Natural Indicator for Acid-Base Titration from Thai Yellow Flower Extracts

Naruwan Pattarapongdilok, Primpak Malichim, Natthaphol Simmee, and Jirapast Sichaem

Abstract—**This study was aimed at investigating the efficiency of extract indicators from three yellow flowers in Thailand (*Acacia auriculiformis* A. Cunn., *Crotalaria juncea* L. and *Sesbania javanica* Miq.). The flowers were extracted with deionized water and evaporated in order to get dried extracts. The flower extracts (5% w/w) were prepared as indicator. In the primary experiment, the flower extracts were tested in order to determine their indicator property using three types of solutions, different pH, buffer solutions, HCl/NaOH solutions and CH_3COOH/NaOH solutions. The results show that the colors will be changed in basic solution. Then, the indicator activities of flower extracts were used in acid-base titration in which a strong base was used as a titrant and the results were compared using a standard indicator, phenolphthalein. The results suggest that the flower extracts can be used as an alternative indicator for strong acid (HCl) – strong base (NaOH) titration and weak acid (CH_3COOH) – strong base (NaOH) titrations. The color of solution will be changed from light brown to dark brown for *A. auriculiformis* A. Cunn., and transformed from light brown into yellow for *C. juncea* L. and *S. javanica* Miq. when the solutions have more basicity. The color changes were clear and sharp when the strength of NaOH solution was increased. Therefore, the use of these flowers' extracts as indicators is their new application which can be applied in the chemistry class because these natural indicators are safe, cheap and easy to prepare.**

Index Terms—**Acacia auriculiformis A. Cunn., crotalaria juncea L., sesbania javanica Miq., acid-base titration, natural indicator.**

I. Introduction

Titration or titrimetry is a general laboratory method of quantitative chemical analysis which can be observed from the quantity of a liquid of standard solution, the titrant or the solution of known concentration, to convert the constituent into another form [1]-[3]. A change of color or the formation is used to determine the concentration of an analyte, titrand or unknown solution [2]. The method of quantitative analysis of acid and base by an acid or base of standard solution exactly neutralizing with an acid or base of unknown concentration is called an acid-base titration [3], [4]. The equivalent point is very difficult to observe because the reaction between an acid and base will yield colorless salt and water. Acid-base indicators, also known as pH indicators, are usually weak acids or bases, which when dissolved in water dissociate slightly and form ions. A good indicator is a weak acid or weak base that is slightly soluble in water. The commercial indicators are relatively expensive and have a toxic effect on the user and can also cause environmental pollution [5].

Therefore, a lot of research is focusing on an alternative to substitute the commercial indicators. The alternative needs to have the end point and equivalence point volumes coinciding closely for low titration error. Moreover, it should be cheaper, more available, easier to be extracted, less toxic to the user and environmentally friendly. A natural indicator is a natural substance typically from a plant origin that can be used to determine the pH of another substance [6].

Nerium indicum and *Aspilia africana* extracts can be used as acid-base indicators that can replace phenolphthalein (indicator) because it is easy to find and prepare and yields precise and accurate results [7]. In addition, *Rosa setigera*, *Allamanda cathartica* and *Hibiscus rosa-sinensis* had been effectively used as a substitute for commercial indicators [8].

A. auriculiformis A. Cunn. (Fabaceae) is an important medicinal plant and is a well-known source of phenolics, tannins and terpenoids. This plant has been used as natural medicine for the treatment of anti-helminthes, antifungal and anti-microbial effects [9].

C. juncea L., commonly known as brown hemp, Indian hemp, Madras hemp, or sunn hemp, belong to Fabaceae family. This plant possesses hypolipidemic, reproductive, antioxidant, antibacterial, antifungal, antidiarrheal, anti-inflammatory, hepatoprotective and many other pharmacological effects. Its leaves showed the presence of carbohydrates, steroids, triterpenes, phenolics, flavonoids, alkaloids, aminoacids, saponins, glycosides, tannins and volatile oils [10].

S. javanica Miq. (Fabaceae) commonly known as "Sano" in Thai or "Phak hong hang" (northern Thai). Its flowers are harvested only in the rainy season and commonly consumed in Thailand. In ancient Thai traditional medicine, it was used as an anti-inflammatory for insect bites, detoxification, intestinal abscess healing, stomach discomfort and to relieve internal fever and thirst. The major flavonoids in *S. javanica* Miq. flower extracts are the flavonol glycoside and Quercetin 3-2G-rhamnosylrutinoside [11].

A. auriculiformis A. Cunn., *C. juncea* L. and *S. javanica* Miq. have the same natural product chemical that can

Manuscript received November 30, 2018; revised January 28, 2019.

