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Title: **Traditional Malay Black Ink: Formulation and Analysis of their Characteristics.**

1.0 Introduction

Historically, traditional and indigenous methods of ink making could be scarce as compared to the references related to paper making which is readily traced. There is a strong possibility that the method of producing paper was more difficult, especially for producing it in bulk and besides paper was more easily obtained from traders who came to this region (Siti Hawa Salleh, 2010). Despite, ink could be produced easily by using local sources apart from the ink that were brought abroad. It could be produced either in small quantities or in bulk depending on the purpose of usage. Even though the use of inks originated from European, Indian and Arabian was reported in Malay Manuscripts but the Malays also had a strong tradition of making their own inks. However, the information was mostly passed over generation by oral means rather than properly documented. The only Malay writer who recorded in written the production of ink is Abdullah Munsyi as he mentioned:

> *"Allah penyakit itu pun sembuhlah. Maka badanku pun pulihlah pulang semula. Maka adalah permainanku diberi oleh nenekku itu, sebatang kalam resam dan suatu papan loh dan sedikit dawat beras. Katanya: "Inilah engkau buat main sehari-hari. Jikalau engkau bermain tanah atau pergi main ke panas, aku pukul." Maka takutlah aku pergi ke mana-mana, melainkan duduklah aku."(Abd.H 20:5).*

Today, traditional Malay black inks have lost their popularity mainly due to the complex, tedious and slow process of producing them and the offensive of the imported product that can easily obtained from the local market. The traditional making ink has to undergo heedful process of collecting raw material particularly carbon sources (combustion of kerosene oil) and binding agent materials (mainly from parts of plants) before proceed with the production procedure. The process starts with gathering and selecting the raw materials according to the recipe and then some materials are then expose under natural sunlight for a few days or until it completely dried before proceed to the next process. Another method of process is the mixture of carbon sources with the fruit skins serves as a binding agent that have been boiled earlier into paste and ground into powder form (Ding Choo Ming, 1992).

The sources used for the production of the traditional ink (locally made) ink are very much related to the availability of these materials from their surrounding or neighbourhood. However, the knowledge only passed over generations informally. According to Ding (1992) this locally-made ink was reported superior quality as compared to available commercial modern ink later on due to two main factors; its intense black colour does not fade easily and its possessed acidity, thus it was not harmful to the colour or corrosive to the paper. Even though the traditional locally-made ink was of high quality and permanent in nature, but due to variety in the ingredients composition of the ink preparation, the writings observed in Malay Manuscripts were of varying properties. Furthermore, the source of the ink and its techniques contributed to its unique characteristics. Therefore, it is anticipated that the Malay Qur'an manuscript were written using high quality ink so as the holy book will survive for a long period of time notwithstanding that proper storage and environmental control or preventive measures also plays a crucial role.

2.0 Research aim and objectives

The research aim is to re-produce the traditional black ink recipe from Malay Peninsula region that was previously used by the Malay fork in writing manuscript. Even though the recipes are varied but only one recipe was selected and explore in various aspect. The documentation of manufacturing procedures and instrumentation analyses involved are intended to examine their durability and intensity. The main materials used are soot, mangosteen charcoal, cashew gum, black pepper, salt, virgin coconut oil and distilled water. Soot and mangosteen charcoal are the carbon sources while cashew gum serves as a binding agent. Black pepper, salt, virgin coconut oil is the additives used in making the ink. Selection of ingredients and original recipe is based from the book written by Wan Ali with title *"Pemuliharaan Buku dan Manuskrip*" or in English version "Conservation of Book and Manuscript". There are three methods listed in this book;

Method 1

Soot and mangosteen charcoal are the main material used as a colorant. Ground cashew gum serves as a binding agent, while black pepper, virgin coconut oil and salt are the additives used to adjust pH, viscosity and prevent the ink from mouldy. Pure water used to turn the mixture ingredients into solution.

Method 2

Old and dark cobwebs (spider webs) contained soot which is obtained from burning activities at the traditional Malay kitchen was mixed with fruit skin such as ripe mangosteen, young *rambutan* skin and *Pithecellobium jiringa* (Jack) or also known in Malay as *jering* was burnt and pounded into fine powder. The mixture ingredients were added into container that contained pure water and virgin coconut oil. The ink solution then was undergoing fermentation process for a few days before it is ready to be used.

Method 3

Charcoal, dried cashew gum and sticky rice were pounded separately. The dried mixtures then were added into the container that filled with pure water and boil until the mixture dissolved. Then, the ink solution was sieved using patch cloth and the extracted liquid has been used as an ink.

Out of three, method 1 was selected to explore and formulate standard proportion which is unstandardized according to the original recipe. Selection of the method is based on the availability of the material and other aspect that has been put under consideration. The formulated proportions are expected to create a standard recipe that should be consistent and detectable with a proper written procedures based on systematic process accompany with various level of analysis that quantify the quality of the formulated ink. In other words, the subject is not only based on historical overview which is including examination of handwriting from original Malay manuscript kept in British Library but also discussed on the formulated ink's quality and performance on substrate from the scientific perspective. Selection of the recipe is based on the availability of the ingredient and method of preparation. The selection is very much vital as to ensure the proportion that is develop from this method should be able to reproduce, creating the same colour saturation and colourfastness when the same procedures and ingredients repeated by others. Soot prepared from kerosene oil is a colorant that soluble in the vehicle. While, gum exudate from the stem of the bark tree used as a gum and gives body to the ink and other materials that function as drying agent, absorbing odour and avoiding ink from spreading.

The following are the research objectives:

1. To examine the writing ink employed in the 19th Century historical Malay manuscript.
2. To formulate various proportions of substances to produce black ink based on one selected recipe attributes to east coast of Peninsular Malaysia.
3. To analyse the durability and intensity of the formulated ink via instrumental analysis.

3.0 Research Methodologies

The experimentation of the traditional black ink divided into two stages of the formulation processes:

a) Formulation I : Preparing dry materials for making the ink which obtained from natural resources.

b) Formulation II : Formation of the element proportion with different ratio with the aim to evaluate its performance on substrate.

Under formulation I, the dry materials which contain carbon sources, vehicle (binding agent) and additives were prepared. These dry materials were prepared separately. Detail of the recipe and procedures used in this experiment was shown in Table 3.1. Lamp black or soot obtained from the combustion of kerosene oil follow the traditional method done in Indonesia that probably similar method used by the Malay folk in the past (Figure 3.1). The deposited soot removed by means of a feather with care to reject all oily particles. Soot made from oils and wood burned in air, may have an elemental carbon content as low as 60% with variable amounts of organic carbon, such as polycyclic aromatic hydrocarbons (PAHs) (Watson & Valberg, 2001). According to Mitchell & Hepworth (1904) the quality of the lamp black has a very great influence upon the character of the ink, and the royal ink is prepared from the very lightest and purest that can be obtained. Another carbon sources used in the making of ink is a mangosteen charcoal. The colorant obtained from burnt mangosteen shell was believed to increase the darkness and quality of the ink produced (Wan Ali, 1988). 3 kilograms of ripe mangosteen (Index 6) was purchased from the mangosteen farm in Jerantut, Pahang. The ripe mangosteen shells were dried under the heat of the sun for three days until it completely dry. Then, it was burned into charcoal following Malay traditional method as shown in Figure 3.2. In order to obtain fine mangosteen charcoal, the burnt mangosteen shell was grind using planetary mill machine (pulverisette 5) that was prepared in the Composite Material Laboratory in Kulliyyah of Engineering, International Islamic University Malaysia.

Table 3.1: Selected ingredients and procedures of making the traditional black ink adopted in this research.

