

The Use of Metals in the Voltaic Series and Its Implications on How Natural Batik Dye is Fixed

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Abstract

The presence of natural colorants in the batch industry supports efforts to create sustainable products. However, the disadvantage of natural coloring substance is that tissue fibers generally have a low affinity to the pigment components, so the natural colorant is easily flourishing. This fact is based on exploring natural coloring substances and the type of fixator of the corresponding natural coloring substance. In addition to strengthening the absorption of color substances into the fiber, the fixator also serves to know the direction of color produced by the natural coloring substance. In testing, fixers are used that contain metals present in voltaic series. The object of the study is to described the color characteristics produced by natural dyeing substances (secang and tegeran woods) on various types of fixers that are included in the voltaic series. Color quality is assessed from 3 aspects i.e. color intensity parameters visually, color resistance with grey scale and color direction with website colors.co. In general, the secang wood produces the pink color (warm category) while the tegeran wood color is yellow (vintage category). There is a regular sequence of the color concentration of the fabric achieved by each voltaic series metal used as a fixer. If the metal is applied as a fixer to the natural coloring material, the stronger oxidative properties of a metal on the voltaic series, the older the resulting color will be.

Keywords: color quality; natural batik dye; voltaic series

Introduction

Natural colorants are generally obtained from the results of extracts of various parts of plants such as roots, wood, leaves, seeds and flowers (Saefudin & Basri, 2018). Batik craftsmen have known a lot of plants that can color textile materials some of them are the leaves of Nila (*Indigofera sp.*), bark of sog

tingi (*Ceriops candolleana* Arn.), wood of tegeran (*Cudraina javanensis*), turmeric (*Curcuma sp.*), roots of Noni (*Morinda citrifolia*), bark of sog jambal (*Pelthophorum ferruginum*), kesumba (*Bixa orellana*), leaves of guava (*Psidium guajava*), dan wood of secang (*Caesalpinia sappan* L.) (Rini et al., 2011).

The presence of this natural coloring substance strongly supports the efforts to create sustainable products. However, the disadvantage is that it generally has a low affinity to fabric fibers. Low affinity results in a lot of natural color substances dissolved in water or said natural color substance easily undergoes coloring (Suharno et al., 2020). This fact is based on the exploration of natural coloring substances, not only on the type of pigment or part of the plant that contains pigment but also has been extensively studied on the kind of fixator of natural coloring substance. In addition to strengthening the absorption of color materials into the fiber, the fixator also serves to know the direction of color produced by the natural color materials (Utari, 2014)."

The fixers of natural colorants that are frequently utilized include tunjung (FeSO_4), tawas ($\text{Al}_2(\text{SO}_4)_3$), and limestone (CaCO_3). The whole fixator contains a complex of metal that functions to lock the color substance that enters the fiber so that it does not fade or fade easily (Amalia & Akhtamimi, 2016). In addition, the three metals will give a different color direction even though they are used on the same type of color material (Figure1).

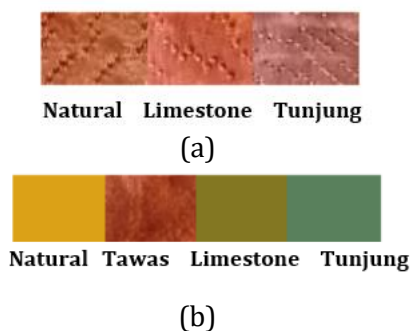


Figure 1. The orientation of the colors of (a) wood and (b) bixa on various types of fixers (Rini et al., 2011)

In the chemical concept, the three metals are reducers. Not only are these three metals, but there are still other metals that are reducers that have the potential to be used as fixers of natural color substances. Some metals such as lithium (Li), potassium (K), barium (Ba), sodium (Na), and so on are known as voltaic series. Voltaic series gives information about the sequence of a metal's

ability to reduce/oxidize certain chemical substances that react with the metal. (Figure 2).

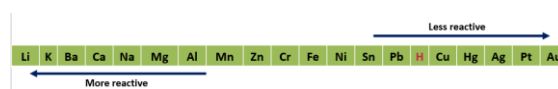


Figure 2. Order of metal elements in the voltaic series (Talbot, 2019)

The rows of metals in Figure 2 are the basis of the relationship between the reaction of the metal in the process of reduction and oxidation (redox) with the direction of color produced by the natural coloring substance if the metals are used as fixers. Not just on the technical and commodities sides, but also on the scientific side, bat conservation research can benefit from the findings of this study.

Methods

This is an experimental study used to look for the influence of certain treatments on others under controlled conditions (Sugiyono, 2021). The purpose of this study is to analyze the quality of color and the resistance of the color of the fabric of batik products resulting from the fixation process using the voltaic series metal on the material of the natural color of wood Secang and Tegeran. In sample fabric evaluation used 3 types of analysis, namely (1) color quality analysis (color density) evaluated from color code, (2) color resistance analysis against washing soap and sweat assessed from the greyscale, and (3) color resistant analysis against the night release process (lorod) assessed by the staining scale.

