Ecological dyeing of natural fabrics with renewable raw materials-plant derived colorants

Patrycja BRUDZYŃSKA[1,*], Alina SIONKOWSKA[1]

*[1]Department of Biomaterials and Cosmetic Chemistry, Faculty of Chemistry, Nicolaus Copernicus University in Toruń, Gagarina 7 street, 87-100 Toruń, Poland, * patrycja.brudzynska@umk.pl*

NICOLAUS COPERNICUS UNIVERSITY IN TORUŃ

1.Colorants

Currently the most of society is aware of how important is sustainable development, the ecological approach in many different industries and using renewable and green raw materials.
The application of natural and renewable materials and the need to create various products not contributing to the destruction of the environment and available resources are renewed. In various areas for example in cosmetics, food, textiles, leather or paper industries substances like colorants are widely applied.

2.Textile industry

- It is estimated that nowadays textile industry consumes one of the greatest amounts of colorants.
- Mainly synthetic ones are used to impart the desired color to different materials. However, they can have unfavorable environmental and health effects. Receiving them is associated with numerous stages and reactions contributing to the consumption of toxic or not environmentally friendly substances and solvents.
- Recently, plant derived colorants have become increasingly desired, because of their eco-friendly properties and beneficial health effects.

3.Plant derived colorants

- As a renewable and green source of color may provide a healthier alternative.
- They are biodegradable, do not pollute the environment and do not require the usage of harmful solvents and substances
- Besides dyeing ability, botanical colorants have various other properties like antimicrobial or antioxidant ones, which provide additional benefit of application.
- Are known to society for thousands of years and were used in many fields.
- Those colorants are successfully applied in food but have also potential to be successfully applied in the textile and cosmetic industry.

4.Limitations on use of plant derived colorants

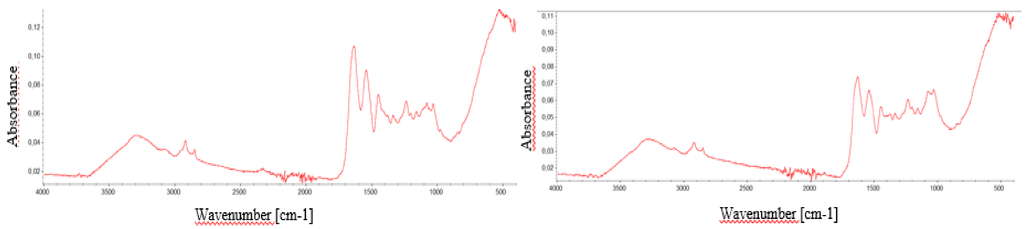
are related to instability under various conditions: pH, temperaturę, UV radiation, storage.

5.The aim of the work

- the possibility of using plant derived colorants for dyeing different types of fabrics such as cotton, linen, silk and leather without inorganic mordants.
- assessment of the effect of additives such as chitosan and shellac on the properties of the colored fabrics
- evaluation of stability of colored fabrics under influence of UV radiation, washing and evaluation of mechanical properties.

Type of fabric	L	a	b
Dyed cotton	42.44	22.35	6.71
Dyed cotton after 30 minutes exposure to UV radiation	50.38	16.58	7.70
Dyed cotton after 2 hours exposure to UV radiation	58.44	12.43	9.44
Dyed cotton after 4 hours exposure to UV radiation	63.21	9.85	10.43
Dyed cotton after 30 minutes of washing	57.60	4.52	3.0

CIE Lab values of cotton dyed with 1% water solution of blueberry and carrot extract before and after exposure to UV radiation and after washing.