Method	Recipes	Procedures
Method 1 (Boiling)	5 cups soot/lamp black Fistful ground cashew gum Exiguous mangosteen charcoal 1 tea spoon ground black pepper 5 litre pure water A pinch of salt A drop of coconut oil	Dried cashew gum and black pepper was pounded into powder form. Water was added in the vessel that contains dry ingredients. Salt and coconut oil were added at this stage. Boil all ingredients until its homogenised.

Figure 3.1: A form of flame carbon prepared by burning kerosene oils. The soot produced in the cracker container gradually became thick and swept out by means of a feather brush.

Figure 3.2: Traditional way of burning mangosteen shell into charcoal by using coconut coir as a fire starter.

Gum obtained from the cashew nut tree *(Anacardium Occidentale L.)* was collected from trees grown in northern part of Peninsular Malaysia. No details of the botanical aspects of the species were recorded. The gum exudates from the tears were somewhat contaminated and produced colourless to light amber in colour (see figure 3.3). Samples of gum were collected after one month with total amount of 108.32 grams. In order to gain dry gum the moisture contents were determined by drying overnight at 105°C to constant weight (Mat Zakaria & Zainiah Ab.Rahman, 1996). 79.83 grams of dried cashew gum were gained after drying process (Figure 4). Samples were ground to pass through 0.5 mm sieve. Virgin coconut oil also has been added in a small amount that was purchased from the art and craft material supplier.

Figure 3.3: Exudation from the bark of cashew nut tree (*Anacardium Occidentale L)*.

Figure 3.4: Dried cashew gum after expose in the drying oven.

Black pepper and salt are the additives used to adjust properties of the ink or add a property to the ink thus increasing its performance. Both materials were purchased from hypermarket that was readily to be used.

Under formulation II, the process of making traditional black ink were explained according to the procedures described by Wan Ali (1988) based on personal communication with the mosque servant or in Malay they called *lebai*, Kassim Abbas from Pasir Mas, Kelantan who is also studied in several Islamic religious school (*pondoks*). There are three main methods have been described by him; i) cobwebs (spider web) and fruit rinds (mangosteen and rambutan), ii) ash and fruit rinds, iii) lamp black or soot with fruit rinds. As mentioned by Wan Ali in his MA thesis "An Introduction to Malay Palaeography" there are many types of fruit rinds were used, but the most preferable is the rinds from mangosteen (*Garcinia Mangostana L.)* and rambutan (*Nephelium lappaceum*). However, only one recipe was selected based on the availability of the material and time constraint. The experimental procedures were set mainly based on the original recipe labelled as T1R1. However, due to insufficient performance when tested on substrate, the element proportions were increased accordingly until reach required consistency. In order to obtain required consistency, another three different formulas were setting up labelled as Ex1R1, Ex2R1 and Ex3R1. Each sample was tested on substrate and the ink performance was recorded in a troubleshooting chart.

Each samples of the formulated ink were tested on European handmade paper (Magnani Platinum paper) as a substrate. These handmade papers are imported from supplier namely Talas (Professional Archival, Bookbinding, Conservation, Preservation and Restoration) that was operated since 1962 in Brooklyn New York, USA. The material was purchased through online from their website www.talasonline.com. 15 sheets of Magnani Platinum papers with dimension 22 x 30 and weight 145 gsm were ordered with total cost $175.89.

3.1: Experimental procedures

3.1.1: Formulation I: Material preparation

Dry materials were prepared separately at this stage. In addition, the material properties and chemical composition of the materials involved in this research were studied as to understand their role and contribution towards the ink produced.

A form of flame carbon or carbon black prepared by burning kerosene oil in a container, the soot being collected on a cooler surface arranged as to allow the particles to be gathered. Another source of the colorant is obtained from mangosteen charcoal. The ripe mangosteen shells were burn into charcoal and grind using ball mill machine in order to transform it into powder form. These mangosteen charcoals were believed to increase the darkness and improve the lustre of the ink produced. Gums exudates from cashew tree bark are used to give body to make the ink adhere into the substrate. The process of exudates gum is the tougher process due to the slow and extensive period that was taken. Other dry materials such as ground black pepper, salt and virgin coconut oils are the readily stock that were purchased from local hypermarket.

3.1.2: Formulation II: Formation of the element proportion

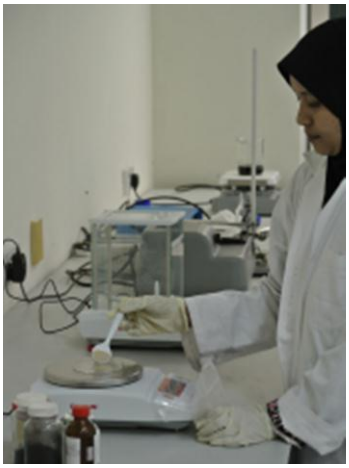
3.1.2.1: Experimental procedure

The formulation of ink was carried out in six (6) formulations as shown in Table 3.2. Each of the formulation was labelled as T1R1, Ex1R1, Ex2R1, Ex3R1, Ex2aR1 and Ex2bR1. The formulated ink labelled as T1R1 is the original recipe referred. According to the original recipe the portion of gum and additives are less then carbon or colorant sources. 2 part of colorant, 1 part of gum and 0.5 part of additives employed in the original recipe. However, due to the weak performance of the ink on substrate, another set of formula labelled as Ex1R1, Ex2R1 and Ex3R1 were carried out. Out of these formulas, Ex2R1 formula has shown good performance on substrate but need further modification on the additives proportion. Therefore, another formula that was set up by increasing proportion of the additives proportion labelled as Ex2aR1 and Ex2bR1. The experimental procedures of making ink illustrates in Figure 3.5.

Table 3.2: The formulation of traditional Malay black ink.

Component	T1R1 (original recipe)	Ex1R1	Ex2R1	Ex3R1	Ex2aR1	Ex2bR1
Lamp black/soot	2 g	4 g	4 g	4 g	4 g	4 g
Mangosteen charcoal	2 g	4 g	4 g	4 g	4 g	4 g
Cashew gum	1 g	4 g	2 g	8 g	2 g	2 g
Black pepper	0.5 g	1 g	1 g	1 g	2 g	3 g
Virgin coconut oil	0.5 ml	0.1ml	0.1 ml	0.1 ml	0.1 ml	0.1 ml
Salt	0.1 g	0.2g	0.2 g	0.2 g	0.3 g	0.5 g
Distilled water	100 ml	100 ml	100 ml	100 ml	100 ml	100 ml

