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USE OF *TECTONA GRANDIS* (TEAK) LEAVES EXTRACT AS AN INDICATOR IN ACID-BASE TITRATIONS

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ABSTRACT

Indicators are the chemical agents which aid in determining the equivalence point in acid–base titrations.They are normally weak acids and bases that show significant change in colour as the pH of the solution changes. Today's acid-base indicators are synthetic in nature, but because of pollution caused by them, availability, and expense, the quest for natural compounds as an acid-base indicator began. The aim of this study was to find environmental friendly natural indicators for neutralization titrations. The indicator properties of *Tectona grandis* Linn. leaves extract was tested for acid-base titrations. The end point colours and average titre values obtained, when used in different types of acid-base titration, were nearly identical to those obtained with standard indicators except weak acid and weak base titration of specific molar strength. The results refer to a new way of enriching laboratory practical's with natural indicators that is useful, economic and environment friendly.

Keywords: Acid-base titration, Indicator, Leaf extract, Phenolphthalein and *Tectona grandis*

INTRODUCTION

Titration has been the most common quantitative method of analysis used for determining analyte concentration in laboratory settings. An indicator is used which helps in the identification and determination of the equivalence point in acid-base titrations. It shows a shift in colour of the analyte and titrant mixture as the titration approaches its end point. Use of synthetic compound in analytical research can produce harmful effects by causing environmental pollution and it is not economical as well. Although automated titrations apparatus are widely used to determine the end point at laboratory levels, indicators are still being used in simple titration **[1, 2]**. Natural compounds as they are are less toxic, economical, readily available and environmentally friendly; are being studied extensively as now a days the world is becoming more aware of environmental issues **[3]**.

Highly coloured substances (dyes and pigments) can be found in different plant parts, such as leaves, flowers and seeds **[4]**. Some of the organic and inorganic compounds which attribute to colour property of plant part includes flavonoids, acylated flavonoids, anthocyanins, glucosylated acylated anthocyanins, flavonols, quinines, imines, polymethines, dihydropyrans, napthaquinones, anthra-quinonoids, indigoids, diaryl-methanes and carotene. Among them more contribution is of flavones and anthocyanins **[5]**.

Flavones: Flavones are yellow pigments found in plants in the free state, or in combination with glycosides or tannins. Flavonol are hydroxylated derivative of flavone (2- phenyl chromen-4-one).

Anthocyanins: The water soluble pigments responsible for attractive colours of flowers, leaves, fruits etc are anthocyanins. Chemically they are glycosides and the sugar free pigments are anthocyanidins. The basic nucleus is 2- phenyl chromenylium chloride.

The property of these natural compounds to exhibit colour change with respect to change in pH can be utilized as an indicator **[3]**.

A pH indicator is simply a weak acid or weak base (or their corresponding conjugate base or conjugate acid) differ in their colours. In solution, when plant constituents react with acids or bases, the molecular level reaction occurs which leads to change in the colour of solution with respect to change in pH value **[3]**.

Tectona grandis Linn. **(Table1, Figure 1)**, commonly known as Teak tree (Sagwan), is a member of the Verbenaceae family. It is a large deciduous tree with quadrangular, channelled, and stellately tometose branchlets. Leaves are 30-60 cm long and 15-30 cm wide **(Figure 2)**. Pedicellate flowers with a short pedicellate. Fruit is subglobose and four lobed, with a diameter of 1.3cm. It is a native of Central India, South India, the Konkan Western Deccan

Peninsula, and Burma, where it grows in higher altitudes **[6, 7]**.

The roots are used to treat anuria and urinary retention. Bronchitis, biliousness, and urinary discharge are treated with the flowers and bark. Headache, biliousness, piles, leukoderma, dysentery, burning pain in the stomach, and dispersion of inflammatory swellings are all treated with wood. Flower oil stimulates hair growth and is effective in the treatment of scabies **[6]**.

Tectona grandis Linn. leaves consist of different chemical constituents **(Table 2)** which are responsible for various pharmacological activities and other chemical and physical properties therefore their extracts are used for the therapeutic use and other applications.

