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Performance Analysis of Natural–Synthetic Wax Blends, In Batik Silk Dyeing

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ABSTRACT

This study investigates sustainable practices in Batik silk dyeing by analyzing the performance of natural–synthetic wax blends. The objective is to identify optimal ratios of beeswax and paraffin wax that improve resist quality while ensuring Eco-efficiency. Experimental trials were conducted with different blend proportions applied to silk fabric. Key performance indicators, including crackle formation, dye penetration resistance, wax adhesion, ease of removal, and factors such as material efficiency and cost, were systematically evaluated. The results reveal that balanced combinations of beeswax and paraffin wax not only maintain the traditional artistic value of Batik but also provide eco-conscious alternatives that enhance durability and reduce environmental impact. The findings highlight that strategic blending offers a practical solution for artisans and small enterprises, supporting both creative expression and sustainable textile practices. This research contributes to the advancement of eco-friendly innovations in Batik silk dyeing, demonstrating how material efficiency and artistic integrity can be achieved simultaneously.

Introduction

Batik is a traditional wax-resist dyeing technique that has been widely practiced in Indonesia and other parts of the world. It is most commonly produced on natural fabrics such as cotton and silk, which provide excellent absorbency and durability for wax application and dye penetration. Cotton has long been considered the most suitable base due to its accessibility and ease of handling, while silk is valued for its luster and ability to produce vibrant colors, giving Batik textiles an elevated aesthetic quality (Susanto, 1980; Kerlogue, 2004).

The resist effect in Batik relies heavily on the composition of wax. Natural waxes such as beeswax provide flexibility and strong adhesion, while synthetic waxes like paraffin offer brittleness and ease of removal. Blending these waxes allows artisans to control effects such as crackle formation, dye penetration resistance, and overall texture. Beyond artistic outcomes, the composition of wax blends also influences material efficiency, cost, and sustainability in Batik production. Investigating these aspects is therefore essential to balance traditional craftsmanship with modern Eco-conscious practices, ensuring that Batik continues to evolve as both an artistic and sustainable textile tradition. Batik is a traditional craft of wax-resist dyeing applied to textiles, producing intricate and colorful designs. This practice is widespread in countries such as Indonesia, Sri Lanka, India, Nigeria, Malaysia, Singapore, Japan, and China, with Indonesian batik—particularly that from Java—being the most renowned for its artistic mastery, technical refinement, and symbolic depth (Kerlogue, 2004). Beyond its material value, batik motifs embody layers of cultural philosophy and spiritual meaning, making it a significant medium of intangible heritage (Susanto, 1980).

Techniques of batik vary widely, ranging from freehand drawing with wax (written batik) to the use of copper stamps (cap or stamped batik), and more modern combinations that integrate both approaches (Doellah, 2002). Industrial methods such as textile printing emerged in the 1970s, enabling mass production but diminishing the uniqueness of traditional hand-crafted batik (Kartiwa, 1989). These techniques influence the precision of motifs, the complexity of patterns, and the cultural authenticity preserved within the finished fabric.

The tools of batik also play a critical role in defining its artistic outcome. The canting tulis, a traditional copper-and-wood tool for applying hot wax, enables highly detailed designs, while the cap (wooden or copper stamp) allows for faster coverage and pattern repetition (Kerlogue, 2004). Other methods, such as colet, involve painting dyes onto the fabric before wax application, requiring high skill and producing unique, non-replicable results (Doellah, 2002). While machine-printed batik democratizes access through affordability, the handcrafted forms remain cultural masterpieces that embody Indonesia's textile heritage, recognized by UNESCO in 2009 as a Masterpiece of Oral and Intangible Cultural Heritage of Humanity (UNESCO, 2009).

Wax

Waxes are organic compounds primarily composed of long-chain aliphatic hydrocarbons, though some may also contain aromatic compounds or functional groups such as fatty acids, alcohols, ketones, and esters (Gittings, 1990). They are broadly classified into natural and synthetic categories. Natural waxes include animal-derived types such as beeswax and lanolin, as well as plant-based waxes such as soya, carnauba, and rice bran wax. Mineral and petroleum-derived waxes, including paraffin and microcrystalline waxes, represent common synthetic types used in various industries (Kerlogue, 2004).

