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Allium sativum L as Olfactory Indicators for Acid-Base Olfactory Titration for Visually Impaired Chemistry Students

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Abstract: The study investigated *Allium sativum L* bulbs extracts as olfactory indicator for visually impaired Chemistry students as an alternative to Methyl orange and Phenolphthalein. In this study, concentrations of 0.1M, 0.5M, 1M and 2M HCl and NaOH were used for the Olfactory Titration using *Allium sativum L* olfactory indicator extracts, Methyl orange and Phenolphthalein. The results of the study revealed that the mean titre values for olfactory titration of 0.1M HCl and 0.1M NaOH using *Allium sativum L* olfactory indicator and Methyl orange were 13.000 and 0.000 with S. D Error of 0.000, signifying that *Allium sativum L* olfactory indicator, for this study cannot conveniently replace Methyl orange in 0.1M HCl: 0.1 M NaOH olfactory titration. The mean titre values for the Allium sativum L indicator used for olfactory titration of 0.5M HCl: 0.5M NaOH showed a great significant difference. For the olfactory titration of 1M HCl: 1M NaOH, the mean titre values of 3.0667 for *Allium sativum L olfactory indicator; 3.2000* for Phenolphthalein and 3.1333 for Methyl orange indicators were recorded. The results revealed an almost total agreement, signifying that at a molar concentration of 1, *Allium sativum L* olfactory indicators can equivocally replace Phenolphthalein and Methyl orange indicators. Interestingly, the mean titre values for olfactory titration of 2M HCl: 2M NaOH using olfactory indicators and Phenolphthalein were, *Allium sativum L* = 5.000 and Phenolphthalein = 5:000, showing that *Allium sativum L* can be used as an alternative to Phenolphthalein indicator for concentrations of 2M. For the same 2M, the mean titre value for using Methyl orange was 24:000, almost 5x>the two indicators. Thus there is a very significant difference in the mean titre values of *Allium sativum L* olfactory indicators and that of Methyl orange. It is also concluded that the use of *Allium sativum L* bulbs extracts as olfactory indicators is of great economic benefits as it is affordable, bioavailable, bioactive, ecofriendly, ease of preparation, non-carcinogenic and gives accuracy and very near or same precision with visual indicators.. The *Allium sativum L* indicators gives a strong and more stringent steady ordour at completion of the reaction.

Keywords: *Allium sativum L*, Olfactory Indicator, Acid-Base Olfactory Titration, Methyl Orange, Phenolphthalein

1. Introduction

In a bid to search for a better and alternative indicators for teaching acid-base titration to the inclusion of visually impaired and disadvantaged chemistry students who might have difficulties in reading end points of neutralization reaction via meniscus on burettes due to color blindness, chemists have introduced the concepts of chemistry and smell. [5, 8]. This is to ensure that color blind chemistry students who might have difficulties with visual indicators like Methyl orange and Phenolphthalein etc., are not excluded from chemistry experiments like Acid-base titration which are solely dependent on color change observations [3] of the visual indicators.

In a research titled ‘An Olfactory indicator for Acid-Base titration, a laboratory technique for visually impaired [8] introduced the concept of chemistry and smell otherwise known as Olfaction. This was to diversify Acid-Base titration away from the chemistry and sight which has been the norm. Olfactory titration are carried out in the presence of both the visual and olfactory indicators respectively [3, 13] to enable the chemistry students compare the times at which the two very direct indicators signals the end-point of the neutralization reactions.

These novel indicators are employed to help the students detect when the neutralization of Acid-Base are completed by the olfaction rather than by the conventionally visually reading of the meniscus in the burettes. The student employs his sense of smell to detect the end-point from the stench in the acid-base mixture in the Erlenmeyer flask.

A study was carried out on olfactory titration using Garlic (*Allium sativum L*), Onion (*Allium cepa L) by these authors* [3, 5, 10] Vanillin as acid-base olfactory indicators. From their investigation, results showed that *Allium cepa, Allium sativum* and Vanillin can be employed to serve as olfactory indicators for students with color blindness. This is because their results were in tandem with visual color indicators like Methyl orange and Phenolphthalein.