Table 1: Taxonomical Classification of *Tectona grandis* Linn. [8-10]

Kingdom	**Plantae**
Subkingdom	***Tracheobionta***
Super division	***Spermatophyta***
Division	***Magnoliophyta***
Class	***Magnoliopsida***
Subclass	***Asteridae***
Order	***Lamiales***
Family	***Verbenaceae***
Genus	***Tectona L. f.***
Species	***grandis L. f.***

Figure 1: *Tectona grandis* Linn. Tree

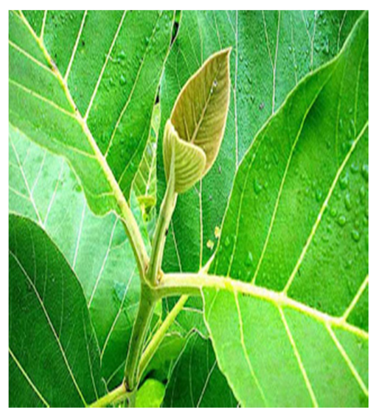


Figure 2: *Tectona grandis* Linn. Leaves

Table 2: Chemical constituents present in the *Tectona grandis* Linn.(Teak) Leaf [11,12]

S. No.	Chemical Class	Chemical Constituent
1.	Flavonoids	Rutin and Quercetin
2.	Phenols and Phenolic acids	Gallic acid, Ellagic acid, Acetovanillone, E-isofuraldehyde, 3-hydroxy-1-(4-hydroxy-3,5-dimethoxyphenyl)propan-1- one, Evofolin A and Syringaresinol.
3.	Glycosides	Apocarotenoids: Tectoionols A and B Steroidal glycoside: Beta-sitosterol-beta-D-[4'-linolenyl-6'-(tridecan-4'''-one-1'''-oxy)], glucuranopyranoside.
4.	Alkaloids	Quinones: 9, 10-dimethoxy-2-methyl anthra-1,4- quinone. 1,4-anthraquinone, Tectoquinone, Lapachol, Dehydro-a-lapachone, Tecomaquinone I.
5.	Naphthoquinones & Anthraquinones	Naphthotectone and Anthratectone - Tectoleaf quinone

Cold acetone extraction of matured, dry leaves produced a mixture of quinonoid pigments, from which tectoleaf quinone, a dark anthraquinone, was extracted **[13]**. Leaves have been confirmed to contain a yellow or red dye that has been used and highly recommended for dyeing silk yellow, olive, or similar shades. In India, crushed leaves have long been known to turn red when rubbed with saliva **[14, 15]**. The current study focuses on the use of aqueous extract of *Tectona grandis* Linn. leaf as an indicator in titrations based on the acid base neutralization reaction.

Mechanism of Acid-Base Indicators

Indicators are used in titration to indicate when the acid-base neutralization reaction is completes. Acid-base (pH) Indicators are halo chromic chemical agents that are used in small quantities to assess the pH (acidity or basicity) by visual observation of change in colour with change in pH of the solution. Weak acids or bases that dissociate slowly and incompletely to produce ions are usually used as indicators **[4]**.

The colours of the acids and bases, which are used as an indicator, are different at different pH ranges. The concentration of H_3O^+ is high at low pH values, so the equilibrium shift to the left and A is the colour of the equilibrium solution. The concentration of H_3O^+ is low at high pH values, so the equilibrium shift to the right, and B is the colour of the equilibrium solution. When a few drops of indicator are added to a solution, the pH of the solution can be approximately identified **[4]**.

Reaction:

$$\underset{\text{(Colour A)}}{\underset{\text{Acid}}{HIn\,(aq.)}} + H_2O \rightleftharpoons \underset{\text{(Colour B)}}{\underset{\text{Conjugate Base}}{H_3O^+(aq.) + In^-(aq.)}}$$

MATERIALS AND METHODS

All the required solutions were prepared using analytical grade reagents and methods used for preparation of volumetric solutions were taken from 8th edition of Indian Pharmacopoeia.

