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Urena lobata Flowers: A Green Route to Volumetric Analysis

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Abstract

The aqueous and alcoholic extract of *Urena lobata* flowers has been used in acid/alkali titrations over a wide range of concentration. The results obtained with the flower extracts have been compared with those obtained by using traditional chemical indicators like phenolphthalein and methyl orange. It has been established experimentally that the flower extract can be successfully used in place of phenolphthalein and methyl orange for acid/alkali titrations. The presence of anthocyanins is supposed to impart pH sensitive colour dependence to the natural indicator.

Keywords

***Urena lobata* Flowers, Phenolphthalein, Methyl Orange, Acid-Base Titration, Anthocyanin**

1. Introduction

Ever since the beginning of chemical science, extensive use of chemicals in different types of processes, reactions, synthesis etc. has brought the humanity at a dangerous edge where the tolerance of environment pollution has reached its limit. Nowadays, trials are being made to accomplish all the chemical processes through green routes. This has given birth to a new branch of chemistry, the Green chemistry. A green route is environment-friendly and minimizes hazards from chemicals. It also cuts the cost of a process phenomenally and may contribute to the economic growth of a country. It is really difficult to limit the scope of green chemistry.

Volumetric estimation is one of the common procedures for quantitative evaluation of solutions. The process involves a pH sensitive indicator namely phenolphthalein, methyl orange etc. which cause environment pollution [1]. The authors have made an attempt to replace the chemical indicator by a natural one. *Urena lobata* is a plant (Malvaceae family) found abundantly in tropical and sub-tropical regions of the land. The plant blooms with pink coloured flowers. Present studies have made use of these flowers for preparing the indicator solutions.

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2. Materials and Methods

2.1. Natural Indicator Solution

The flowers of *Urena lobata* were collected from Kotdwar region of Garhwal Himalayas in Uttarakhand and authenticated by Prof. A. K. Agarwal, Head Department of Botany, Government P. G. College, Uttarkashi. The flowers were washed thoroughly with distilled water and the petals were fragmented into small pieces and macerated for 36 hours in distilled water. Another portion of the fragmented petals was dried in shadow until the mass lost water layer. These were then soaked into pure alcohol. About 5.0 gram of the petals were soaked into 50 mL of a liquid. A soaked mixture was then vortexed for 5 minutes at room temperature (about 25˚C) and then filtered through a Whatman No.1 filter paper into a clean dry culture tube capped with Teflon cap and stored away from sunlight. The aqueous and alcoholic solution so obtained were named ULFE, *Urena lobata* flowers extract, and used as indicator solutions in the present study.

2.2. Reagents and Apparatus

All the chemicals used namely sulphuric acid, Hydrochloric acid, Acetic acid, sodium hydroxide, methyl orange, phenolphthalein, Oxalic acid and ammonium hydroxide were analytical grade BDH chemicals. The alcohol was BDH chemical. All the chemicals were used without further purification. The distilled water used in all these studies was doubly distilled.

All the glassware namely Burette, pipette, beaker, conical flask etc. were Corning glass apparatus.

2.3. Procedure

The standard solutions of sodium hydroxide, sulphuric acid, hydrochloric acid, ammonium hydroxide are difficult to prepare and special care was taken to prepare these. In order to prepare any such solution, say sodium hydroxide, first about 10 times more concentrated solution was prepared. This was standardized by titrating it with a standard oxalic acid solution using two drops of phenolphthalein as indicator. This was named as mother solution, Further, a quantitative aliquot of the mother solution was diluted to prepare, say 0.1 M NaOH solution. This was again titrated against standard oxalic acid solution and its strength confirmed. Similarly, mother solution of sulphuric acid, hydrochloric acid and ammonium hydroxide were prepared and diluted to prepare a said solution by way of standardization using appropriate indicator. It is emphasized that unless these solutions are accurate, it would not be possible to observe the correct titre value.

Titration was performed of a strong base (NaOH) against strong acids (H_2SO_4 & HCl) and weak acids ($C_2O_4H_2{\cdot}2H_2O$ & CH_3COOH); A weak base (NH_4OH) against strong acids (H_2SO_4 & HCl) and weak acids ($C_2O_4H_2{\cdot}2H_2O$ & CH_3COOH). A particular titration was repeated with every indicator namely, aqueous *Urena lobata* flower extract $(ULFE)_{aq}$, alcoholic *Urena lobata* flower extract $(ULFE)_{al}$, methyl orange, and phenolphthalein. The titre values were determined according to the standard method [2] and every value shown in the **Figures 1-3** is an average of four experiments including standard deviation of ±0.25.

