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Review Article

Green Indicators-An Ecofriendly Endpoint

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ABSTRACT

Although acid-base titrations can be done using numerous indicators which are either synthetic or semi-synthetic, the investigation was started for natural compounds as the former ones result in polluting the habitat despite their limited availability, complicated method of preparation, and expensiveness. Equivalence point determination is the point of interest in neutralization titrations. With the change in pH, the indicators which are natural, usually end up giving a sharp color change. Plant-derived pigments that are of various shades and tints generally vary in their dyeing nature by altering pH. An indicator is a substance that exhibits the property of interchangeable color of the reaction mixture when reaching the vicinity of point with the change in pH. Acid-base titration indicators are normally weak acids or bases. *Hibiscus rosa-sinensis, Ipomoea biloba, Dahlia pinnata*, etc. are among the typical neutralization indicators that are extracted from plants. These natural Indicators are easily available and economical. In this review, we are discussing an overview of plant extracts, and natural pH indicators, and their significance in correspondence to analytical chemistry is illustrated.

Keywords: Anthocyanins, Dyes, Flavones, Natural indicators, Pigments.

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INTRODUCTION

In the past few years, various environmental issues came to light. Various plant elements such as flowers and leaves are symbolic and seen as symbols of love or a message of good wishes.[1] The flowers of the plant attract insects to pollinate. The transfer of pollen happens due to the attraction of insects toward flowers. Flower's attraction extends to the animal kingdom as well. Hence a flower is great magic from nature. Flowers are thus, a natural wonder created by God for the benefit of the entire world. Apart from flowers, leaves also serve as a great natural source to prepare indicators.

The interest of research workers in the area of analytical research has been continuously increasing day by day towards natural products as the synthetic ones are not environmentally friendly, expensive, and are also harmful in a few cases. Hence studies have been carried out to replace synthetic indicators with natural indicators. Plants are easily available everywhere to extract natural indicators. Natural indicators have more aesthetic value than commercially available indicators. While being simple and economical, they are eco-friendly and are accurate for acid-base titrations to indicate the accurate endpoint. An indicator is a substance that exhibits the property of interchangeable color of the reaction mixture when reaching the vicinity of the point with the change in pH. Equivalence point determination is the point of interest in neutralization titrations. Plant-derived pigments that are of various shades and tints generally vary their dyeing nature by altering pH.[2-5]

Pigments are dyes that can be extracted from several resources, such as floral petals, algae, fungi, and are termed as indicators. Irrespective of the color of the flower, a specialized class of organic pigments named anthocyanins will be present which is capable of showing color variation with the change in pH.[6]

Sir Robert Boyle in the year 1964 for the first time reported the usage of natural dyes as neutralization indicators. These are usually obtained due to the interaction of the electronic structure of pigments with the sunlight. The most commonly occurring plant pigments include chlorophyll and carotenoids that are located in plastids, anthocyanins, and betalains that are dissolved in vascular sap. Some pigments can give highly pronounced intensive colors when present in combination. The compounds which are either organic or inorganic that are responsible for natural colors include flavonoids, flavanols, acylated flavonoids, glycosylated acylated anthocyanin, anthraquinonoids, dihydropyrans, diarylmethanes among which the major ones include anthocyanidins and flavones.[7,8]

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Flavonoids

Biologists are greatly attracted towards yellowish pigments that are flavones, flavanol's along with their glycosides as they have a great role in food plants and medicinal plants. They have a great solubility in alcoholic and aqueous solutions. Chopping, macerating, and soaking are the steps to be taken to extract the flavones. Flavonoids are available as free pigments or as glycosides.[9]

Anthocyanins

Anthocyanin and its derivatives are the other pigments that can be located in plants. They have aqueous solubility and are accountable for drawing attention by producing highly attractive colors to the leaves, flowers, and fruits.[9]

pH

Hydrogen ion concentration plays a vital role in research and development and usually located in minute quantity and is reported in the pH units. pH is defined as negative of the base 10 logarithms of hydrogen ion concentration.[10] This is the most convenient method to express the concentration of hydrogen ions, which was introduced first in 1909 by Sorenson.[11]

$$pH = -\log_{10}[H^+]$$

A solution's acidity or the concentration of hydrogen ions can be conveniently expressed using a pH scale. once the concentration of hydrogen ions is determined the values are converted as pH using the above formula.[12]