Olfactory indicators aids in determination of the Acidity or basicity of a solution by changing its smell [2] rather than it colors. [6, 11] Substances often used as olfactory indicators are eugenol, thymol, vanillin and thiophenol, [8]; Cloves, [11]; Onions, [7, 15] Clove oil and Vanillin extract [9].

1.1. Purpose of Study

The aim of this study is to investigate *Allium sativum L* bulbs extracts as olfactory indicator [13] for visually impaired Chemistry students as an alternative to Methyl orange and Phenolphthalein.

1.2. The Chemistry of Allium sativum L (Garlic)

Garlic is scientifically called *Allium sativum L* with the main compound *Allicin.*

Chemical formula $C_6H_{10}S_2O$.

The vallicin is said to possess an ordoriferous, unstable anti-bacterial substances. Angewandte, [2]. The sulphur containing compound of *Allium sativum L* are responsible for both it pungent ordor and many of its medicinal effect. [4, 6].

1.3. Hypothesis

The following null hypothesis was stated and tested.

HO: There is no significant difference between the mean titre values of the results obtained for Olfactory Titration using *Allium sativum L* olfactory indicators and those obtained for visual Acid-Base Titration using Methyl orange and Phenolphthalein with same concentrations of 0.1M, 0.5M, 1M and 2M HCl and NaOH respectively.

2. Methodology

The research was carried out in the Chemistry laboratory of the College of Education, Zing, Taraba State, Nigeria. The Primary method adopted for the study was the experimental design.

2.1. Reagents, Apparatus and Equipment

The principal raw materials employed in the study was macerated bulbs of *Allium sativum L*. All reagents used in the experimental work were of analytical grade. These includes Hydrochloric acid (HCl, 33-36%, NaOH 98%). Visual indicators were Methyl orange, $C_{14}H_{14}N_3NaO_3S$, Phenolphthalein ($C_2OH_{14}O_4$). The instruments that were used in the study were Electronic analytical balance. The following apparatus and equipment such as Erlenmeyer flask, 250ml, 250ml beakers burette 50ml, pipette, 10ml, 25ml, graduating measuring cylinders, 10ml, 20ml, Whatman filter paper No 41, funnel, retort stand and clamp. Pestle and mortar, distilled water and a knife.

2.2. Sample Collection and Preparation of Allium sativum L

Ten *Allium Sativum L* bulbs were purchased from Zing local Market of Zing Local Government Area of Taraba State.

2.3. Extraction of Allium sativum L as Olfactory Indicators

50 g of *Allium sativum L* bulbs were washed and weighed on a top balance. The weighed *Allium sativum L* were macerated and triturated in a mortar with pestle. The macerated and triturated samples were dissolved in 200ml of distilled water in a 250 ml beaker for aqueous extraction. The mixture was stored for 24 hours at room temperature. The extract was filtered with Whatman filter paper and preserved in tight closed bottle and stored away from sunlight to prevent photolysis and decomposition. The findings of research [12, 14] are used as olfactory indicators for acid-base olfactory titration.

2.4. Application of Allium sativum L as Olfactory Indicator for HCl and NaOH Olfactory Titration

50 ml of 0.1M, 0.5M, 1M and 2M HCl from the Burette were titrated with 25ml of 0.1M, 0.5M, 1M and 2M of NaOH solution in a 250ml Erlenmeyer flask and 3 drops of the indicators were added.

The results of the titrations are recorded in Tables 1 to 16.