3.1.2.2: Experimental flow-chart



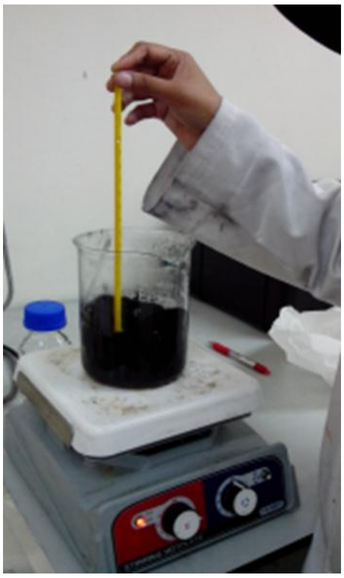
1. Measuring weight of the ingredients

2. Mixture of the dry ingredients

3. Virgin coconut oil was added into solution by using pipette

4. The mixture was blend until become homogenized

5. The solution was boiled for 30 minutes



6. Measuring temperature of the boiled ink

7. The boiled ink was left to settle at room temperature

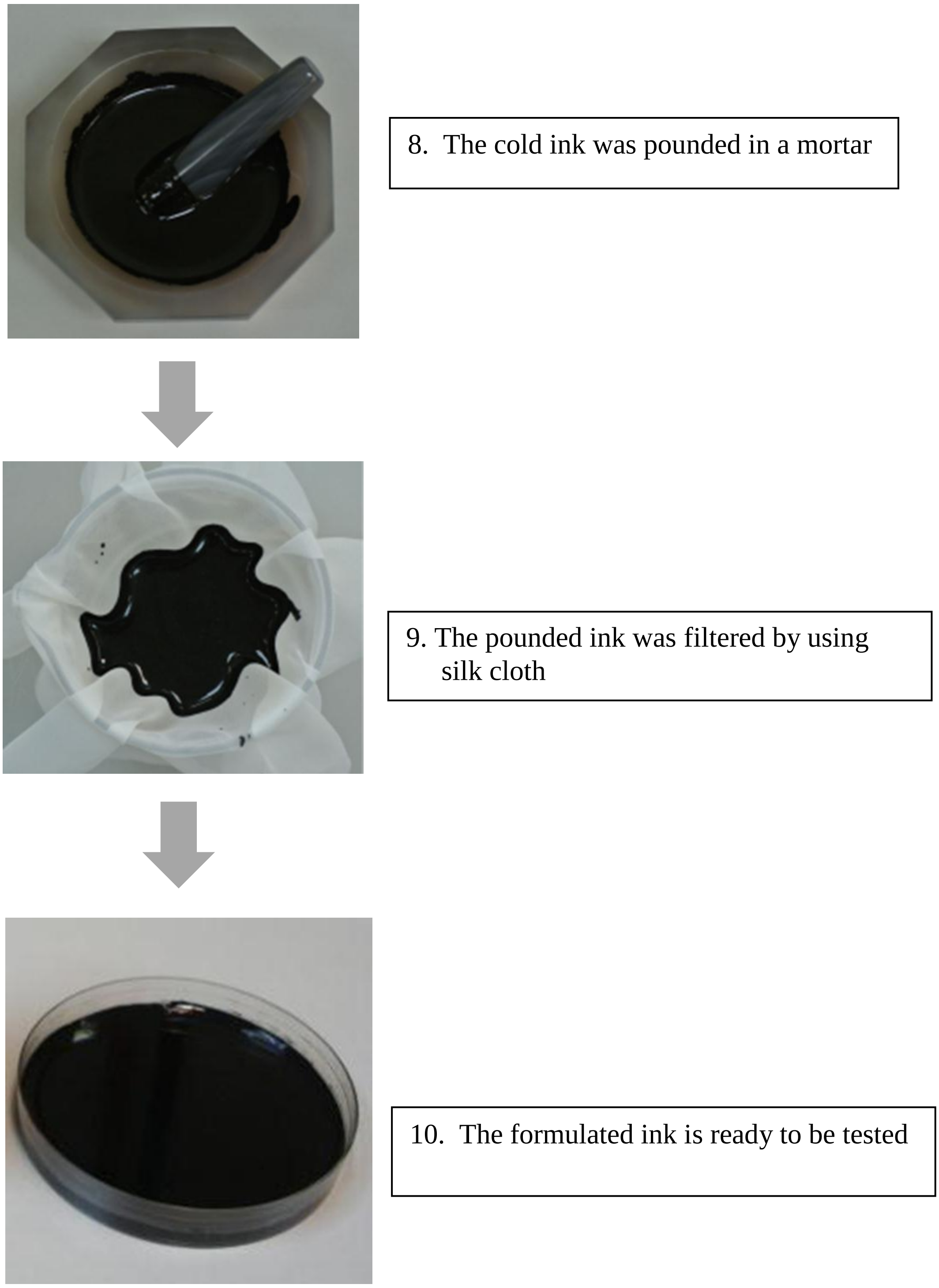
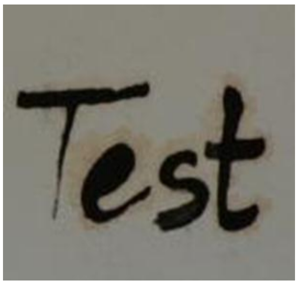
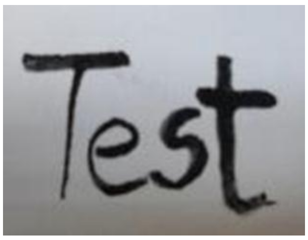
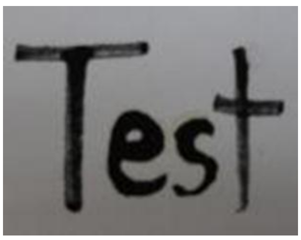


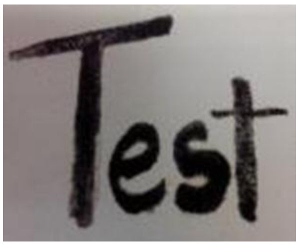
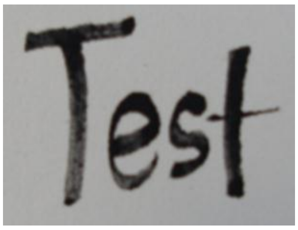
Figure 3.5: Flow chart of the experimental procedures of making the ink.

4.0: Formulated ink tested on substrate.

Formulated inks were tested on European handmade paper (Magnani Platinum paper) in order to record its performance. The qalam (*batang resam*) made of fern stem was used as a pen. Performance of the formulated inks was described in the Table 4.1. The fluidity and drying of the ink also have been tested. All samples are viscous with Newtonian behaviour. According to drying test, sample Ex2bR1 dry quickly in 3 minutes while, sample T1R1 takes approximately 30 minutes to dry which the longest time as compared to the other ink samples.

Table 4.1: Description of the formulated ink's performance.

Formula	Sample	pH				Descriptions
		Day 1	1 month	6 month	1 year	
T1R1 (original recipe)		6.1	9.1	8.8	8.9	- Ink does not flow well out of pen on day 1. - Ink flow well after kept for 2 months. - Brown stain probably due to too much oil. - Too little gum
Ex1R1		7.8	7.8	8.1	8.1	- Ink does not flow well out of pen. - The ink particle flacking after dry.
Ex2R1		7.9	8.2	8.4	8.7	- Ink flow well out of pen. - Dark colour. - Thin ink

Ex3R1		7.7	7.5	7.2	7.4	- The ink is too thick. - The ink does not flow well out of pen. - The ink particles flacking after dry.
Ex2aR1		7.4	7.9	8.3	8.4	- The ink is too watery. - Pale colour - Difficult to control when apply on substrate.
Ex2bR1		7.2	8.8	8.2	8.2	- The ink flow well out of pen. - Thin ink - Dark and glossy

5.0: Lightfastness test of formulated inks.

The formulated ink, drawn on a European handmade paper (Cartiere Magnani), is then subjected to the light fastness test with standard procedures ASTM D 3424 & ASTM G 155 (Xenon Arc) with total exposure 120 hours. The colour changes are evaluated through visual inspection against a grey scale and also instrumentally measured colour coordinates.

The colour space L*a*b* (CIE) was applied in the investigations of the formulated Malay black ink layer colour changes upon accelerated ageing. Lightness, L*, is a quantity that measures the percentage of total solar spectral reflectance in relation to a pure white surface; a*is a measure of the degree red $\leftrightarrow$ green; and b* characterize the quantity yellow⟺ blue (Ragauskas AJ, Lucia LA, 1998, 1999). The total colour difference ΔE* was calculated according to Eq. (1):

$$\Delta E^* = \sqrt{(L_2^* - L_1^*)^2 + (a_2^*-a_1^*)^2 + (b_2^*-b_1^*)^2} \quad (1)$$

Where ΔL*=L*(t)-L*(0); Δa*=a*(t)-a*(0); Δb*=b*(t)-b*(0) are the difference calculated for aged ink films (t) and the original (0) ink layers.

