

1 **Comparative analysis of different carboneous waste for the formulation of erasable ink**
2 **for white board marker refill**

3 **ABSTRACT**

4 *This article is aimed at carrying out comparative analysis of erasable ink from locally*
5 *sourced carboneous wastes (lampblack, tyre and coconut shell soot). Different formulation*
6 *and modification were adapted in this research with effect to three different pigments for the*
7 *produced inks using non- oleoresinous varnish preparation method for the assessment and*
8 *evaluation of the physiochemical properties. **standard** test methods for adhesion, viscosity,*
9 *opacity, drying time, erasability, eligibility were done on the formulated samples as*
10 *described by SONS 1990. **it** was found that the size and shape of the pigment particles affects*
11 *the colorfastness, colloidal stability, viscosity as well as other properties. **increasing** gum*
12 *Arabic increases viscosity which is inversely proportional to the drying time and as seen to*
13 *give the ink a better performance and stability. This work is hoped to proffer alternative*
14 *sources of pigment in ink formulation.*

15 *Keywords; **ink**, gum Arabic, erasable, viscosity, carboneous waste*

16 **INTRODUCTION**

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

24 Ink is defined as a solution of an organic or inorganic pigments or dye dissolved or suspended
25 in a solvent used for drawing, writing or printing. Ink formulations vary, basic raw material
26 includes; colorant, binders, solvent [1]. The colorant also known as pigments are the chief
27 component of ink responsible for ink colour and opacity while binders bind the ink and the

28 surface into a film [2, 3]. The solvents make the ink flow so that it can be transferred to the
29 printing surface. In many of the ink formulation, the solvent is removed by the drying of the
30 ink and in some cases such as uv-curing inks, the solvent will remain behind and become part
31 of the binder. Other substances known as additives are sometimes added to ink to either
32 adjust the properties of the ink or add a property to the ink thus increasing its performance
33 and these materials are either sourced for or purchased locally or overseas by manufacturers
34 [4]. The knowledge of the inks, their recipes and the techniques for their production comes
35 from archaeological analysis or from written text itself. As referenced by Gottsegen. [5],
36 Since the 23rd century BC, Chinese inks can be traced with the utilization of animal, natural
37 plant (plant dyes), and mineral inks based on materials such as graphite that were blended
38 with water and applied with ink brushes. The earliest Chinese inks, similar to modern ink
39 sticks, showed up around 256 BC in the end of the Warring States period and it was obtained
40 from soot and animal glue. Resin from the pine tree presents the best inks for drawing or
41 painting on paper or silk. They must be between 50 and 100 years old. The traditional
42 Chinese method of making ink was to grind a mixture of hide glue, carbon black, lampblack,
43 and bone black pigment with a pestle and mortar, then pour the mixture into a ceramic dish
44 where it could dry. To use the dry mixture, a wet brush would be applied until it reliquaries
45 [6, 4]. They used fine particles of carbon (lampblack) as the colorant and gum, saps or glues
46 as the vehicles or bonding agents [5].

47 Binder are important part of ink composition, it can be synthetic or natural (gums, oils,
48 waxes, glues), whose function is to maintain a certain degree of stability and flow ability of
49 the coating process or hold together the ink and the surface into a film [7]. The term “gum” is
50 general used to define all substances which thrust out of various trees, especially fruits and
51 are said to be soluble in water and insoluble in alcohol oils and essences. Gum Arabic is a
52 chemically complex mixture of macromolecules consisting of different sizes and

53 composition. The features and properties of gum Arabic have been developed and is used in
54 different industrial application which include textiles, pharmaceuticals, cosmetics, ceramics,
55 lithography and food. It is widely used as thickener or emulsifying agent and stabilizer in
56 food industries [8]. This research is focused towards formulation of erasable ink from
57 different pigments with physical properties such as viscosity, drying time, erasability similar
58 to those of an imported ink.