Table 1. *0.1MHCl: 0.1MNaOH with 3 drops Allium sativum L Olfactory Indicator (ASLOI).*

Burette	Aliquot 1 CM^3	Aliquot 2 CM^3	Aliquot 3 CM^3
Final Reading	13.20	26.40	39.80
Initial Reading	0.00	13.20	26.40
Vol of HCl used	13.20	13.20	13.40

Mean Titre Value (MTV)= $\frac{13.20+13.20}{2}$=26.40/2 = 13.20 CM^3

Table 2. *0.1MHCl: 0.1MNaOH with 3 drops Methyl orange Indicator (MOI).*

Burette	Aliquot 1 CM^3	Aliquot 2 CM^3	Aliquot 3 CM^3
Final Reading	15.20	30.00	45.20
Initial Reading	0.00	15.20	30.00
Vol of HCl used	15.20	14.80	15.20

Mean Titre Value (MTV)= $\frac{15.20+15.20}{2}$ =30.40/2 = 15.20 CM^3

Table 3. *0.1MHCl: 0.1MNaOH with 3 drops Phenolphthalein Indicator (PhPhI).*

Burette	Aliquot 1 CM^3	Aliquot 2 CM^3	Aliquot 3 CM^3
Final Reading	15.10	30.60	46.00
Initial Reading	0.00	15.10	35.50
Vol of HCl used	15.10	15.50	15.50

Mean Titre Value (MTV)= $\frac{15.50+15.50/2}{2}$ =31.00.20/2 = 15.50 CM^3

Table 4. *0.5MHCl: 0.5MNaOH with 3 drops Allium sativum L Olfactory Indicator (ASLOI).*

Burette	Aliquot 1 CM^3	Aliquot 2 CM^3	Aliquot 3 CM^3
Final Reading	17.30	34.00	34.00
Initial Reading	0.00	17.30	17.30
Vol of HCl used	17.30	16.70	16.70

Mean Titre Value (MTV)= $\frac{16.70+16.70}{2}$ =33.40/2 = 16.70 CM^3

Table 5. *0.5MHCl: 0.5MNaOH with 3 drops Methyl Orange Indicator (MOI).*

Burette	Aliquot 1 CM^3	Aliquot 2 CM^3	Aliquot 3 CM^3
Final Reading	28.10	28.30	28.30
Initial Reading	0.00	0.00	0.00
Vol of HCl used	28.10	28.30	28.30

Mean Titre Value (MTV)= $\frac{28.30+28.30}{2}$ =56.60/2 = 28.30 CM^3

Table 6. *0.5MHCl: 0.5MNaOH with 3 drops Phenolphthalein Indicator (PhPhI).*

Burette	Aliquot 1 CM^3	Aliquot 2 CM^3	Aliquot 3 CM^3
Final Reading	34.10	34.10	34.20
Initial Reading	0.00	0.00	0.00
Vol of HCl used	34.10	34.10	34.20

Mean Titre Value (MTV)= $\frac{34.10+34.10}{2}$ =68.20/2 = 34.10 CM^3

Table 7. *1MHCl: 1MNaOH with 3 drops Allium sativum L Olfactory Indicator (ASLOI).*

Burette	Aliquot 1 CM^3	Aliquot 2 CM^3	Aliquot 3 CM^3
Final Reading	3.10	6.10	9.20
Initial Reading	0.00	3.10	6.10
Vol of HCl used	3.10	3.00	3.10

Mean Titre Value (MTV)= $\frac{3.10+3.10}{2}$ =6.20/2 = 3.10 CM^3

Table 8. *1MHCl: 1MNaOH with 3 drops Methyl Orange Indicator (MOI).*

Burette	Aliquot 1 CM^3	Aliquot 2 CM^3	Aliquot 3 CM^3
Final Reading	3.40	6.40	9.40
Initial Reading	0.00	3.40	6.40
Vol of HCl used	3.40	3.00	3.00

Mean Titre Value (MTV)= $\frac{3.00+3.00}{2}$ =6.00/2 = 3.00 CM^3

Table 9. *1MHCl: 1MNaOH with 3 drops Phenolphthalein Indicator (PhPhI).*

Burette	Aliquot 1 CM^3	Aliquot 2 CM^3	Aliquot 3 CM^3
Final Reading	3.00	6.30	9.60
Initial Reading	0.00	3.00	6.30
Vol of HCl used	3.00	3.30	3.30