5.1: The CIE L*a*b* Value measurement after exposure to Light for Lightfastness Test

The CIE *L*a*b** measurement of values obtained from the formulated ink samples labelled as T1R1, Ex1R1, Ex2R1, Ex3R1, Ex2aR1 and Ex2bR1 after being exposed for 120 hours under artificial light (Xenon Arc) are shown in Table 5.1. The result indicated that there is no colour changes was visible to the naked eye after exposure to light, the grey scale index for all samples excludes sample Ex2aR1are 5. The colour change was assigned to an index from 1 to 5, no. 1 indicating the most fast and no.5 the least fast. Table 5.2 shows the coordinates L*, a*, b* and the colour differences ΔE* between non-irradiated samples (control) and the test pieces after exposure to the light. According to ΔE*, formulated samples has noticeable colour changes, sample Ex2aR1 is obviously changes while samples T1R1 and Ex2R1 had shown only minor differences (Figure 5.1).

Table 5.1: The CIE L*a*b* value of formulated ink after exposure to Light for Lightfastness Test

No.	Ink samples	Visual Assessment	CIE		
			L*	a*	b*
1.	T1R1	5	16.98	-0.17	0.14
2.	Ex1R1	5	26.64	0.00	1.03
3.	Ex2R1	5	18.72	0.05	0.61
4.	Ex3R1	5	18.45	-0.06	0.84
5.	Ex2aR1	5	17.98	-0.19	0.33
6.	Ex2bR1	5	18.03	0.01	0.62

Table 5.2: Shows the coordinates L*, a*, b* and the colour differences ΔE* between non-irradiated samples (control) and the test pieces after exposure to the light. The instrument measurements confirm the visual assessment; the value ΔE* were always limited.

	T1R1	Ex1R1	Ex2R1	Ex3R1	Ex2aR1	Ex2bR1
Control						
L*	*16.8*	26.2	18.3	17.6	16.9	17.2
a*	*0.10*	0.07	0.05	0.08	0.05	0.20
b*	*0.29*	0.96	0.67	0.67	0.27	0.43
After treatment						
L*	0.14	0.40	0.38	0.83	1.07	0.8
a*	-0.27	-0.07	0.00	-0.1	-0.24	-0.19
b*	-0.15	0.07	-0.06	0.1	0.06	0.19
ΔE*	0.34	0.44	0.38	0.8	1.10	0.85
Visual Assessment	5	5	5	5	4/5	5

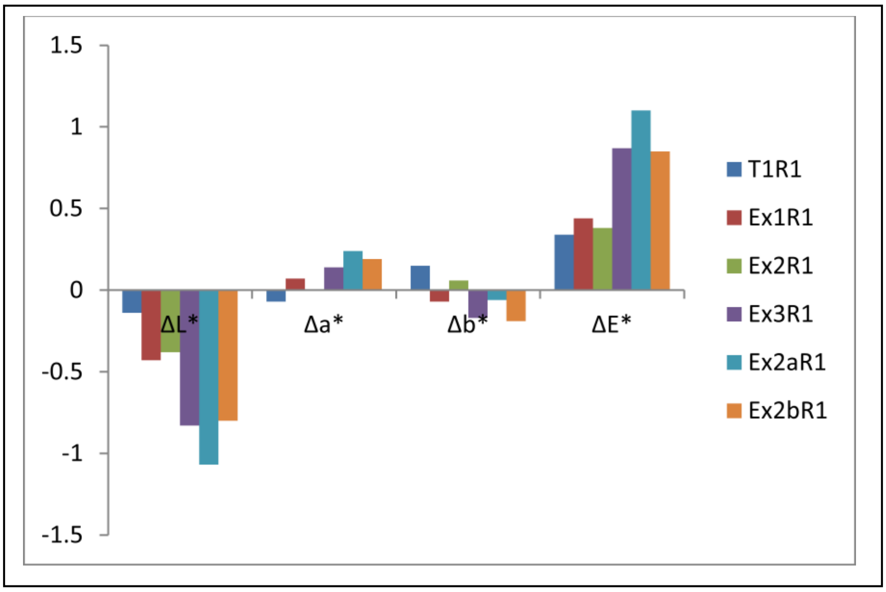


Figure 5.1: Graph indicates minor difference of sample T1R1 and Ex2R1, while sample Ex2aR1 has obviously colour change.

6.0: Multispectral-Imaging Analysis of the writing ink employed in the 19th Century Malay Manuscript text and Malay Royal letters

Research carried out in the Preservation Advisory Centre, The British Library, London takes approximately 7 weeks (28 May -13 July 2012) in order to identify writing materials specifically writing ink employed in Malay manuscripts from their collection. Dr. Paul Garside, a Conservation Scientist plays a role as a supervisor and supporting on training and materials analyses by using Multi-spectral Imaging system during the placement period. This instrument has been suggested as a method for the non-destructive identification of pigment. Full application of Multispectral imaging can typically span the wavelength range from 380 nm to 1100 nm, capturing ultraviolet (UV), visible (VIS) and near infrared (NIR) spectral regions.

There are 15 manuscripts samples; 3 Malay Manuscript text and 12 Malay Royal letters recommended by Dr. Annabel Teh Gallop (Lead Curator, Southeast Asian studies) were examined. Upon examination, the physical condition of the writing inks through 'naked eyes' observation and simple microscopy analysis have been done. All samples are in a good condition. Table 6.1 has described the selected manuscript samples that have been examined.

The multispectral analysis revealed that the writing ink used in all of Malay manuscript texts are made of carbon based black. However, out of 12 samples only 6 samples Malay Royal letters with shelfmark Mss Eur D742/1/147, Mss Eur G38/III/137b, Mss Eur D742/1/2, Mss Eur D742/1/3, Eur F148/4/105 and Mss Eur G38/116b were identified employed with carbon based ink. Through the analysis the ink probably made with lamp-black and binder is uniformly black throughout the visible (VIS) and Infrared (IR) region (Figure 6.1). While another 6 samples are written with iron gall ink. From the data, the writing ink identified as iron gall ink is tend to transparent in the infrared (about 700nm) and distinctly brown appearance (Figure 6.2).

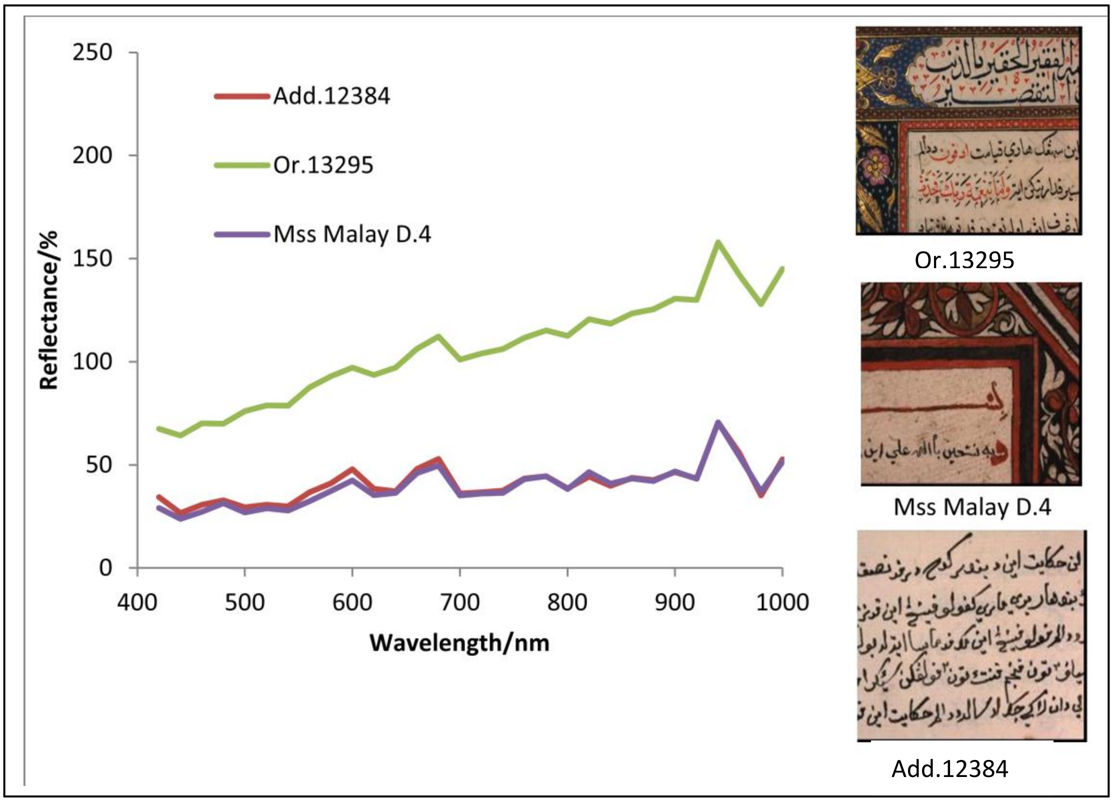


Figure 6.1: Spectral of writing ink uniformly black under visible (VIS) and infrared (IR) region