ACID-BASE INDICATORS AND MECHANISM

Neutralization indicators are the chemical reagents and halo chromic in nature usually added to the solution in less quantity to determine the acidity or basicity by simultaneous observation of the color change with pH variation. It is a basis for the Arrhenius model.[13] These indicators i.e., weak acids or bases when dissolved in the water get slightly dissociated.

$$HIn\,[aq.] + H_2O\,[Ion] \leftrightarrow H_3O^+\,[aq.] + In^-[aq.]$$

Usually, there exists a color variation between the acid and its conjugate base. Low pH values indicate higher acidic nature and vice-versa. Equilibrium positions usually shift towards the right at higher pH values and shift towards the left at lower pH values.

A mixture of indicators that is capable of inducing color change gradually over a wide range of pH is termed as a universal indicator. The indicators in acid-base titration are used for signaling the completion of titration. Few synthetic neutralization indicators include phenolphthalein, methyl orange, bromo cresol green, methyl red, and phenol red.

There are four different types of neutralization titrations: strong acid against the strong base (HCl v/s NaOH), weak acid against the strong base (CH_3COOH v/s NaOH), strong acid against a weak base (HCl v/s NH_3), and weak acid against the weak base (CH_3COOH v/s NH_3) are done to get accurate and precise results.[14]

NATURAL INDICATORS

Long before scientists invented synthetic acid-base indicators, natural indicators were employed for hundreds of years. Sir Robert Boyle discussed in his book entitles in "The Experimental History of Colours," 17th-century, indicators produced from roses and other plant materials. Boyle included the capacity to turn plant juices red among the attributes of acids. Red cabbage isn't the only natural indicator that changes color, as there are several different substances derived from plants that can be used as indicators.[15]

Many natural colors have been extracted and separated from various plant sections. Robert Boyle described how to make an indicator out of rose juice, brazilwood, cochineal, and litmus.[16] Similarly, the juice and pigments of red cabbage (*Brassica oleracea, Capitata rosa*)[17,18] and tea show varied hues depending on the pH. When tea is steeped in a basic solution, the color darkens, but when lemon juice is added, the color lightens. In a basic solution, red cabbage juice turns blue, while in an acidic solution, it retains its red hue. Turmeric, Ratanjot (*Arnebia nobilis*),[19] yellow onion (*Allum cepa*) skins,[20] Jack tree heartwood (*Artocarpus heterophyllus*),[21] beetroot (*Beta vulgaris*),[22] and Jungle flame (*Ixora coccinea*)[23,24] are among the naturally occurring substances that change color with pH.

INDICATOR PROPERTIES

Flowers and other colored materials abound in nature, making everything vibrant. The intensity of the color is determined by several elements, including the composition. Flavonol, xanthine, azo compounds, anthocyanins, and other naturally occurring organic chemicals give plants their color. Flavones, flavonol, anthocyanins, and other colorful compounds found in nature are pH-sensitive. In acidic and basic media, they have different colors. When an acidic medium is changed to an alkaline medium, these indicators produce a distinct and stable color shift. As a result, they can be employed in the volumetric analysis as acid-base indicators.

The aqueous extract of red cabbage has been found to have color variations[25,26] including red (pH 2), purple (pH 3), violet (pH 5), blue (pH 7), blue-green (pH 9), and green (pH 12). The presence of one or more colored compounds in it is assumed to be the cause of the color change. The colored components differ from species to species and plant to plant; for example, red cabbage contains only one anthocyanin,[27] but blue berries contain three: delphinidin, petundin, and malvidin.

NATURAL ACID-BASE INDICATORS

Several plants have good acid-base indicator performance when compared to synthetic pH indicators.

The following are a few of them;

Anthurium andraeanum[28]

Amar V Desai *et al*., (2021) examined *Anthurium andraeanum* as shown in Figure 1 (Common name: Flamingo flower) belongs to the family Araceae for its acid-base indicator activity against phenolphthalein as a standard indicator. The extract of methanolic petals of flowers was used as an indicator. In the titrations of HCl v/s NaOH, HCl v/s NH_3, CH_3COOH v/s NaOH, and CH_3COOH v/s NH_3, 0.1 mL of flower extract was used as an indicator. In acid-base titrations, the equivalence point of titration using Flamingo flower extract is extremely close to the equivalence point of titration using phenolphthalein as an indicator. However, in some circumstances, flower extract outperforms phenolphthalein in terms of the color change that occurs is quite sharp and observable.

