

ORIGINAL

Open Access

Comparison between antibacterial activity of some natural dyes and silver nanoparticles

Mohammad Mirjalili and Mina Abbasipour*

Abstract

Curcuma longa rhizome (turmeric), walnut, and henna are medicinal plants which are traditionally used for fiber colorations. In this study, the viscose rayon fabrics were dyed with different mordant at a variety of conditions. The dyed fabric and treated fabric with Ag nanoparticles were evaluated for antibacterial activity against pathogenic strain of Gram-negative (*Escherichia coli*) bacteria. Durability of antibacterial activity to laundering was also investigated. The results indicated that treated fabrics with these natural dyes had excellent antibacterial activity as well as Ag nanoparticles before and after wash.

Keywords: Natural dyes, Ag nanoparticles, Antibacterial activity, Durability

Background

Nowadays, the demand for antibacterial fabric and health care has increased; so, finding a method to get antibacterial textile is a challenge. Fibers, especially natural fibers (wool and cotton), provide basic requirements such as moisture and nutrients for bacterial growth and multiplication. This often leads to objectionable odor, dermal infection, product deterioration, and other related diseases [1-4]. A variety of materials like quaternary ammonium salt, metal oxide nanoparticles, and nanocomposites are reported as antibacterial agents [1-3]. Using synthetic non-biodegradable chemical compounds for these approaches cause environmental and health concerns. Although natural dyes are known for a long time for dyeing as well as medicinal applications, the structures and protective properties have been recognized only in the recent past [4,5]. Many of the plants used for dye extraction are classified as medicinal, and some of these have recently been shown to possess remarkable antimicrobial activity [6]. Several sources of plant dyes rich in naphthoquinones such as lawsone from henna, juglone from walnut, and lapachol from alkanet are reported to exhibit antibacterial and antifungal activities [7-10].

Curcuma longa, also known as 'turmeric', is used as a coloring agent, and has medicinal properties. Various

sesquiterpenes and curcuminoids have been isolated from the rhizome of *C. longa*, attributing to its biological characteristics such as antioxidant, anti-inflammatory, wound healing, anticancer, antiproliferative, antifungal, and antibacterial properties [11,12].

In this study, viscose fabric was dyed with walnut, turmeric, and henna, and its antibacterial properties were those treated with Ag nanoparticles.

Results and discussion

Antimicrobial activity of natural dyes

Table 1 shows the antimicrobial activity of turmeric, walnut, and henna in different conditions. The dyed fabric with turmeric powder under alkaline condition created a greater effect in reducing bacteria concentration as compared to that under acidic condition. As results show, the dyed fabrics with these natural dyes show high bacterial reduction activity.

Table 2 shows the reduction of bacterial concentration of Ag nanoparticles. The fabric treated with silver nanoparticles performed very high activity with reduction of bacteria against *E. coli*.

As Table 3 shows, the dyed samples with turmeric, walnut shell, and henna in different conditions have good washing fastness.

Figure 1 shows a summary of the antibacterial activities of the samples dyed with turmeric, henna, and walnut and the sample treated with Ag nanoparticles after 20 washings, respectively. As it is evident, the dyed

* Correspondence: mina.abbasipour@gmail.com
Department of Textile Engineering, Yazd Branch, Islamic Azad University, Yazd, Iran

Table 1 Antimicrobial evaluation against *E. coli* in different conditions

Condition of dyeing	Mordant	% R (turmeric)	% R (henna)	% R (walnut shell)
Neuter	-	91.25	97.65	99.56
Acetic acid	-	99.3	99.1	99.6
NaOH	-	97.65	98.41	99.12
Acetic acid	Potash alum	97.41	99.96	99.64
NaOH	Potash alum	97.52	98	99.3
Acetic acid	Potassium bichromate	99.75	99.89	99.92
NaOH	Potassium bichromate	99.82	99.98	99.4

samples withstand severe laundering which indicate good durability.

Conclusion

Viscose fabric was dyed with three different natural dyes (walnut, turmeric, and henna) under different conditions. The antibacterial activity of dyed samples against *E. coli* were compared with treated samples containing silver nanoparticles. The results indicated that treated fabrics with these natural dyes had excellent antibacterial activity as well as those treated with Ag nanoparticles before and after wash. The dyed fabric with turmeric powder under alkaline condition created a greater effect in reducing bacteria concentration as compared to that under acidic condition. The dyed fabric with potassium bichromate mordant had good reduction of bacteria concentration in alkaline and acidic condition. Dyed sample with turmeric under neutral condition did not have good antibacterial activity.