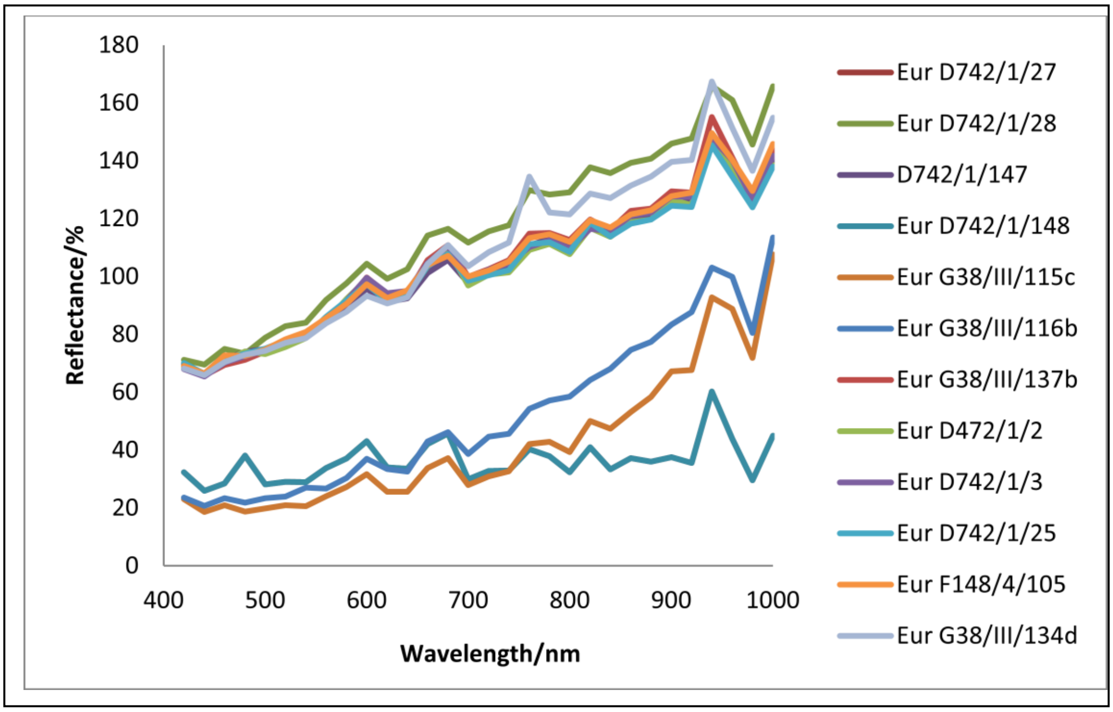


Figure 6.2: Reflectance spectra of black ink for Malay Royal letter samples.

Table 6.1: Physical description of Malay manuscripts text and Malay royal letters selected for analysis.

No.	Title	Shelf mark	Date	Physical Descriptions
1	Taj As-Salatin, Penang	Or. MS 13295	31 July 1824 AD	Dimensions: 240 x 180 mm. 13 lines per page, black ink with rubrication; Finely illuminated with decorated double frames in colours and gold at beginning (ff.1v-2r) and end (ff.190v-191r), with text frames in black, gold, blue and red on every page..
2	Hikayat Hang Tuah, Kedah	Add.12384	Between 1805 and 1842 AD	Dimensions: 310 x 190 mm. 25 lines per page, black ink; catchwords on each folio.
3	Hikayat Nabi Yusuf	Mss Malay D.4	5 Ramadhan 1216 AH /January 1802 AD	Dimension 31x19.5 cm. ink; black, green and ochre on oriental paper, original paper covers of one sheet of oriental paper stuck to one sheet of European paper with chain lines, very soiled, with scribbled notes in Malay and Tamil.
4	Letter from Sultan Johor Sultan Ali Iskandar Syah to O.Cavenagh	Mss Eur G38/III/115c	30 May 1861	Dimension: 33.0 x 34.1 cm Ink on blue English paper Red ink seal
5	Letter from Sultan Umar, Terengganu to O.Cavenagh	Mss Eur G38/III/116b	10 Zulhijjah 1278/ 8 June 1862	Dimension: 337 x 318 mm. Governor of the Straits Settlements. Ink on blue European paper, lamp black seal

6	Letter from Sultan Mahmud Syah of Riau-Johor and Pahang to T.S Raffles in Malacca	Mss Eur F148/4/105	9 Zulhijjah 1225/ 5 January 1811	Dimension: 49 x 38.5 cm. Malay in Jawi script; ink and gold on English paper, 'G Taylor 1802'; lamp-black seal
7	Letter from the Sultan of Kedah to Raffles	Mss Eur D742/1/2	26 Rabiulakhir 1226/ 20 May 1811	Dimension: 267 x 325 mm. Ink on English paper, red ink seal.
8	Letter from Sultan Muhammad of Selangor in Kelang to E.A Blundell, Governor of the Straits Settlements	Mss Eur G38/III/134d	29 Rabiulakhir 1272/ 8 January1856	Dimension 328 x 228 mm. Ink on English paper, 'J Whatman', lamp-black seal. Another lamp-black seal (of Sultan Abdul Samad of Selangor) from an unrelated document is stuck on to the bottom part of the letter.
9	Letter from Raja Kelantan to Gabenor Straits Settlements	Mss Eur G38/III/137b	12 Syawal 1278/ 12 April 1861	Dimension: 33.5 x 34.3 cm Ink on English paper
10	Letter from the Sultan of Kedah to Lord Minto (1811)	Mss Eur D742/1/3	26 Rabiulakhir 1226/ 20 May 1811	Dimension: 409 x 325 mm. Ink on English paper, '1808', red ink seal.
11	Letter from Raja Jaafar of Riau to T. S Raffles in Malacca	Mss Eur D742/1/25	Jumaat 2 Rabiulakhir 1226/ 26 April 1811	Dimension: 313x201mm. Black seal. Heading: Qawluh al-haqq. Ink on English paper, "Curteis & Son 1805", Britannia.
12	Letter from Encik Pandak Syahbandar of Lingga to Raffles	Mss Eur D742/1/28	Selasa 6 Rabiulakhir 1226/ 30 April 1811	Dimension: Lampblack seal. Heading: Nur al-syams wa al-qamar. Watermark: Britannia.
13	Letter from Sultan Mahmud Syah of Johor and Pahang to Philip Dundas, Governor of Pulau Pinang	Mss Eur D742/1/147	25 Zulhijjah 1221/ 5 March 1807	Lampblack seal. Heading: Qult hadha. English paper: J Whatman, 1794.
14	Letter from Temenggung Abdul Rahman of Johor to Sir T.S Raffles	Eur D742/1/148	27 Zulhijjah 1239/ 23 August 1824	Dimension: 408 x 252 mm. Lampblack seal. Ink on European paper.

