PLANT EXTRACTS AS NATURAL INDICATORS IN ACID-BASE TITRATIONS

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Abstract

Natural indicators are a non-toxic, environment-friendly, and sustainable alternative to synthetic ones. The study aimed at identifying viable plant sources as natural indicators for acid-base titrations. Hibiscus, oleander and periwinkle flower extracts displayed sharp color transitions for strong acid-strong base titration comparable to their synthetic counterparts. For strong acid-weak base titration, moringa leaf extract proved to be a beneficial indicator against methyl orange. Colour transition was significant for periwinkle flower, tomato fruit and oleander flower extracts against weak acid-strong base titration. The indicators can be a promising alternate to reduce reliance on synthetic indicators for laboratory and industrial applications.

Keywords: Indicators, Acid-base titration, Plants, Eco-friendly, Non-toxic.

Introduction

Commercial indicators used nowadays are synthetic in nature, which are toxic to humans as well as the environment. Acid-base indicators, which respond to pH change, find their application in various fields, including analytical chemistry laboratories, food and beverage industries, environmental monitoring, industrial manufacturing, agriculture, etc. [1]. Sustainability and toxicity considerations pose an alert towards exploration of novel indicators of plant origin.

Synthetic indicators are reported to have toxic effects and can cause eye irritation, lung damage, skin destruction, dermatitis and some are carcinogenic in nature [2]. Plant parts, leaves, roots, fruits, and flowers are reported to have indicator action mainly due to the presence of anthocyanins, betalains, flavonoids, carotenoids, chlorophyll and other pigments [3]. Pigments in plants render their application as alternative, non-toxic, sustainable, environment-friendly and cost-effective indicators. Some natural indicators that are currently used are roses, hibiscus, red cabbage, turmeric, beetroot, and red onions [4-6].

Though the revolution started in the year 1964, still now the use of synthetic indicators is common in all the fields of application [7, 8]. The present study aims for Moringa leaves, banana flower, henna leaves, periwinkle, hibiscus, tomato, beetroot and oleander as natural indicators in acid-base titrations.

Materials and Methods

Chemicals used: Hydrochloric acid, oxalic acid, sodium carbonate, sodium hydroxide used here are of AR grade.

Preparation of natural extracts:

Tomato and beetroot were crushed using a mortar and pestle and filtered using filter paper.

Extracts from Moringa leaves, banana flower, henna leaves, Catharanthus roseus, hibiscus, and oleander were filtered out by boiling the respective sources with a minimum amount of water.

Acid-base titrations:

For strong acid-strong base titration, hydrochloric acid (0.01 N) and sodium hydroxide (0.01 N) were titrated using phenolphthalein as a standard indicator. The same titration was repeated using natural indicator extracts.

Similarly, using phenolphthalein as a standard indicator, oxalic acid (0.01 N) was titrated against sodium hydroxide (0.01 N). The titration was performed using natural indicators also.

Hydrochloric acid (0.01 N) and sodium carbonate (0.01 N) were titrated using methyl orange as a standard indicator. The titration was conducted using natural indicators also.

Results and Discussion

All the selected plant extracts effect a sharp colour transition with respect to the change in pH (Table 1). Equivalence points for the respective acid-base titrations were tabulated against standard synthetic indicators.

Red hibiscus flower, oleander flower and periwinkle flower extracts show a close agreement with that of the standard for strong acid-strong base titration. All the above extracts show a change in colour from green to colourless. Other natural indicators impart a value lower or higher than the standard value (Table 2). For titration between hydrochloric acid and sodium carbonate, drumstick leaf extract proves to be a suitable indicator. A sharp colour transition from green to colourless signifies the equivalence point (Table 3).

Table 1: Colour change in indicators with respect to medium

Source	**Acid medium**	**Basic medium**
Banana flower	Light brown.	Dark green
Drumstick leaves	Yellow	Green
Henna leaves	Light green	Brown
Red hibiscus flower	Pink	Green
Periwinkle flower	Pink	Fluorescent green
Tomato fruit	Pink	Light yellow
Beetroot	Pink	Yellow
Oleander flower	Red	Green

Again, for titration between oxalic acid and sodium hydroxide, periwinkle flower, tomato fruit and oleander flower extracts are found to have a close resemblance to that of the standard one. The end point is indicated by a change in colour from yellow to colourless for both periwinkle flower and tomato fruit extracts (Table 4), and from green to colourless for oleander flower extract.

