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Short Communication

Opuntia ficus indica (L.) Fruit Extract as Natural Indicator in Acid-Base Titration

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Abstract

In routine experiments synthetic indicators are the choice of acid base titrations. But there are some limitations like environmental pollution, availability and higher cost which leads to search for natural compounds as an acid base indicator was started. The present work highlights the exploit of the methanolic and aqueous extract of the fruit of *Opuntia ficus* indica plants as a natural acid base indicator in acid base titrations. *Opuntia ficus* indica plant was identified and fruits were washed and cleaned by distilled water, grinded by a mechanical blender and soaked in 50 ml methanol for 48 hours and then triturated in mortal and pestle and the resulting solution were filtered through muslin cloth. The resulted methanolic extract and aqueous extract which was prepared by heating fruits in water for half an hour and filtered used as natural indicator for acidimetry and alkalimetry. For each type of acid base titrations *t*-value and standard deviation were calculated from results obtained. Natural indicator is easy to prepare, easily available and have no toxic effects and promising results were obtained when it was tested against standard synthetic indicators. Titration shows sharp colour change at the equivalence point. The equivalence points (end points) obtained by the fruit extract correlate with the equivalence points obtained by standard indicators. In strong acid and strong base titration, the results obtained in the fruit's extract matched with the results obtained by standard indicator. Hence, natural indicator is found to be a very useful, readily available, non-hazardous, economical, simple to prepare and accurate for the acid-base titrations.

Keywords: Natural indicator, Acid base indicator, Titration, equivalence point, *Opuntia ficus indica*

1.Introduction

The use of natural dyes as acid-base indicator was first reported by Sir Robert Boyle in collection of assays "Experimental History of Colours" in 1664. Almost any flower such as blue, purple or red in colour contains class of organic pigment called anthocyanins that change colour with pH. The term titrimetric analysis refer to the quantitative chemical analysis carried out by determining the volume of solution of accurately known concentration which required to react quantitatively with a measured volume of a solution of the substance to be determined. The addition is done until reaction is complete. This is called the end point or equivalence point of the reaction. The end point is detected by using a chemical compound known as an indicator. Indicator may be used internally or externally. Many acid base titration themselves indicate the end point of the reaction.[1] A pH indicator is a halo chromic chemical compound that is added in small quantity to a solution so that the pH (acidity or basicity) of the resultant solution can be determined visually. So, a pH indicator is a chemical detector for hydronium ions (H_3O^+) or hydrogen ions (H^+) in Arrhenius model. The indicator causes change in the colour of the solution depending on the pH. *Opuntia ficus indica* plant mucilage contains D-glucose, D-galactose, L-arabinose, D-xylose, L-rhamnose and D-galacturonic and glucuronic acids and sugars like hexoses, pentoses.[2] The flavanoid components of the plant are isorhamnetin and its glucoside, penduletin, luteolin, kaempferol, quercetin, rutin, flavonol 3-O-glycosides (quercetin, kaempferol, and isorhamnetin), dihydroflavonols, flavonones, and flavanonols. *Opuntia ficus indica* fruit contains betalain pigments which has a good potential for the use as a natural food colorant.[3-4] Betalains constituents are red and yellow indole derived pigments found in the plants of the caryophyllales, where they replace anthocyanin pigments. Betalains are aromatic indole derivatives constituents synthesized from tyrosine and they are not chemically related to the anthocyanins and are not flavonoids.[5] Betalain is chemically a glycoside and consists of a sugar portion and a colored portion and their synthesis is promoted in presence of light.[6] The major betalain is betanin which is extracted mainly from the plant red beet roots. Betanin is a glucoside, and hydrolyzes into the sugar glucose and betanidin. It is generally used as a food coloring agent and the produced color is sensitive to pH.[7] The aim behind this study is simply to bring in market the use of plant pigments and to increase the wealth of traditional medicinal system.[8]

2.Material and Methods

Opuntia ficus indica was identified from the department of the Pharmacognosy at college Aksharpreet Institute of Pharmacy. Fruits were collected during summer season. *Opuntia ficus indica* fruits were collected for the purpose of study of natural indicator and it is available throughout the year. Several plant pigments like betalain, anthocyanins and flavonoids present in which acts like natural indicator. Fruits were washed and cleaned by distilled water, grinded by a mechanical blender and soaked in 50 ml methanol for 48h and then triturated in mortal and pestle and the resulting solution were filtered through muslin cloth. The resultant methanolic extract was used as natural indicator for acidimetry and alkalimetry. The extract was preserved in light closed container and stored away from direct sunlight. Following the similar process aqueous extract of fruit was prepared, filtered and used as aqueous natural indicator. Analytical grade HCl, NaOH, CH_3COOH, NH_4OH, phenolphthalein, methyl orange, and phenol red were made available by the Department of Chemistry at the college Aksharpreet institute of pharmacy. All required reagents and volumetric solutions were prepared as per standard. The experimental work was carried out using the same set of glass wares for all types of titration. Same sample quantities were used for both titrations the standard indicator and fruit extract. The equinormal titrations were performed using 10 ml of titrant with four to five drops of natural indicator. A set of four experiments each for all types of acid base titrations were carried out. For each type of acid base titrations *t*-value and standard deviation were calculated from results obtained.