7.0 Conclusion

The recipes of writing ink attributes to Peninsular Malaysia are varied. However, the significant of the substance composition used in the ink making particularly black ink is the most crucial to highlight in order to identify the novelty of the recipe and their influence in this region. The research carried out divided into three stages; investigation, experimentation and instrumentation analysis. Investigation towards type of black writing employed in the original Malay Manuscripts from the British Library collection was first investigated. 15 samples of the 19^{th} Century Malay Manuscript text and Malay Royal letters were involved in the examination by using Multispectral analysis system (MuSIS). The findings revealed that carbon black ink probably made of lamp black have been applied in all Malay Manuscript texts and partly of the Malay Royal letters also employed with the same ink. The second stage is the most crucial part in this research. Upon experimentation, only one recipe was selected and their proportions have been formulated. The carbon materials; soot and mangosteen charcoal are prepared traditionally and adhesive made of cashew gum exudates freshly from the cashew nut tree (*Anacardium Occidentale L.)*. The preparations of raw materials are the longest period which is also influenced delaying of the experimentation process. Based on the observation and instrumental analysis, the formulated ink with label Ex2bR1 has shown good performance but further research on the permanency of the ink is required. In conclusion, this traditional black ink recipe invented by the Malays has significant with the cultural context in the Malay society in terms of material selection but the procedures of making the ink is closely with the method of preparing Chinese or Indian ink.

8.0 Financial Summary

Expenses	Local Currency (MYR)	Pound Sterling (£)
<u>Travel 1 : Data Collection</u> Internship programme at the Preservation Advisory Section, the British Library London 7 weeks (28 May -13 July 2012)		
Airfares: K.Lumpur – Heathrow,London (return)	**4,400**	**876.78**
Lodging: £15x7 weeks	**3,675**	**735**
Transportation: Underground tube	**1,200**	**219.18**
Per diem: £15x 7 weeks	**725**	**132.42**
<u>Travel 2: Data Collection</u> Field Trip to Traditional Ink Workshop		
Airfares: K.Lumpur– Bandung (return)	**500**	**91.14**
Lodging: Rp. 300,000 x 5 days	**435**	**79.45**
Per diem: Rp. 350,000 x 5 days	**510**	**93**
Fuel : Rp. 7000,000 (trip to Cianjur)	**200**	**37**
Transportation	**2000**	**368**
<u>Materials & Supplies</u>		
European handmade paper (Magnani Platinum) Purchased (web order from TALAS; conservation and art supplier) 145 Gsm 22 x 30	**633.29**	**115.44**
Experiment materials and equipment	**3,000**	**551.81**
Transportation (preparing and collection of raw materials)	**1,000**	**183.93**
Video (Data compilation)	**500**	**91.14**
Laboratory Analysis	**5,000**	**919.81**
Miscellaneous	**2750.80**	**505.90**
Total	**MYR 26,529**	**£ 5000**

Publication poster/ article/ journal

NO	CONFERENCE/JOURNAL	TITLE	VENUE	DATE	REMARKS
1.	**The Eight Islamic Manuscript Conference**	Historical Analysis of Traditional Malay Recipes for Making Ink: A Case Study on the Application of Red Ink as a Preventative Measure	Queens' College, University Of Cambridge, Cambridge, England	July 9-11, 2012	Paper Presenter
2	**IIUM Research, Invention and Innovation Exhibition 2013 (IRIIE)**	Historical Analysis on the Traditional Recipes of Malay Inks	Cultural Activity Centre, International Islamic University Malaysia, MALAYSIA	February 19-20, 2013	Won Silver Award
3	**ICOM -CC 17th Triennial Conference,**	The legacy of traditional Indonesian Ink: Its intensity and durability	Melbourne Convention and Exhibition Centre Melbourne, Australia	September 15-19, 2014	Paper presenter/ Conference Proceeding
4	**249th ACS National Meeting & Exposition (ACS 2015)**	The stability of formulated traditional Malay black ink on the European handmade paper upon accelerated ageing	Colorado Convention Centre, Denver, Colorado, USA	March 22-26, 2015	Accepted for oral presentation and paper will be published in *Restaurator*

Around the Library

Retiring
Anne Dixon, O&S, after eight years
David Henderson, O&S, after nearly eight years

Leaving
James Clements, S&C, after 11 years
Kate Hampson, S&C, after 11 years
Angus Shields, O&S, after 11 years
Vincent Ryan, O&S, after ten years
Alastair Morrison, S&C, after nine years
Sara Lesan, O&S, after nearly seven years
Caroline Hooley, HR, after five years

Welcome
David Gimson, SM&C
Tom Johnson, SM&C
Roly Keating, CEO
Mary Milne, eIS
David Sweeney, eIS

Visiting scholar from Malaysia

"We were pleased to host a placement for PhD student Rajabi (Shasha) Razak from the International Islamic University of Malaysia," says Barry Knight, Head of Conservation Research.

Annabel Gallop, Lead Curator, South-East Asian Studies (pictured left with Shasha), identified manuscripts for Shasha to work on and says: "Shasha's work is truly pioneering – there have never before been any projects to analyse scientifically the inks used in manuscripts from the Malay world. I am particularly pleased that Shasha is focusing on manuscripts in the British Library."

Shasha says: "It has been a great honour to be at the British Library. I would like to express my deep gratitude to my supervisors Annabel Gallop and Paul Garside (who supported Shasha's work to analyse materials) for their kind assistance and support during my stay here.

"Thank you also to Barry Knight, Christina Duffy, Julia Foster, John Webster, Catherine Atkinson and all staff of the British Library. I really hope this is not the end but just a beginning."

Learning support for staff rewarded

From left to right: Iwona Jurkiewicz (Prospect HQ), Marjorie Newson, Andy Robinson, Denise McGuire (Prospect HQ) and Kate Antoniou (Prospect HQ).

The Library's Prospect Union Learning Reps were presented with an 'Outstanding contribution to workplace learning' award by Prospect HQ recently for their role in setting up the Library's 2012 Learning at Work Days.

Sarah Hamlyn, Prospect Secretary, says: "Learning at Work Days are very much a joint effort between all the Library's unions and Human Resources colleagues and we were pleased to accept this award in recognition of everyone's hard work in setting up this year's events for staff."

Successful science placement

PhD graduate, Catriona Manville (pictured), has recently spent three months with the Library's Science Team on a placement funded by the Biotechnology and Biological Sciences Research Council.

"After studying I was keen to find out what jobs are available to scientists who want to stay in science but not at the lab bench," says Catriona.

"My main task at the Library was to lead on the organisation of a TalkScience event to debate the broader impacts of scientific research," continues Catriona. "I identified discussion topics before securing high profile panel members and helping to market and promote the event."

"I also had the opportunity to spend time in other scientific organisations; attended the British Science Association's annual science communications conference and

Peter Warner

Cheltenham Science Festival and also wrote an article for the Litmus Paper."

Catriona concludes: "My placement at the Library allowed me to discover and explore the hidden world of opportunities out there for people with science backgrounds. I feel reassured that there are potential jobs in science outside of the laboratory."

ICOM-CC
17th Triennial Conference
2014 Melbourne

GRAPHIC DOCUMENTS

The legacy of traditional Indonesian ink: Its intensity and durability

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KEYWORDS: legacy, optical microscope, preserves, permanency, soot, traditional ink, workshop

ABSTRACT

In Indonesia, the traditional ink also known as *mangsi gentur* is obtained indigenously by burning kerosene fuel to produce soot. Soot as a carbon source is admixed with sticky rice as a binding agent and then diluted with purified water. The only traditional ink workshop preserving the legacy of this tradition is located in Peuteuy Condong Village, Cianjur, West Java province. The manufacturing process and ink characteristic analysis were carried out in order to examine the ink's permanency and other properties. This preliminary investigation was conducted using a viscometer, an optical microscope and advanced field emission scanning electron microscopy (FESEM) to identify the ink's quality as well as its characteristics on two different substrates: Magnani Platinum paper and *daluang* paper. At constant temperature, the ink is fairly stable and may last for as long as a year without the formation of any insoluble deposit.