Fresh young leaves were obtained, washed, and made into small pieces. 12 grams of these pieces were boiled for 20-25 minutes in 60 ml of water. The filtrate (leaves extract) was collected after filtration, and the volume was made to 15 ml with distilled water before being transferred in a tightly sealed glass container. The container was kept away from direct sunlight **[16-18]**.

All types of titrations i.e. titrations with standard indicators and titrations with leaves extract were carried out with the same set of glasswares and using the same aliquots. The titrations were carried out with 10 mL of titrand and three drops of indicator. **Table 3** summarizes all the experimental parameters. A set of five experiments was carried out, and the findings were used to measure the mean and standard deviation **[16-18] (Table 4 and 5)**.

The leaves extract was evaluated to see whether it could be used as an indicator for acid-base titrations, and the findings were compared to those obtained using standard indicators such as Methyl red, Phenolphthalein and Mixed indicator (Methyl orange + Bromocresol Green 1:2). Comparison was made for strong acid-strong base (HCl vs. NaOH), strong acid-weak base (HCl vs. NH_3), weak acid-strong base (CH_3COOH vs. NaOH) and weak acid-weak base (CH_3COOH vs. NH_3) titrations. The screening was done with acid and alkali solutions of four different molar strengths i.e. 0.1, 0.5, 1.0, and 5.0 **(Figure 3 and 4)**.

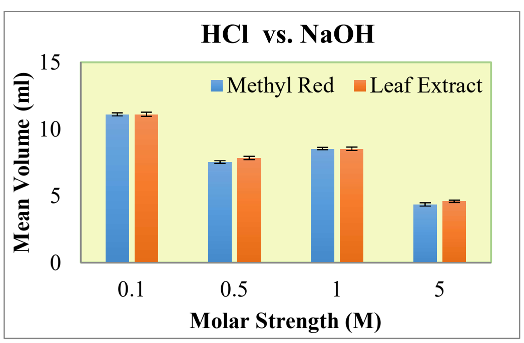
Table 3: Experimental Parameters of titrations

Titrand	Titrant	Standard Indicator- Colour change (pH range)	Leaves Extract (pH range)
HCl	NaOH	Methyl Red-Red to Yellow (4-6.2)	Pink to Yellow (2.5-6)
HCl	NH_3	Phenolphthalein-Colourless to Pink (8.2-10)	Pink to Yellow (2.5-6)
CH_3COOH	NaOH	Phenolphthalein-Colourless to Pink (8.2-10)	Pink to Yellow (2.5-6)
CH_3COOH	NH_3	#Mixed Indicator-Orange to Blue Green (3-4.3)	Pink to Yellow (2.5-6)

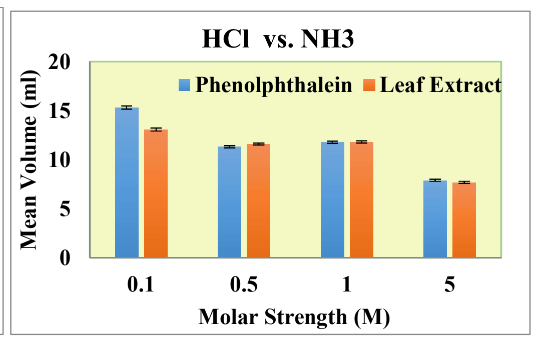
Mixed Indicator: Methyl orange + Bromocresol Green (1:2)

Table 4: Equivalence point (Mean volume ±S.D.) for titrations (Strong acid vs. Strong Base & Strong acid vs. Weak Base)