Bauhinia racemose[29]

Rohit M Jamdar *et al*., (2019) examined *Bauhinia racemose* of subfamily Caesalpiniaceae is shown in Figure 2, for its acid-base indicator activity against methyl red as a standard indicator such as HCl v/s NaOH, HCl v/s NH_3, CH_3COOH v/s NaOH, CH_3COOH v/s NH_3. The macerated extract of ethanolic petals of flowers was used as an indicator. The endpoint was observed with a color change from red to colourless. The results obtained from titration of natural indicators (i.e., *Bauhinia racemose* flower extract) are almost the result obtained from titration of ordinary indicators (i.e., methyl red).

Passiflora incarnate[30]

Akshata S Gavade *et al*., (2018) determined *Passiflora incarnate* of the family Passifloraceae as shown in Figure 3, for its acid-base indicator activity against phenolphthalein as a standard indicator.

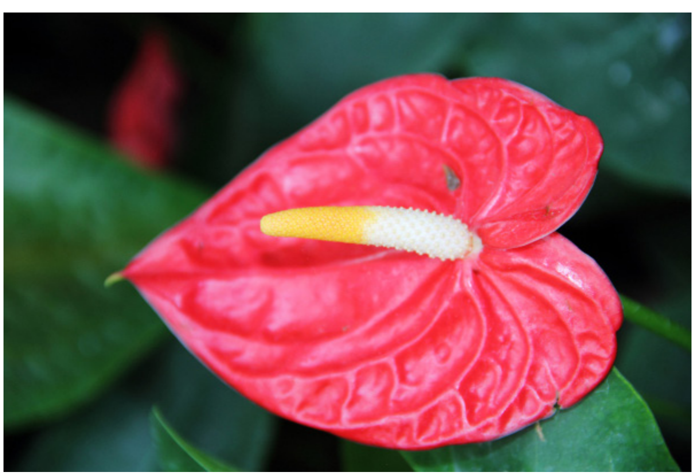

Figure 1: An image of *Anthurium andraeanum.*

The Passion flower extract of ethanolic petals of flowers was screened for use as a natural indicator in an acid-base titration, and the results were compared to those obtained from other tests., such as a result of using a typical indicator like phenolphthalein for HCl v/s NaOH, HCl v/s NH_3, CH_3COOH v/s NaOH, and CH_3COOH v/s NH_3 titrations. The results of titration of a passion flower extract are similar to the results of titration of a phenolphthalein. The end point was observed with a color change from pink to greenish with a pH range of 2.6-5.4.

Curcuma longa[31]

Patil N B *et al*., (2018) determined *Curcuma longa* (Turmeric) of family Zingiberaceae is shown in Figure 4, for its acid-base indicator activity against phenolphthalein and methyl orange as a standard indicator. In this method, the extracted solution from rhizomes of *Curcuma longa* was used as an indicator for titrations when the titrate and titrant were strong acid v/s strong base, weak acid v/s weak base, strong acid v/s weak base, and weak acid v/s strong base. The results of titration of a natural indicator is similar to the results of titration of a standard indicator like phenolphthalein. The endpoint was observed with a color change from yellow to brownish red.

Rhoeo syathacea and *Allamanda cathartic*[32]

Nayana Pimpodkar *et al*., (2014) examined *Rhoeo syathacea* of family Commelinaceae is shown in Figure 5 and *Allamanda cathartic* of family Apocynaceae as shown in Figure 6, for its acid-base indicator activity. In this method flowers and leaves of *Allamanda cathartic* and *Rhoeo syathacea* were used to get the macerated ethanolic extracts. These extracts were taken as the indicator for the weak acid and weak base titrations in which usually range of mixed indicators are preferred. This color change was due to the presence of pigment anthocyanins which is a class of flavonoids. The titrate and titrant used in this titration were CH_3COOH and NH_3 respectively. The endpoint was observed with a color change from green to violet with a pH range of 4.6-6.2. The results were compared against standards such as methyl red, mixed indicator [methyl orange: bromocresol green (0.1:0.2)], and phenolphthalein.

