RJPBCS vol 7 no. 2 (2016)

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ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Optimization of Batik Wax Waste Reutilization by Blending Method using Gum rosin, Paraffin, and Lard on Handmade Batik Fabric Production Towards Zero Waste Management.

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ABSTRACT

The purpose of this study was to optimize the reutilization of batik wax waste, as one of the largest components in the solid waste of batik industry, through blending method using gum rosin, paraffin, and lard. The stage of batik wax waste reutilization through modification waxs making can minimize the quantity of solid waste that is discharged into water bodies and minimizing production costs of batik industry. However, further research is needed on the blending composition that can produce high-quality dyeing result. High quality dyeing result produced in this study were evaluated using the parameters of wax latched power on the fabric and it's resistance to cracking and alkaline solution, which is widely used in the dyeing process of batik industry. Composition of batik wax waste blending with the gum rosin, paraffin, and lard in this study, varied be 100/0; 80/20; 60/40; 40/60; 20/80; 0/100 (% w/w). The latched power of wax on the fabric are evaluated based on the temperature required to remove the wax from the fabric sample. The higher temperatures are used to remove wax from the fabric, the higher wax latched power is concerned. Based on the results obtained, it is known that latched power onto modification wax 1(mixed wax waste and gum rosin) most high produced by the composition of 80% wax waste (WW) - 20% gum rosin (R), where the wax can be removed from the entire sample of fabric at a temperature of 80 – 90 ° C. The latched power with the same pattern is also shown by modification wax 2 (wax waste - paraffin), in which a wax latched power on the sample will increase when the quantity of paraffin in the mix is getting high. The highest wax latched power resulting from the composition of the 80%WW-20%P and 60%WW-40%P, which had the ability to withstand the heat produced by a temperature range up to 70 – 80 °C and fully detached on the heat temperature range 80– 90 °C. While slightly different results shown by modification wax 3 (wax waste - lard), where it has detected a lower latched power on the wax of this type. The removal process of modification wax 3 from the fabric sample showed that all wax compositions of these types only able to maintain their latched power until the temperature of 60-70 °C and fully removed from the fabric at a temperature of 70-80 °C. Based on the results of a resilience test of the wax against the cracking, it is known that the cracking was detected in the wax composition 20% WW/80% GR; 100% P; also 20% WW/80% L and 100% L. Meanwhile based on the result of resilience test of the wax against alkaline solution showed that all wax composition has an excellent resilience in alkaline solution.

Keyword: Batik, Wax, Gum rosin, Paraffin, Lard.

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ISSN: 0975-8585

INTRODUCTION

Batik is an ancient art in which melted wax is applied in intricate designs on fabric which is then dyed and the wax is removed [1]. The batik wax will be released from the fabric after the desired coloring process has been completed. Kusumawati et al (2015), reported a high quantity of batik wax waste disposal into water bodies by batik SMEc in Indonesia. Based on functional groups testing of batik wax waste, it is known that no significant damage to the structure of the batik wax waste compound. Therefore, it can be said that the actual batik wax waste still has great potential for reusable without or with through a process of quality improvement. One of the method that can be used to improving the quality of batik wax waste is by blending method using gum rosin, paraffin, and lard.

Rosin, also called colophony or Greek pitch, is a solid form of resin obtained from pines and some other plant, mostly conifers, produced by heating fresh liquid resin to vaporize the volatile liquid terpene components. It is semi transparent and varies in color from yellow to black. At room temperature rosin is brittle, but it melts at stove-top temperature. It chiefly consists of various resin acids, especially abietic acid [2]. Rosin is brittle and friable, with a faint piny odor. It is typically a glassy solid, though some rosins will form crystals, especially when brought into solution [3]. The practical melting point varies with different specimens, some being semi-fluid at the temperature of boiling water, others melting at 100 °C – 120 °C. It is soluble in alcohol, ether, benzene and chloroform. Rosin is largely employed in making sealing wax, various adhesives and also for preparing shoemakers wax.

In Indonesian batik production, known some type of gum rosin : American Gum rosin, Hongkong Gum rosin, Aceh Gum rosin and Pekalongan Gum rosin. Specifically, the properties of Indonesian gum rosin : (a) take a long time to melt; (b) easily penetrates the fabric; (c) easy to crack; (d) not resistant with alkaline solution; and (e) Gum rosin melting point between 70–80 °C [4-6]. Properties of gum rosin very closely resembles with bee wax, but with a more complex chemical structures. A more complex chemical structure has led gum rosin to have a higher melting point than bee wax or wax waste , i.e. of 86,73 °C. While bee wax and wax waste, each has a melting point of 46,17 °C and 47,57 °C.