Molar Strength (M)	HCl vs. NaOH		HCl vs. NH_3	
	Volume in mL Mean ± S.D. (n = 5) (Indicator: Methyl Red)	Volume in mL Mean ± S.D. (n = 5) (Indicator: Leaf Extract)	Volume in mL Mean ± S.D. (n = 5) (Indicator: Phenolphthalein)	Volume in mL Mean ± S.D. (n = 5) (Indicator: Leaf Extract)
0.1	11.1±0.12	11.1±0.16	15.32±0.18	13.06±0.16
0.5	7.54±0.10	7.84±0.12	11.32±0.12	11.6±0.10
1.0	8.54±0.08	8.52±0.12	11.78±0.12	11.8±0.12
5.0	4.36±0.12	4.6±0.10	7.9±0.10	7.68±0.10



(A)

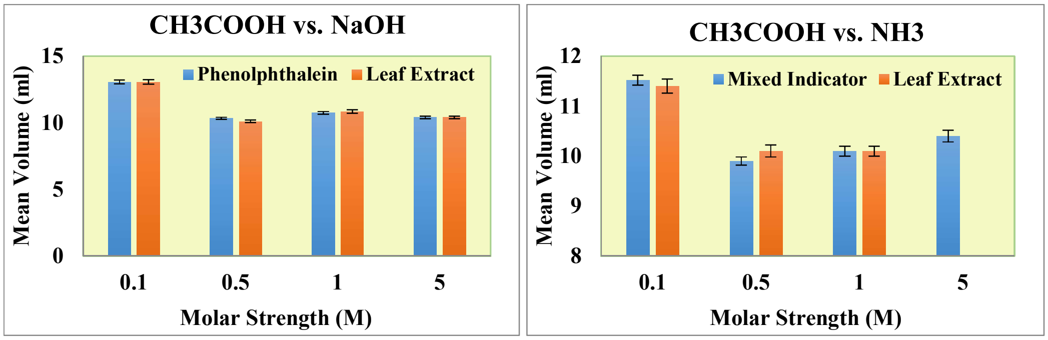


(B)

Figure 3: Plot showing Equivalence point (Mean volume ± S.D.) for titrations (A) HCl vs. NaOH & (B) HCl vs. NH_3

Table 5: Equivalence point (Mean volume ±S.D.) for titrations (Weak acid vs. Strong Base & Weak acid vs. Weak Base)

Molar Strength (M)	CH_3COOH vs. NaOH		CH_3COOH vs. NH_3	
	Volume in mL Mean ± S.D. (n = 5) (Indicator: Methyl Red)	Volume in mL Mean ± S.D. (n = 5) (Indicator: Leaf Extract)	Volume in mL Mean ± S.D. (n = 5) (Indicator: Phenolphthalein)	Volume in mL Mean ± S.D. (n = 5) (Indicator: Leaf Extract)
0.1	13.06±0.14	13.06±0.17	11.52±0.10	11.4±0.14
0.5	10.34±0.08	10.10±0.10	9.9±0.08	10.1±0.12
1.0	10.74±0.10	10.84±0.14	10.1±0.10	10.1±0.10
5.0	10.4±0.10	10.4±0.10	10.4±0.12	--



(C) (D)

Figure 4: Plot showing Equivalence point (Mean volume ±S.D.) for titrations (C) CH_3COOH vs. NaOH & (D) CH_3COOH vs. NH_3

RESULT AND DISCUSSION

The correlation (in Equivalence point) was obtained when the leaves extract and standard indicators were compared for neutralization titrations like strong acid-strong base, strong acid-weak base, weak acid-strong base using molar strengths i.e. 0.1, 0.5, 1.0, and 5.0, whereas for weak acid-weak base it works for molar strengths i.e. 0.1, 0.5 and 1.0 but not in case of the molar strength 5.0.

CONCLUSION

The findings show that *Tectona grandis* Linn.leaves extract is suitable indicator for all types of neutralization titration except for weak acid- weak base titrations of molar strength 5.0 and can successfully replace the standard widely used indicators. It is also cost-effective, easy to prepare, and plant is widely available in India. The study reveals the analytical importance of plant extract as natural indicators over harmful and expensive synthetic indicators for titrimetry analysis.

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CONFLICT OF INTEREST

The authors do not have any conflict of interest regarding publication of this article.

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