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Research

Phytochemical Analysis and Eco-Friendly pH Indicator *Catharanthus Roseus*: A Green Chemistry Approach

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Abstract:
Due to increasing demand in sustainability and non-toxic alternatives in chemical practices has driven interest in naturally occurring pH indicator from plant sources. This study explores the potential of Catharanthus roseus flower aqueous extract (commonly known as Madagascar periwinkle) as a pH indicator in acid-base titrations. Aqueous extract of Catharanthus roseus has been investigated as it has the same indicator activity compared to that of the standard synthetic indicator's phenolphthalein. To evaluate its potential four type of neutralization titration were performed and the result had been recorded. The results shows that the green pH indicator from Catharanthus roseus has the comparable performance as that of the synthetic indicators. Thus, this green Catharanthus roseus pH indicator can be an alternative to various chemical synthetic indicators, as it is Eco-friendly, easy availability, cost-effective and most importantly provides sustainability in analytical practices. This research supports the use of Catharanthus roseus as a viable alternative to synthetic indicator, aligning with green chemistry principle by promoting biodegradable, low toxicity and renewable materials in analytical chemistry.

Keywords: Catharanthus roseus, titration, pH indicators, Eco-friendly, Green indicator, analytical practices.

Introduction

In recent years, global awareness of environmental issues has significantly increased. Various plant parts, such as flowers and leaves, have long held cultural and symbolic significance, often representing expressions of love and well-wishes. Beyond their symbolic roles, flowers play a critical ecological function by attracting insects for pollination. As such, flowers can be viewed as remarkable natural structures with intricate biological functions.

Synthetic compounds, commonly used in analytical and research applications, are associated with high levels of environmental pollution and human health hazards. These substances are often expensive, hazardous, and non-biodegradable, prompting extensive research into natural alternatives. Natural products are increasingly favoured due to their lower toxicity, reduced environmental impact, greater availability, and cost-effectiveness.

Multiple studies have reported that conventional synthetic acid-base indicators may exhibit carcinogenic, mutagenic, and genotoxic effects on both humans and aquatic organisms. Laboratory wastewater containing these indicators contributes to elevated levels of chemical and biological contaminants in water systems, leading to various waterborne and riverine diseases. Specific synthetic indicators pose distinct health risks: methyl red can irritate the gastrointestinal and respiratory tracts; phenolphthalein may cause thinning of the intestinal wall and disrupt normal mucosal patterns in the terminal ileum; and phenol red has been linked to adverse effects on the cardiovascular and central nervous systems, including arrhythmias, coma, and seizures.

The following table summarizes some of the known adverse health effects associated with excessive exposure to commonly used synthetic pH indicators.

Table 1: Toxicity of Some frequently used Acid-Base Indicator

S.No.	Acid-Base Indicator	Toxicity
1	Methyl orange	Skin and Eye Irritation
2	Methyl Red	Skin and Eye Irritation
3	Phenolphthalien	Carcinogenic

The utilization of plant-based extracts derived from flowers, leaves, and roots as natural acid-base indicators presents a viable alternative to synthetic indicators, with the potential to mitigate associated health and environmental risks. Acid-base reactions in the presence of indicators are fundamental processes widely employed in analytical chemistry and chemical engineering, particularly for the standardization of solutions and quantitative analyses. Typically, a few drops of an indicator are added to a base to visually detect the end point of titration, as these substances undergo distinct color changes in response to pH variations.

Commonly used acid-base indicators are synthetic compounds that are not only expensive and limited in availability but also pose significant toxicological risks. Numerous studies have linked these compounds to carcinogenicity, genotoxicity, and harmful ecological effects. Table 1 provides a summary of adverse health effects caused by overexposure to frequently used synthetic indicators.

Plants such as *Catharanthus roseus* (commonly known as Madagascar periwinkle), which are abundant in Eritrea and globally widespread, are frequently cultivated in gardens due to their aesthetic value. These plants are readily available and offer promising natural alternatives for analytical applications. Traditional wet chemistry methods, including titrimetric and gravimetric analysis, continue to play a vital role in modern analytical chemistry. Titrimetric analysis, in particular, involves determining the volume of a titrant of known concentration needed to react completely with an analyte solution, with indicators playing a critical role in endpoint detection.