For Batik production, wax selection directly influences resist quality, crackle formation, and ease of removal. In this study, two types of wax were employed: beeswax (animal wax), and paraffin wax (petroleum-based). Each contributes distinct properties—adhesion and flexibility from beeswax, Eco-friendliness, and brittleness and removability from paraffin—making them suitable for evaluating sustainable Batik practices (Doellah, 2002).

Figure 1 Bees wax

Figure 2 Paraffin wax

Dyeing

Dyeing is a major process in the textile industry, as it imparts new colors and enhances the appearance of fabrics. It is a cost-effective method in which the shade and brilliance of color depend on the class of dye applied to the substrate. Dyeing involves treating a textile product with dye so that color is absorbed and fixed within the fibers, thereby improving aesthetic value. For natural dyes, mordants are often required to improve color fastness properties (Shenai, 1993). The process of diffusion allows dye molecules to move from the fabric surface into the fiber core, ensuring uniform coloration. Effective dyes must exhibit solubility in water, substantiation or reactivity with the fiber, and durability in terms of light fastness, wash fastness, and rubbing resistance.

Dye Class

Dyes are classified into several groups, including reactive, direct, vat, disperse, sulfur, and azoic dyes, each selected according to the fiber type and fabric construction. However, from a range of dyes few dyes are not suitable or are not ideal for Batik due to their incompatibility with wax-resist techniques (Shenai, 1993).

Vat dyes represent one of the oldest dyeing methods, traditionally performed in wooden vessels. Indigo, extracted from the leaves of indigo-bearing plants, is a well-known vat dye and remains widely used, especially in denim production. Reactive dyes, on the other hand, can be particularly suitable for batik, the ability to form covalent bonds with fiber polymers ensures strong fixation, resulting in excellent color yield along with high light, wash, and rubbing fastness (Broadbent, 2001).

In reactive dyeing, the dye is dissolved in water and combined with an electrolyte to enhance penetration into the fiber structure. The addition of alkali activates the reactive groups, enabling covalent bonding between the dye molecule and fiber polymer depending on the dye type, this reaction may occur at room temperature ideal for Batik.

Fabrics: Base Materials for Batik

Batik can be applied to a variety of fabrics, but the most commonly used and suitable bases include cotton, silk, viscose, and linen. Silk is also regarded as a favorable fabric because of its natural luster, smooth texture, and ability to absorb both wax and dye efficiently (Kasmudjo, 2010). While viscose and linen are sometimes employed, they are less common in traditional practices compared to cotton and silk.

Silk fibers are primarily derived from silkworm cocoons and consist of two main proteins: fibroin, which forms the core structure, and sericin, which acts as the surrounding adhesive coating. Raw silk filaments contain longitudinal striations and display a unique composition of amino acids—primarily glycine, serine, and alanine—that form β-pleated sheet structures, contributing to the fiber's strength, flexibility, and sheen (Zhang, 2002). These properties make silk highly receptive to batik dyeing processes and capable of producing vibrant, durable patterns.