Mean Titre Value (MTV)= $\frac{3.30+3.30}{2}$ =6.60/2 = 3.30 CM^3

Table 10. *2MHCl: 2MNaOH with 3 drops Allium sativum L Olfactory Indicator (ASLOI).*

Burette	Aliquot 1 CM^3	Aliquot 2 CM^3	Aliquot 3 CM^3
Final Reading	4.00	8.00	12.00
Initial Reading	0.00	4.00	8.00
Vol of HCl used	4.00	4.00	4.00

Mean Titre Value (MTV)= $\frac{4.00+4.00}{2}$ =8.00/2 = 4.00 CM^3

Table 11. *2MHCl: 2MNaOH with 3 drops Methyl Orange Indicator (MOI).*

Burette	Aliquot 1 CM^3	Aliquot 2 CM^3	Aliquot 3 CM^3
Final Reading	24.00	48.00	24.00
Initial Reading	0.00	24.00	0.00
Vol of HCl used	24.00	24.00	24.00

Mean Titre Value (MTV)= $\frac{24.00+24.00}{2}$ =48.00/2 = 24.00 CM^3

Table 12. *2MHCl: 2MNaOH with 3 drops Phenolphthalein Indicator (PhPhI).*

Burette	Aliquot 1 CM^3	Aliquot 2 CM^3	Aliquot 3 CM^3
Final Reading	2.00	4.00	6.00
Initial Reading	0.00	2.00	4.00
Vol of HCl used	2.00	2.00	2.00

Mean Titre Value (MTV)= $\frac{2.00+2.00}{2}$ =4.00/2 = 2.00 CM^3

3. Results and Discussion

3.1. Application of Allium sativum L Extracts in Acid-Base Olfactory Titration and Comparing with Synthetic Indicators

Table 1 to Table 12 shows the results of the olfactory titration of 0.1M, 0.5 M, 1M and 2M HCl and 0.1M, 0.5M 1M, and 2M NaOH respectively, and using Allium sativum L olfactory indicators, Methyl Orange and Phenolphthalein. The mean titre values obtained from the studies coincided with that of visual synthetic indicators, Methyl Orange and Phenolphthalein. They indicated colorless solution at the end-points just as Phenolphthalein. These results concurred with the findings [5, 9, 16].

3.2. Test of Hypothesis

HO There is no significant difference between the mean titre values of results obtained for Olfactory titrations of 0.1M, 0.5M, 1M and 2M HCl and 0.1M, 0.5M, 1M and 2M NaOH using Allium sativum L Olfactory indicators and those obtained using Methyl orange and Phenolphthalein visual indicators respectively.

Tables 13 to Table 16 shows the mean titre values of titration of 0.1M, 0.5M, 1M and 2M HCl and 0.1M, 0.5M, 1M and 2M NaOH using ASLOI, MeO and PhPh, S. D, and S. D Error.

The results from these tables gives the test for the Hypothesis.

Table 13. *The Mean titre values of titration of 0.1M HCl: 0.1M NaOH Using ASLOI, MeO, PhPh, S. D & S. D Error.*

S/N	NO OF TITRATION	CONC M	INDICATOR	MTV	S. D	S. D ERROR
1	3	0.1	ASLOI	13.0000	0.00000	0.00000
2	3	0.1	MeO	15.3667	0.23094	0.13333
3	3	0.1	PhPh	15.1333	0.11547	0.06667

From the results in the Table 13 above the MTV of Olfactory titration of 0.1M HCl: 0.1M NaOH using ASLOI, PhPh and Methyl orange indicators are 13.0000, 15.1333 and 15.3667, with S. D of 0.11547, 0.0000 and 0.13333 showsing that there is a significant difference in the mean titre values of olfactory titration using ASLOI, PhPh and Methyl orange for Concentrations of 0.1M of HCl and NaOH respectively. The hypothesis is rejected. Therefore, ASLOI cannot be used in place of Phenolphthalein and Methyl orange for these concentrations.