Dahlia pinnata[33]

Jain P *et al*. (2012) examined *Dahlia pinnata* of family Asteraceae for its acid-base indicator activity against phenolphthalein, phenol red, and methyl orange as standard indicators. The extract of macerated hydro alcoholic 40:60 Aq. and methanolic petals of flowers were used as an indicator. If the titrate and titrant were strong acid v/s strong base, weak acid v/s strong base then the endpoint observed with a color change from colourless to yellow. While a color change from yellow to colourless was observed in the case of weak base v/s strong acid and weak acid v/s strong base. This color change at the endpoint can be usually observed within a pH range of 3-5 against methyl orange (ethanolic extract

Figure 2: An image of *Bauhinia racemose*.

Figure 3: An image of *Passiflora incarnate.*

Figure 4: An image of *Curcuma longa.*

of *Dahlia pinnata*). The color change at the endpoint may vary from orange to wine red, orange to yellow, and pink to red yellow.

Calendula officinalis[34]

Vyas A *et al*., (2012) evaluated *Calendula officinalis* belongs to the family Compositae for its acid-base indicator activity against phenolphthalein and methyl red as a standard indicator. The ethanolic extract of macerated petals of flowers was used as an indicator. If the titrate and titrant were strong acid v/s strong base, weak acid v/s weak base, and weak acid v/s strong base then the end point was observed with a color change from colorless to yellow. While a color change from yellow to colorless was observed in the case of strong acid v/s weak base.

Hibiscus rosa-sinensis[35,36]

Jain P *et al*., (2012) evaluated *Hibiscus rosa-sinensis* belonging to the family Malvaceae for its acid-base indicator activity against

Figure 5: An image of *Rhoeo syathacea.*

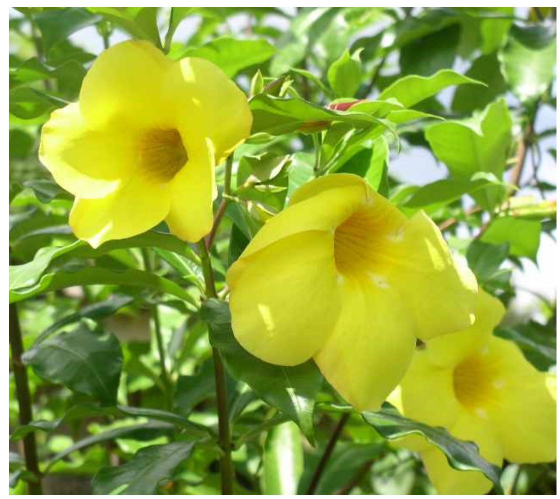

Figure 6: An image of *Allamanda cathartic.*

methyl orange, phenol red, and phenolphthalein as standard indicators. Soaked aqueous and methanolic petal extracts are used as indicators. If the titrate and titrant were strong acid v/s strong base, weak acid v/s weak base, and weak acid v/s strong base then the endpoint was observed with a color change from colorless to yellow. While the strong acid v/s weak base then the end point was observed with a color change from pink to greenish-yellow.

Phyllanthus reticulatus[37]

Jadhav R L *et al*., (2012) evaluated *Phyllanthus reticulatus* of family Euphorbiaceae for its acid-base indicator activity against mixed indicator [methyl orange: bromocresol green (0.1:0.2)], Phenolphthalein and methyl red as a standard indicator. The fruits extract of ethanolic HCl flowers was used as an indicator. If the titrate and titrant were NaOH v/s HCl, NaOH v/s CH_3COOH then the endpoint was observed with a color change from red to colorless. While the NH_3 v/s HCl, NH_3 v/s CH_3COOH then the end point was observed with a color change from wine red to violet-black.

Ipomoea biloba[38]

Abbas S K *et al.*, (2012) examined *Ipomoea biloba* of the family Convolvulaceae for its acid-base indicator activity against phenolphthalein as a standard indicator. The extract of macerated aqueous petals of flowers is used as an indicator. This bright red color change occurred at the pH range of 3 which was maintained using the acid-phthalate buffer and the dark green color was observed at the pH range of 9-10 which was maintained using alkaline borate buffer.

