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# Imparting functionality *viz* color, antioxidant and antibacterial properties to develop multifunctional wool with *Tectona grandis* leaves extract using reflectance spectroscopy

Shahid-ul-Islam [a,*], Shahnawaz Ahmad Wani [b], Faqeer Mohammad [a,*]

[a] Department of Chemistry, Jamia Millia Islamia (Central University), New Delhi, 110025, India
[b] Department of Biosciences, Jamia Millia Islamia, New Delhi, India

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ABSTRACT

In recent years, considerable attention has been given to plant colorants for use in dyeing applications because of their newly discovered properties such as insect repellency, deodorizing, antioxidant, sun protection, and antibacterial activity. In view of their better biocompatibility, biodegradability, less-toxicity, natural colorants are gaining worldwide interest for producing elegant hues and highly functional value-added textiles. In the present work, we investigated the coloring and functional finishing of wool with *Tectona grandis* L. leaves extract with the emphasis on effect of metallic salt mordants on colorimetric potential, fastness, radical scavenging potential, and antibacterial activity in an attempt to develop bioactive fibres for use in health care applications. The pretreatment of wool with ferrous sulfate, potassium aluminium sulfate and stannous chloride provided a significant enhancement in CIELa*b* parameters and fastness properties. Antioxidant tests showed that the control dyed wool had excellent radical scavenging activity than mordanted samples. In addition, metal mordants particularly ferrous sulfate enhanced the durability of antibacterial efficacy to several laundering cycles. It can be concluded that the extract of *Tectona grandis* may be developed as multifunctional finishing agent to impart simultaneous color, antioxidant and antibacterial properties to wool based fabrics.



## 1. Introduction

In recent years, researchers have paid intense attention to the organic dye extracts produced from plants, animals, and fungi for use in various industries notably in the dyeing and finishing industry [1–4]. There is new increasing interest worldwide on the revival of natural dyes considering their biocompatibility, biodegradability, minimal toxicity, in addition to newly explored functional properties including insect repellency, deodorizing, UV protection, antioxidant and antimicrobial activities [5–9]. Evidence suggests that a great deal of research has been done and is currently underway on wool coloration with plant dyes for assessment of dyeing, fastness and other functional properties [10–13]. Mirjalli et al. [14] reported that wool dyed with weld natural dye gives good fastness results and has the potential to act as co-partner with synthetic acid dyes. Yusuf et al. [15] studied coloration of wool yarns using henna and madder extracts and found that metal mordant pretreatments have greatly improved colorimetric values and wash, rub and light fastness properties. Ghoulia et al. [16] extracted a chalcone based coloring compound isosalipurposide from *Acacia* cyanophylla flowers using spectroscopic methods and studied its dyeing ability on wool. They noticed that *Acacia* cyanophylla flower extract in the presence of metallic salts results in bright yellow hues with good light and wash fatness properties. More recently, Ren et al. [17] studied the effect of dyebath pH on wool dyeing using aqueous extract of tea as natural dye and found that at pH5.5 wool displays good color and fastness properties. Navid et al. [18] studied dyeing process optimization of wool with rutin as a natural dye using one-factor-at-a-time (OFT) and central composite design method. Their experimental results revealed that at optimum dyeing condition rutin dye produced deep shades with acceptable fastness properties. Several investigations have also been carried out on the antimicrobial finishing of wool fabrics with plant extracts. Han and Yang [19] reported that wool fabric dyed with curcumin colorant showed antibacterial activity against gram-negative *E. coli* KCTC 1039 and the gram-positive *S. aureus* KCTC 1928. Dev et al. [20] noticed that the leaves extract of henna had

* Corresponding authors.
*E-mail addresses:* shads.jmi@gmail.com ( Shahid-ul-Islam), faqeermohammad@rediffmail.com (F. Mohammad).