Natural indicators can be derived from various biological sources such as plants, fungi, and algae. Many flowers that are red, blue, or violet in color contain anthocyanins, a class of water-soluble flavonoid pigments known for their pH sensitivity. Anthocyanidins, the aglycone forms of anthocyanins, are responsible for the vivid red to blue coloration of many flowers. These amphoteric pigments display a range of colors depending on the pH: red in acidic conditions, green in basic conditions, blue when complexed with metal ions, and violet in neutral solutions. Structurally, anthocyanidins are polyhydroxylated derivatives of flavylium chloride and are classified as flavonoids due to their resemblance to flavone compounds.

Almost any intensely colored fruit, vegetable, or flower petal has the potential to function as a natural pH indicator. Such indicators are used to determine the pH or to mark the endpoint of acid-base titrations. They function as weak organic acids or bases that exist in multiple tautomeric forms, at least one of which is colored. Their intense coloration ensures that minimal quantities are required, reducing the impact on solution acidity. Accurate interpretation of indicator color change should be restricted to the defined pH transition range.

A pH indicator is defined as a halochromic compound that changes color depending on the hydrogen ion concentration of the solution, thus allowing for easy pH determination. These indicators act as chemical detectors for hydronium (H_3O^+) or hydrogen ions (H^+) in accordance with the Arrhenius acid-base model.

Catharanthus roseus belongs to the family Apocynaceae and is a semi-woody, evergreen perennial plant often cultivated as an annual. In frost-free environments, it can develop woody basal stems and grow to a height of 0.6–0.9 meters. The plant has opposite, glossy green leaves ranging from 5.1–7.6 cm in length and bears five-petaled flowers in various colors including rose pink, red, purple, and white, depending on the cultivar.

Despite its ornamental and analytical potential, extracts from *Catharanthus roseus* should not be used for medicinal or experimental purposes outside of controlled clinical settings, as advised by the American Cancer Society. Given the presence of pH-sensitive flavonoids in its flowers, it is hypothesized that *C. roseus* extracts can be utilized as natural indicators in acid-base titrations.

This study aims to investigate the feasibility of using aqueous extracts from flowers such as *Catharanthus roseus* and *Nerium oleander* as natural acid-base indicators. The potential findings could support the development of plant-based raw materials for industrial production of environmentally friendly analytical reagents, including indicators, pH paper, and dyes. Unlike commercial synthetic indicators known for their toxic effects, these natural alternatives are expected to reduce environmental pollution and associated health hazards..

MATERIAL AND METHOD

COLLECTION

Catharanthus roseus is collected from the Van Vihar of Bhopal in the month of February and march . The height of the plant is approximately 1-2 feet. The plant were Identified and authenticated by Dr. Mayur Chaubey associate professor at faculty of pharmacy VNS group of institutions Bhopal , M.P. The reagents were prepare as per the standard procedure.

REAGENT

All the reagent and chemicals are of the synthetic grade, chemicals used were; HCL; NaOH; CH3COOH; NH4OH; Phenolphthalein Indicator and aqueous extract of *Catharanthus Roseus* .

All reagents and chemicals of synthetic grade were used, HCl; NaOH; CH3COOH; NH4OH; Phenolphthalein Indicator etc were obtained from the laboratory of department of Chemistry in VNS Group of Institutions, Faculty of Pharmacy. The reagent and volumetric solutions were prepared as per standard procedures.

GLASSWARES AND APPATRATUS

1. 1)Burette 2) Pipette 3) Measuring Cylinder 4) Glassware 5) Mortar Pestle 6) Conical Flask 7) Volumetric Flask.
2. 1) Hot air Oven 2) Weighing Balance 3) Magnetic Stirrer Hot Plate.

PREPARATION OF FLOWER EXTRACT

Aqueous extract of Catharanthus roseus was prepared by following the steps mentioned below;

- Flower of catharanthus rosea were cleaned by distilled water and the petals of flowers were dried in hot air oven
- The 5-10 gm dried petals were crushed with mortal pestle.
- The 5-10 gram dried powder transfer into the beaker and add 50ml distilled water and boil or steep the mixture for 5-15 minutes to extract the pigment.
- Cool the solution and filter it to obtain a clear solution.
- The filtrate is then collected and stored in a bottle and then tested with different pH solution to observe colour change.