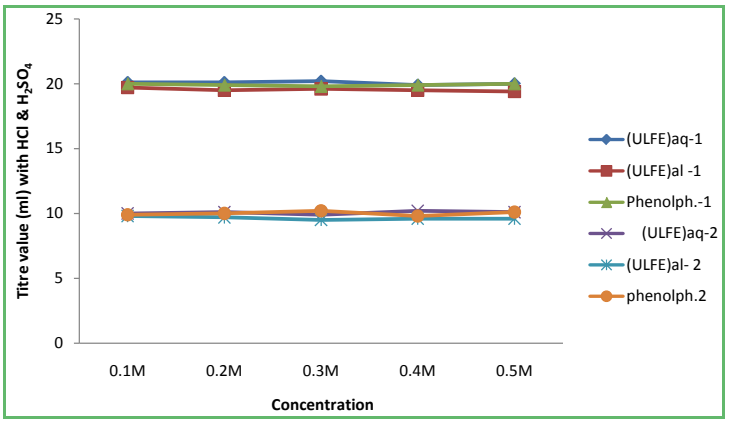

Figure 1. Equivalence points with different indicators for strong acid/strong base (1 for H_2SO_4 & 2 for HCl).

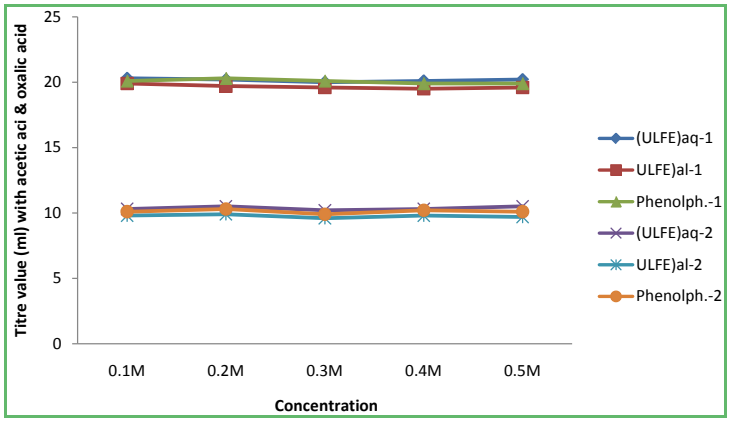

Figure 2. Equivalence points with different indicators for weak acids/strong base (1 for oxalic acid & 2 for acetic acid).

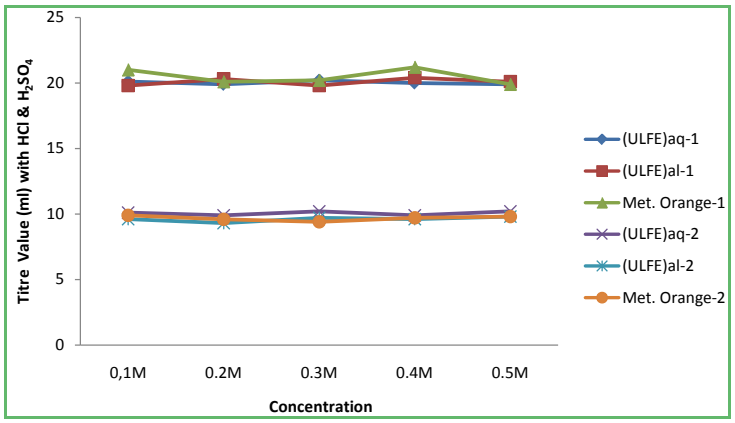

Figure 3. Equivalence points with different indicators for strong acids/ weak base (1 for HCl & 2 for H_2SO_4).

3. Results and Discussion

The ULFE indicator possesses a light pink color both in aqueous and in alcoholic preparation. It retains its light pink colour in acidic medium but the colour turns light green in alkaline medium. The change of colour makes the basis of this indicator. The process of colour change is found reversible. That is, if the medium of the solution containing the ULFE indicator is changed from alkaline to acidic, the colour changes from light green to light pink. The colour change is so distinct that it can be recognized visually without any aid of colorimeter or spectrophotometer.

The scheme of titration has been shown in **Table 1**. When the strong base NaOH, was chosen as titrant, the ULFE indicator in strong acids, H_2SO_4 & HCl, retained its pink colour. As the titrant was added gradually to 10 ml of a titrate (H_2SO_4 or HCl), the point of equivalence was noted when the titrate solution turned light green. The point of equivalence was then determined by taking a few drops of phenolphthalein in titrate solution. This time the solution turned light pink at the point of equivalence. The results were plotted in **Figure 1**. Each and every point shown in the figure was the result of at least four repetitions and includes standard deviation of not more than ±0.25. A comparison of the curves is shown in **Figure 1**. clearly indicates that when strong base, NaOH, is used as titrant for titrating the strong acids H_2SO_4 & HCl, the equivalence points observed in presence of $(ULFE)_{al}$ were a little lower for all the concentrations. Thus $(ULFE)_{aq}$ can very well replace the chemical indicator, phenolphthalein, in these titrations.

