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# Combination of ozone and ultrasound in pretreatment of cotton fabrics prior to natural dyeing

Hüseyin Benli [a, *], Muhammed İbrahim Bahtiyari [b]

[a] Mustafa Çıkrıkçıoğlu Vocational School, Erciyes University, Kayseri, Turkey
[b] Department of Textile Engineering, Erciyes University, Kayseri, Turkey

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ABSTRACT

In the study it was aimed to show an alternative finishing process for cotton fabrics. The fabrics were pretreated with ozone and ultrasound combination instead of conventional energy intensive and chemical based finishing processes. Moreover the coloration of the pretreated fabrics was conducted by the use of plant based natural dyes. For this aim the extracts obtained from pomegranate peels, nutshell, orange tree leaves and alkanet roots were used. By this way it was planned to introduce an environmentally friendly finishing for the cotton fabrics and at the same time the usability plantal wastes in textile coloration processes were presented. It was observed that with the use of ozone gas and ultrasonic washing, sufficient pretreatment values with limited tensile losses could be obtained. Moreover it was found that by the use of tested plantal wastes the coloration of cotton fabrics can be managed.



## 1. Introduction

Cotton fibers grow in the seed hair pod of cotton plants and cultivated in warm climates (Needles, 1986). Pretreatment of the cotton fibers is required to remove natural and human-induced impurities (Wakelyn et al., 2007). Conventional pretreatment processes such as desizing, scouring, bleaching and mercerization for cotton fabrics consume enormous amounts of energy, water and chemicals (Min and Huang, 1999). In addition, current pretreatment processes, using harsh chemicals and severe conditions, are also problematic from an environmental point of view because of the high COD, BOD, pH, and salt content in textile effluents and high air pollution due to high energy consumption (Ibrahim et al., 2004). In this respect, instead of conventional pretreatment processes studies on environmentally friendly methods are of great importance.

Ozone can be an alternative in terms of ecological demands. It is a strong oxidizing agent, capable of participating in many chemical reactions with inorganic and organic substances (Iglesias, 2002). There is a lot of research papers published about use of ozone in the textile wet processes. For instance, Both Prabaharan and Rao (2001) and Perincek et al. (2007) reported the importance of moisture amount and the pH of moisture during ozone bleaching of greige cotton fabric and they showed the use of ozone in bleaching of cotton fabrics. Atav and Yurdakul (2011) used ozone in order to improve the dyeability of mohair fibers. Likewise in another study the effect of ozone on the whiteness degrees and dyeability of Angora rabbit fiber was investigated and it was found that by ozonation the dyeability of angora fibers has increased significantly after dyeing with milling type acid dyestuffs (Perincek et al., 2008). The other environmentally friendlier alternative can be the use of ultrasounds. Because ultrasound, and its beneficial effects offer the potential for shorter reaction cycles, cheaper reagents, and less extreme physical conditions, leading to less expensive and, perhaps, smaller plants (Vajnhandl and Le Marechal, 2005). Several researchers have reported the usability of ultrasound in textile processes. For example, Yachmenev et al. (2004) reported the positive effect of ultrasonic energy for intensification of the cotton bio-preparation and Hao et al. (2013) were studied the ultrasonic effect on the desizing efficiency of cotton fabrics. In another study, the efficiency of raw wool scouring process via ultrasound was searched and the authors were reported benefits of the use of ultrasound in wool scouring (Bahtiyari and Duran, 2013). Likewise the positive effect of ultrasound in bleaching processes of cotton (Mistik and Yükseloğlu, 2005) and wool (Bahtiyari et al., 2012) has been reported too.

* Corresponding author.
*E-mail addresses:* hbenli@erciyes.edu.tr, hbenli.2013@gmail.com (H. Benli).

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The dyeing of textiles can also cause environmental problems too. Up to the end of the 19th century natural dyes were the main colorants for textiles. But the introduction of synthetic dyes led to an almost complete replacement of natural dyes due to the several advantages such as wide range of available colors, higher reproducibility, improved quality and etc. (Bechtold et al., 2006). However almost all the synthetic colorants being synthesized from petrochemical sources through hazardous chemical processes pose threat towards its eco-friendliness (Samanta and Konar, 2011). Generally, large volumes of wastewater, containing significant amounts of dyes and chemicals, are discharged from typical cotton dye warehouse. Therefore, natural dyes are generally environmentally friendlier and have many advantages over synthetic dyes (Kamel et al., 2009). Additionally different advantages of using natural dyes sources have been studied recently. For example, Baliarsingh et al. (2012), examined the solvent extraction of natural dyes from two plant species called "Saraca asoca" and "Albizia lebbeck", and they have reported that the dyed silk displayed excellent antimicrobial activity. Ghaheh et al. (2014) studied five different natural dyes obtained from green tea, madder, turmeric, saffron petals, and henna they showed that all these natural dyes could provide some antibacterial activity against *Staphylococcus aureus*, *Escherichia coli*, and *Pseudomonas aeruginosa* bacteria on wool fabric. In another study ultraviolet protective properties of the fabrics dyed by *Rheum* and *Lithospermum erythrorhizon* were investigated. This study has showed that some natural dyes have got solar UV-protective properties (Feng et al., 2007). Hou et al. (2013) were used orange peel extracts for dyeing of wool fabrics. They have reported that orange peel extracts have great potential as a natural textile dyestuff and could impart remarkable UV-protection properties. Besides this, studies on introduction of different natural dye sources are popular too. For instance, Tutak and Benli were studied the dyeing properties of the leaves, coat, shell and dice of the hazelnut in coloration of wool, cotton and viscose fabrics by using different mordants (Tutak and Benli, 2012). In another study, the usability of green shell of almond fruit as a novel natural dye was introduced by Erdem Işmal et al. (2014).