This work was supported by the grant from Bansomdejchaopraya Rajabhat University, Thailand.

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doi: 10.18178/ijcea.2019.10.1.734

generate colors in the acid-base solutions such as flavonoid. The flavonoid has subgroups which are the color pigments such as anthocyanins and flavonones [12], [13]. It is interesting to use it as an indicator in acid-base titration.

Hence in this study, we aim to evaluate the properties of some natural substances such as *A. auriculiformis* A. Cunn., *C. juncea* L. and *S. javanica* Miq. flowers in order to ascertain their analytical potentials as indicators.

II. Materials and Methods

A. Materials

The three flowers were collected from different places in Thailand. Northern black wattle flowers (*A. auriculiformis* A. Cunn., AAC) and Sunn hemp flowers (*C. juncea* L., CJL) were collected from Kalasin province. Sesbanea pea flowers (*S. javanica* Miq., SJM) were collected from Bangkok. The flowers were stored in a dried form. Fresh petals were separated from flowers and cut into small pieces. They were cleaned with deionized water and dried at 60 ℃ for two hours. All chemicals and reagents used in this investigation were of analytical grade.

B. Methods

Exactly 6 grams of dried petals of flowers (*A. auriculiformis* A. Cunn., *C. juncea* L. and *S. javanica* Miq.) mixed with 200 mL of deionized water were heated at 100 ℃ for one hour. The aqueous extracts were filtered by a filter paper, Whatman 1, and evaporated through a vacuum rotary evaporator at 60 ℃. The extract indicators for study were prepared using 5 % (w/w) of dried extracts in water.

The color change of the extracts was observed by adding five drops of flower extracts into 6 mL of different pH solution of buffer solutions, hydrochloric acid/sodium hydroxide (HCl/NaOH) solutions, and acetic acid/sodium hydroxide (CH_3COOH/NaOH) solutions. The buffer solutions were prepared using mixtures of hydrochloric acid/potassium chloride (HCl/KCl) for pH values 1, 2, 12, and 13, hydrochloric acid/potassium hydrogen phthalate (HCl/KHP) for pH values 3 and 4, potassium hydrogen phthalate/sodium hydroxide (KHP/NaOH) for pH values 5, potassium dihydrogen phosphate/sodium hydroxide (KH_2PO_4/NaOH) for pH values from 6 to 8, hydrochloric acid/sodium tetraborate decahydrate (HCl/$Na_2B_4O_7 \cdot 10H_2O$) for pH values 9, and hydrochloric acid/sodium bicarbonate in pH values 10 and 11 [14], [15]. The HCl/NaOH solutions and CH_3COOH/NaOH solutions have various pH values from 1 to 14.

Acid-base titrations with flower extracts were carried out using 15 mL of 1.0 M HCl as a titrand, and 0.5 M NaOH and 1.0 M NaOH as a titrant for strong acid-strong base titration. 15 mL of 1.0 M CH_3COOH solution, and 0.5 M and 1.0 M NaOH were used for weak acid-strong base titration. We used the 50-mL beaker to replace the Erlenmeyer flask and used a magnetic bar for stirring during titration. KHP was used as a primary standard for determining concentration of HCl and CH_3COOH solutions. The results were compared using phenolphthalein (three drops per sample) as a standard indicator. The mean and standard deviation for each type of acid-base titrations were calculated from the results of trials repeated for five times. Moreover, there is measurement of pH range for each sample by pH meter.

