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Acid-base titration using plant extracts as natural pH indicators

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ABSTRACT

The analytical potential of the plant extracts is very promising as seen in its application in acid-base titration. Three plant extracts from Red Hibiscus flower powder (shoe flower) Turmeric powder, and Henna Leaves powder were used as an indicator in strong acid-strong base titrations. A sharp and clear colour change was observed from Light Pink to Light Green for Red Hibiscus flower extract. These three extracts were in good agreement with the titre values obtained using phenolphthalein indicator. These flower extracts can be extracted using a very simple, inexpensive, environmentally friendly procedure and excellent performance with sharp colour changes at the end points of the titration, which can replace the standard indicators being used in conventional laboratories with natural flower indicators.

Keywords: *Natural Indicators, Titration, Synthetic Indicators, Plant Extract, Acid-Base Titration, pH Range*

I. INTRODUCTION

The concept of an acid-base reaction was first proposed in 1754 by Guillaume-François Rouelle, who introduced the word "base" into chemistry to mean a substance which reacts with an acid to give it solid form (as a salt) (Jensen, 2006). In spite of the numerous instrumental techniques currently available for the chemical analyses of various samples, conventional methods of analyses are still relevant and find application in many situations. In titrimetric assays, the equivalence point is determined by the end point of the titration which is usually indicated by some substances added into the analytic solution, that change colour immediately after the equivalence point has been attained. Most indicators are synthesised from chemical reactions, but some indicators can be easily extracted from plant materials example, red cabbage, beetroot, turmeric, hibiscus, heena, blackcurrant and black bean using water or an organic solvent. Today synthetic indicators are the choice of acid-base titrations. Due to environmental pollution, availability and cost, natural compounds began to be investigated as acid-base indicators. (Thomas, 2018). There are several types of titrations including Acid- Base titration, Redox titration, Complexometric titration and Spectrophotometric titration. Hibiscus (Red shoe flower) contains anthocyanin which reacts in different ways to acids and bases. Similarly, Lawsonia inermis (Henna) contains the pigment lawsone (2-hydroxy-1,4-naphthoquinone), which yields a reddish-brown colour. The rhizome of Curcuma longa (Turmeric) on the other hand contains a group of strong yellow pigments known as curcuminoids (Agarwal OP, 2013).

II. MATERIALS AND METHODOLOGY

All the materials used for the experiment were L.R. grade and were purchased from Hi Media. Hibiscus powder, Turmeric powder and Heena powder were purchased from local market from Pune, Maharashtra.

Extraction of pigments

The extracts to be used for the experiments were prepared by various methods**Water Extract (Overnight soaking)**
Materials: Hibiscus powder, Turmeric powder, Heena powder, distilled water, conical flasks, Filter paper.
Method: Hibiscus, Turmeric and Heena powders were soaked in distilled water overnight and then filtered after 24h. The filtrate was used as a pH indicator (A. Elumalai and M. C. Eswaraiah, 2012).

Centrifuged Water extract

Materials: Hibiscus powder, Turmeric powder, Heena powder, distilled water, conical flasks, centrifuge tubes, centrifuge.
Method: 0.25 g of each Hibiscus, Turmeric powder and Heena powder were mixed separately with 25 mL distilled water and then centrifuged at 1500 rpm for 10min. The supernatant was used as a pH indicator (Yakasai et.al., 2005).

Boiled Water extract
Materials: Hibiscus powder, Turmeric powder, Heena powder, distilled water, conical flasks, Bunsen burner.
Method: 10g each of Hibiscus, Turmeric powder and Heena powders were boiled in 100mL of distilled water for 20min. The samples were cooled and then filtered. The filtrate was used as a pH indicator (Thomas, 2018).

Reaction of the Extracts with Acids and Bases.
Samples of all the extracts obtained were added to different acids and bases to test the colour change. The acids used were Vinegar (pH= 2) and Con. HCl (pH= 1.2) while the bases used were NaOH (pH= 13.2), NaHCO3 (pH= 8.6) and NH4OH (pH=10). Along with various acid and bases, water (pH= 7) was also used. Each test tube was filled one third with the known pH solution. Approximately 1 ml of plant powder extract was added in each test tube and mixed. The change in colour of the plant extract under the different pH condition were observe and recorded (Okoduwa et.al., 2015).

Acid – Base Titration
Materials: HCl, NaOH, Burette, Conical flask, phenolphthalein indicator, plant extracts.
Method: Acid – base titrations were performed to compare the performance of plant extracts to that of the standard chemical indicator (phenolphthalein). 1M HCl was titrated against NaOH using phenolphthalein indicator and the various plant extracts as indicators (Yakasai et.al., 2005).

III RESULT AND DISCUSSION

Extraction of pigments

The pigments were extracted from Hibiscus flower powder, Turmeric powder and Heena powders using various different methods as shown in the figures 1-4. In all the cases, the initial colours obtained were as follows: yellow from turmeric, orange from henna and dark red colour from shoe flowers (Fig. 1,2,3,4).