EXPERIMENTAL FOR TITRATION

The below mentioned point were the experimental procedure for the titration to observe the indicator property of the Catharanthus roseus aqueous extract;

- ✓ 1 ml of the extract was added as indicator for each titration type.
- ✓ Weak acid against strong base and weak acid against weak base and the trials were repeated 3 times to check the precision.
- ✓ The titrations were again performed using phenolphthalein or methyl orange indicator as standard.
- ✓ The results obtained were compared with the results of titrations using plant extract indicator.

OBSERVATION

Table 2-5 shows the result of titration of both one in which Catharanthus is used as an indicator and the other in which the phenolphthalein is used as an indicator. And the Table 6 shows the color change that the Catharanthus roseus indicator give in different pH.

Table:- 2 titration of strong acid and strong base(HCL vs NaOH)

EXTRACT	VOLUME OF TITRE (ml)	VOLUME OF TITRANT (ml)	MEAN
CATHARANTHUS ROSEUS	10	10.4	10.23
	10	10.2	
	10	10.1	
PHENOLPHTHALEINE	10	10.56	10.41
	10	10.45	
	10	10.23	

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Table:- 3 Titration Of Strong Acid And Weak Base (HCL Vs NH_4OH)

EXTRACT	VOLUME OF TITRE (ml)	VOLUME OF TITRANT (ml)	MEAN
CATHARANTHUS ROSEUS	10	20	19.66
	10	19	
	10	20	
PHENOLPHTHALEINE	10	19.5	19.66
	10	19.6	
	10	19.9	

Table:- 4 Titration Of Weak Acid And Strong Base (CH_3COOH Vs NaOH)

EXTRACT	VOLUME OF TITRE (ml)	VOLUME OF TITRANT (ml)	MEAN
CATHARANTHUS ROSEUS	10	5	5.1
	10	5.5	
	10	4.8	
PHENOLPHTHALEINE	10	4.8	4.9
	10	5.1	
	10	4.8	

Table:- 5 Titration Of Weak Acid And Weak Base (CH_3COOH Vs NH_4OH)

EXTRACT	VOLUME OF TITRE (ml)	VOLUME OF TITRANT (ml)	MEAN
CATHARANTHUS ROSEUS	10	6.7	6.7
	10	6.5	
	10	6.5	
PHENOLPHTHALEIN	10	6.6	6.5
	10	6.5	
	10	6.4	

Table :-6 Test for Color Change at Different pH

TITRANT vs TITRATE	INDICATOR	COLOR
HCL vs NaOH	CATHARANTHUS	PINK-YELLOW
HCL vs NH4OH	CATHARANTHUS	PINK -GREEN
CH3COOH vs NaOH	CATHARANTHUS	PINK-YELLOW
CH3COOH vs NH4OH	CATHARANTHUS	PINK-GREEN

RESULT AND DISCUSSION

The extract obtained from the flowers of *Catharanthus roseus* was evaluated for its potential application as a natural acid-base indicator. The performance of the flower extract was compared with that of the conventional synthetic indicator, phenolphthalein, across various types of acid-base titrations to assess its viability as a cost-effective, eco-friendly alternative.

The following titrimetric analyses were conducted:

- Strong acid vs. strong base (HCl and NaOH)
- Strong acid vs. weak base (HCl and NH_4OH)
- Weak acid vs. strong base (CH_3COOH and NaOH)
- Weak acid vs. weak base (CH_3COOH and NH_4OH)

In all titrations performed, the equivalence points determined using the *Catharanthus roseus* flower extract were found to be closely aligned with those obtained using phenolphthalein, as illustrated in the accompanying table.

The efficacy of the flower extract is attributed to the presence of anthocyanin pigments, which exhibit pH-sensitive chromatic properties. These compounds function as natural pH indicators, undergoing visible color changes in response to variations in the hydrogen ion concentration of the solution.

CONCLUSION

The results demonstrate that the natural pH indicator derived from *Catharanthus roseus* exhibits performance comparable to that of conventional synthetic indicators. This green indicator presents a promising alternative due to its eco-friendly nature, widespread availability, cost-effectiveness, and potential to enhance the sustainability of analytical practices.

The findings of this study support the viability of *Catharanthus roseus* as a substitute for synthetic indicators, in alignment with the principles of green chemistry. Specifically, it promotes the use of biodegradable, low-toxicity, and renewable resources in analytical chemistry, thereby contributing to safer and more sustainable laboratory environments.

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