Methods

Materials

In this study, the viscose rayon fabric, Ag nanoparticles, walnut, turmeric, and henna powders were used throughout experiments. Alum and potassium bichromate were purchased from Merk Co., Ltd (Whitehouse Station, NJ, USA). Silver nanoparticles (average size of <150 nm) were supplied from Sigma Aldrich Co., Ltd (St. Louis, MO, USA).

The method of dyeing

Viscose fabrics were dyed by exhaustion method in different conditions (acidic, alkaline, and neuter) as shown in Figure 2. In the dye preparation, 3 g of turmeric and henna powder were dissolved in 40 ml of distilled water, and temperature was gradually raised to 90°C over 30

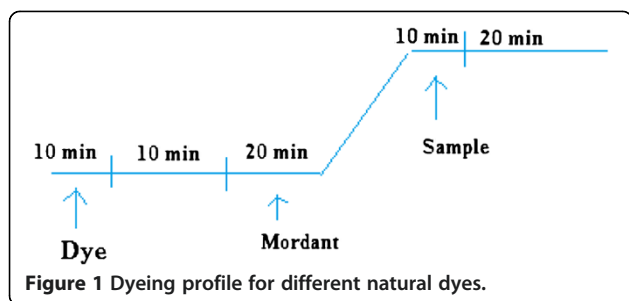
min and maintained at 90°C for 5 min. In using walnut shell as the dye, 5 g of walnut were added to 50 ml of distilled water and temperature was maintained at 90°C for 40 min. Viscose fabrics were dyed with 2% (owf) of dye. Alum and potassium bichromate were used as mordant. The material-to-liquor ratio was 1:20 and temperature was raised to 90°C over 30 min and

Table 3 Evaluation of washing fastness of treated samples

Condition of dyeing	Washing fastness	
	Color change	Staining on cotton
Turmeric		
Neuter	3	2
Acetic acid	5	3.5
NaOH	4.5	4.5
Acetic acid + Potash alum	3	3
NaOH + Potash alum	3	4
Acetic acid + Potassium bichroate	4.5	4.5
NaOH + Potassium bichroate	4.5	4.5
Henna		
Neuter	3	3
Acetic acid	3	3
NaOH	4.5	5
Acetic Acid + Potash alum	4.5	5
NaOH + Potash alum	4.5	5
Acetic acid + Potassium bichroate	4.5	5
NaOH + Potassium bichroate	4.5	5
Walnut shell		
Neuter	4	5
Acetic acid	4.5	5
NaOH	4.5	5
Acetic acid + Potash alum	5	4.5
NaOH + Potash alum	5	4.5
Acetic acid + Potassium bichroate	5	4.5
NaOH + Potassium bichroate	5	4.5

Table 2 Antibacterial activity of Ag nanoparticles against *E. coli*

Sample	% R (<i>E. coli</i>)
Nanosilver-treated fabric	100



maintained at 90°C for 30 min. Dyed fabric was rinsed with cold water and dried.

Treated fabric with Ag nanoparticles

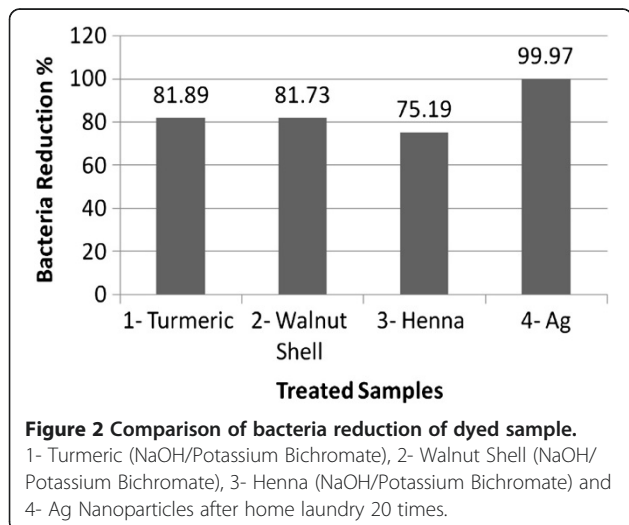
The fabric was dipped in the 5% Ag colloidal solution; dried at 80°C and cured at 160°C for 4 min.

Wash fastness test

The treated samples were washed according to the ISO 105 C10 (2006) to determine the color change and the antimicrobial effect of fabrics after laundering. A gray scale was selected for evaluating washing fastness.

