for conventional treatment) and more than **85% of global energy** (direct energy plus the energy needed for the raw materials treatment, approximately 0,615 MJ for plasma against 50MJ for conventional treatment);
- The new dyeing protocol requires a **smaller quantity of auxiliaries (about 30% less for 100 g of fiber)** and this leads to a general reduction in waste water pollution.
  Overall, the **combination of plasma treatment and the use of new auxiliaries leads to a reduction in CO_2 emissions of approximately 37% and an overall energy saving of 25%;**
- From the energy consumption point of view, the new dyeing protocol allows **savings of 55% of direct energy and about 70% of indirect energy** thanks to the use of raw materials whose production requires less energy;
- About 0,1 cubic meter of water is used per kg of wool fabric, meaning a treatment with **60% less water consumption** compared to the conventional process;
- **3.82 kg of CO_2 equivalent emissions per kg of treated wool fabric are saved with a reduction of approximately 55% of the emissions** compared to the conventional process.

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Acronym
BISCOL

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ECO/09/256112/SI2.567273

Reference Programme
[COMPETITIVENESS AND INNOVATION FRAMEWORK PROGRAMME (CIP) ECOINNOVATION]

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EU contribution
764.813,00

Call Year
2010

Start Year
2010

End Year
2013

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