Exemplary FTIR-ATR spectra of leather fabric before dyeing and after dyeing with chitosan pre-treatment

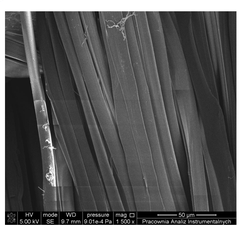


Fig. 1

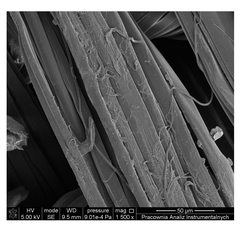


Fig. 2

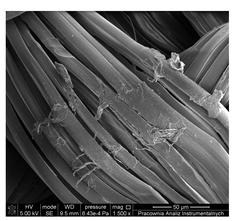


Fig. 3

Non dyed silk fabric (Fig.1), silk fabric pretreated with 1% chitosan solution in 3% citric acid solution and dyed with 1% water solution of chokeberry, elderberry and apple extracts (Fig. 2), silk fabric pretreated with 1% chitosan solution in 3% citric acid solution and dyed with 1% water solution of chokeberry, elderberry and apple extracts after 4 hours under the influence of UV radiation (Fig. 3)

6.Materials and methods

- 60 g/m^2 **silk satin** was dyed four different colors: **green** (powder form; safflower, spirulina with maltodextrin as carrying agents), **yellow** (liquid form; pumpkin, apple), **pink** (liquid form; beetroot, carrot) and **red** (liquid form; chokeberry, black lilac, apple) in two concentration of colorant: **1%** and **4%** in liquor ratio **1:25** in acidic conditions in a cold process at room temperature without heating (**cold dyeing**) for 1 day
- 225 g/m^2 **cotton** was dyed **yellow** (powder form: safflower and lemon with maltodextrin as carrying agents) in **1%** concentration of colorant, in liquor ratio **1:25** in acidic conditions in a **cold dyeing** for 1 day
- 240 g/m^2 **cotton and linen** was dyed **purple** (liquid form: blueberries and carrot) in **1%** concentration of colorant, in liquor ratio **1:25** in acidic conditions in a **cold dyeing** for 1 day
- **Vegetable tanned goat leather** was dyed **purple** (liquid form: blueberries and carrot) in **1%** and **5 %** concentration of colorant, in liquor ratio **1:25** in acidic conditions in a **cold dyeing** for 1 day

7.Modification of fabric with polymers

To modify and improve properties of colored fabrics different additives were applied in subsequent dyeing process:

1. To all types of materials
1% solution of **chitosan** in 3% citric acid was added. In first variant chitosan was applied to dyebath and in other 1 hour of pre-treatment before dyeing process was carried out.

In textiles chitosan has the ability to increase color yield and binder efficiency, can give stiffness to the fabric or antimicrobial properties.

2. Moreover all types of materials after dyeing process were covered with 20% of **shellac** etanol solution.

Shellac is used in textile industry, it can improve fabrics strength and stiffen them, improve their water-resistance and thus can ensure longevity by providing protection against moisture weakening.

8.Methods for fabrics evaluation

- To study colorfastness of dyed fabrics under the influence of light the colored samples were treated with UV radiation.
- Colored materials were examined by ATR-FTIR measurements.
- Mechanical properties-tensile properties of dyed fabrics were tested with Zwick&Roell machine.
- Their resistance to washing was examined.
- Also colorimeter measurements and SEM analysis were performed

9.Results

- Not all plant derived food colorants were appropriate for fabrics dyeing.
- A 1% concentration of colorants was sufficient to dye fabrics, only in the case of leather higher concentration of 5% were required.
- However, after washing, the color fastness of dyed fabrics deteriorated significantly, also with chitosan addition.
- After 4 hours of UV irradiation, all fabrics showed the change in color shade, but the dyed cotton showed the poorest colorfastness.
- Chitosan treatment and shellac covering influence tensile properties.

Some of the colored fabrics are shown below (Fig. 4):

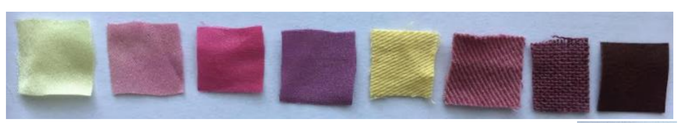


Fig. 4

Sample of dyed cotton (above)
and sample of cotton
after 4h of UV exposure (below) (Fig. 5)

Fig. 5

10.Conclusions

Plant derived colorants have potential to dye natural fabrics. Dyed fabrics show acceptable colorfastness over time. Their colorfastness after washing was not acceptable and resistance to UV radiation particulary of cotton and linen requires further research.