

RESEARCH ARTICLE



Synthesizing Easily Erasable Whiteboard Ink Using Locally Available *Azadiracta Indica* (Neem) Gum

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Abstract

Objective: To synthesize the easily erasable, user-friendly, and low-cost whiteboard ink from the locally available raw sources. **Methods:** The ink was prepared by mixing the Neem-gum, n-butanol, dyes of different colours in different ratios, and the mixture thus obtained was heated at constant temperature and then was cooled to room temperature and filtered. **Findings:** Out of different combinations three different ink formulations SH1, SH2, and SH3 were obtained, and later they were tested to different physiochemical analysis. The results thus obtained for SH1, SH2, and SH3 respectively were pH (5.9, 4.7, and 3.4), viscosity (0.0011628 Ns/m², 0.0086425Ns/m² and 0.0046242Ns/m²) and drying time (5.24 seconds, 18.04 seconds and 8.22 seconds). Samples SH1 and SH3 depict the best properties like drying time, viscosity, and erasability. To know the elemental concentration in the samples, the XRF analysis was conducted and the results thus obtained were on par with that of the standard ink available in the market. **Novelty:** Ink manufacturers of international repute often synthesize them with chemicals that might harm the users like teachers and other professionals if they come into improper contact with it. So we prepared an ink from the naturally available neem gum which is both user-friendly and eco-friendly.

Keywords: Azadirachta indica; erasability; ink; Phenolphthalein; viscosity; XRF analysis

1 Introduction

Neem! What a tree, nature has provided as a gift for us. Neems is called 'arista' in Sanskrit that reflects as perfect or complete. The Gum from *Azadirachta indica* (neem gum), is tasteless, soluble natural exudates of bright fellow to amber-coloured, material⁽¹⁻³⁾. In the present work, neem gum is used to prepare easily erasable whiteboard marker ink.

Ink can be technically called a colloidal system with fine pigment particles dispersed in a solvent and generally consist of binders, solvents, and additives⁽⁴⁾. In India, it is called masi and using for ages. In the early 19th century, a type of ink known as logwood ink was synthesized from a logwood tree using sodium carbonate and potassium

chromate. The erasable or dry-erase ink was invented in 1975 by Jerry Woolf of Tech form laboratories but, ink-based markers and boards became popular in the mid-1990 because of their advantages over chalk^(5,6). Though many advantages are there, after a certain period not much of the research work is done on the erasable ink due to its standardization. Moreover, the chemical composition of the ink and the trace elements present in it is a concern for synthesizing new formulations. In general, there are two types of ink dye-based and pigment-based; Dye-based inks are generally stronger than pigment-based inks and can produce much more colour of a given density per unit mass. In the usage of pigment-based ink, and long-run exposure to it, the volatile organic compounds (VOCs) are released into the air and the side effects are explained in detail in Table 1. Literature review shows that not much of the work is carried out on the ink made from locally available sources. Akande&Nwosibe's study proved that producing the ink from locally sourced materials can significantly reduce overall production cost. According to Cueppers & Christoph^(7,8), the faster the ink dries the more easily erasable it is. So the objective of the present work is to synthesize an easily erasable whiteboard ink from the locally available sources that will be user and eco friendly. The novelty of the present lies in the fact that it is synthesized from the neem gum along with local dyes which makes the ink low cost and can compete with the brands of international repute if produced at a commercial scale.