59 MATERIALS AND METHOD

60 Materials

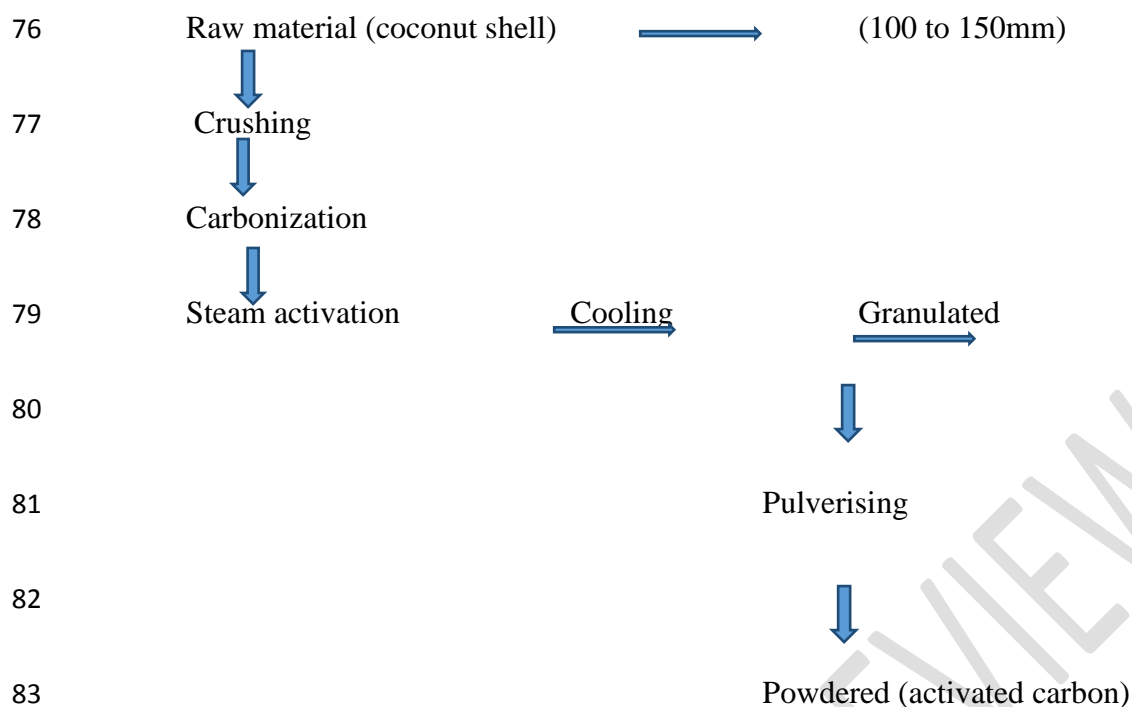
61 Ethanol (99.5% Analytical grade), magnesium Sulphate salt were obtained from Fisher
62 Scientific. Distilled water, Arabic gum

63 Extraction of Carbon Black

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

72

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



85 **Fig 1: Conceptual Framework**

86 **EXPERIMENTAL PROCEDURE**

87 8g lumps of Arabic gum were added to a beaker containing 60ml of water and allow to stay
 88 overnight and stirred to form a viscous liquid. 1.8g of carbon soot was measured using a
 89 weighing balance and poured into a beaker containing 10ml of water. 20ml of ethanol was
 90 measured using measuring cylinder and added to the mixture to form a solution. The solution
 91 was stirred to **achieved** a homogeneous solution. 0.4ml of the dissolved Arabic gum was
 92 added to the mixture and stirred for about 3 minutes to achieve homogeneity. 0.15g of
 93 magnesium sulphate was measured and added to the ink sample to serve as a drier, after
 94 which the ink produced was transferred into a small container and allow for 2hours before
 95 filtering using a white handkerchief and stored in an air tight container prior to the following
 96 physiochemical test: viscosity, erasability, drying time, eligibility, opacity and adhesion, the

97 procedure was repeated using lampblack, coconut shell and tyre soot as pigment by varying
98 the volume of Arabic gum

99 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	

100

101 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	

102

103 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	40	0.30	20	

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108 **Quality Test**

109 The resulting ink was subjected to physiochemical analysis and quality assessment tests to
110 ensure it conformed to standard. The analysis was carried out according to the methods of
111 Standards Organization of Nigeria, SON [9].

112 ***Opacity***

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

115 ***Viscosity***

116 1ml volume of the ink sample was collected with 2 ml syringe, the syringe was held in a
117 vertical position and the plunger of the syringe was removed and the ink was allowed to flow
118 freely. The time of flow of the ink was recorded using stopwatch. Triplicate evaluations was
119 made for each sample and mean value assessment recorded.

120 ***Drying time***

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

124 ***Erasability***

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

128

129

130 **Eligibility**

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

134 **Adhesion**

135 Adhesion property of ink was carried out by applying on a whiteboard and allowed to dry for
136 24 hours. Two sets of lines, one crossing perpendicularly over the other was drawn on the
137 board. An adhesive tape was pressed firmly with the thumb covering all the interactions of
138 the perpendicular line. The adhesive tape was held at its loose ends and forcibly removed
139 from the surface. Removal of more than 50% of the square lines of the ink sample indicates a
140 poor adhesion and erasability. Triplicate determinations was made for each sample for quality
141 assessment.