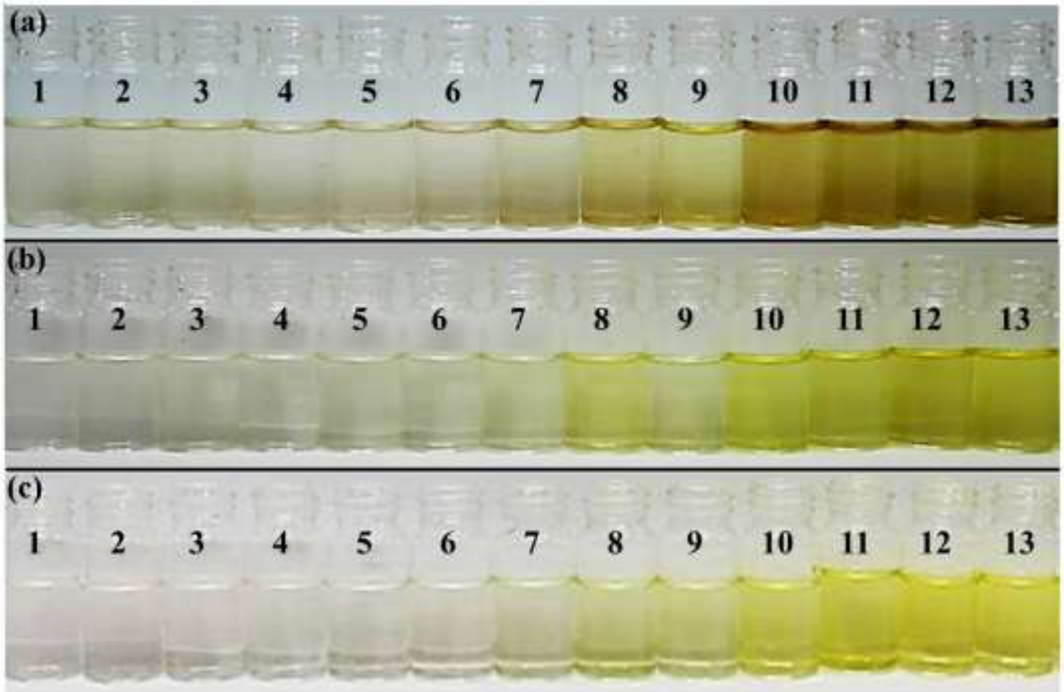

Fig. 1. Color change of buffer solutions in pH values from 1 to 13 added (a) AAC, (b) CJL and (c) SJM.

III. Results and Discussion

The flower extracts of three flowers, *A. auriculiformis* A. Cunn. (AAC), *C. juncea* L. (CJL) and *S. javanica* Miq. (SJM) have the coloring natural pigments such as subgroup of flavonoids and sensitive to pH. From Fig. 1, the color changing trials in buffer solutions with various pH values from 1 to 13 show that color of acidic solutions are light brown, and pH 8 and 9 solutions have sharper color for ACC extract as indicator. There is a dark brown color at pH 10-13 of buffer solutions. For CJL and SJM extracts, the colors of buffer solutions were very light brown in pH values ranging from 1 to 6 and yellow for pH values from 7 to 13. The test using HCl/NaOH solutions and CH_3COOH/NaOH solutions with pH values from 1 to 14 was conducted in different pH solutions and then flower extracts were added (see Fig. 2 and Fig. 3). The results found that solutions have clear color in pH values from 10 to 14 for HCl/NaOH solutions (Fig. 2 (a)-(c)) and in pH values from 11 to 14 for CH_3COOH/NaOH solutions (Fig. 3 (a) - (c)). It is possible that there are the pH changes of solutions because the flower extracts have acidity of pH 5 approximately. The colors of acidic solutions of buffer solutions and HCl/NaOH solutions are the same but the color of acidic solutions in CH_3COOH/NaOH solutions using CJL and SJM extracts as indicators is sharper than in buffer and HCl/NaOH solutions, while using AAC in CH_3COOH/ NaOH solutions produces a similar color to those of buffer and HCl/NaOH solutions.