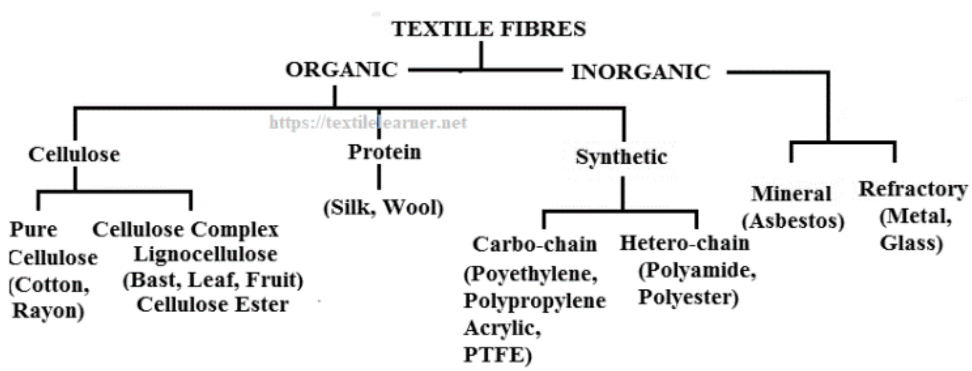


Fig: Types of Textile Fibers

Figure 3

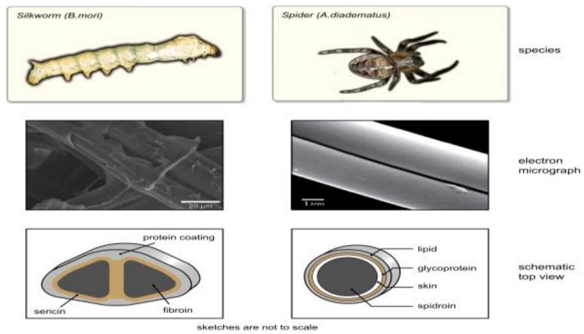


Figure 4

Literature Review

Batik is one of the world's oldest and most distinctive textile traditions, widely recognized as both an artistic practice and a cultural heritage of Indonesia (Sulisworo, 2017). Historically, Batik has been produced on cotton and silk fabrics using natural and synthetic waxes to create resist effects in dyeing. Indonesian Batik, especially that of Java, remains the most renowned for its quality, craftsmanship, and symbolic meaning (Kusumawati et al., 2017). Over time, Batik has evolved from a purely traditional art to a contemporary textile practice supported by exhibitions, academic curricula, and international promotion, ensuring its continued relevance in both cultural and economic contexts even in Pakistan as well.

The wax composition used in Batik plays a decisive role in the quality of resist dyeing, influencing factors such as crackle formation, adhesion, removability, and dye penetration. Prior studies have analyzed the thermo-physical behavior of beeswax and paraffin individually on textiles, showing that beeswax provides flexibility and strong adhesion, while paraffin contributes brittleness and ease of removal (Masae et al., 2015). Some researchers have examined blends of waxes that include beeswax, paraffin, damar, or rosin, testing their resistance to cracking, chemical durability, and staining quality (Kusumawati et al., 2017; Pratiwi et al., 2018). Others have explored alternative waxes, such as soy wax, as more sustainable substitutes (Bowen, n.d.). These studies confirm that blending natural and synthetic waxes can improve certain performance outcomes, but they generally involve multi-component formulations or focus on single-property assessments.

Despite these contributions, there is limited research that systematically evaluates bees wax & paraffin wax solution across varying ratios in batik dyeing. No study to date has comprehensively tested these blends against multiple indicators such as crackle formation, dye penetration resistance, wax adhesion, removability, cost, and sustainability. This research addresses that gap by analyzing beeswax & paraffin ratios applied to silk fabric, thereby offering both artistic insights and eco-conscious solutions for contemporary batik production. The novelty in the wax solution has obtained in respect of taking bees wax constant, scale of 20 grams/ ration and the ratio of paraffin wax kept changing on 20 ration up till it reached to 100 ratio in the molten. Which is in its self a unique approach which not only impact the wax surface texture but also bring change in the viscosity of the molten solution as well which add innovation in crackle effect and ease of wax removal from the sample substrate.

Material And Methods

The study focuses on only a blend of waxes Bees wax and Paraffin wax. Experiments performed on the base fabric of silk substrate. Where the reactive dye recipe is adopted for dying silk samples.The major assessment is to inspire new life in to the impressive, magnificent craft, batik by recognizing different strategies and the correlation in the field of Textile Batik Design, dissolving methodology of set of wax in ratios and the use of reactive dye recipe introduced to bring change to the old culture batik application.

Objectives of the Study

1. To measure the correlation of Bees and Paraffin waxes in scale of gram to achieve exact ration of blend.
2. To measure various degrees of temperature to get the best suitable melting point of wax
3. Application of Reactive dye recipe to achieve the best colour effect.
4. Performance of samples will be checked as before and after by standard tests scale.

Parameters

1. To calculate the suitable ratio of (Bees wax and Paraffin wax), starting from 20-80 grams
2. To calculate the suitable Temperature level by direct heat system, (Hot plate)
3. To calculate the melting point of set of waxes i.e. (Bees wax & Paraffin wax)

Materials and Tools

1. Wax samples Bees wax & Paraffin wax
2. Metallic saucepan and cooking pot
3. Hot plate
4. Disposable cups for dye solution
5. Polka sticks for mixing purpose
6. Apron, face mask and gloves
7. Match box, napkin,
8. Dyes, reactive dye
9. Brushes medium and small size
10. Water

Results & Discussion

Test Results of Pure Silk sample swatch

Details of observations of results are presented in tabular form as below.