Fig. 1 Boiled Extract

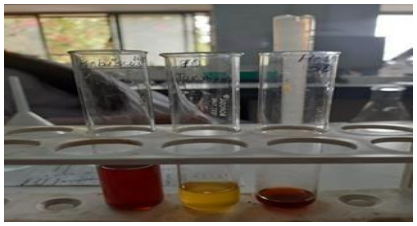

Fig.2 Over Night incubated Extract

Fig.3 Alcohol extract

Fig. 4 Centrifuged Extract

Determination of pH of the plant extracts
After the preparation of extracts, pH of these pure extracts was measured using a pH meter. The pH values indicate that except henna leaf extracts all other extracts are almost neutral. Henna leaf extract shows lowest pH value and indicates that it is acidic in nature (Table 2) (Thomas, 2018).

Table 2: pH of the plant extract

Sr No.	Extract	pH
1	Turmeric powder	6.4
2	Henna leaves powder	5.2
3	Red Hibiscus flower powder	6.0

Investigation of indicator colour change with Ph

In order to study the colour change of the plant pigment with change in pH, six solutions of different pH were taken and 1 ml of the extract was added and the colour change was recorded (Table 3 and 4) (Fig 5,6,7) (Thomas, 2018).

Table 3: Solutions and their pH

Sr.No	Solutions (0.1M)	pH

1	Con. HCl	1.2
2	Vinegar	2
3	Water	7
4	$NaHCO_3$	8.6
5	NH_4OH	10.0
6	NaOH	13.2

Table 4: Colour change seen in plant extracts with respect to change in pH

Plant Extract	pH					
	1.2	2	7.0	8.6	10	13.2
	Conc. HCl	CH_3COOH (Vinegar)	Water	$NaHCO_3$	NH_4OH	NaOH
Turmeric	Red	Light Yellow	Light Green	Yellow	Light Orange	Orange
Henna	Light Yellow	Orange	Orange	Red	Dark Red	Red Brown
Shoe flower	Pink	Pink	Light Pink	Pale Yellow	Brown	Green

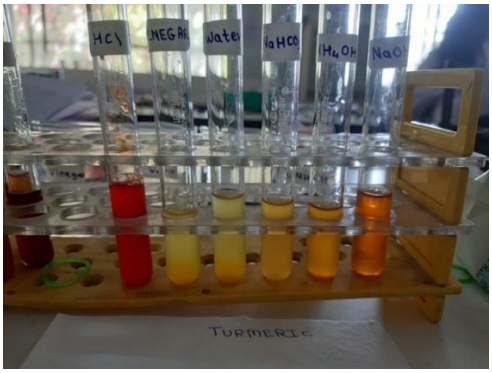

Fig 5: Change in colours of turmeric extract (boiled) with respect to pH

Fig 6: Change in colours of henna extract (boiled) with respect to pH

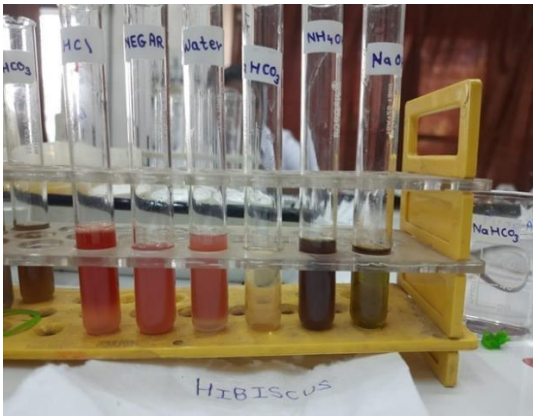

Fig 7: Change in colours of hibiscus flower extract (boiled) with respect to pH

Titration using natural indicators

In order to evaluate the possible use of the dyes as indicators in acid-base titration, a number of titrations were conducted. The end points of the demonstrated titrations using 2 to 3 drops of the dyes are reported in Table 5. The end points of the demonstrated acid-base titrations using commercially available indicators are also reported in the table. It can be seen that phenolphthalein and *Hibiscus* flower extract have similar CBR. Therefore, it can be said that shoe flower extract can be used instead of commercially available indicators for acid- base titration. Since, these extracts show colour change with change in pH, these can be used to identify acids and bases (Thomas, 2018).

Table 5: Indicator end points using natural indicators

Indicators used	***End Point***	***Volume of NaOH(ml) (CBR)***
Chemical indicator (Phenolphthalein)	Colourless to pink	5.9
Plant Extracts		
Hibiscus	Light pink to Light green	6.1

IV. CONCLUSION

In the present study, the results showed that the dye extracts have excellent analytical potential, as demonstrated by its application in acid-base titration in which it performed best in strong acid-strong base titration with a sharp and clear colour change. The sharp contrast between their colours in acid and base made the pigment suitable for use as acid-base indicators. Out of the three plant extracts prepared, Heena, Hibiscus, Turmeric extracts can serve as suitable indicators in acid-base titration involving a strong acid and a strong base. These plant materials are readily available and the extraction procedure is simple, with excellent performance, precise and accurate results, making them an ideal replacement for presently available synthetic indicators. Thus, the use of natural indicator in acid base titration is more beneficial because of its economy, easy to prepare, simplicity, easy availability, pollution free, inert and accurate results (Thomas, 2018; Sharma et al.,2013).

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