INTRODUCTION

Ink, also known as *tinta*, *da'wat* (*dakwat*) and *mangsi* in the Malay region, is an indispensable material for writing on paper, parchment, vellum, palm leaves and tree bark, such as *daluang* (mulberry paper), which can be produced in small quantities or in bulk. The materials used in making the ink are varied and prepared traditionally. In Indonesia, particularly in the West Java provinces, there were six traditional ink *(mangsi gentur)* workshops in 1999 (Tedi Permadi, personal communication, 3 December 2012). Unfortunately, since 2003, only one workshop continues to be operational, located in Peuteuy Condong Village, Desa Songgom, Kecamatan Warung Kondang, Kabupaten Cianjur. Owned by *Ibu* Enung, who inherited it from her mother, the family business may be continued by her son, *Dodi*, who helps with its running to ensure the family legacy is preserved.

At the end of 2012, the authors had an opportunity to visit and witness the workshop and meet *Ibu* Enung and her son. The journey took approximately three hours by road from Bandung City to Cianjur. According to the ink maker, the basic ingredients needed to make the traditional ink are soot and burnt sticky rice. Purified water is also used to dilute the ingredients into a solution. The soot acts as a carbon source, while the sticky rice serves as a vehicle (binding agent) to adhere the ink to the paper fibres. This type of ink is also known as soot or carbon ink. Carbon ink, known commonly as China or India ink, is essentially made of very fine powdered particles of lampblack, a form of carbon held together by some kind of glue (Pines 1931). It consists of fine grains of carbon black suspended in liquid and was first used as early as 2500 BC. This *mangsi gentur* is considered to be of good quality, yields a uniform liquid, free of abrasive particles or flakes, creates permanent writing, flows easily from the *qalam* (pen) and penetrates well into the paper fibre without passing through the substrate, thus fulfilling the requirements for a good ink listed by Mitchell and Hepworth (1904). In terms of stability when storing the ink, it may be kept for as long as a year without the formation of any insoluble deposit in the vessel (*Ibu* Enung, personal communication, 3 December 2012). *Mangsi gentur* is usually manufactured twice a year or according to demand from the Islamic religious schools *(Pesantren)*; it is also distributed to the Islamic bookstores in Cianjur, Sukabumi and Bandung City. Even though users have the option of choosing commercial writing ink available from the art market, demand from this specific group of users has contributed greatly to the availability of this traditional ink until today.

MANUFACTURING PROCESS

The main ingredients used to make the ink are soot and sticky rice. Soot is prepared traditionally (Figure 1) as a source of carbon for the ink-making process, while sticky rice serves as a binding agent (vehicle). Purified water or tap water is used to dilute the ingredients into a solution.

First, sticky rice is fried in a vessel until it turns black in colour. Next, hot water is added to the fried sticky rice and the mixture is boiled until the texture is completely homogenised. Then it is left to cool for a few hours before it is sieved to remove the rice grains. Soot is then added to the remaining liquid from the boiling process at a ratio of 1:1 and this is boiled again with 1 litre of water in order to dilute the mixture. The boiling process should take another 2 hours at 100°C until the mixture has reached the required consistency. It is left to settle at room temperature and more soot is added later if the colour is pale black. Once the ink has cooled completely, the ink mixture is pounded in a mortar to obtain a uniform mix and then finally sieved. The prepared liquid ink is then ready to be used and kept in an airtight container or bottle (Figure 2).

Figure 1
A form of flame carbon prepared by burning kerosene oils. The soot produced in the cracker container gradually thickens and is swept out by means of a feather brush

Figure 2
Ready-to-use *mangsi gentur* kept in a tightly sealed container can last for at least one year without gelatinising or becoming mouldy

INK TESTING AND ANALYSIS METHODS

The newly prepared ink was tested on two different substrates: Magnani Platinum paper (Cartiere Magnani), produced by a European paper mill, and *daluang* paper (mulberry paper), originally from Indonesia. Both types of paper are popular writing materials that have a long tradition of use in the Malay Archipelago. In order to examine the durability and intensity of the ink, various levels of analysis were carried out. The fluidity of the ink was tested using a viscometer (ViscoTester VT550), the penetration of the ink through the paper fibres was analysed with the aid of an optical microscope (Olympus CX21), and the morphological structure and micrograph images of the traditional ink on these substrates were characterised using a JEOL JSM-6700F field emission scanning electron microscope (FESEM).

The rheological behaviour of the ink was investigated by means of a HAAKE VT550 Viscometer. A standard-size ink sample (0.130 ml) was placed symmetrically in the centre of the plate. The ink sample was monitored by increasing the shear rate from 0 up to 120 s^{-1} over 1 minute. Rotational viscometry measurements were taken at a room temperature of 28°C.

Optical light micrographs of the inked paper samples were taken to measure ink penetration and drop width in paper after each slice. The penetration of ink pigment into the paper structure is one of the physical events that were examined under optical microscopy (Olympus CX21). Samples 2 mm wide by 5 mm long were cut out and embedded in epoxy resin and then ground and polished. The samples were polished with the intention of producing smooth cross sections by removing scratches using the finest grinding abrasive. In addition, the samples were held parallel to the abrasives to obtain consistently flat, smooth and level cross sections. These cross sections were then placed parallel to the microscope objectives for consistently focused photomicrographs.

The ink's behavioural characteristics and the morphological structure of its particles on both Magnani paper and *daluang* paper were analysed using FESEM at the Characterisation Laboratory, Faculty of Engineering, the International Islamic University Malaysia (IIUM). The ink was applied via *qalam resam* (fern stick) to the paper samples.

RESULTS AND DISCUSSION

Viscosity of the ink

Prior to the measurement of the ink's viscosity, its pH was tested and recorded an acidity level of 4.26. Figure 3 shows the apparent viscosity versus the shear rate plot obtained from the rotational viscometry measurement. The ink sample showed a decrease in apparent viscosity with an increasing shear rate (i.e. shear thinning behaviour). At low shear rate values, there seemed to be two overlapping pseudoplastic profiles. However, as the shear rate was increased, the data fluctuation was less pronounced. Most probably, these profiles resulted from non-homogeneous and coarse ink particles. The viscosity data were then fitted to a power law viscosity model (Ostwald–de Waele equation) in the following form to determine the consistency coefficient (k) and flow behaviour index (n) (Sahin and Sumnu 2005):

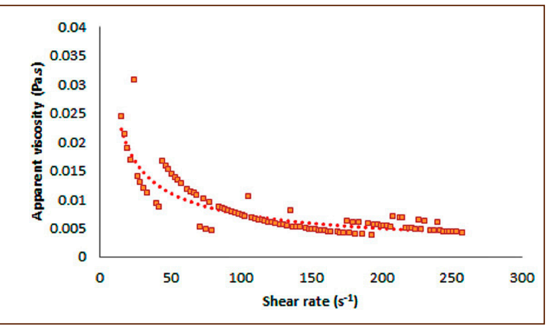
$$\tau = k\dot{\gamma}^{n} \qquad \text{(Eq. 1)}$$

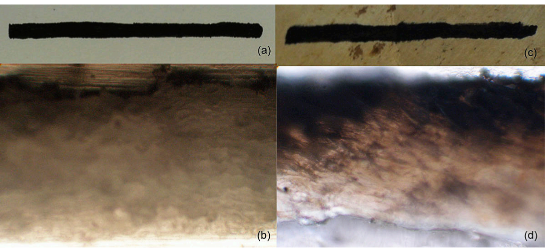
where τ and $\dot{\gamma}$ denote the shear stress and the shear rate, respectively.