The purpose of gum rosin usage in batik wax blends is to get louder batik wax, not freeze quickly so that the line shape produced by batik wax is better [7-9]. However, need to do more research about the optimum wax waste-gum rosin blending composition which are able to produce high quality dyeing process which is equivalent to that produced by a bee wax as a positive control. Therefore, at this research has done the making of modification wax 1 by blending method using wax waste and gum rosin as the main ingredient.

Paraffin wax ia a white or colorless soft solid derivable from petroleum, coal or oil shale, that consists of a mixture of hydrocarbon molecules cantaining between twenty and forty carbon atoms. It is solid at room temperature and begins to melt above approximately 37 °C (99 °F) [10], it's boiling point is >370 °C (698 °F) [11]. It is distinct from kerosene, another petroleum product that is sometimes called paraffin. In chemistry, parafin is used synonymously with alkane, indicating hydrocarbons with the general formula CnH_{2n+2}. The name is derived from Latin parum ("barely") + affinis, meaning "lacking affinity" or "lacking reactivity", reffering to paraffin's unreactive nature [12].

Paraffin used in batik wax blends, so that they have good resistant power to wet penetrate and easy to released. In addition, paraffin serves as a filler material cause paraffin prices are cheaper than other wax materials. Paraffin properties are as follows: (a) have a good resistant power to wet penetrate; (b) easy thawed and frozen quickly; (c) a small latched power onto fabric, so it easily off from the fabric; (d) a low melting point that is at a temperature of 56– 60°C; and (e) are resistant to an alkaline solution, although not durable [13-15]. Paraffin wax suitable for the mixture of wax used on wet eve or rainy season. Same thing with gum rosin, paraffin used to be wax blend, especially for lower quality batik making.

The making of modification wax 2 by blending method using paraffin and wax waste materials, expecting to be able to minimize the weak nature of the both of them and maximize the advantages of both. The addition of paraffin materials on the wax waste will be able to improve the resistant power to wet penetrate by water that is the largest component used in the batik fabric production process, especially on the dyeing stages. Meanwhile, the use of wax waste will be able to increase the latched power of paraffin materials on the fabric. Not only that, the blend of wax waste and paraffin materials will be able to improve paraffin resilience against alkaline solution, which is often used as a dyeing medium for naphtol dyes.

Lard (animal fat), also known as fat or vat. The colour is white like butter. In Indonesia, lard usually taken from beef or buffalo fat. The nature of lard is easily melted and its melting point is low, i.e. 45 – 49 °C [13,15]. Lard used as batik wax blends in relatively small amounts to get lower melting point of batik wax, reduce the hardness of batik wax, so makes it easy to pull off from the fabric. Making of wax modification 3 using blending method from wax waste materials and lard, is expected to be able to minimize the disadvantage from both of them and maximize the advantages of both. Generally, the utilization of lard as a mixed of batik wax at the dry season, where a relatively high room temperature, has been making batik wax (bee wax) into having the harder structure.

In this research, the success of the batik wax waste and enhancing quality agent materials utilization in the form of modifications wax making, evaluated using parameters : it's ease released from the fabric, the wax resistance against cracking and alkaline solution. To find out the ease level of the wax release from the fabric sample, has done warming of the wax sample which has applied to the fabric using a water medium on 6 temperature range, i.e. 40-50 °C; 50-60 °C; 60-70 °C; 70-80 °C; 80-90 °C; and 90-100 °C. The temperatures range where the wax successfully removed 100% from fabric without causing color fade and lowering mechanical strength of the fabric, becomes the optimum temperature range for the wax release at the real conditions production of homemade batik [15].

METHOD

Chemicals

The materials needed for the modification wax product making: wax wastes (62,5 °C, obtained from Namiroh Batik SMEs Sidoarjo - Indonesia), gum rosin (melting point 86,73 °C), paraffin (melting point 60,31 °C), and lard (melting point 45,21 °C). While the material needed for quality test of wax include: mori fabric (obtained from Namiroh Batik SMEs Sidoarjo - Indonesia), caustic soda (≥48%, CV. Water Surabaya - Indonesia) and water.

