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

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Abstract
The study sought to use Allium cepa L bulbs extracts as olfactory indicators for visually impaired Chemistry students as an alternative to visual indicators like Methyl Orange and Phenolphthalein. In this study varying concentrations of Allium cepa L olfactory indicator extracts as substitute for Methyl Orange and Phenolphthalein in Strong Acid-Strong Base olfactory titration for students with visually impaired for concentration of 0.1M, 0.5M, 1M and 2M HCl and NaOH respectively were used. The results of the study revealed that the mean titre values for olfactory titration of 0.1M HCl and 0.1M NaOH using Allium cepa L olfactory indicator and Methyl orange visual indicators were 15.1667 and 15.1333 with S.D Error of 0.06667, signifying that Allium cepa L olfactory indicator can conveniently replace Methyl orange in 0.1M HCl: 0.1 M NaOH olfactory titration. The mean titre values for all the indicators 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 2.9667 for Allium cepa L olfactory indicator; 3.0667 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, the Allium cepa L olfactory indicators can equivocally replace Phenolphthalein and Methyl Orange indicators in Olfactory strong acid- base titration.
Interestingly, the mean titre values for olfactory titration of 2M HCl: 2M NaOH using olfactory indicators and Phenolphthalein were, Allium cepa L olfactory indicator = 5.000; and Phenolphthalein = 5:000, showing that Allium cepa L olfactory indicators can be used as an alternative to Phenolphthalein indicator in strong Acid – strong Base olfactory titration for concentrations of 2M. The mean titre value for using Methyl orange for the same 2M concentrations of HCl: NaOH olfactory titration was 24:000, almost five times greater that of the two indicators. Thus, there is a very significant difference in the mean titre values of Allium cepa L olfactory indicator and that of Methyl orange.
It is also concluded that the use of Allium cepa L bulbs extract as olfactory indicator in strong acid-strong base type olfactory titration is of 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 like Methyl orange an Phenolphthalein. The uniqueness in the application of Allium cepa L olfactory indicators in determining the end point of titration is that, as the reaction progresses to completion, it gives a strong and more stringent steady ordour.

Keywords: *Allium cepa L*, Olfactory indicator, Acid-Base Olfactory Titration, Methyl Orange and Phenolphthalein.

Introduction
In a bid to search for a better and alternative indicator 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. (Kerry et al, 2005; Mark and William, 1990). 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 visual indicators.
In research titled 'An Olfactory indicator for Acid-Base titration, A laboratory Technique

for visually impaired, Mark and William, (1990), 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. Wood and Roberta, (1996), re-iterated that the Olfactory titration are carried out in the presence of both the visual and olfactory indicators respectively to enable the Chemistry students compare the times at which the two very direct indicators signal the end-point of the neutralization reactions.

These novel indicators are employed to help the students detect when the neutralization of Acid-Base is 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.

Kerry et al, (2005), carried out an in-depth study on olfactory titration on Garlic (Allium sativum L), Onion (Allium cepa L) 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 aid in determination of the Acidity or basicity of a solution by changing its smell rather than it colors. (MSTET Varg 2 Science, (2019). Substances often used as olfactory indicators are Eugenol, Thymol, Vanillin and Thiophenol, (Mark and William, (1996); Cloves, MSTET Varg2Science, (2019); Onions, Clove oil and Vanillin extract (Chemistryforcomplete.com, 2022)

The Chemistry of Allium cepa L (Onion)

Onion (Allium cepa) is a member of the family Amaryllidaceae and one of the most widely cultivated species of the genus Allium. Onion has plentiful chemical compounds such as allicin, quercetin, fisetin, and other sulphurous compounds: diallyl disulphide and diallyl trisulphide Mahyar et al,(2021)

The common bulbing onion (Allium cepa L) is reported to have been cultivated for the past 5000 years In part of the world. Timothy, (2007). The Allium genius also contain several other species commonly referred to as onion. They are cultivated as food, such as Japanese bunching Onion (A. fistolosum)-www.wkipedia.2014 in Moses and Gideon, (2014). Onions contain phenolics and flavonoids, anti-cholesterol and anti-oxidant properties.

Chemical formula of Allium cepa L. C_3H_6SO

Name: - Syn-propanethial-S-Oxide

Allium cepa L is said to be an olfactory indicator with two and a distinct ordors in the presence of an acid and ordorless in an alkaline medium. It retains it ordor in an acidic medium. (Vedantu.com/qu.2023

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 cepa L olfactory indicator 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.

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.

Reagents, Apparatus and Equipment

The principal raw materials employed in the study was macerated bulbs of Allium cepa 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

Sample Collection and Preparation of Allium cepa L and Allium sativum L.

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

Extraction of Allium cepa L as Olfactory Indicators

Allium cepa L Olfactory Indicator Extraction

50 g of Allium cepa L bulbs were washed and weighed on a top balance. The weighed Allium cepa 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. (Nhapi, 2016, Sintayehu and Baye, 2020), to be used as olfactory indicators for acid-base olfactory titration.

