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Comparative Analysis of Different Carboneous Waste for the Formulation of Erasable Ink for White Board Marker Refill

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Authors' contributions

This work was carried out in collaboration among all authors. Author MJ designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors SAO and BJD managed the analyses of the study. Author BJD managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

This article is aimed at carrying out comparative analysis of prepared erasable ink from locally sourced carboneous wastes (lampblack, tyre and coconut shell soot). Different formulation and modification were adapted in this research with effect to three different pigments for the produced inksusing non- oleoresinous varnish preparation method for the assessment and evaluation of the physiochemical properties. Standard test methods for adhesion, viscosity, opacity, drying time, erasability, eligibility were done on the formulated samples as described by SONS 1990.It was found that the size and shape of the pigment particles affects the colorstrength, hue, saturation, viscosity as well as other properties. Increasing gum Arabic increases viscosity which is inversely proportional to the drying time and as seen to give the ink a better performance and stability. This work is hoped to profferalternative sources of pigment in ink formulation.

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1. INTRODUCTION

One of the relatively new products flooding the Nigeria market today is the crucial educational material called "erasable white board marker" or" temporary marker" used on white board which has now almost replaced the traditional chalk used on black board. This product is in high demand at all level of education due to advent of whiteboard. However, all the temporary marker currently in circulation in Nigeria are imported which drives the costs. This practice drains our economy and hence the need to engage on useful research to produce this item locally.

Ink is defined as a solution of an organic or inorganic pigments or dye dissolved or suspended in a solvent used for drawing, writing or printing. Ink formulations vary, basic raw material includes; colorant, binders, solvent [1]. The colorant also known as pigments are the chief component of ink responsible for ink colour and opacity while binders bind the ink and the surface into a film [2,3]. The solvents make the ink flow so that it can be transferred to the printing surface. In many of the ink formulation, the solvent is removed by the drying of the ink and in some cases such as uv-curing inks, the solvent will remain behind and become part of the binder. Other substances known as additives are sometimes added to ink to either adjust the properties of the ink or add a property to the ink thus increasing its performance and these materials are either sourced for or purchased locally or overseas by manufacturers [4]. The knowledge of the inks, their recipes and the techniques for their production comes from archaeological analysis or from written text itself. As referenced by Gottsegen, [5]. Since the 23rd century BC, Chinese inks can be traced with the utilization of animal, natural plant (plant dyes), and mineral inks based on materials such as graphite that were blended with water and applied with ink brushes. The earliest Chinese inks, similar to modern ink sticks, showed up around 256 BC in the end of the Warring States period and it was obtained from soot and animal glue. Resin from the pine tree presents the best inks for drawing or painting on paper or silk. They must be between 50 and 100 years old. The traditional Chinese method of making ink was to grind a mixture of hide glue, carbon black, lampblack, and bone black pigment with a pestle and mortar, then pour the mixture into a ceramic dish where it could dry. To use the dry mixture, a wet brush would be applied until it reliquaries [6,4]. According to Dannenberg in [7], Carbon black was first produced many centuries ago for use as a pigment in inks and lacquers by a simple lampblack process. They used fine particles of carbon (lampblack) as the colorant and gum, saps or glues as the vehicles or bonding agents (Gottensgen, 2006).

Binder are important part of ink composition, it can be synthetic or natural (gums, oils, waxes, glues), whose function is to maintain a certain degree of stability and flowability of the coating process or hold together the ink and the surface into a film [8]. The term "gum" is general used to define all substances which thrust out of various trees, especially fruits and are said to be soluble in water and insoluble in alcohol oils and essences. Gum Arabic is a chemically complex mixture of macromolecules consisting of different sizes and composition. The features and properties of gum Arabic have been developed and is used in different industrial application which include textiles, pharmaceuticals, cosmetics, ceramics, lithography and food. It is widely used as thickener or emulsifying agent and stabilizer in food industries [9]. This research is focused towards formulation of erasable ink from different pigments with physical properties such as viscosity, drying time, erasability similar to those of an imported ink.

2. MATERIALS AND METHOD

2.1 Materials

Ethanol (99.5% Analytical grade), magnesium Sulphate salt were obtained from Fisher Scientific. Distilled water, Gum Arabic.