Antirrhinum majus[39]

Sidana J *et al.*, (2011) evaluated *Antirrhinum majus* belonging to the family Scrophulariaceae for its acid-base indicator activity against phenolphthalein as a standard indicator. The extract of macerated methanolic petals of flowers was used as an indicator. The titrate and titrant used in this titration were NaOH and HCl respectively. The endpoint was observed with a color change from colorless to pink. This color change was due to the presence of pigment anthocyanins belongs to flavonoids. The volume of the titrate required for equivalence points of methanolic extract of *Antirrhinum majus* (10.2±0.21) and the standard indicator (10.5±0.3) i.e., phenolphthalein and methyl orange were quite closer.

Alternanthera dentata[40]

Shyama Nair *et al.*, (2011) evaluated *Alternanthera dentata* belongs to the family Amaranthaceae for its acid-base indicator activity against mixed indicator [methyl orange: bromocresol green (0.1:0.2)], phenolphthalein and methyl red as a standard indicator. The aqueous extract of leaves of the *Alternanthera dentata* is red, due to the presence of a pigment anthocyanin. The color change from red to greenish-yellow at the end point has been observed with the change in pH from less than 7 to more than 7 i.e., from acidic pH to basic pH. The extract of leaves was used as an indicator for titrations when the titrate and titrant were HCl v/s NaOH, $H_2C_2O_4$ v/s NH_4OH, HCl v/s NH_4OH, and $H_2C_2O_4$ v/s NaOH. The extract of *Alternanthera dentata* when observed under UV-visible spectrometry showed a maximum at two different wavelengths, out of which one lies in the visible region (475-560 nm) i.e., 521 nm, and the other lies in the UV-Visible region (275-250 nm) i.e., 284 nm. The color change was observed due to the number and position of functional groups i.e, hydroxyl and methoxyl groups. If their count is fixed and position doesn't change then the color change usually depends on pH and solvent properties. This color change that occurred at the end point is mainly due to the presence of pH-sensitive plant pigments.

Dianthus plumarius[39]

Sidana J *et al.*, (2011) evaluated *Dianthus plumarius* of family Caryophyllaceae for its acid-base indicator activity against phenolphthalein as a standard indicator. The extract of macerated methanolic petals of flowers was used as an indicator. The titrate and titrant used in this titration were NaOH and HCl respectively. The end point was observed with a color change from colorless to violet. This color change was due to the presence of pigment anthocyanins which is a class of flavonoids. The volume of the titrate required for equivalence points of methanolic extract of *Dianthus plumarius* (10.4±0.31) and the standard indicator (10.5±0.3) i.e., phenolphthalein and methyl orange were quite closer.

Butea monosperma[41]

Kurmi B D *et al.*, (2011) examined *Butea monosperma* of family Fabaceae for its acid-base indicator activity against phenolphthalein, methyl red, and methyl orange as standard indicators. The extract of macerated ethanolic petals of flowers was used as an indicator. If the titrate and titrant were strong acid v/s strong base, weak acid v/s weak base, and weak acid v/s strong base then the end point was observed with a color change from colorless to yellow and in the case of strong acid v/s weak base, the color change from yellow to colorless.

Punica granatum[42]

Raj N R *et al.*, (2011) examined *Punica granatum* belonging to the family Punicaceae was performed for its acid-base indicator activity against phenolphthalein, phenol red, and methyl red as a standard indicator. The macerated extract of methanolic seeds was used as an indicator. If the titrate and titrant were HCl v/s NaOH, CH_3COOH v/s NH_3, CH_3COOH v/s NaOH and HCl v/s NH_3. The endpoint was observed with a color change from pink to colorless.

Bombax malabaricum[43]

Patrakar R *et al.*, (2010) determined *Bombax malabaricum* of family Malvaceae for its acid-base indicator activity against phenolphthalein and methyl orange as standard indicators. The extract of methanolic hydrochloric acid petals, was used as an indicator. The equivalence point was observed with a color change from green to colorless.

Ixora coccinea[44]

Deshpande A *et al.*, (2010) evaluated *Ixora coccinea* belongs to the family Rubiaceae for its acid-base indicator activity against mixed indicator [methyl orange: bromocresol green (0.1:0.2)], methyl orange as standard indicator. The extract of flowers is used as an indicator. If the titrate and titrant were strong acid v/s strong base, strong acid v/s weak base, and weak acid v/s strong base then the end point was observed with a color change from green to pink. While a color change from blue to pink was observed in the case of weak acid v/s weak base.

Jacaranda acutifolia[45]

Patrakar R *et al.*, (2010) determined *Jacaranda acutifolia* of family Bignoniaceae for its acid-base indicator activity against

Table 1: Summary of natural indicators v/s endpoints.