Manual Fabric Purity Tests for Silk Swatch

Silk	Textured	Rough	Soft	Smell	Soft smell	Strong smell	Powder Ash	Bead Ash	Ash colour
Hand feel			√						
Crush			√						
Absorbency	√								
Burn				√	Hair		√		Grey
Lustre	√								
Weave	√		√						

Table 01: Silk burn test

Manual Swatch test were performed to check the purity of silk sample

Feel test

Pure silk gives warm feeling when rub in two fingers

Ring test

Pure silk will smoothly glide through the finger ring no matter how much, yards fabric you are passing through.

Lustre/ Shine test

Shine will appear in different colours if you hold the fabric in different directions

Burn test

The most reliable test is burn test. Pure silk will caught fire when close to flame. The fire will be in transparent colour smell is of hair burn and ash will be soft powdery in form.

Silk sample Details

Fabric material: Pure Silk

GSM	36
Ends Per Inch	80
Picks per Inch	78
Warp count	120
Weft Count	116
Fabric Weave	1/1 plain weave

Results of Bees and Paraffin wax direct heat, (Hot plate)

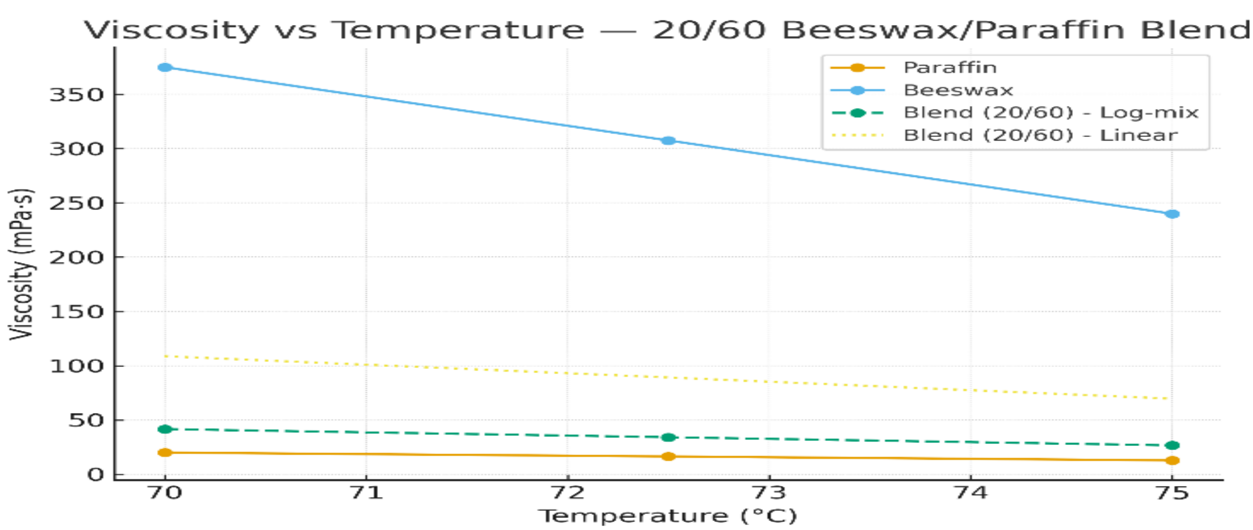
Where the sample size of wax was already adjusted in grams.

Wax Samples size, scale 20 grams remain constant for Bees wax

S.no	Wax blend	Scale in grams	Melting points
1	Bees wax constant	20	70-80℃
2	Bees –Paraffin	20/20	70-75℃
3	Bees –Paraffin	20/40	70-74℃
4	Bees –Paraffin	20/60	70-75℃
5	Bees –Paraffin	20/80	70-75℃

Table: 02 Wax Blends ratios

Viscosity graph 20/60 beeswax–paraffin blend, 70–75 °C



Graph: 01 Viscosity vs Temperature

Figure 05: Molten state of Bees wax and Paraffin wax

Result Conclusion

Silk sample

Measured resulted wax scale size of bees wax and paraffin wax is 20/ 60 with 70-75�a temperature, ideal crystal formation and smooth application and fast removal of wax on the silk sample was achieved. The viscosity–temperature relationship of the 20/60 beeswax–paraffin blend presented in Figure X is based on estimated means derived from rheological principles and literature values. A closely related study by Da Silva, Ribeiro, Gioielli, and Gonçalves (2007) characterized beeswax–paraffin blends and confirmed that viscosity decreases significantly with increasing temperature.