Antibacterial test

The antimicrobial activity was quantitatively evaluated against *Escherichia coli* (ATCC 6538), a Gram-negative organism, according to the AATCC 100 test method. The fabric samples with 4.8 ± 0.1 cm in diameter were placed in a 250-ml glass jar with screw cap and absorbed 1.0 ± 0.1 ml of bacterial inoculum. After incubation over contact periods of 24 h, 100 ml of sterilized distilled water was added into the jar and shaken vigorously for 1 min. The solution was then serially diluted to 10¹, 10², 10³, and 10⁴. The diluted solution was plated on a nutrient agar and incubated for 24 h at 37°C ± 2°C. Colonies of bacteria recovered on the agar plate were counted,



and the percent reduction of bacteria (R) was calculated by the following equation:

$$R(\%) = (B-A) \times \frac{100}{B}, \quad (1)$$

where A is the number of bacterial colonies from treated specimen after inoculation over 24 h of contact period and B is the number of bacterial colonies from untreated control specimen after inoculation at 0 contact time.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

MM participated in the design of the study and performed the statistical analysis. MA conceived of the study and participated in its design and coordination. Both authors read and approved the final manuscript.

Acknowledgements

The authors want to express their thanks to Prof. Omid Moradi.

Received: 6 April 2013 Accepted: 24 May 2013

Published: 30 May 2013

References

- Han, S, Yang, Y: Antimicrobial activity of wool fabric treated with curcumin. *Dyes and Pigments* **64**, 157–161 (2005)
- Ali, S, Hussai, T, Nawaz, R: Optimization of alkaline extraction of natural dye from henna leaves and its dyeing on cotton by exhaust method. *J. Cleaner Prod.* **17**, 61–66 (2009)
- Sarkar, RK, De, P, Chauhan, PD: Bacteria-resist finishes on textiles using natural herbal extracts. *Indian Journal of Fiber and Textile Research* **28**, 322–331 (2003)
- Othmers, K: *Encyclopedia of chemical technology*. Interscience **7**, 7–81 (1967)
- Hussein, SAM, Barakat, HH, Merfort, I, Nawwar, MAM: Tannins from the leaves of *Punica granatum*. *Photochemistry* **45**, 23–819 (1997)
- Gerson, H: Fungi toxicity of 1,4-naphthoquinones to *Candida albicans* and *Trichophyton mentagrophytes*. *Can. J. Microbiol.* **21**, 197–205 (1975)
- Schuerch, AR, Wehrli, W: beta-Lapachone, an inhibitor of oncornavirus reverse transcriptase and eukaryotic DNA polymerase-alpha inhibitory effect, thiol dependence and specificity. *Eur. J. Biochem.* **84**, 197–205 (1978)
- Wagner, H, Kreher, B, Lotter, H, Hamburger, MO, Cordell, GA: Structure determination of new isomeric naphthol [2,3-b] furan- 4,9-diones from *Tabebuia avellanedae* by the selective INEPT technique. *Helv. Chim. Acta* **72**, 67–659 (1989)
- Machado, TB, Pinto, AV, Pinto, M, Leal, IC, Silva, MG, Amaral, AC, Kuster, RM, Netto-dosSantos, KR: In vitro activity of Brazilian medicinal plants, naturally occurring naphthoquinones and their analogues, against methicillin-resistant *Staphylococcus aureus*. *Int. J. Antimicrob. Agents* **21**, 84–279 (2003)
- Gulrajani, ML, Gupta, D: Wash fastness tests to test durability. In: *NCUTE Workshop on Dyeing and Printing with Natural Dyes*, pp. 3–5. IIT, Delhi (2001)
- Barik, A, Mishra, B, Kunwar, A, Kadam, RM, Shen, L, Dutta, S, Padhye, S, Satpati, AK, Zhang, HY, Priyadarshini, KI: Comparative study of copper(II) ecurcumin complexes as superoxide dismutase mimics and free radical scavengers. *Eur. J. Med. Chem.* **42**, 431–439 (2007)
- Singh, R, Jain, A, Panwar, S, Gupta, D, Khare, SK: Antimicrobial activity of some natural dyes. *Dyes and Pigments* **66**, 99–102 (2005)

doi:10.1186/2193-8865-3-37

Cite this article as: Mirjalili and Abbasipour: Comparison between antibacterial activity of some natural dyes and silver nanoparticles. *Journal Of Nanostructure in Chemistry* 2013 **3**:37.