



# Science Teachers Association of Nigeria

**RESOURCES FOR SCIENCE, TECHNOLOGY, AND  
MATHEMATICS (STM) EDUCATION**



## **Proceedings of the 47th Annual Conference 2006**

**UCHENNA NZEWI**

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## PAPER 32

### PLANT DYES: A RESOURCE FOR EFFECTIVE TEACHING AND LEARNING OF TITRIMETRIC ANALYSIS IN CHEMISTRY

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#### Abstract

*This study on plant dyes as a resource for effective teaching and learning of titrimetric analysis in chemistry focused on identifying and determining the workability of local plant dyes suitable for use as indicators for monitoring acid-base titrations. Six local plants, in Uyo Local Government Area of Akwa Ibom State, with coloured parts were selected for investigation – hibiscus, sterculia, kola nut, cam wood, teak leaf, and ginger. The study was a true experimental research with six laboratory activities, carefully planned and carried out in order to answer the two research questions which were raised to guide the study. The results showed that only ginger dye met the requirements of good indicators with respect to distinct colour change in acid and basic solutions and sensitivity. Consequent upon this observation, it is recommended among others that chemistry teachers make effective use of ginger dye in enhancing student performance in titrimetric analysis.*

#### Introduction

The role of chemistry and the other physical sciences (physics and biology) in technology and national development is acknowledged world over. Consequently, the past four decades have witnessed significant reforms in the field of education, with emphasis in the objectives of science education shifting from teaching the informational aspects of science with minimal attention to the processes of science to teaching sciences as they relate to what is known (Gagne, 1966; Jenkins and Whitfield, 1974). The process approach to science sees science education as a human enterprise requiring both the teachers and the learners to be actively involved in the teaching-learning process to make both teaching and learning effective and meaningful (Kampa, 1990); Shaibu and Mari, 2000).

By its very nature, the process approach is cost intensive and in Nigeria the harsh economic realities in the country has made it virtually impossible for the government and school proprietors to provide adequate science equipment and facilities for meaningful hands-on-activities by the learners (Nwosu, 2000; Shaibu and Mari, 2000). Teachers continue to teach science, particularly chemistry as a body of abstract knowledge with little or no students involvement in the learning process. The results have become persistent poor performance in internal and public examinations, general lack of interest on the part of the students in science and declining enrolment in science and related courses. (Nwosu, 2000).

Attempts to remedy the situation led to the introduction of the concept of improvisation in science teaching, with attention directed towards sourcing for, selecting and utilizing resources in the learners own environment which can effectively complement standard materials in the teaching of scientific concepts (Eshiet, 1996). Literature is replete with lists of improvised materials for the teaching of chemistry. (Eshiet, 1996; Ochonogor, 2000). With regard to titrimetric analysis, Oloyede (1997) and Ochonogor (2000) reported that extract from hibiscus flowers compare favourably with phenolphthalein as indicator for weak base-strong acid titration. Akpabio and Inyang (1998) reported that ginger extract is a working substitute for methyl orange indicator.

#### Statement of the Problem

Titrimetric analysis form a significant part of students' practical work in external examiners in chemistry at the secondary school level in Nigeria. Reports from the Chief Examiners for the West African Senior School Certificate Examinations in Chemistry blame students' persistent poor performance in chemistry on

their inadequate exposure to practical work. This inadequate exposure, in part, is due to inadequate materials for effective hands-on-activities. Ndu (2002) noted that indicators for titrimetric analysis in the Senior School Certificate Examination (SSCE) is restricted to methyl orange and maintains that this is punitive considering the high cost of this standard material. Akpabio and Inyang (1998) indicated that ginger dye is a working substitute for methyl orange as indicator but failed to indicate how workable in terms of meeting the requirements of good indicators. In a similar vein, Ochonogor (2000) failed to state how workable hibiscus dye is as a substitute for phenolphthalein as indicator for weak acid-strong base titration. The question therefore remains: how workable are these substitutes?

### **Purpose of the study**

This present study is aimed at investigating the local plant dyes that could be used as effective substitutes or complements to standard or commercial indicators in acid-base titrations. The specific objectives were:

1. To explore the local environment for coloured plants/plants parts, which could provide coloured dyes suitable as acid-base indicators.
2. To determine the workability of such plant dye as acid-base indicators.
3. To determine the comparability of such improvised indicators with standard indicators.