Table 2: Titration between hydrochloric acid and sodium hydroxide

Indicator	Volume of HCl consumed (ml)	Colour change
Phenolphthalein	14.8	Pink to colourless
Banana flower	21.7	Green to colourless
Drumstick leaves	16.5	Green to colourless
Henna leaves	18.1	Yellow to Colourless
Red hibiscus flower	14.6	Green to colourless
Periwinkle flower	15.1	Green to colourless
Tomato fruit	11.8	Yellow to colourless
Beetroot	9.2	Light red to pink
Oleander flower	14.7	Green to colourless

Table 3: Titration between hydrochloric acid and Sodium carbonate

Indicator	Volume of HCl consumed (ml)	Colour change
Methyl orange	18.3	Yellow to red
Banana flower	15.0	Brown to colourless
Drumstick leaves	17.6	Green to colourless
Henna leaves	21.0	Yellow to colourless
Red hibiscus flower	11.0	Green to colourless
Periwinkle flower	10.0	Green to colourless
Tomato fruit	10.9	Yellow to colourless
Beetroot	15.3	Light red to pink
Oleander flower	9.7	Green to Colourless

Indicator action could be addressed based on the molecular structural changes with the gain or loss of protons due to pH change, which alters the pigment's light absorption properties, resulting in visible colour change [9, 10]. The performance of natural indicators is optimum for concentrated solutions, whereas it diminishes on dilution [11].

Compounds that are reported for indicator action include flavonoids, anthraquinonoids, dihydropyrans, acylated flavonoids, glycosylated acylated anthocyanin, etc. [12]. Tomatoes are rich in the red pigment lycopene and the yellow pigment carotene, which are responsible for their dyeing properties [13]. Secondary metabolites, carotenoids, anthocyanins and phenols present in oleander are being used for mordanting commercially [14].

Table 4: Titration between oxalic acid and Sodium hydroxide

Indicator	Volume of oxalic acid consumed (ml)	Colour change
Phenolphthalein	14.5	Pink to colourless
Banana flower	18.2	Brown to colourless
Drumstick leaves	10.1	Green to colourless
Henna leaves	22.0	Yellow to colourless
Red hibiscus flower	15.6	Green to colourless
Periwinkle flower	14.1	Yellow to colourless
Tomato fruit	14.9	Yellow to colourless
Beetroot	9.3	Light Red to pink
Oleander flower	14.8	Green to colourless

Eleven anthocyanins, including two new anthocyanins (hirsutidin 3-galactoside and rosinidin 3-galactoside) and 7-methylcyanidin 3-galactoside, have been reported in periwinkle flowers [15]. Hibiscus flowers are reported to have major anthocyanins, cyanidin-3, 5-diglucoside, quercetin-3-diglucoside, kaempferol-3-xylosylglucoside, cyanidin-3-sophoroside-5-glucoside, and 3, 7-diglucoside [16]. The main natural pigments in moringa leaves are chlorophyll derivatives and carotenoids, which include 13-Z-lutein, all-E-lutein, all-E-luteoxanthin, all-E-zeaxanthin, all-E-β-carotene, and 15-Z-β-carotene [17, 18].

Besides, these plants are reported to have medicinal properties, being used to treat a number of ailments, which include diabetes, blood pressure, asthma, constipation, cardiovascular and neurodegenerative diseases, skin health and cancer. Plant pigments have radioprotective, anti-inflammatory, wound-healing, antibacterial, antioxidant, and anticonvulsant properties; prevent DNA damage; reduce LDL; and have anti-carcinogenic activity [19-26].

Though the poor stability of natural pigments may not meet the application requirement in some cases, research towards improving the stability can lead to the formulation of an efficient indicator [3, 13, 27].

Conclusion

Plant indicators can be a good substitute for their synthetic counter parts because of their multi-faceted advantages. Among the selected plant sources, hibiscus, oleander, tomato, moringa and periwinkle can emerge as indicators for acid-base titrations. The indicators show a sharp equivalence point, though its stability should be overlooked.

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