Equipment

The equipment needed for making and quality test of modification waxs product include: beaker glass, stirrer, magnetic stirrer with hot plate, analytical balance, thermometer, wax mold, red naphtol, and water.

Characterization of wax waste, gum rosin, paraffin, and lard

To determine the proper blending procedures of batik wax, characterization wax using Mettler Toledo TGA/DSC 1) Differential Scanning Calorimetry (DSC). Meanwhile, to determine the functional groups and the influence of the functional groups on the latched power and resistance of wax waste, gum rosin, paraffin, and lard against cracking and alkaline solution, an infra red analysis using Nicolet IS10 Thermo Scientific Fourier Transform Infra Red (FTIR) has been done.

Manufacture of modification wax 1 and 2

The modification wax 1 with the blending composition of wax waste/gum rosin (%w/w) 20/80 preceded by a stage in which as many as 40 grams of gum rosin put into a beaker glass and then heated using a hot plate at temperature of 90 °C. Further, into the beaker glass was added 160 grams of wax waste. To ensure the formation of a homogeneous blending product, the wax mixture is stirred using a spatula while the heating process continuing approximately 15 minutes, so that all the water is trapped in the wax blending products can evaporate. After that, the hot wax liquid casted and allowed to stand for 24 hours. The modification waxs product 1 was ready to be tested (melting point, latched power on the fabric, resistance to alkaline, and cracks). The same procedure is applied to the manufacture of wax blending products with another composition, namely wax waste/gum rosin (%w/w) 40/60; 60/40; 80/20; and 100/0.

The manufacturing of modification waxs 2 followed the same procedure with the modification wax 1 manufacture. However, there is a difference in heating temperature is used, ie 65 C, which is needed for melting paraffin.

Manufacture of modification wax 3

The modification wax 3 with the blending composition of wax waste/lard (%w/w) 20/80 preceded by a stage in which as many as 40 grams of wax waste put into a beaker glass and then heated using a hot plate at temperature of 65 °C. Further, into the beaker glass was added 160 grams of lard. To ensure the formation of a homogeneous blending product, the wax mixture is stirred using a spatula while the heating process continuing approximately 15 minutes, so that all the water is trapped in the wax blending products can evaporate. After that, the hot wax liquid casted and allowed to stand for 24 hours. The modification waxs product 3 was ready to be tested (melting point, latched power on the fabric, resistance to alkaline, and cracks). The same procedure is applied to the manufacture of wax blending products with another composition, namely wax waste/lard (%w/w) 40/60; 60/40; 80/20; and 100/0.

Latched power test of modification waxs product

The latched power test of wax on the fabric begins with the application of the wax into fabric by dipping method. Fabrics that have been coated with batik wax then dried for 24 hours. The process of it test was conducted by soaking a fabric in water heated in the range temperature of 40-50 °C; 50-60 °C; 60-70 °C; 70-80 °C; 80-90 °C; and 90-100 °C.

Cracking test of modification waxs product

The cracking test of modification waxs product done by involving dyeing process using naphtol red and begins with the application of the wax into fabric by dipping method.

Dyeing process with red naphthol begins with the stage of making the dye solution. Preparation of naphthol dye is done by dissolving 1.7608 grams of naphthol and 0.6220 grams of caustic soda in 200 mL of boiling water. To ensure has formed a homogeneous solution, the solution has stirred with a magnetic stirrer for 5 minutes. While, the naphthol salt solution made by dissolving 3.0015 grams of naphthol salt in 100 mL of cold water (room temperature). Similarly, in the manufacture of naphthol dye solution, to ensure has formed a homogeneous solution, the solution has stirred with magnetic stirrer for 5 minutes.

After naphthol dye solution available, fabric dyeing process is carried out by following procedure: 2 pieces of fabric 10x10 cm was immersed in naphthol dye solution for 30 minutes and then dried for 5 minutes. Thereafter, the fabric was immersed in a salt solution for 30 minutes. Then, fabric was aerated for 15 minutes and the process of fabric dyeing terminated by drying the fabric in the sun for 15 minutes.