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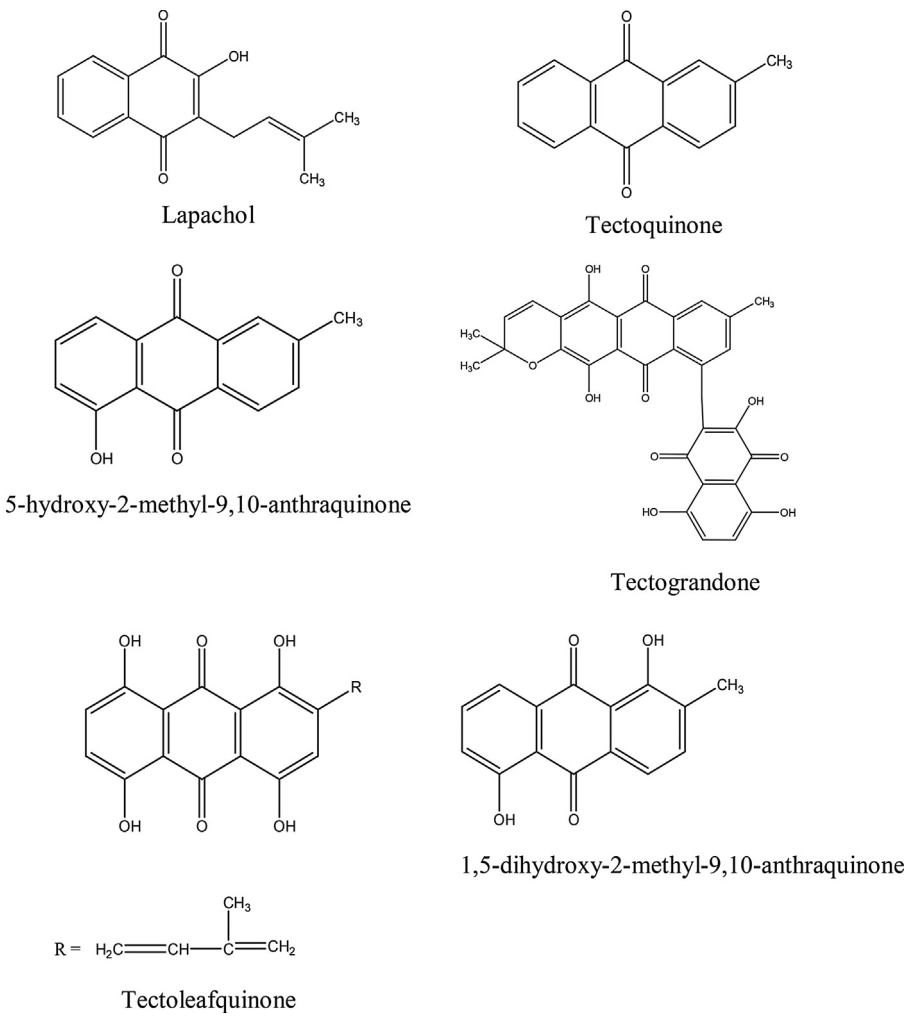


**Fig. 1.** Chemical constituents of *T. grandis* leaves extract.

strong affinity to wool, and the pre-treatment using cationic polymer chitosan improved fastness and antibacterial activity against *Staphylococcus aureus* and *Escherichia coli*. Khan et al. [21] reported that wool yarns treated with *Rheum emodi* root extract displayed antibacterial and antifungal properties that could be correlated to anthraquinone compounds present in its root extracts. Haji et al. [22] observed the excellent antibacterial activity of wool pretreated with biomordant namely *Rumex hymenosepolus* and afterward dyed with berberine dye extracted from Berberis vulgaris wood. In addition, Haji and Shoushtari [23] also reported the development of antibacterial wool with the same colorant via β-cyclodextrin grafting on wool using plasma treatment. Despite the notable progress made in wool coloration using natural colorants, their potential is yet to be fully explored for the functional finishing of textile surfaces. It has also been recently discovered that certain plant extracts display attractive radical scavenging properties after application to textile materials [9,24,25]. Antioxidant finishing using plant dyes has opened a new area of research for scientists to develop textiles for health and hygiene applications [26,27]. Therefore in this study, natural anthraquinone derived colorants from *Tectona grandis* leaves extract were applied to wool yarns previously pre-mordanted with metallic salts to investigate colorimetric and fastness properties. Subsequently, it was attempted to evaluate the antioxidant and antibacterial activity of wool in an attempt to develop multifunctional textile material.

## 2. Experimental

### 2.1. Materials

Pure New Zealand wool yarns were purchased from MAMB Woolens Ltd. Bhadohi, (U.P.) India. *Tectona grandis* dye was purchased from Sir Biotech India Ltd. Kanpur (U.P.), India. Alum, ferrous sulfate, and stannous chloride metallic salts used were of laboratory grade. DPPH, a free radical generator was purchased from Calbiochem (Darmstadt, Germany). Sodium hydrogen carbonate, phosphate, and sodium acetate buffer were purchased from MERCK.

For antibacterial testing, *E. coli* (gram negative bacteria), and *S. aureus* (gram positive bacteria) were selected due to their resistance to commonly used antimicrobials.

### 2.2. Methods

#### 2.2.1. Mordanting and dyeing

Wool samples were mordanted by pre-mordanting method using 10% (o.w.f) (on the weight of fabric) alum ($K_2Al_2(SO4)_4{\cdot}24H_2O$), 5% (o.w.f) ferrous sulfate ($FeSO_4{\cdot}7H_2O$), and 1% (o.w.f) stannous chloride ($SnCl_2{\cdot}2H_2O$) as mordants. Before the application of mordants, woolen yarns were soaked in water containing (5 mL/L non-ionic detergent; Safe Wash Wipro). Selected