Table 1. Solvent used in ink and their side effects

Solvent	Side effect	References
Diacetone alcohol	Corneal damage and also irritates the eyes, skin, nose, and throat	(9)
Ethanol	Lassitude, drowsiness, headache and also an irritant to the eyes, skin, and nose	(9)
Isopropyl alcohol	Dizziness, headache and drowsiness as well as irritate the nose, eyes, and throat	(9)
Methyl isobutyl ketone	Irritates the eyes, mucous membrane and the skin	(9)
2-butoxy-ethanol	Eyes, skin, nose and throat irritation, destruction of red blood cells, central nervous system depression, headache, and vomiting	(10)
Toluene(Long-term exposure)	Hearing and colour vision loss while repeatedly breathing in toluene may permanently damage the brain.	(10)
Xylene(Short term exposure)	Irritation of the skin, eyes, nose, and throat, difficulty in breathing, etc.	(10)

2 Methodology

A few lumps of gum obtained from locally available *Azadirachta indica* (neem) are dissolved in a small amount of deionised water to form a viscous liquid. 4.5 g of dye was taken using a weighing balance and poured into a beaker containing 20 ml of deionised water to form a solution. 40 ml of n-butanol was measured using a measuring cylinder and added to the solution in a mixer. The solution was enthused at a constant speed to achieve a homogeneous solution. 5 ml of humidified gum (obtained from neem) and 1.5 ml of phenolphthalein were added to the mixture and stirred. The resulting mixture was heated to 60°C using a heating mantle for five minutes. This is done to achieve homogeneity of the mixture. The ink solution was cooled and strained using a filter cloth to get rid of un-dissolved particles. 0.15 g of magnesium sulphate was measured using a weighing balance and added to 30 ml of the ink that serves as a drying agent. The ink thus obtained was subjected to XRF analysis to ensure that it complies with the standards. The physiochemical analysis like viscosity, drying time, erasability was calculated and they are shown below

Viscosity

For ideal ink, there should be maximum colour strength at minimum velocity. To calculate the time of flow a flow cup and a stopwatch were used. Equal amounts (in ml) of water and ink were separately allowed to flow freely from a flow cup and the time of each sample was noted. The viscosity was then calculated using the relationship between time of flow and viscosity as shown in equation 1.

$$\text{Time of flow of water (t)} / \text{Viscosity of water } (\mu) = \text{Time of flow of ink (t)} / \text{Viscosity of ink } (\mu) \quad (1)$$

Drying Time

For the good ink, the solvent should vaporize swiftly after writing on the whiteboard surface leaving the colorant and the binder, so that the ink attached to the surface and not absorbed by it. In this research work, dry time was measured and recorded at room temperature using a stopwatch. Cleaning agents like ethanol are not at all needed for the good ink.

Erasability

Both the standard ink and ink that are prepared were used to write on a whiteboard, allowed to dry, and then erased to determine its erasability.

XRF Analysis

X-ray fluorescence analysis was conducted to find out the metals and oxides that are active in the ink mixture. Their identity can be confirmed by taking into account, the energy (wavelength) of the x-ray light (photon) emitted by any one particular element at a time.