Resistance test on modification wax product against alkaline

The resistance test of wax product against alkaline solution begins with the application of the wax into fabric by dipping method. Samples of fabric that had been coated with the wax then weighed and allowed to stand at room temperature until dry (24 hours). After that, the fabric are immersed in an alkaline solution (0.6220 grams of caustic soda in 200 ml of water) for 30 minutes and then dried for 24 hours. At the final stage, fabric weighed using an analytical balance. A significant difference between the weight of fabric sample before and after immersed in an alkaline solution, show the resistance of the modification wax products against alkaline.

RESULT AND DISCUSSION

Modification wax characterization

The infra red spectra of wax waste, gum rosin, paraffin, and lard was displayed in Fig. 1. From Fig. 1, it was discovered that the IR spectra of the wax waste, show the emergence of 3 characteristic peaks at wave number 1600-1800 cm^{-1} (C = O), 1500-3000 cm^{-1} (OH on the carboxylic acid), and 1.000- 1300 cm^{-1} (CO on

ISSN: 0975-8585

ester), also another peak at wave number 3735.42 cm^{-1} which indicate the presence of -OH. The existence of a functional group C = O and -OH at wax waste infra red spectra indicate the presence of dyes contamination at wax waste, cause wax compound only consisting of the long chain alkane compound, usually with 20-40 C atoms.

The dye contamination on wax that came from the previous uses, it can give a positive or negative impact. The positive impact that may be caused is wax waste has a molecular structure that is more complex, which eventually led a wax waste to have a higher melting point than the bees wax products (new wax), as shown at Table 1. Increased melting has caused the line of batik patterns generated by wax waste products can be thinner (neat). While the negative impact that arises is the high temperature which needed for wax removal from the fabric, has the potential to increase the quantity of dye that might fade when wax removal done.

Meanwhile, on the other side, it was found a similarity peaks in the IR spectrum of gum rosin, paraffin and lard. The difference was observed just only on the intensity of absorbance and the presence of -OH functional groups that are not found in the IR spectra of those material.

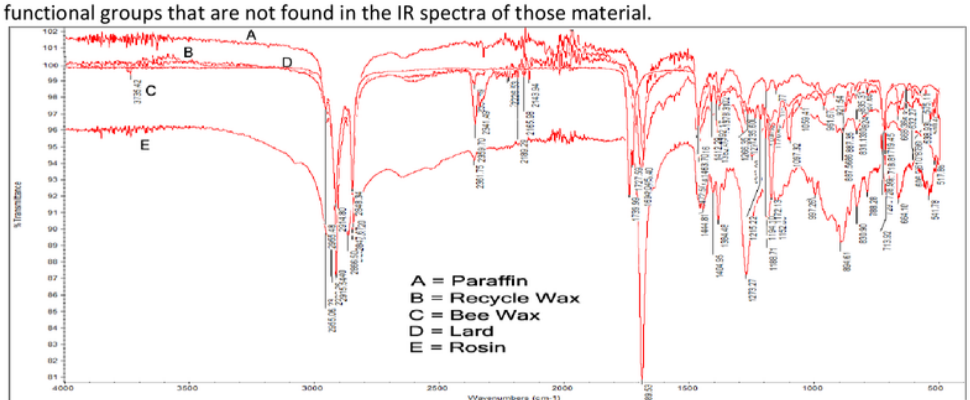

Figure 1: Infra red spectrum of : wax waste (a); gum rosin (b); paraffin (c); and lard (d)

Table 1: Melting point of wax waste, gum rosin, paraffin, and lard

No	Materials	Melting Point (°C)
1	Bee wax	46,17
2	Wax waste	47,57
3	Gum rosin	86,73
4	Paraffin	60,31
5	Lard	45,21

Lard absorption intensity that much lower than the gum rosin and paraffin, shows that lard has a molecular structure that is not as complex as gum rosin and paraffin. The condition has caused lard has a melting point much lower than gum rosin and lard, as shown in Table 1.

The quality test of modification wax product

The effect of blending composition wax waste with gum rosin, paraffin, and lard to the latched power of wax on fabric

The results of wax product latched power test shown in the table 2. In Table 2, it was appear that: (a) increased levels of gum rosin, respectively on a modification waxs product 1, has improved wax latched power on the fabric; (b) increased levels of paraffin, respectively on a modification waxs product 2, has not improved wax latched power on the fabric; and (c) increased levels of lard on wax product modifications 3 has lowered wax latched power in question on the fabric.