### **The Research Questions**

The following research questions were raised for answering:

1. Which local plant dyes would prove useful as indicators for acid-base titrations considering the characteristics of good indicators?
2. To what extent would such improvised indicators compare with standard/commercial indicators in monitoring acid base titrations?

### **Methodology**

The research was a true experimental study

### **The Study Area**

The study was conducted in Uyo Local Government Area of Akwa Ibom State.

### **The Research Procedures**

The following laboratory activities were planned and carried out.

**Activity: 1** Sourcing for plant/plant parts with coloured extracts from the local environment.

**Objectives:** To select plants for laboratory investigations.

**Procedures:** Several plants with coloured parts in the local environment were identified and collected; and from among these, those selected for study were as shown on Table 1.

**Table 1:** Local Plant/Plants Parts Selected for Laboratory Investigations

S/N	Common Name	Botanical Name	Local (Efik/Ibibio) Name	Part Used
1.	Steculia	Sterculia tragacantha	Idud	Seed
2.	Hibiscus	Hibiscus rosasinensis	Hibiscus	Flower
3.	Kola nut	Kola nitida	Ibon	Seed
4.	Camwood	Baphia notida	Ukpa	Stem
5.	Teak	Tectona grandis	Mmon-nwed adiaha ekiko	Leaf
6.	Ginger	Zingiber officinale	Aran unen	Stem

**Activity 2:** Extraction of dyes from the selected plants' parts.

**Objective:** To obtain the dyes from the various plants' parts

**Materials:** The specimen (selected plant parts), manual grinder or mortar and pistle, 98% ethanol, 250cm<sup>3</sup> beakers, filter-funnel, filter paper, stove, improvised sand bath (discarded aluminium pot or bowl filled with sand), electronic balance storage bottles, and distilled water.

**Procedure:** 20g of each of the freshly selected plants' parts were carefully weighed after peeling, washing and drying under the sun for about an hour. These specimen, were then group

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separately into powder/paste and soaked in 150cm<sup>3</sup> 98% ethanol in separate 250cm<sup>3</sup> beakers, properly labeled, for about 3 hours. Thereafter, the extracts were filtered off and evaporated to dryness on a sand bath and the residue re-weighed. The heating and re-weighing continued until constant weights were obtained in each case.

**Observation:** The observations made are presented on table 2.

**Table 2:** Mass of dyestuff obtained from 20g of plants' parts in 150cm<sup>3</sup> of ethanol.

Plant Part	Kola nut seed	Hibiscus flower	sterculia seed	camwood stem	Teak leaf seed	Ginger stem
Mass of dye (g)	1.94 <sup>(2)</sup>	0.65 <sup>(6)</sup>	1.52 <sup>(3)</sup>	3.64 <sup>(1)</sup>	0.75 <sup>(5)</sup>	1.43 <sup>(4)</sup>
Percentage yield	9.65	3.15	7.60	18.20	3.75	7.15

Tables 2 indicates that Camwood had the highest percentage yield (18.20%), followed by Kola nut (9.65%), sterculia (7.60%), ginger (7.15%), Teak leaf 93.75%, and Hibiscus flower (3.15%).

**Activity 3:** Test of solubility of the plants' dyes

**Objectives:** To determine the solubility of the dye samples in cold water, dilute methanol and dilute ethanol.

**Materials:** The plants' dyestuff samples, measuring cylinder, distilled water, 30% methanol/water, 30% ethanol/water, beakers, spatula, stirrers and electronic balance.

**Procedures:** 0.10g of each of sterculia, hibiscus, Kola nut, camwood, teak leaf and ginger dyestuff samples was carefully weighed into 6 beakers and labeled accordingly. 50cm<sup>3</sup> of distilled water was then added to each of the samples in their respective beakers, stirred and allowed to stand for 10 minutes. The observations made were recorded. The process was repeated with 30% methanol/water, and 30% ethanol/water respectively.

**Observations:** The observations made are as summarized in Table 3.

**Table 3:** Solubility of 0.10g of plants' dyes in 50cm<sup>3</sup> each of distilled water, 30% methanol/ water and 30% ethanol/water at 302.0k.

Dyestuff	Coldwater	30% Methanol/water	30% ethanol/water
Sterculia	Insoluble	Soluble	Soluble
Hibiscus	Soluble ✓	Soluble	Soluble
Kola nut	Insoluble	Soluble	Soluble
Camwood	Insoluble	Soluble	Soluble
Teak leaf	Insoluble	Soluble	Soluble
Ginger	Soluble ✓	Soluble	Soluble

Table 3 shows that all the plant dyes were soluble in methanol and ethanol solutions but only hibiscus and ginger dyes were soluble in cold water.