3. Results and Discussion

The methanolic and aqueous fruit extract were screened for its use as

an indicator in acid base titration and the results were compared with the results obtained by standard indicators phenolphthalein, methyl orange and phenol red. The results of the experiments for strong acid-strong base (HCl and NaOH), strong acid-weak base (HCl and NH_4OH), and weak acid-strong base (CH_3COOH and NaOH), weak acid-weak base ($H_3BO_3$and NH_4OH) are shown in Table 1 and 2.

Table 1. Colour change in titration

		Indicator colour and pH changes at end point				
Titrant	**Titrand**	**Standard**	**Methanolic fruit extract of OFI**	**pH**	**Aqueous fruit extract of OFI**	**pH**
HCl	NaOH	Colourless to pink (PH)	Pink to Yellow	7.11±0.017	Pink to Yellow	7.21±0.046
Hcl	NH_4OH	Pink to yellow (MO)	Pink to light yellow	5.63±0.044	Pink to light yellow	5.85±0.028
CH_3COOH	NaOH	Colourless to pink (PH)	Pink to light yellow	7.87±0.029	Pink to light yellow	7.94±0.035
H_3BO_3	NH_4OH	Yellow to red (PR)	Pink to light yellow	7.29±0.032	Pink to light yellow	7.18±0.087

PH: Phenolphthalein, MO: Methyl orange, PR: Phenol red, OFI: Opuntia ficus indica

Table 2. Statistical data of methanolic and aqueous fruit extract of OFI as natural indicator compared with standard indicator for acid base titration

Titration Titrant V/s Titrand	**Strength in Normality**	**Methanolic fruit extract of OFI as natural indicator**	***t*-value ± S.D***	**Aqueous fruit extract of OFI as natural indicator**	***t*-value ± S.D***
NaOH v/s Hcl	1.0	PH v/s MFE	1.16 ± 0.12	PH v/s AFE	1.05 ± 0.05
	0.1	PH v/s MFE	1.36 ± 0.25	PH v/s AFE	1.56 ± 0.14
	0.5	PH v/s MFE	1.89 ± 0.08	PH v/s AFE	0.70 ± 0.17
NH_4OH v/s HCl	1.0	MO v/s MFE	1.05 ±0.39	MO v/s AFE	0.84 ± 0.39
	0.1	MO v/s MFE	1.83 ±0.33	MO v/s AFE	1.76 ±0.18
	0.5	MO v/s MFE	1.65 ±0.17	MO v/s AFE	0.85 ±0.31
NaOH v/s CH_3COOH	1.0	PH v/s MFE	1.73 ±0.16	PH v/s AFE	1.41 ± 0.17
	0.1	PH v/s MFE	0.97 ±0.22	PH v/s AFE	0.48 ± 0.27
	0.5	PH v/s MFE	0.85 ±0.21	PH v/s AFE	1.26 ±0.09
H_3BO_3 v/s CH_3COOH	1.0	PR v/s MFE	1.20 ±0.78	PR v/s AFE	1.02 ±0.36
	0.1	PR v/s MFE	0.48 ±0.38	PR v/s AFE	0.83 ±0.17
	0.5	PR v/s MFE	1.55 ±0.26	PR v/s AFE	1.48 ±0.15

*The table represents t value and standard deviation for four type of titration. *All values are t-value ± S.D. for n = 4; HCl: Hydrochloric acid, \NaOH: sodium hydroxide, CH_3COOH: Acetic acid, NH_4OH: Ammonium hydroxide, PH: Phenolphthalein, MO: Methyl orange, PR: Phenol red, MFE: Methanolic fruit extract, AFE: Aqueous fruit extract.*

As described in Table 1 the strength of acid and bases (HCl, CH_3COOH or H_3BO_3, NaOH, NH_4OH) taken were 0.1N, 0.5N and 1N. Four different types of acid base titration performed were strong acid/strong base, strong acid/weak base, weak acid/strong base, and weak acid/weak base. The titrant v/s titrand were HCl v/s NaOH, HCl v/s NH_4OH, CH3COOH v/s NaOH, H_3BO_3 v/s NH_4OH. The colour changed from pink to yellow in the case of methanolic fruit extract and aqueous fruit extract of *Opuntia ficus indica* as natural indicator. The standard deviation ranged from ±0.05 to ±0.78 (described in Table 2) in methanolic fruit extract and aqueous fruit extract of *Opuntia ficus indica*. The results obtained showed that the routinely used chemical indicator can be replaced successfully by *Opuntia ficus indica* (OFI) fruit extract.

4.Conclusion

The results obtained in all the four types of acid base titrations showed that because of the presence of betalains and flavonoids it produces sharp colour changes at end point of titrations. The standard deviation calculated for synthetic indicator and methanolic and aqueous fruit extract of natural indicator showed very less variation in the results. Thus statistically also it proves the use of natural indicator in acid base titrations. As the methanolic and aqueous fruit extract provide similar results, methanolic and aqueous fruit extract can be used with equal reliability and accuracy for acid base titration. Thus the use of natural indicator in acid base titration is more beneficial because of its economy, easy to prepare, simplicity, easy availability, non hazardousness, inert and accurate results.

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Conflicts of Interest

The author reports no conflict of interest.

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