2.2 Extraction of Carbon Black

Preparing of carbon black from lampblack, spent tyre and coconut shell respectively. For lampblack, a kerosene lamp was used to make a very sooty flame by interrupting the flame with a non- combustible pan suspended just above the flame known as lid. The soot deposited on the lid is swept over a wide container using a feather. The lid is closed on the flame again and this process continues until the oil is finished. Shredded piece of spent automobile tire was washed and dried. It was charged into the reactor after which flame was ignited to initiate combustion. A fluffy black residue after the completion of combustion was recovered in a ready-made form of fine particles sizes [10].

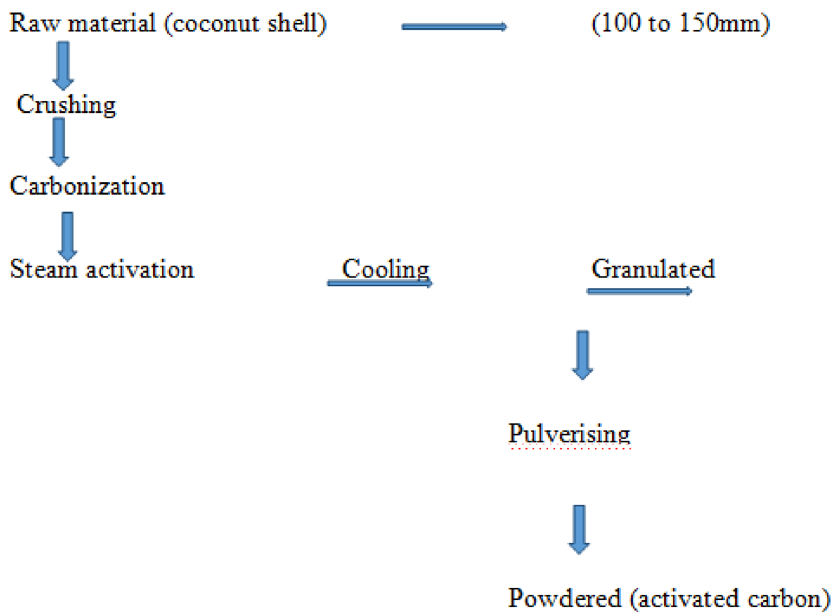

Fig. 1. Process flow diagram

The coconut shell char was collected from the local market in Yola. The procured shell char sample was cleaned and sub-divided to smaller lump sizes and activated with direct fired with wood in a close steel pot at a controlled condition to obtain granulated carbon.

3. EXPERIMENTAL PROCEDURE

8g lumps of Gum arabicwere added to a beaker containing 60ml of water and allow to stay overnight and stirred to form a viscous liquid. 1.8g of carbon soot was measured using a weighing balance and poured into a beaker containing 10ml of water. 20 ml of ethanol was measured using measuring cylinder and added to the mixture to form a solution. The solution was stirred to achieve a homogeneous solution. 0.4 ml of the dissolved Gum arabic was added to the mixture and stirred for about 3 minutes to achieve homogeneity. 0.15 g of magnesium sulphate was measured and added to the ink sample to serve as a drier, after which the ink produced was transferred into a small container and allow for 2 hours before filtering using a white handkerchief and stored in an air tight container prior to the following physiochemical test: viscosity, erasability, drying time, eligibility, opacity and adhesion, the procedure was repeated using lampblack, coconut shell and tyre soot as pigment by varying the volume of Gum Arabic.

3.1 Quality Test

The resulting ink was subjected to physiochemical analysis and quality assessment tests to ensure it conformed to standard. The analysis was carried out according to the methods of Standards Organization of Nigeria, SON [11].

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3.1.1 Opacity

A sample test to check opacity was done by visual comparison after application of ink on paper, the paper was placed across a solid bar positioned so that both sheet touch.

3.1.2 Viscosity

1 ml volume of the ink sample was collected with 2 ml syringe, the syringe was held in a vertical position and the plunger of the syringe was removed and the ink was allowed to flow freely. The time of flow of the ink was recorded using stopwatch. Triplicate evaluations was made for each sample and mean value assessment recorded.

3.1.3 Drying time

The ink was used to write on the whiteboard and the drying time was measured and recorded using a stopwatch. Dry to touch was taken when the ink is no longer sticking to the finger. Triplicate evaluations was made for each sample and mean value assessment recorded.

3.1.4 Erasability

The ink should be easily erased without leaving ghosts or coloured residue behind. The ink was used to write on a whiteboard and allow to dry for 5 minutes and 24 hours before wiping with a dry eraser to determine its erasability respectively.

3.1.5 Eligibility

The ink was used to write on the whiteboard and allow to dry, the writing on the board was observed from a far distance of 5 meters to check how distinct and clear the ink appear on the board.