**Activity 4:** Colour change determination.

**Objectives:** To determine the colour change of plant-dye indicators in neutral, acidic and alkaline solutions.

**Materials:** Prepared solutions of the 6 plant-dye indicators in ethanol, 6 Clean 50cm<sup>3</sup> beakers, 0.1mol dm<sup>-3</sup> NaOH<sub>(aq)</sub>, 0.1mol dm<sup>-3</sup> HCl<sub>(aq)</sub> and distilled water and dropping pipettes.

**Procedure:** 25cm<sup>3</sup> of 0.1mol dm<sup>-3</sup> HCl<sub>(aq)</sub> was put into each of the 6 beakers labeled A-F. Sterculia, hibiscus, Kola nut, Camwood, teak leaf, and ginger dye solutions were added to the solutions in A, B, C, D, E, and F respectively, drop wise until distinctive clear colour change was observed. The colour change was recorded. The process was repeated for 0.1mol dm<sup>-3</sup> NaOH<sub>(aq)</sub> and 25cm<sup>3</sup> of distilled water respectively, and the observations recorded.

**Observation:** The observations made are as summarized in Table 4.

**Table 4:** The colour change of plant dye solutions in 25cm<sup>3</sup> of neutral, basic and acidic solutions at 302.0K.

Dyestuff	Colour in stock Solution	Number of drops required	Colour in aqueous solution		
			Basic	Acidic	Neutral
Sterculia	Yellow	10	Yellow	Yellow	Yellow
Hibiscus	Dark coffee	10	Yellow	Pink	Pink
Kola nut	Yellow	10	Yellow	Yellow	Pinkish-yellow
Camwood	Purple	2 or 3	Purple	Pink	Purple
Teak leaf	Purple	10	Purple	Purple	Purple
Ginger	Yellow/Orange	2 or 3	Yellow/orange	Green	Green

Table 4 shows that sterculia, kola nut and teak leaf dyes had constant colour in neutral, basic and acidic solutions irrespective of the number of drops added. Hibiscus dye had distinct colour changes in neutral, acidic and basic solutions but required up to 10 drops to bring about the colour changes. Camwood dye required 2 or 3 droops but the colour changes were not quite distinct-purple in acid and pink in basic solutions. However, ginger dye had distinct colour changes in basic and acidic solutions and required just 2 or 3 drops to bring about the colour changes, indicating that only ginger dye met the requirements of a good chemical indicator.

#### Comparability of Ginger Dye and Methyl Orange as Acid-Base Indicators

**Activity 5:** Titrating strong acid against strong base using ginger dye and methyl orange as indicators.

**Objective:** To determine the comparability of ginger dye and methyl orange as indicators for strong acid versus strong base titrations

**Materials:** 50cm<sup>3</sup> burette; 25cm<sup>3</sup> pipette, clamp and clamp stand, 250cm<sup>3</sup> conical flasks, a white tile, 0.10 moldm<sup>-3</sup> HCl<sub>(aq)</sub>, 0.10 moldm<sup>-3</sup> NaOH<sub>(aq)</sub>, 0.10 moldm<sup>-3</sup> CH<sub>3</sub>COOH<sub>(aq)</sub>, distilled water, ginger dye solution and methyl orange solution.

**Procedure:** 25.0cm<sup>3</sup> of 0.1 moldm<sup>-3</sup> NaOH<sub>(aq)</sub> were carefully titrated against 0.1 moldm<sup>-3</sup> HCl<sub>(aq)</sub> using ginger dye as indicator. The results were recorded and average titre value determined. The procedure was repeated but with methyl orange as indicator.

**Observation:** The observations made as presented on table 5.

**Table 5:** A comparison of results of titration of 0.1 moldm<sup>-3</sup> HCl<sub>(aq)</sub> against 0.10 moldm<sup>-3</sup> NaOH<sub>(aq)</sub> Using ginger dye and methyl orange as indicators.

Titration	Vol of NaOH <sub>(aq)</sub> in cm <sup>3</sup>	Titre value (cm <sup>3</sup> )	
		Ginger dye	Methyl orange
Rough	25.00	24.80	25.00
1 <sup>st</sup>	25.00	24.60	24.90
2 <sup>nd</sup>	25.00	24.70	24.85
3 <sup>rd</sup>	25.00	24.80	24.90
Average titre (cm <sup>3</sup> )		24.70	24.88

In Table 5, the average titre in respect of ginger dye is 24.70cm<sup>3</sup>, while that of methyl orange is 24.88cm<sup>3</sup>. These results are comparable (mean difference = + 0.18cm<sup>3</sup>).