## 2. Methodology

In the light of the introduction part it is easy to talk about the serious demand and studies on the environmentally friendly finishing of textile goods. As a result of this, the study was aimed to develop an environmentally friendly textile finishing process. For this aim, pretreatment of cotton was managed with the use of both ozone gas-ultrasonic energy and further dyeing was conducted with natural dyes obtained from plantal wastes such as; pomegranate peels, nutshell, orange tree leaves and alkanet roots as schematized in Fig. 1.

### 2.1. Materials

#### 2.1.1. Fabric and the natural dye sources

In the study 100% woven, starch sized cotton fabric with a weight of 200 g/m$^2$ was used for experiments.

For the coloration of the fabrics pomegranate peels, nutshell, orange tree leaves and alkanet roots were used:

*Pomegranate peels:* Pomegranate is native to Western Asia, most likely from Iran, Northeastern Turkey and the region of the South Caspian Sea. It has been cultivated from early antiquity for its valuable fruit throughout the Mediterranean and North African regions, including Central Saharan oases (Bruni et al., 2011). The major coloring component in pomegranate is tannins, ellagic acid, extracted from the fresh and dried peels (Adeel et al., 2009). During the study grinded dried pomegranate peels were used as natural dye source.

*Nutshell:* Turkey is the main hazelnut producer in the world, contributing approximately 70% of the total global production (Alasalvar et al., 2003). During the study grinded nutshell was used as natural dye source.

*Orange tree leaves:* Oranges are grown in tropical and subtropical climates throughout the world. Brazil and the United States are the top-producing countries and Turkey is the other principal country that grows oranges (Shultz, 2005). The dried orange tree leaves from Turkey has been used as natural dye source.

*Alkanet root:* Alkanet (*Alkanna tinctoria*) belongs to the family Borginaceae. The roots, which are often very large in proportion to the size of the plant, yield in many of the species a red dye. The main pigment is alkannin, which was earlier called anchusin (Rekaby et al., 2009). During the study grinded root of alkanet was used as natural dye source.

#### 2.1.2. Equipments

During the study ozone generator and ultrasonic bath used to remove noncellulosics matter on the raw cotton and pretreatment of it. The capacity of the ozone generator (ProdOzon) is 25 g/h. The ozone gas flow was maintained at a constant rate of 5 L/min for the all experiments. An ultrasonic bath (Wiseclean) with a volume of 2 L in 28 KHz frequency was used for ultrasonic treatment. Meanwhile to obtain dyes from the natural dye sources a soxhlet based system has been equipped.

### 2.2. Methods

***Conventional pretreatment method:*** Firstly, greige cotton fabrics were pretreated conventionally with the recipes shown in Table 1.

Instead of the conventional pretreatment processes, the fabrics were also pretreated with the aid of ozone and ultrasound. These processes were called as environmentally friendly ***pretreatment methods*** in the study.

Environmentally friendly ***pretreatment method:*** The aim of this study is to show the usability of ozone gas and ultrasound as pretreatment of cotton fabric prior to natural dyeing without mordant. All samples were dried in room temperature before testing.

Ozone and ultrasound has been applied to the fabrics step by step. In the first application step the wetted fabrics were treated directly with ozone gas for 15 min in a closed system. It is well

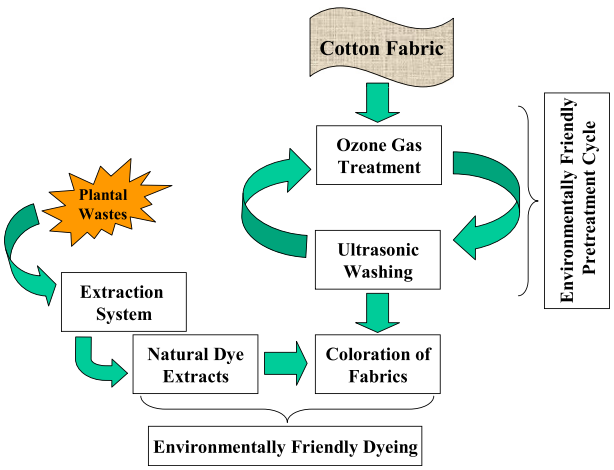


**Fig. 1.** The schema of the proposed green process line.

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