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Table 2: The wax latched power test result

No	Modification wax Product (%w/w)	Wax Busting Temperature (°C)	No	Modification wax Product (%w/w)	Wax Busting Temperature (°C)
1	100%WW	70-80	9	40%WW/60%P	90-100
2	80%WW/20%GR	70-80	10	20%WW/80%P	90-100
3	60%WW/40%GR	80-90	11	100%P	90-100
4	40%WW/60%GR	80-90	12	80%WW/20%L	70-80
5	20%WW/80%GR	80-90	13	60%WW/40%L	70-80
6	100%GR	80-90	14	40%WW/60%L	70-80
7	80%WW/20%P	90-100	15	20%WW/80%L	70-80
8	60%WW/40%P	90-100	16	100%L	50-60

The effect of blending composition to the cracking of wax on fabric

The results of wax cracking test shown in the table 3. In Table 3, it was appear that: (a) on modification wax product 1 (wax waste – gum rosin) with level gum rosin 20-60%, there is undetectable cracks, which are marked with undetectable red color in the fabric sample. While for level gum rosin 80%, detected cracks; (b) increased levels of paraffin, respectively on a modification waxs product 2, has not improved wax cracking on the fabric when the paraffin level was 20-80% and has improved wax cracking when the paraffin level reach 100%; and (c) increased levels of lard on modifications wax product 3 has improved wax cracking on the fabric, only when the lard level reach 80-100%.

Table 3: The wax cracking test result

No	Modification wax Product (%w/w)	Cracking on The Wax	No	Modification wax Product (%w/w)	Cracking on The Wax
1	100%WW	not cracking	9	40%WW/60%P	not cracking
2	80%WW/20%GR	not cracking	10	20%WW/80%P	not cracking
3	60%WW/40%GR	not cracking	11	100%P	cracking
4	40%WW/60%GR	not cracking	12	80%WW/20%L	not cracking
5	20%WW/80%GR	cracking	13	60%WW/40%L	not cracking
6	100%GR	not tested, (not applicable)	14	40%WW/60%L	not cracking
7	80%WW/20%P	not cracking	15	20%WW/80%L	cracking
8	60%WW/40%P	not cracking	16	100%L	much cracking

The effect of blending composition to the resistance of wax against alkaline solution

The results of the wax product resistance test against alkaline solution shown in the table 4. In Table 4, it was appear that: (a) increased levels of gum rosin, paraffin and also lard respectively on a modification waxs product, has not cause a change in resistance of modification waxs product to alkaline solution.

From results of the alkali resistance test also showed that the detection of cracks on modification waxs product 1 with gum rosin levels of 80%; modification wax product 2 with paraffin content of 100%; and modification waxs product 3 with lard levels of 80-100%, is not influenced by the resistance of the wax against an alkaline solution, but is more influenced by the increasing levels of the hardness of modification waxs product 1 and 2, as well as the very low level of hardness of modification waxs product 3. Very low levels of hardness on the modification waxs product 3 has caused a layer of wax applied to the ic becomes thin and easily cracked.

ISSN: 0975-8585

Table 4: The result of wax resistance test against alkaline solution

No	Modification wax Product (%w/w)	Resistance Against Alkaline Solution	No	Modification wax Product (%w/w)	Resistance Against Alkaline Solution
1	100%WW	Resistance	9	40%WW/60%P	Resistance
2	80%WW/20%GR	Resistance	10	20%WW/80%P	Resistance
3	60%WW/40%GR	Resistance	11	100%P	Resistance
4	40%WW/60%GR	Resistance	12	80%WW/20%L	Resistance
5	20%WW/80%GR	Resistance	13	60%WW/40%L	Resistance
6	100%GR	not tested, (not applicable)	14	40%WW/60%L	Resistance
7	80%WW/20%P	Resistance	15	20%WW/80%L	Resistance
8	60%WW/40%P	Resistance	16	100%L	Resistance

CONCLUSION

Based on results of the research that have been obtained, it is known that from the 16 types of wax blended product has been manufactured and tested in this study, as many as 12 types of wax was very potential to be used in the production process of batik and as many as four types of wax, which is 20% WW/80% GR, 100% P, 20% WW/80% L, and 100% L, still require quality improvement because of detected cracks on all four types of the wax when applied.

AKNOWLEDGEMENT

This study was carried out with financial support from the Indonesian Government through The National Priority Research Programs - masterplan of acceleration and expansion of Indonesia's economic development.

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