Table 14 shows a marked difference in the mean titre values obtained from Olfactory titration using 0.5M HCl: 0.5M NaOH, Signifying that there is a significant difference between the mean titre values obtained using ASLOI, MeO and PhPh in 0.5M HCl: 0.5M NaOH Olfactory titration respectively. Thus the Hypothesis is rejected for concentrations of HCl and NaOH.

Table 14. *The Mean titre values of titration of 0.5M HCl: 0.5M NaOH Using ASLOI, MeO, PhPh, S. D & S. D Error.*

S/N	NO OF TITRATION	CONC M	INDICATOR	MTV	S. D	S. D ERROR
1	3	0.5	ASLOI	17.3000	0.00000	0.00000
2	3	0.5	MeO	28.2333	0.11547	0.06667
3	3	0.5	PhPh	13.1667	0.04557	0.03333

Table 15. *The Mean titre values of titration of 1M HCl: 1M NaOH Using ASLOI, MeO, PhPh, S. D & S. D Error.*

S/N	NO OF TITRATION	CONC M	INDICATOR	MTV	S. D	S. D ERROR
1	3	1	ASLOI	3.0667	0.05774	0.03333
2	3	1	MeO	3.2000	0.17321	0.10000
3	3	1	PhPh	3.1333	0.23094	0.13333

Table 16. *The Mean titre values of titration of 0.5M HCl: 0.5M NaOH Using ASLOI, MeO, PhPh, S. D & S. D Error.*

S/N	NO OF TITRATION	CONC M	INDICATOR	MTV	S. D	S. D ERROR
1	3	2	ASLOI	5.0000	0.00000	0.00000
2	3	2	MeO	5.0000	0.00000	0.00000
3	3	2	PhPh	13.166	0.00000	0.00000

Table 15 shows that the mean titre values for the olfactory titration of 1MHCl: 1M NaOH using the Allium sativum L olfactory indicator and the two visual indicators are almost the same. Thus signifying that there is no difference between the mean titre values using ASLOI, MeO and PhPh indicators. Therefore, the Null Hypothesis is rejected when using the 1M HCl: 1M NaOH concentrations. Thus ASLOI can be used in place of MeO and PhPh for concentrations of 1M HCl and 1M NaOH.

Results from Table 16 shows that the mean titre values for olfactory titration of 2M HCl and 2M NaOH using ASLOI and Methyl orange indicator are the same. This shows that there is no mean difference between the mean titre values obtained using ASLOI and that obtain using Methyl orange. The null Hypothesis is rejected.

There is a difference between the mean titre values of ASLOI and that of Phenolphthalein. Therefore, the null hypothesis is accepted.

4. Conclusions

Acid-base titration in Chemistry laboratory is often carried out using visual indicators like Methyl orange, Methyl red and Phenolphthalein etc. These synthetic indicators have their short comings. For instance, end points of titrations are determined by colour change in the reaction mixture of the Acid-base. Students with visual impairment will always have difficulties reading the endpoint from the meniscus of the burette. Therefore, the address this anomalies, the research adapt an alternative indicator for such students known as the olfaction indicators where such students will deploy their sense of smell to determine the end point of Acid-Base Neutralization reaction. The study was to investigate whether *Allium cepa L* and *Allium sativum L* can be used as alternative to Methyl orange and Phenolphthalein indicators respectively. From the results of the study, Allium *cepa L* and *Allium Sativum L* are better olfactory indicators. They can be used in the absence of Methyl orange and Phenolphthalein.

Abbreviations

MTV: Mean titre vaue.
S. D: Standard Deviation.
S. D Error: Standard Deviation Error.
ASLOI: *Allium sativum* Olfactory Indicator.
MeO: Methyl orange.
PhPh: Phenolphthalein.

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