Recipe for Batik, Reactive Dying, Silk Sample

Dye = (x) grams per litter according to the shade intensity Light to Dark whatever required For example,

1. Dye = 10 grams per litter
2. Water = 1000 ml
3. Caustic = 15 grams
4. Dying time = 40 minutes
5. Normal tap wash = 1to 2 minutes
6. Neutralization Acetic acid = 7.5 grams in 500 ml water
7. Acetic acid dip time = 5 minutes
8. Hard wash hot water with detergent = 2 to 3 minutes

Method, Dye make up

Take reactive dye, (10 grams per litter) mix the dye in a normal room temperature water, (1000 ml) add caustic, (15 grams) in the solution mix the solution well now dip the sample (wax treated) in the solution for maximum 10 minutes.

Figure: 6 Reactive dye solution

Figure 7 Neutralization

After that take out the samples and wash it with normal running tap water for at least 2 minutes. Take Acetic acid, (7.5 grams in 500 ml water) for neutralization of the dyed samples. Dip the sample in the solution for 5 minutes

Soaping

After that take out the sample and wash it with normal running tap water for at least 2 minutes, then give it a hard wash (hot water) with detergent for 2 to 3 minutes for the removal of wax.

Drying process

Dry the sample by iron keeping news prints, (paper) under and over the sample to make sure maximum removal of wax keep repeat the iron process unless you achieve the neat news print. Repeat the process with more different colours to achieve colour variations in samples. Now the sample is ready for further tests.

Conclusion

The result effect were extraordinary and highly recommended due to ease while performing batik dying because this specific dye is cool dye class which does not require heat, further dying in reactive dyes are more simple and take shot time to complete the procedure.

Standard Tests

- American Association of Textile Chemists and Colorists
- Water Absorbency (AATCC-79:2010
- International Organization for Standardization
- Colour Fastness to Washing (ISO- 105 CO3)
- Air permeability (ISO9237: 1995)
- Colour Fastness to Crocking (ISO-105X12)
- Fastness properties Test

(Batik treated Silk fabric of Bees wax and Paraffin wax)

S.N	Recipe	Washing Fastness Soap/ Surf (5-8)Washes		Crocking Fastness	
		Cold wash	Hot wash	Wet	Dry
1	Reactive Dye	4-5	4-5	4	4

Table: 03 Fastness Properties Test

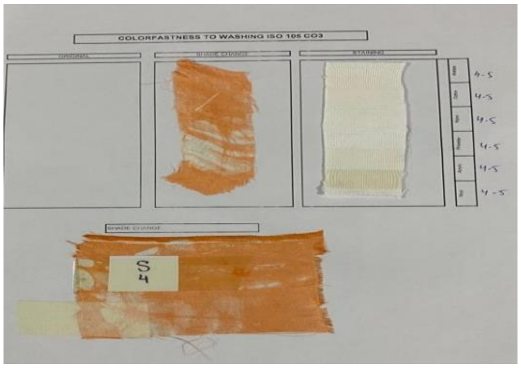


Figure 08: Fastness test result, Silk sample **Figure 09: Fastness test, Silk sample**

Washing Fastness

Sample	Recipe	Bees wax and Paraffin wax
Silk	Reactive Dye	4

Table: 04 Washing Fastness

Results Comparison Crocking Fastness of (Bees + Paraffin wax) Batik treated Silk Samples

Crocking Fastness

Sample	Recipe	Bees wax and Paraffin wax
Silk	Reactive Dye	4

Table: 05 Crocking Fastness

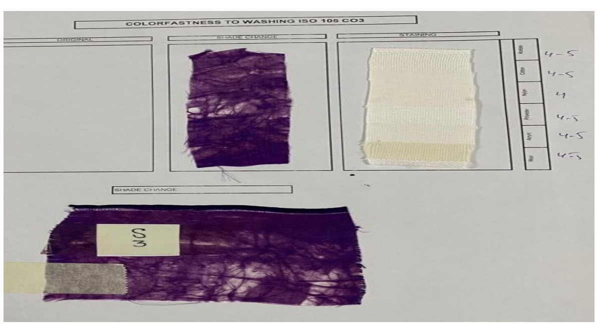


Figure 10: Washing fastness test result, Silk sample **Figure11: Washing fastness, Silk sample**

Washing Fastness

Sample	Recipe	Bees wax and Paraffin wax
Silk	Reactive Room Temperature Dye	4

Table: 06 Washing Fastness

Air Permeability (MM/SEC @ 100 PA) (ISO-9237:1995)