Sl. No.	Plant Name	Natural Indicators	Synthetic Indicators	Titrant v/s Titrand	Type of Titration	Endpoint	References
1	*Anthurium andraeanum*	Methanolic extract of petals of flowers	Phenolphthalein	HCl v/s NaOH	Acid-Base titration	Sharp color change	Amar V. Desai *et al.*,[28]
2	*Bauhinia racemose*	Ethanolic extract of petals of flowers	Methyl red	HCl v/s NH_3	Acid-Base titration	Red to colourless	Rohit M. Jamdar *et al.*,[29]
3	*Passiflora incarnate*	Ethanolic extract of petals of flowers	Phenolphthalein	CH_3COOH v/s NaOH	Acid-Base titration	Pink to Gray	Akshata S. Gavade *et al.*,[30]
4	*Curcuma longa*	Extracted solution from rhizomes	Phenolphthalein and methyl orange	CH_3COOH v/s NH_4OH	Acid-Base titration	Yellow to Brownish red.	Patil N. B. *et al.*,[31]
5	*Rhoeo syathacea and Allamanda cathartic*	Ethanolic flowers and leaves extract	Methyl red, mixed Indicator [methyl orange: bromocresol green (0.1:0.2)], and phenolphthalein	CH_3COOH v/s NH_3	Acid-Base titration	Green to Violet	Nayana Pimpodkar *et al.*,[32]
6	*Dahlia pinnata*	Hydro alcoholic (40:60) petals extract	Phenolphthalein, phenol red, and methyl orange	H_2SO_4 v/s NH_4OH	Acid-Base titration	Pink to Red	Jain P *et al.*,[33]
7	*Calendula officinalis*	Ethanolic extract of petals of flowers	Phenolphthalein and methyl red	HCl v/s NaOH	Acid-Base titration	Yellow to Colorless	Vyas A *et al.*,[34]
8	*Hibiscus rosa sinensis*	Aqueous and methanolic extract of petals	Methyl orange, phenol red, and phenolphthalein	HCl v/s NH_3	Acid-Base titration	Pink to Greenish-yellow.	Jain P *et al.*,[35,36]
9	*Phyllanthus reticulatus*	Fruits extract of ethanolic HCl flowers	Mixed indicator [methyl orange: bromocresol green (0.1:0.2)], phenolphthalein and methyl red	NH_3 v/s HCl	Acid-Base titration	Wine red to Violet-black	Jadhav R L *et al.*,[37]
10	*Ipomoea biloba*	Aqueous extract of petals of flowers	Phenolphthalein	HCl v/s NaOH	Acid-Base titration	Appearance of green color	Abbas S K *et al.*,[38]
11	*Antirrhinum majus*	Methanolic extract of petals of flowers	Phenolphthalein	NaOH v/s HCl	Acid-Base titration	Colorless to Pink	Sidana J *et al.*,[39]
12	*Alternanthera dentata*	Aqueous extract of leaves	Mixed indicator [methyl orange: bromocresol green (0.1:0.2)], phenolphthalein and methyl red	$H_2C_2O_4$ v/s NH_4OH	Acid-Base Titration	Red to Greenish yellow	Shyama Nair *et al.*,[40]
13	*Dianthus plumarius*	Methanolic petals of flowers	Phenolphthalein	NaOH v/s HCl	Acid-Base titration	Colorless to Violet	Sidana J *et al.*,[39]