Materials and Instruments

Materials used in this study include: night/candle batik, cotton fabrics, secang wood, tegeran wood, calcium sulfate, sodium sulfat, magnesium sulphate, aluminum sulphide, iron (III) sulphite, water. The equipment used for this research includes a table cap, gas stove, canting cap, body protective fabric, ender, gawangan, embroidery, cracks, drug scales, gloves, mixers, boot shoes, spectrophotometer UV-

PC ISR 2200, grey scale and staining scale ISO 105-A02.

Procedure

Generally, it is carried out in 3 stages, namely, the first stage is the manufacture of natural wood color materials secang and tegeran (ekstraksi). The second stage is the manufacture of batik with the coloring of natural wood color substances secang and tegeran and the third phase is the evaluation of the color quality and color resistance on the cloth (Figure 3).

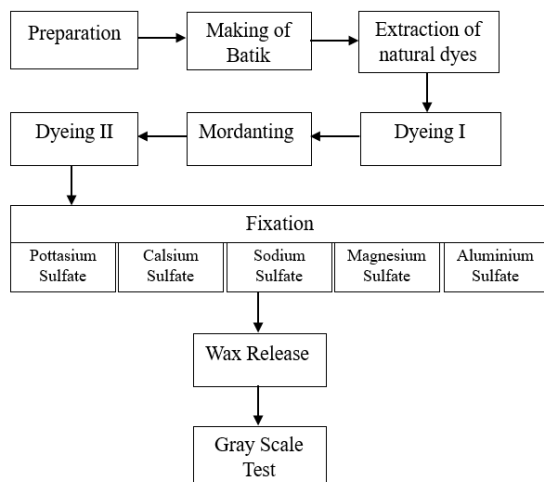


Figure 3. Research steps

Result and Discussion

The presence of natural colorants strongly supports the efforts to create sustainable products. The property of natural coloring substances in general is to have a low affinity to fabric fibers, so many are soluble in water or are said to have natural colorants easily flowering(Kant, 2012). Therefore, it is necessary to use fixers in any process of coloring natural coloring substances. In addition to strengthening the absorption of color materials into the fiber, the fixator also serves to know the direction of color produced by the natural color materials (Saefudin & Basri, 2022).

Color substances for batik are adjective substances such as the colour of natural secang and tegeran wood, before the coloring process is needed aid substances that are

reducers to have affinity with fiber. Once the colorant is bound to the fiber in the melting process, then the colourant must be oxidized using an oxidator (fixator) so that the color does not slip. Generally, batik fermentation uses oxidants such as sulphuric acid, nitric acid or metal complexes such as tawas (Al₂(SO₄)₃), limestone (CaCO₃), tunjung (FeSO₄). Some of these fixers are metal complexes that serve to lock the color substance that enters the fiber so that the resulting color does not fade easily (Aziz et al., 2018). In addition, such a metal complex will give a different color direction even though it is used on the same type of color material.

In the chemical field, iron metals (Fe), aluminum (Al), and calcium (Ca) are in one row of regulation related to the function of such metals as oxidants known as voltage series. This study was conducted to determine the ability of some metals in voltaic ranges if the metal was functioning as an oxidator.



Figure 4. Colors produced by various metal fixators on dyes natural secang (pink) and tegeran (yellow)

In general, the color of cotton cloth with the color material of secang wood gives the color pink while tegeran wood the color yellow. According to the colors.co website (Figure 5), the colors produced by the natural wood coloring substance with the metal fixers Ca, Na, Mg, Al, and Fe belong to the warm colors. Different from the colors produced by the material of natural wood color, with the same metal fixers, the resulting colors belong to the vintage colors.

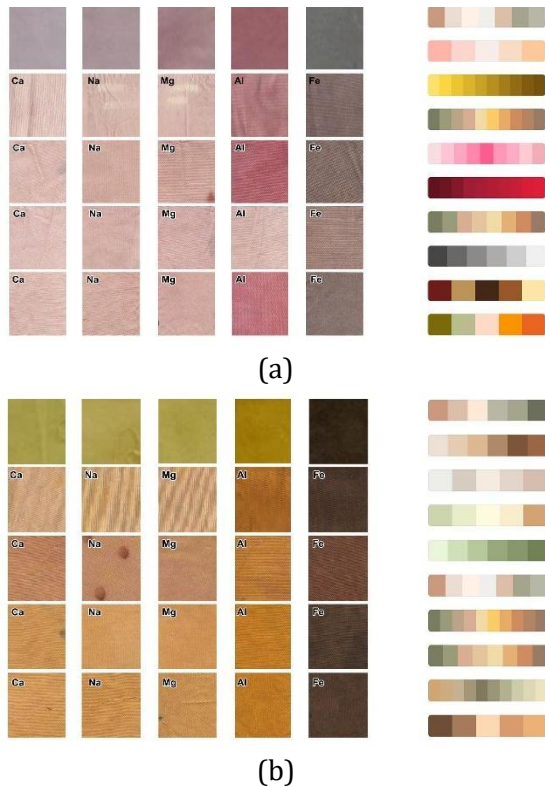


Figure 5. Warm (a) and vintage colors (b), left side: results, right side: colors.co