Sample	Material	Bees wax and Paraffin wax
1	Silk	800mm /sec

Table: 07 Air Permeability

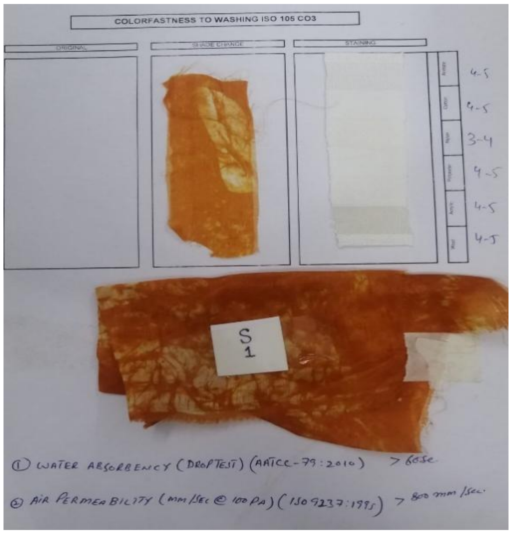


Figure 12: Air permeability test result, Silk sample **Figure 13: Air permeability, Silk sample**

Water Absorbency (Drop test) (AATCC-79:2010

Sample	Material	Bees wax and Paraffin wax
Silk	Silk	60 sec

Table: 08 Water Absorbency

Result Table Comparison of Recipe (Reactive Dye) of (Bees wax + Paraffin wax) blend (Bees wax & Paraffin wax) of Batik treated Silk Samples

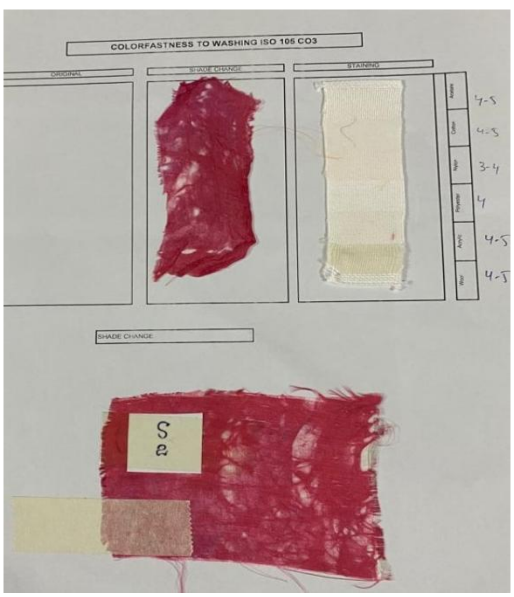


Figure 14: Batik Silk sample result **Figure 15: Batik Silk sample result**

Sample	Recipe	Bees wax	Procedure	Time Duration
Silk	Reactive Dye	Excellent 4	Simple	Short

Table: 09

Hazard and Precautions

No such hazard were noticed while working in wax regarding inhaling and respiration. Main precaution should be taken care of, while working on direct flame keep the flame on medium to avoid fire, because wax catches fire in no time.

1. Be care full and never leave hot wax un-attended, as it is a fire hazard. Always make sure you have a fire extinguisher or bucket of sand nearby if in case of emergency.
2. Keep water away from the wax pot, as it will splatter.
3. Avoid use of open flames, such as a gas or propane burner, instead use a Hot plate with a degree temperature indicator.
4. Make sure your hair is tied back and sleeves are rolled up when using heating equipment.
5. Wear mask, rubber gloves, apron, Utensils used for dyeing should never be used for food preparation.

Conclusion

The study concludes that the ratio distribution of paraffin with a constant 20 grams of beeswax produces significant variations in the cracking effects of the wax solution. This variation allows artists to achieve finer details in smaller cracks as well as broader effects where structural emphasis is less critical, such as in landscape panels. The findings suggest that ratio adjustments provide greater creative flexibility, enabling artists to select the most suitable composition for specific crack design requirements. In contrast, traditional wax solutions appear less adaptable to the needs of contemporary batik practitioners, who increasingly seek innovative methods. Furthermore, the dyeing recipe tested in this research demonstrates that reactive dyes offer a simple, efficient, and practical approach for batik dyeing. Unlike conventional dip-dyeing methods, this process is shorter, requires no heating or advanced technical expertise, and is particularly suitable for small-scale batik production. These findings contribute to advancing batik practices by aligning traditional techniques with modern artistic and practical demands. All the parameters and objectives were meet at the end of the research positively.

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