Application of Allium cepa L as Olfactory Indicator for HCl and NaOH Olfactory Tiration.

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 12

Table 1: 0.1MHCl:0.1MNaOH with 3 drops Allium cepa L Olfactory Indicator (ACLOI).

Burette	Aliquot 1 CM^3	Aliquot 2 CM^3	Aliquot 3 CM^3
Final Reading	13.10	26.20	39.50
Initial Reading	0.00	13.10	26.20
Vol of HCl used	13.10	13.10	13.30

Mean Titre Value (MTV)= $\frac{13.10+13.10}{2}$ =26.20/2 = 13.10 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)= $\frac{15.50+15.50}{2}$ =31.00.20/2 = 15.50 CM^3

Table 4: 0.5MHCl:0.5MNaOH with 3 drops Allium cepa L Olfactory Indicator (ACLOI).

Burette	Aliquot 1 CM^3	Aliquot 2 CM^3	Aliquot 3 CM^3
Final Reading	18.10	36.20	36.00
Initial Reading	0.00	18.10	18.20
Vol of HCl used	18.10	18.10	17.80

Mean Titre Value (MTV)= $\frac{18.10+18.10}{2}$ =36.20/2 = 18.10 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 cepa L Olfactory Indicator (ACLOI).

Burette	Aliquot 1 CM^3	Aliquot 2 CM^3	Aliquot 3 CM^3
Final Reading	2.90	5.90	8.90
Initial Reading	0.00	2.90	5.90
Vol of HCl used	2.90	3.00	3.00

Mean Titre Value (MTV)= $\frac{3.00+3.00}{2}$ =6.00/2 = 3.00 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 cepa L Olfactory Indicator (ACLOI).

Burette	Aliquot 1 CM^3	Aliquot 2 CM^3	Aliquot 3 CM^3
Final Reading	5.00	10.10	15.10
Initial Reading	0.00	5.00	10.00
Vol of HCl used	5.00	5.10	5.10

Mean Titre Value (MTV)= $\frac{5.10+5.10}{2}$ =10.20/2 = 5.10 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

Results and Discussion

Application of olfactory indicators of Allium cepa L extracts in Acid-Base Olfactory titration and Comparing with Methyl Orange and Phenolphthalein visual indicators.

Table 3.1 to Table 3.12 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 cepa 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 Flair and Seltzer, (1990), Wood and Roberts, (1996), and Kerry et al, (2005)

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 cepa 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 ACLOI, 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 ACLOI, MeO, PhPh, S.D and S.D Error.

S/N	No of Titration	CONC M	Indicator	MTV	S. D	S.D Error
1	3	0.1	ACLOI	15.1667	0.11547	0.06667
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 ACLOI and PhPh indicators are 15.1667 and 15.1333 with and S.D of 0.11547 shows that there is no difference in the mean titre values of olfactory titration using ACLOI and PhPh for Concentrations of 0.1M of HCl and NaOH respectively. The hypothesis is accepted. Therefore, ACLOI can be used in place of Phenolphthalein. ACLOI can also be used in place of Methyl orange.

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

S/N	No Of Titration	Conc M	Indicator	Mtv	S. D	S.D Error
1	3	0.5	Acloi	18.0667	0.05774	0.03333
2	3	0.5	Meo	28.2333	0.11547	0.06667
3	3	0.5	Phph	13.1667	0.04557	0.03333

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 ACLOI, MeO and PhPh in 0.5M HCl:0.5M NaOH Olfactory titration respectively. Thus, the Hypothesis is rejected for concentrations of HCl and NaOH 0.5M.

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

S/N	No Of Titration	Conc M	Indicator	Mtv	S. D	S.D Error
1	3	1	Acloi	2.9667	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 15 shows that the mean titre values for the olfactory titration of 1MHCl:1M NaOH using ACLOI olfactory indicator and the two visual indicators are almost the same. Thus, signifying that there is no difference between the mean titre values using ACLOI, MeO and PhPh indicators. Therefore, the Null Hypothesis is rejected when using the 1M HCl: 1M NaOH concentrations. Thus, ACLOI can be used in place of MeO and PhPh for concentrations of 1M HCl and 1M NaOH

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

S/N	No Of Titration	Conc M	Indicator	Mtv	S. D	S.D Error
1	3	2	Acloi	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

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

Conclusion

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 anomaly, the research adapts 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 can be used as alternative to Methyl orange and Phenolphthalein indicators respectively. From the results of the study, Allium cepa L is a better olfactory indicator. It can be used in the absence of Methyl orange and Phenolphthalein.

Keys:

*MTV-Mean titre vaue
*S.D –Standard Deviation
*S.D Error- Standard Deviation Error
*ACLOI-Allium cepa L Olfactory Indicator
*MeO- Methyl orange
*PhPh- Phenolphthalein

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