3 Results

Table 2, shown below depicts the results of the physical analysis for the ink samples of Standard ink 1 and 2 which are commercially available brands. Whereas samples SH1, SH2, and SH3 are the ink samples obtained by taking different mixtures. From the physical analysis viscosities of standard ink 1 and 2 are 0.0010282 N.s/m² and 0.0007814 N.s/m² respectively. The viscosities of samples SH1, SH2 and SH3 are 0.0011628 N.s/m², 0.0086425 N.s/m² and 0.0046242 N.s/m² respectively. This depicts that there is a correlation between viscosity and drying time i.e., the more viscous the ink, the more the drying time. The difference in viscosity can be attributed to the changes in the quantity of gum used. From Table 2, we can see that the drying times of standard inks 1&2 are 2.09 and 2.08 seconds which can be attributed to the low viscosity of both the standard ink samples. Due to these reasons, the standard inks erases quite easily. The drying time of samples SH1, SH2, and SH3 are 5.24, 18.04, and 8.22seconds respectively. The drying time of samples SH1 and SH3 are closer to standard ink samples than sample SH2; this is due to lower viscosities. For the ink to get easily erasable the drying time should be low which results in sticking the ink components to the whiteboard surface; otherwise, they will get absorbed. The erasability of standard inks is very high; while that of samples SH1 and SH3 are high and for sample SH2 is low. The reasons can be attributed to low viscosities and drying time. The sample SH2 was not easily erasable because of the longer drying time. The colors of the ink samples considered in this work are blue, red, and green for samples SH1, SH2, and SH3 respectively. The required color for the ink sample was obtained from the dye. The visible or legible nature of the ink fully depends on its chemical composition. The visibilities for the standard inks 1 & 2 are high and can be concluded from the distinct markings. Samples SH1 and SH3 have high visibility and the markings are also distinctive and vivid, whereas for the sample SH2 it was not clear. The nature of sample SH2 is because of its viscous nature which results in delayed drying time. The pH of standard inks 1&2 is 5.3 and 5.4 respectively which makes them slightly acidic. The reason for their acidic nature can be attributed to the existence of Sulphur Oxide SO₃ in its oxidation state of four, an acidic gas. But it is not highly acidic because of the presence of other basic substances like chlorine and magnesium oxide which are reflected in the XRF analysis. The pH of sample SH1 is 5.9 which makes it slightly acidic, the pH of sample SH3 is 3.4 which is more acidic and the pH of sample SH2 is 4.7 moderately acidic. The differences in pH for ink samples are due to the use of different types of dyes. Samples SH1 and SH2 have proximity to neutrality. Despite its acidic nature, the sample SH3 can also be used because it doesn't come to contact with the user directly. From the above discussion, we can clearly state that out of all the prepared samples, SH1 can be treated as the best formulation as it fits close to all the parameters of the standard inks 1 & 2.

Table 2. Physical Tests for the Various Ink Samples

Physical test	Erasability	Drying Time(in seconds)	Viscosity(N.S/M2)	Color	pH	Visibility
Standard Ink 1	Easily Erased	2.09	0.0010282	Blue	5.3	Clearly visible
Standard Ink 2	Easily Erased	2.08	0.0007814	Red	5.4	Clearly visible
Sample SH1	Easily Erased	5.24	0.0011628	Blue	5.9	Clearly visible
Sample SH2	Mildly Erased	18.04	0.0086425	Red	4.7	Not clearly visible
Sample SH3	Easily Erased	8.22	0.0046242	Green	3.4	Less clear

The ink samples synthesized were further tested for chemical analysis to compare with the Standard inks 1&2 and the results are shown in Table 3. The standard ink1 has SiO₂, TiO₂, SO₃, P₂O₅, Cl, Al₂O₃ as the main ingredients while Cao, Fe₂O₃, CuO, Ru, K₂O, MoO₃, Cr₂O₃, Mn₂O₃, ZnO, SrO were present at a minute level. To our surprise, we found small traces of Ru an inert stable transition metal in the ink sample. The noteworthy thing is that MgO, Na₂O were absent. The pH of the standard ink1 was 5.3 and the reasons can be attributed to the presence of SO₃ which is acidic in a comparatively higher percentage. For the standard ink2, the major active ingredients are P₂O₅, Fe₂O₃, CuO, SiO₂, SO₃, Cl, K₂O, and TiO₂. Whereas the minor

ingredients are MgO, Cr₂O₃, SrO. The ingredients like Na₂O, Ru, MoO₃, Mn₂O₃, ZnO were absent. The main active ingredients in the sample SH1 are P₂O₅, CuO, Fe₂O₃, SiO₂, SO₃, Cl, K₂O, Al₂O₃, TiO₂, SrO. Whereas Cao, MoO₃, Cr₂O₃, Mn₂O₃, ZnO are present as minor constituents. Ru, Na₂O, MgO was absent. Acidic nature SH1 is due to the presence of SO₃ and cl. The percentage of SO₃ in sample SH3 is 16.165 which is the highest for all samples, as a result, it has the lowest pH value of 3.4. The presence of heavy metals like Chromium, magnesium, and manganese, in general, makes any substance toxic but the ink samples prepared are minute as shown in Table 3 which makes them user-friendly in health point of view. Because of its anti-caking agent nature, Silicon oxide is the highest percentage ingredient in both the standard and locally prepared ink samples as conformed in Table 3. This anti-caking nature of silicon dioxide prevents the ink from precipitating and solidifying with time, and also the reason for the slippery nature of the ink.