**Activity 6:** Titrating weak acid against strong base using ginger dye and methyl orange as indicator.

**Objectives:** To determine the comparability of ginger dye and methyl orange as indicators for weak acid versus strong base titration.

**Materials:** 50cm<sup>3</sup> burette, 25cm<sup>3</sup> pipette, 250cm<sup>3</sup> conical flasks, clamp and clamp stand, white tile, 0.10mol dm<sup>-3</sup> NaOH<sub>(aq)</sub>, 0.1 mol dm<sup>-3</sup> CH<sub>3</sub>COOH<sub>(aq)</sub>, ginger dye, methyl orange.

**Procedure:** 25cm<sup>3</sup> of 0.1 mol dm<sup>-3</sup> NaOH<sub>(aq)</sub> were carefully titrated against 0.1 mol dm<sup>-3</sup> CH<sub>3</sub>COOH<sub>(aq)</sub> using (a) ginger dye and (b) methyl orange as indicators and the results recorded.

**Observation:** The observations made are shown on Table 6

**Table 6:** A comparison of results of titration of weak acid against strong base using ginger dye and methyl orange as indicator.

Titration	Vol of NaOH <sub>(aq)</sub> in cm <sup>3</sup>	Titre value (cm <sup>3</sup> )	
		Ginger dye	Methyl orange
Rough	25.00	27.50	26.20
1 <sup>st</sup>	25.00	26.30	26.10
2 <sup>nd</sup>	25.00	26.20	25.95
3 <sup>rd</sup>	25.00	26.30	26.20
	Average titre(cm <sup>3</sup> )	26.27	26.08

In Table 6, the average titre using ginger dye is 26.27cm<sup>3</sup> while that of methyl orange is 26.08cm<sup>3</sup>. These results are comparable (mean difference = + 0.19cm<sup>3</sup>).

### Answering the Research Questions

#### Research Question 1:

Which local plant dyes would prove useful as indicators for acid-base titrations considering the characteristics of good indicators?

The observations from Activities 1-4, summarized in Tables 1-4, show that out of the six local plant extracts investigated-sterculia, hibiscus, kola nut, camwood, teak leaf and ginger- only ginger dye met the requirements of a good indicator. Its colour change in acid and basic solutions were quite distinct; and only 2 or 3 drops were required to bring about colour change as opposed to hibiscus 10 drops.

#### Research Question 2:

To what extent would such improvised indicators compare with standard/commercial indicators in monitoring acid-base titrations?

The observations from Activities 5 and 6 summarized in Tables 5 and 6 respectively show that ginger dye compared favourably with standard methyl orange as indicator for monitoring strong acid/strong base and weak acid/strong base titrations.

### Discussion

It should be recalled that, the focus of this study was investigating local plant dyes for workable substitutes or complements to standard indicators for monitoring acid-base titrations. The results showed that out of the six local plant dyes investigated only ginger-dye met the requirements of a good indicator and compared favourably with methyl orange on monitoring strong acid-strong base and weak acid strong base titrations. These observations confirm earlier findings by Akpabio and Inyang (1998) who reported that ginger dye is a working substitute for methyl orange. However, with regard to the effectiveness of hibiscus flower dye as acid-base indicator the observation from this study showed that, even though it has distinct colour change in acidic and basic solution, its sensitivity is too low, requiring up to 10 drops to bring about the colour change. Hence, hibiscus dye is not a good indicator for acid-base titrations. This observation is in disagreement with those of Oleyed (1997) and Ochonogor (2000).

### Recommendation

Consequent upon the findings from this study, the following recommendations are made.

1. Ginger- dye meets the requirements of a good indicator and compares favourably with standard methyl orange as indicator for strong acid-strong base and weak acid-strong base titrations. Hence, teachers of chemistry should make effective use of this resource in enhancing the teaching and learning of titrimetric analysis.

- Curriculum planners and writers of textbooks in chemistry should include the use of ginger- dye as improvised indicator for acid- base titration in the chemistry curriculum and chemistry textbooks respectively.

### **Conclusion**

Based on the findings of this study, it is hereby concluded that the most veritable local plant resource for use as acid-base indicator is ginger dye.

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