3.1.6 Adhesion

Adhesion property of ink was carried out by applying on a whiteboard and allowed to dry for 24 hours. Two sets of lines, one crossing perpendicularly over the other was drawn on the board. An adhesive tape was pressed firmly with the thumb covering all the interactions of the perpendicular line. The adhesive tape was held at its loose ends and forcibly removed from the surface. Removal of more than 50% of the square lines of the ink sample indicates a poor adhesion and erasability. Triplicate determinations was made for each sample for quality assessment [12].

4. RESULTS AND DISCUSSION

Table 1, 2 and 3 shows the different formulation of ink produced from lampblack, tyre soot and coconut shell soot respectively.

Table 4 showed the comparative analysis of the physiochemical properties of the different formulated ink samples. From the table it can be seen that there is a gradual increase observed in viscosity from sample A to D with increase in pigment or respect to increasing solid fractions is more likely that particles collide in a liquid acts as obstacle hindering the liquid flow therefore increasing the flow resistance. The samples A to B and C to D are less viscous because it contains lower binder concentration and pigment mass with more solvent which gives good interaction between the binder and pigment thereby bringing about better ink stability. Whereas sample E and F are more viscous due to increase molecular weight of increase or decrease in particle size and particle size distribution or attributed to the fractions of the dispersed pigment leading to larger interaction.

Similarly, the drying time of the different ink sample produced revealed that drying time is a function of ink viscosity. The lower the viscosity, the lower the drying time. Sample A gave the lowest drying time because it has the lowest viscosity, whereas the unusual behavior observed in the abrupt decrease in drying time of sample F could be attributed to the tendency of

Table 1. Formulation of ink produce from lampblack soot

Sample	Component				
	Arabic gum (ml)	**Pigment (g)**	**Ethanol (ml)**	**Drier (g)**	**Water (ml)**
A	0.8	1.8	20	0.15	10
B	2.0	4.5	40	0.30	20

Table 2. Formulation of ink produce from tyre soot

Sample	Component				
	Arabic gum (ml)	**Pigment (g)**	**Ethanol (ml)**	**Drier (g)**	**Water (ml)**
C	2.0	4.5	40	0.30	20
D	0.8	1.8	40	0.15	25

Table 3. Formulation of ink produce from coconut shell soot

Sample	Component				
	Arabic gum (ml)	**Pigment (g)**	**Ethanol (ml)**	**Drier (g)**	**Water (ml)**
E	1.0	10	20	0.15	10
F	2.0	4.5	20	0.30	40

Table 4. The physiochemical properties of imported and produce ink

Physical Test	Standard	A	B	C	D	E	F
Erasability	1	2	3	4	4	5	5
Viscosity (secs)	2.30	1.21	1.51	1.67	2.05	5.32	9.85
Drying time (sec)	14	10.23	22.99	28.01	42.22	49.73	15.49
Eligibility	1	2	2	2	2	5	5
Opacity	1	3	4	3	3	5	5
Adhesion	1	2	3	2	2	5	5

the cross linked structure to retain more water than then diluent (ethanol) thus drying time decreases with increase in solvent ratio.

Furthermore, the erasability of the ink samples produced showed that sample A is of good erasability, sample B, C and D are fairly erasable while sample E and F were of poor erasability which is attributed to the Gum arabic quantity and the particle size and particle size distribution of the pigment dispersed in the solventthereby leaving ghosts or coloured residue on the writing surface.

The eligibility and adhesion of the ink sample is dependent on the pigment particle size [13], the table showed brighter and more pronounce colour/good eligibility of sample A, B, C and D compared to sample E and F due to its smallerparticles which gave an easy stabilize solution (saturation), lower cross linking density of the binder to the pigment leading to failure in stickness and tackiness of the ink sample.

5. CONCLUSION

From the results obtained it can be concluded that three different Carbon black was produced from locally sourced carbonaceous waste of lampblack, spent tire and coconut shell as pigment in the formulation and modification of erasable ink. The resulting erasable ink addressed the problem associated with overdependence on imported materials such as the white board marker and waste management hence converting waste to wealth. The formulated ink from lampblack demonstrated a high degree of compliance to the imported ink in terms of viscosity, opacity, adhesion, eligibility, erasability test and fair drying time with effect to Gum arabic of 0.8ml compared to tire and coconut shell formulated ink. It is hoped that this work introduces the use of Gum arabicas an economically viable binder for the production of erasable ink from local source.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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