The use of metallic cations of sodium (Na), magnesium (Mg), calcium (Ca), aluminum (Al), and iron (Fe) as fixers of natural color substances for secang and tegeran wood has been proven to give different colors to cotton fabrics for each type of metal. (Figure 6). The anion used for each metal is the same sulfate ion (SO_4^{2-}), to prevent the presence of anion or reducer contribution to the ability of the metal as a fixer.

After the coloring process, the fabric must be 'lorod' (malam release). At this stage, generally, the color substance that has already been squeezed into the fabric will experience shrinkage (Kusumawati et al., 2017). After this process, the fabric's color is evaluated for the color concentration, color direction, and resistance of the color.

The results of this study showed the regularity of the color concentration sequence of the fabric achieved by each metal used as a fixer. Metal Ca gives the youngest color, and then the color produced by the metal fixator Na is in number two order.



Figure 6. Color codes produced by various metal fixators on (a) natural secang dyes and (b) natural tegeran dyes

The third color concentration sequence is the color that is fixed using the metal Mg, and the older color is achieved by the fixing metal Al. The oldest color of the five fixation metals is achieved by the Fe metal. Visually the color differences produced by each metal are difficult to distinguish. Therefore, color coding is required to provide information about the color differences that appear.

The difference in color concentration sequence achieved by each type of metal used in this study corresponds to the sequence of the metal on the voltaic series (Mueller et al., 2023). Through this fact, the stronger the oxidative properties of a metal on the voltaic series so if the metal is applied as a fixator to the material of natural color, the color resulting will be older. The principle is consistent with the concept of the coloring process. In this context, the color substance used is the natural color material of secang and tegeran wood.

Table of 2. Data evaluation of the durability of the natural color of secang wood on some types of fixers

Fixer	Colorfastness test value to washing soap	Colorfastness test value to acid perspiration	Color fastness test value to alkaline perspiration
<i>(Greyscale)</i>			
Kalsium sulfat	5	Very Good	4/5 Good 3 Moderate
Natrium sulfat	5	Very Good	4/5 Good 2/3 Poor
Magnesium sulfat	5	Very Good	4/5 Good 2/3 Poor
Aluminium sulfat	5	Very Good	5 Very Good 4/5 Good
Besi (III) sulfat	5	Very Good	5 Very Good 4 Good

A good color quality, in addition to being reviewed from color concentration, can also be observed from the resistance of color slide to washing and sweat. The results of the color resistance assessment are shown in Table 1 and Table 2. Based on the two tables, it appears that the resistance to the climbing color of the fabric shows good average values for the color resistance test against washing and acid sweat. The value of color resistance to base sweat is relatively low, this indicates that the natural coloring material of wood and wood has a relatively high thinning when in contact with the base compounds.

A value of 5 means that there is no change and then up to a value of 1, which means that the change in color is very large. The 5 sliding resistance value is shown on a scale by two identical plates placed side by side in a neutral grey color with a reflection of 12 ± 1 percent. The color difference is zero. Sliding-resistant 4 – 5 to 1 bead are shown by identical comparison plates and used for level 5, coupled with identical but younger neutral grey plates. The visual difference between the pairs of values 4, 3, 2, and 1 is the geometric level of color difference or contrast (El-Shishtawy & Kamel, 2002.)

Table of 3. Data evaluation of the durability of the natural color of tegeran wood on some types of fixers

Fixer	Color fastness test value to washing soap	Color fastness test value to acid perspiration	Color fastness test value to alkaline perspiration
<i>(Grey scale)</i>			
Kalsium sulfat	4	Good	3 Moderate 2/3 Poor
Natrium sulfat	3	Moderate	3 Moderate 3/4 Moderate
Magnesium sulfat	3	Moderate	3 Moderate 2/3 Poor
Aluminium sulfat	4	Good	4/5 Good 1/2 Very Poor
Besi (III) sulfat	4/5	Good	5 Very Good 3/4 Moderate

Conclusion

In general, secang wood produces a pink color (warm category) while tegeran wood produces a yellow color (vintage category). In addition, there is a regular sequence of the color concentration of the fabric achieved by each metal used as a fixer. The stronger the oxidative properties of a metal on the voltaic series as a fixator on a natural coloring substance, the older the resulting color will be.

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