Sl. No.	Plant Name	Natural Indicators	Synthetic Indicators	Titrant v/s Titrand	Type of Titration	Endpoint	References
14	*Butea monosperma*	Macerated ethanolic petals of flowers	Phenolphthalein, methyl red, and methyl orange	HCl v/s NaOH	Acid-Base titration	Colorless to Yellow	Kurmi B D *et al.*,[41]
15	*Punica granatum*	Macerated extract of methanolic seeds	Phenolphthalein, phenol red, and methyl Red	CH_3COOH v/s NaOH	Acid-Base titration	Pink to Colorless	Raj N R *et al.*,[42]
16	*Bombax malabaricum*	Methanolic hydrochloric acid petals	Phenolphthalein and methyl orange	HCl v/s NaOH	Acid-Base titration	Green to Colorless	Patrakar R *et al.*,[43]
17	*Ixora coccinea*	Extract of flowers	Mixed indicator [methyl orange:bromocresol green (0.1:0.2)], methyl orange	CH_3COOH v/s NH_3	Acid-Base titration	Blue to Pink	Deshpande A *et al.*,[44]
18	*Jacaranda acutifolia*	Extract of methanolic HCl petals of flowers	Phenolphthalein, methyl red, and mixed indicator [methyl orange: bromocresol green (0.1:0.2)]	HCl v/s NH_4OH	Acid-Base titration	Green to Colorless	Patrakar R *et al.*,[45]
19	*Helianthus annus*	Macerated methanolic extract of petals of flowers	Phenolphthalein	H_2SO_4 v/s NaOH	Acid-Base titration	Faint blue to Faint yellow	Patil S B *et al.*,[46]
20	*Morus alba*	Macerated extract of methanolic petals of flowers	Methyl red and phenolphthalein	HCl v/s NH_3	Acid-Base titration	Blue to pink	Pathade K S *et al.*,[47]
21	*Careya arborea*	Macerated methanolic leaves	Phenolphthalein	0.1M NaOH v/s 60.1M HCl	Acid-Base titration	Yellow to Reddish-brown	Wadkar K A *et al.*,[48]

phenolphthalein, methyl red, and mixed indicator [methyl orange: bromocresol green (0.1:0.2)] as a standard indicator. The extract of methanolic HCl petals of flowers was used as an indicator. If the titrate and titrant were HCl v/s NaOH, Oxalic acid v/s NH_4OH, Oxalic acid v/s NaOH, and HCl v/s NH_4OH. The endpoint was observed with a color change from green to colorless.

Helianthus annus[46]

Patil S B *et al.*, (2009) evaluated *Helianthus annus* belonging to the family Asteraceae for its acid-base indicator activity against standard indicators. The macerated extract of methanolic petals of flowers was used as an indicator. The endpoint was observed with a color change from faint blue to faint yellow with a pH range of 6.6-7.0. This color change was due to the presence of pigment anthocyanins with an absorbance range of about 0.709, when observed at a wavelength of 254 nm using a UV spectrophotometer.

Morus alba[47]

Pathade K S *et al.*, (2009) examined *Morus alba* of family Moraceae for its acid-base indicator activity against methyl red and phenolphthalein as standard indicators. The macerated extract of methanolic petals of flowers was used as an indicator. If the titrate and titrant were strong acid v/s strong base, weak acid v/s weak base, strong acid v/s weak base, and weak acid v/s strong base. The endpoint was observed with a color change from blue to pink with a pH range of 5.5-8.5.

Careya arborea[48]

Wadkar K A *et al.*, (2008) determined *Careya arborea* belonging to the family Lecythidaceae for its acid-base indicator activity against phenolphthalein as a standard indicator. The extract of macerated methanolic leaves of plants was used as an indicator. The titrate and titrant used in this titration were 0.1M NaOH and 0.1M HCl. The endpoints obtained by the leaf extract coincided with the equivalence points obtained by the standard indicators used in all titrations. The equivalence point was observed with a color change from yellow to reddish-brown.

The overall summary of the Natural indicators vs. endpoints are mentioned in Table 1.

CONCLUSION

The study remained a good source of knowledge about the reagents that are used commonly in neutralization titrations as indicators for the identification of equivalence points. In several cases, it proved to be more consistent than the standard indicator and gave a sharp color change at the endpoint. As the aqueous and methanolic extract provide similar results hence these can be used with 100% reliability and accuracy for acid-base titration. From the results it can be concluded that it was due to the presence of flavonoids, sharp color change occurred at the endpoint of the titrations. The synthetic indicators are very perilous to one's health and pollute the environment, so to solve this problem floral extract has been chosen as a source of indicator for acid-base titration. Lastly, we can say that it is always beneficial to use the natural extract as an indicator in all types of acid-base titrations because of its eco-friendly, cost-effective, simple, accurate, precise, and widely available. Hence, these characters prove that these could be an excellent replacement for synthetic indicators.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ABBREVIATIONS

NaOH: Sodium Hydroxide; **HCl:** Hydrochloric acid; **CH_3COOH:** Acetic acid; **NH_4OH:** Ammonium Hydroxide; **NH_3:** Ammonia; **$H_2C_2O_4$:** Oxalic acid.

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