Table 3. Chemical Test Analysis (XRF Analysis) for all Samples

S.No	Element present	Standard Ink1	Standard Ink2	Sample SH1	Sample SH2	Sample SH3	Concentration (weight %)				
							Standard Ink1	Standard Ink1	Sample SH1	Sample SH2	Sample SH3
1	P ₂ O ₅	✓	✓	✓	✓	✓	4.884	7.932	12.656	8.436	14.784
2	Cao	✓	X	✓	✓	✓	0.342	0.000	0.642	4.862	0.724
3	Fe ₂ O ₃	✓	✓	✓	✓	✓	0.041	0.186	0.069	0.784	0.945
4	CuO	✓	✓	✓	X	✓	2.684	0.735	4.863	0.000	3.264
5	Ru	✓	X	X	✓	X	1.742	0.000	0.000	2.782	0.000
6	Na ₂ O	X	X	X	✓	✓	0.000	0.000	0.000	0.106	0.245
7	SiO ₂	✓	✓	✓	✓	✓	52.784	78.462	54.556	82.640	41.582
8	So ₃	✓	✓	✓	✓	✓	12.364	8.421	9.435	5.212	16.165
9	Cl	✓	✓	✓	✓	✓	7.878	2.334	3.486	1.245	5.565
10	K ₂ O	✓	✓	✓	✓	✓	8.424	4.268	2.145	18.455	15.244
11	MoO ₃	✓	X	✓	X	✓	1.163	0.000	2.334	0.000	1.653
12	MgO	X	✓	X	X	✓	0.000	0.0323	0.000	0.000	0.458
13	Al ₂ O ₃	✓	✓	✓	✓	X	2.344	2.754	2.233	5.878	0.000
14	TiO ₂	✓	✓	✓	✓	✓	0.046	0.548	0.0252	1.764	1.323
15	Cr ₂ O ₃	✓	✓	✓	X	✓	0.076	0.242	0.054	0.000	0.756
16	Mn ₂ O ₃	✓	X	✓	✓	x	0.455	0.000	0.0224	1.465	0.000
17	ZnO	✓	X	✓	X	✓	0.076	0.000	0.045	0.000	1.003
18	SrO	✓	✓	✓	✓	x	0.004	0.012	0.003	0.07	0.000

4 Discussion

Commercially available inks can be prepared from various sources mostly chemical in nature. Many of the researchers used different methods to replace the chemicals with naturally available materials. For example Dagde et al.⁽⁹⁾ prepared ink from the gum arabica which has a pH in the range of 5 to 7 whereas in our work the ink SH1 has a pH of 5.9 which is ideal. In Nwosibe et al. work⁽¹¹⁾ they synthesized another formulation of the ink using the same gum arabica but the dyes and alcohol were different. The viscosity of the present work is lower whereas drying time and pH values are similar to previous report⁽¹¹⁾. Overall, the present work shows better results in terms of the pH, drying time, and viscosity. The results of the present work shows that if the ink is commercially produced the cost of the ink will be low and it benefits the teaching community to a great extent in the health aspect^(9,10).

5 Conclusion

The locally prepared ink is on par with the inks that are produced and marketed internationally. Drying time, pH, other parameters of the ink sample SH1 are closer to the standard inks 1 & 2. All the ingredients that are used in the ink samples were obtained from the local markets which make the production of the ink economically viable and can compete with other standard brands. The limitations of the present work include the drying time, viscosity, and visibility for some samples. There is not much research work done on erasable ink in the recent past. It is therefore recommended that taking this work as reference

further research work on erasable ink from locally available sources can be carried out to synthesize further low-cost and eco-friendly ink.

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