The lower the value of n, the higher the pseudoplastic character. The consistency coefficient (k) can be considered to be the apparent viscosity of the solution at a shear rate of 1 s^{-1} (Cisneros et al. 2009). The n value obtained was 0.58 while the k value obtained was 0.11 $Pa.s^n$. The regression factor determination of n and k was 0.8, indicating a good match with the experimental data, as shown by the red dotted line in Figure 3.

Penetration depth and ink distribution

Figure 4 shows the application of the ink on both substrates and the microscopic images of the ink penetration. The penetration depth and the distribution of the ink were subsequently measured using image analyses under a transmitted light microscope. A cross-sectional image of the ink penetrating into the Magnani paper shows a thick layer of ink on top of the paper surface (Figure 5), as compared to the *daluang* paper, which is more porous and allowed the ink to penetrate deeper into the paper fibre (see Figure 6). The penetration depth may also be difficult to estimate accurately due to the surface roughness of the paper, which may have resulted from the manufacturing process. The dark black ink on the Magnani paper surface penetrated slowly into the paper fibre and its colour changed to a pale grey down to the middle of the substrate. The paper section underneath remained white in colour due to the complex paper structure (coated paper). Cross-sectional images of the ink's penetration depth and distribution on the *daluang* paper showed different results. The indiscernible and luminous images clearly showed deeper absorptions into the paper fibre. It is believed that the porosity of the paper structure could have contributed to these findings. As the ink pigments penetrated





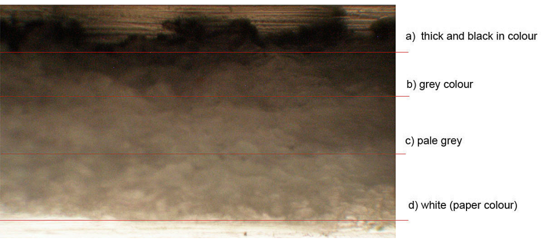


Figure 3
Plot of apparent viscosity as a function of the shear rate of the ink

Figure 4
Mangsi gentur was applied to both substrates labelled in (a) and (c). Cross-sectional images of the ink penetration through Magnani paper (b) and *daluang* paper (d) were both examined under optical microscopy under magnification of x40

Figure 5
Penetration depth and ink distribution through the Magnani paper shows the ink layers from the surface to the bottom of the paper fibres. The ink appears thick and dark black from the top to a quarter of the way through the substrate, distributing slowly and changing colour from grey (b) to pale grey (c). The bottom remains white in colour (d) due to the complex paper structures

deeper into the paper structure, the visibility of the ink on the opposite side also increased.

Ink characteristics and particle morphology

This carbon-based ink is typically permanent and showed significant results on both substrates. Figures 7–8 show FESEM micrograph images of both the Magnani and *daluang* papers before and after the application of *mangsi gentur*. Narrow grain-size distributions of coarse ink particles accumulated on the surface of the Magnani paper. In addition, rounded and uniform ink particles tend to aggregate together and form a thick layer on the paper surface. In contrast with the *daluang* paper, the ink particles impregnated into the paper matrix resulting in a thin layer of ink on top of the paper surface. The rough composition of this paper allowed the ink particles to absorb easily into the paper matrix. Comparisons of the ink characteristics on both substrates are presented in Table 1.

Table 1
Comparison of the characteristics of *mangsi gentur* on the substrates; Magnani Platinum and *daluang* paper

Magnani Platinum Paper (European paper mill)	*Daluang* Paper (papermulberry)
thick layer of ink on top of paper surface	thin layer of ink on top of paper surface
complex composition	rough composition
accumulates and aggregates together on the paper surface	impregnated into the paper matrix
narrow grain size	narrow grain size
rounded, uniform particles morphology	rounded, uniform particles morphology
narrow distribution	wider distribution
durable	less durable
ink flow easily	ink spreading

CONCLUSION

This preliminary study demonstrated the successful initial identification of the durability and intensity of soot ink, the oldest-known ink in both western and eastern cultures. Even though there is very little demand for this traditional ink, its use by a certain group – students from the Islamic religious schools, to be precise – has contributed significantly to its continued availability. It can either be obtained directly from the ink maker or through the Islamic bookstores around the West Java province. This affordable ink is chosen by the students not only for its low cost, but also for its quality. Deep black and durable when applied on paper substrates, along with its other characteristics, it has achieved the standard requirements of a good ink. Its other characteristics include high viscosity, deep penetration into the paper fibres without leaching, stability for up to a year, a permanent yield on paper and suitability for writing (non-sticky). During production, sticky rice is added as a binder to increase viscosity and to help keep the soot in suspension. Even though the ink is acidic, it is stabilised with alkaline paper. Apart from this, the ability of ink makers to create their own formula and ensure their ink is of consistent and uniform quality must be highlighted. Even without formal education and sophisticated equipment, they are capable of creating and formulating

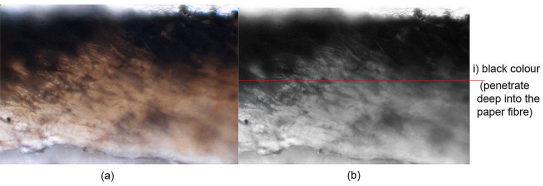


Figure 6
Cross-sectional images of penetration depth and ink distribution on *daluang* paper under magnification of x 40. The invisible image (a) and luminosity image (b) clearly show the ink absorbed deeper into the paper fibre

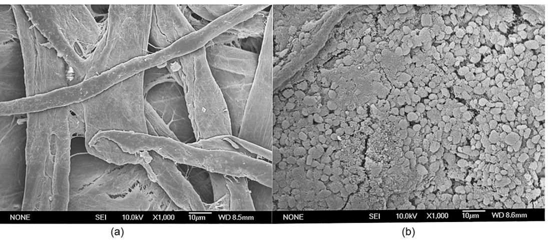


Figure 7
FESEM micrograph of the Magnani paper structure before (a) and after the *mangsi gentur* (b) has been applied. Narrow grain size distribution with coarse particles accumulated on the paper surface

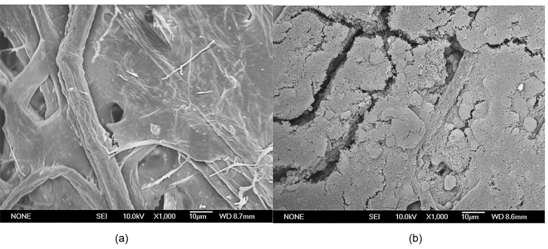


Figure 8
FESEM micrograph of *daluang* paper structures before (a) and after (b) the *mangsi gentur* has been applied. Rounded particles embedded into the paper fibre due to the roughness of the paper surface

a recipe of consistently high quality. It is also crucial that this humble workshop be sustained so as to ensure the preservation of their legacy.

ACKNOWLEDGEMENTS

This field work was conducted as part of a PhD research project supported by a grant from the Islamic Manuscript Association (TIMA), which the authors gratefully acknowledge. Special thanks go to *Ibu* Enung and her son Dodi for their support and willingness to share their secret recipe. A heartfelt thank you also goes to Dr Tedi Permadi, lecturer at the Department of Language and Literature Education Indonesia, Education University of Indonesia. Last but not least, the authors wish to thank Mr Ali Akbar, curator of the Bayt Al-Qur'an & Museum Istiqlal in Jakarta, Indonesia, for introducing the authors to Mr Tedi Permadi.

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MATERIALS LIST

Magnani Platinum Paper (produced by Cartiere Magnani)
Weight: 145 gsm (short grain)
Talas
Brooklyn NY, USA

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