Figure 2 shows the results of using the strong base, NaOH, as titrand against weak acids, ($C_2O_4H_2{\cdot}2H_2O$ & CH_3COOH). The chemical indicator taken is again phenolphthalein. It is because the pH of weak acid solutions generally lies in the range 4 - 5. It may gradually increase to 6 - 8 just before the equivalence point, and near the

Table 1. Scheme of titration.

Titrant	Titrate	Indicator	Colour change at equivalence point	pH range of indicator
NaOH	H_2SO_4	Phenolphthalein	Colourless to light pink	5 - 9
	HCl	Phenolphthalein	Colourless to light pink	
		$(ULFE)_{aq}$	Pink to light green	
		$(ULFE)_{al}$	Pink to light green	
NaOH	$C_2H_2O_4.2H_2O$	Phenolphthalein	Colourless to light pink	7 - 10
	CH_3COOH	Phenolphthalein	Colourless to light pink	
		$(ULFE)_{aq}$	Pink to light green	
		$(ULFE)_{al}$	Pink to light green	
H_2SO_4	NH_4OH	Methyl orange	Orange to yellow	5 - 3
HCl	NH_4OH	Methyl orange	Orange to yellow	
		$(ULFE)_{aq}$	Light green to pink	
		$(ULFE)_{al}$	Light green to pink	

equivalence point, a slight excess of strong base may rise pH to 11 or more. Thus phenolphthalein is a suitable indicator for these titrations too. A careful comparison of the curves is shown in **Figure 2** indicates that $(ULFE)_{aq}$ is again a preferred natural indicator as compared to $(ULFE)_{al}$. So, for titrations of strong base against weak acids, $(ULFE)_{aq}$ should be a good replacement of phenolphthalein.

Figure 3 shows equivalence points obtained titrating weak base, NH_4OH against strong acids H_2SO_4 & HCl. This time phenolphthalein would be completely useless as it would not change colour at any sharp point. The colour change over a range is of no use unless it is observed at a specific sharp titrant volume. In this case strong acids H_2SO_4 & HCl were used in turn as titrant and methyl orange as indicator, to check the validity of ULFE indicators. Methyl orange itself being a weak base, works better when present in weak base [3]. The pH of a weak base lies approximately in the range of 10, and reduced to 8 - 6 just before the equivalence point. Any further addition of strong acid brings pH down to 4 - 3. This is the pH range where methyl orange will work better than phenolphthalein. Methyl orange turns orange from yellow at the end-point in these titrations. The ULFE changes from light green to pink. It is interesting to see (**Figure 3**) that in this case both $(ULFE)_{aq}$ and $(ULFE)_{al}$ show results very close to those obtained with methyl orange. So any of the indicator preparations, aqueous or alcoholic, may replace methyl orange for titrating strong acids against weak base.

Lastly, the validity of ULFE indicators was checked for titrations of weak acids, ($C_2O_4H_2{\cdot}2H_2O$ & CH_3COOH) against weak base, NH_4OH. In this case, the final pH values are in the range 4 - 5 and 8 - 10 and the equivalence point may be in the range 6.5 - 7.5. Some indicators have been used by earlier workers [4]-[6] in titration of weak acid/weak base. However, we experimentally found no single indicator could give invariable correct value of equivalence point. $(ULFE)_{aq}$ and $(ULFE)_{al}$ successfully change colour in these titrations but without any sharp equivalence point. Therefore, the validity of chemical as well as natural indicators in this case is doubtful.

It is proposed that the presence of flavonoid pigments known as anthocyanins are responsible for imparting colour to the ULFE solutions. The anthocyanins are water soluble, pH sensitive strong colour [7] [8]. The colour change is proposed due to formation of flavylium cation [9] and formation of this cation would, obviously, be more favoured in aqueous than alcoholic extract. The aqueous flower extract may work better than the alcoholic one as the pH of the alcohol is not as neutral as that of distilled water.

4. Conclusion

Present studies established that aqueous extract of *Urena lobata* flowers is a versatile natural indicator for acid/alkali titrations. It is a good substitute of phenolphthalein for strong base/strong acid, strong base/weak acid titrations. It is equally good substitute of methyl orange for weak base/strong acid titrations. The anthocyanins present in *Urena lobata* flowers seem responsible for showing pH sensitive colour change. The ULFE indicator, when disposed into water, does not pollute it and is biodegradable. Also, the ULFE dye decays aerobically and

non-aerobically and thus automatically removed from the atmosphere. Hence *Urena lobata* flower extract definitely provides a green route to the volumetric estimations.

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