142 **RESULT AND DISCUSSION**

143 Table 4 showing the physiochemical properties of imported and produce ink

Physical Test	Standard	A	B	C	D	E	F
Erasability	Good	Good	Fair	Fair	Fair	Poor	Poor
Viscosity (secs)	2.30	1.51	18.76	36.11	1.67	5.32	9.85
Drying time (sec)	14	22.99	6.25	2.31	28.01	49.73	15.49
Eligibility	Good	Good	Good	Good	Good	Poor	Poor
Opacity	Good	Good	Fair	Good	Fair	Poor	Poor
Adhesion	Good	Good	Good	Good	Good	Poor	Poor

144

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

147 Table 4 showed the comparative analysis of the physiochemical properties of the different
148 formulated ink samples. From the table it can be seen that the viscosities of sample A and D
149 are less viscous because it contains lower binder concentration and pigment mass with more
150 solvent which gives good interaction between the binder and pigment thereby bringing about
151 better ink stability while sample E and F show a moderate viscosity which was observed due
152 to the effect of increase or decrease in particle size and particle size distribution. Whereas
153 sample B and C are more viscous due to increase molecular weight.

154 Similarly, the drying time of the different ink sample produced revealed it is inversely
155 dependent on the viscosity of the ink. The lower the viscosity, the higher the drying time.
156 Sample C gave the lowest drying time because it contains more ethanol and drier compare to
157 other samples with equal or lower pigment and gum Arabic.

158 Furthermore, the erasability of the ink samples produced showed that sample A is of good
159 erasability, sample B, C and D are fairly erasable while sample E and F were of poor
160 erasability which is attributed to the Arabic gum quantity and the dispersed medium of the
161 pigment in the solvent thereby leaving ghosts or coloured residue on the writing surface

162 The eligibility and adhesion of the ink sample is dependent on the pigment particle size, the
163 table showed brighter and more pronounce colour/good eligibility of sample A, B, C and D
164 compared to sample E and F due to its smaller particles which gave an easy stabilize solution,
165 lower cross linking density of the binder to the pigment leading to failure in stickness and
166 tackiness of the ink sample.

167

168 **Conclusion**

169 In this work, we have demonstrated the production of Carbon black from locally sourced
170 carbonaceous waste such as lampblack, spent tire and coconut shell as pigment in the
171 formulation of erasable ink. The resulting erasable ink addressed the problem associated with
172 overdependence on imported materials such as the white board marker and waste
173 management hence converting waste to wealth. The formulated ink from lampblack
174 demonstrated a high degree of compliance to the imported ink in terms of viscosity, opacity,
175 adhesion, eligibility, erasability test and fair drying time with effect to Arabic gum of 0.8ml
176 compared to tire and coconut shell formulated ink. It is hoped that this work introduces the
177 use of Arabic gum as an economically viable binder for the production of erasable ink from
178 local source.

179

UNDER PEER REVIEW

180 **REFERENCE**

- 181 1. Sharif Ahmed (2007). Polymer science coatings and additives technology of printing
182 inks lecture note
- 183 2. Nwosibe P, O., Nwafolugo F.U., Buhari M.B. and Samuel F. (2018) Comparative
184 analysis of local raw materials for the production of a non-toxic and erasable water
185 base writing ink for white board marker refill vol 5, issue 7, PP 8-13, ISSN 2349-
186 476X
- 187 3. Ali I. Yaumi, Ahmed M. Murtala, Habiba D. Muhd and Fatima M. Saleh (2015).
188 Determination of physiochemical properties of gum Arabic as a suitable binder for
189 emulsion house paint. International journal of environment vol-5, issue-1, ISSN 2091-
190 2854.
- 191 4. Dagde. K.K, Nwosa G. I and Ukpaka. C. P. (2019). Formulation of White Board
192 Marker Ink Using Locally Sourced Raw Materials, *European Journal of Engineering
193 Research and Science* Vol. 4, No. 3
- 194 5. Gottsegen, M. D. (2006). The Painter's Handbook: A Complete Reference Page 30,
195 New York: Watson-Guptill Publications. ISBN 0-8230 – 3496
- 196 6. Bosworth, C. E. (2004). A Mediaeval Islamic Prototype of the Fountain Pen? *Journal
197 of Semitic Christian Science Monitor* 'Think ink' September 21.
- 198 7. Zhang Y., Zhulan L., Yunfeng C., Ren'ai L, and Yi J. (2015). Impact of binder
199 composition on inkjet printing paper. peer- reviewed article biosource 10(1),1462-
200 1476.
- 201 8. Verbeken, D., Dierckx, S, and Dewettinck, K (2003). Exudate gums: Occurrence,
202 production and applications. *Applied Microbiol. Biotechnol.*, 63: 10-21. DOI
203 10.1007/s00253-003-1354-
- 204 9. SON. (1990). Standard for paint and varnish part 6: Test method for paints for
205 decorative purposes. 1-2.