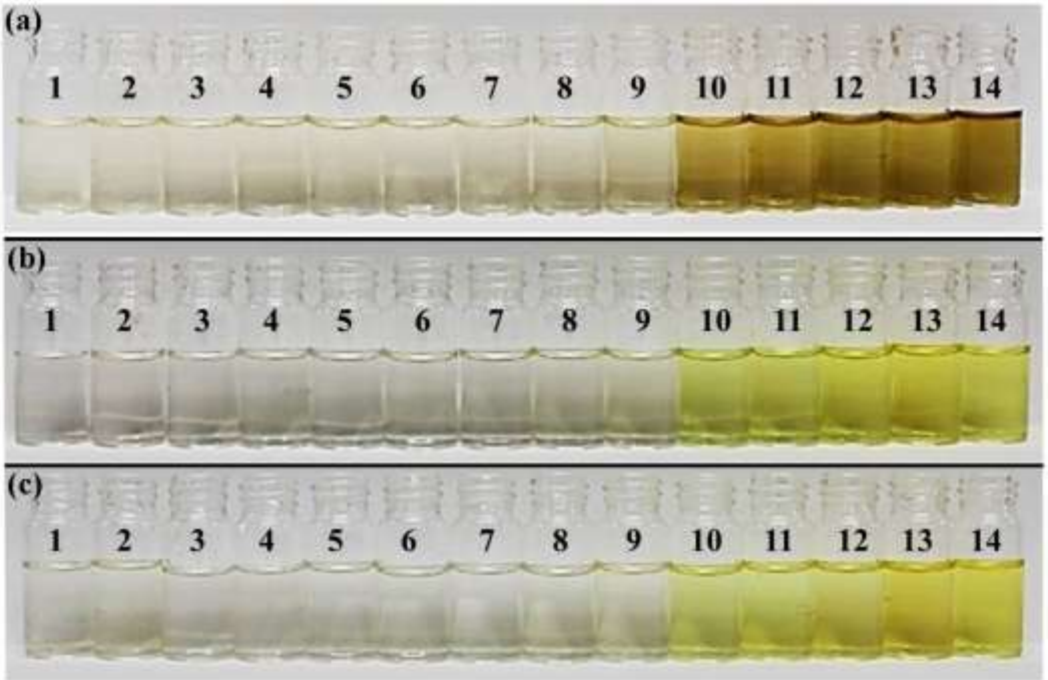

Fig. 2. Color change of HCl/NaOH solutions in pH values from 1 to 14 added (a) AAC, (b) CJL and (c) SJM.

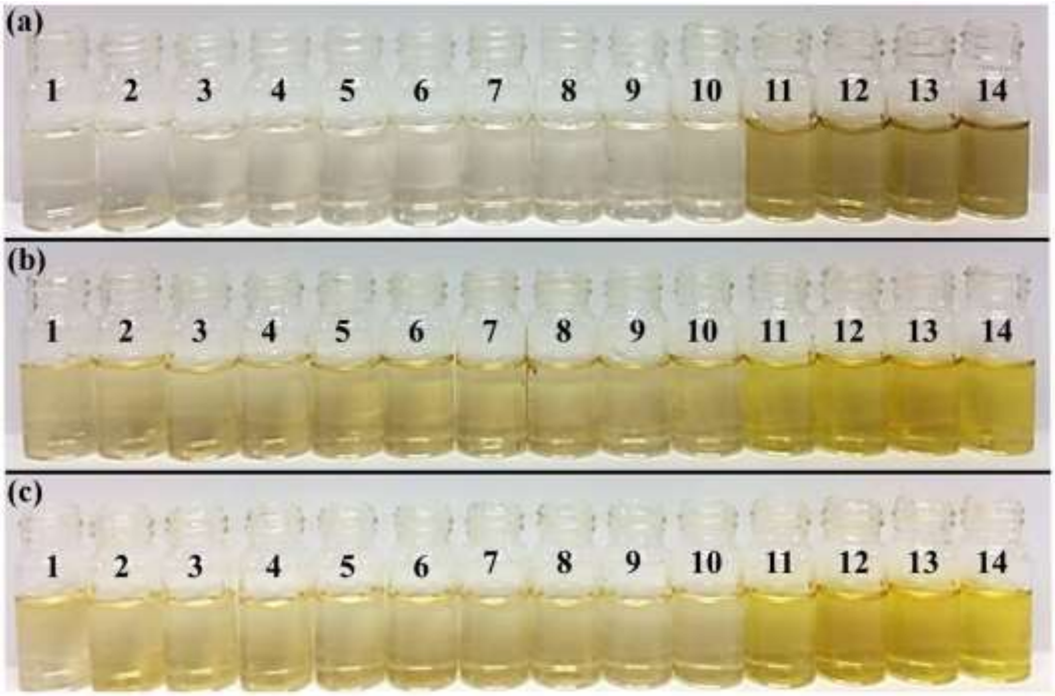

Fig. 3. Color change of CH_3COOH/NaOH solutions in pH values from 1 to 14 added (a) AAC, (b) CJL and (c) SJM.

The efficiencies of extracted indicators were determined by comparing acid-base titrations with the standard indicator (Phenolphthalein). The pH ranges of the color change of flower extracts are boarder than that of Phenolphthalein (Table I). Due to the color change of similar tone and pH range of extracted indicators (see Table I), strong acid-strong base titrations and weak acid-strong base titrations were specifically selected using titration of two concentrated-base titrants. In Table II, the end point of titrations obtained by flower extracts vary similarly to the end point, indicating an equivalent point, obtained by Phenolphthalein. When we increased the strength of strong base, the sharpness of color change was also increased. For the color change of solution, the yellow solution is observed more easily than the dark brown solution when the color of starting solution is light brown. The comparison of the color changes in acid-base titrations can be found in Fig. 4 and Fig. 5.

TABLE I: COLOR CHANGE AND PH RANGE INDICATORS

Indicators	Indicator color changes	NaOH/HCl (Titrant/Titrand)	NaOH/CH_3COOH (Titrant/Titrand)
Phenolphthalein	Colorless to Pink	8.22-10.05	8.22-10.01
AAC	Light Brown to Dark Brown	6.66-11.37	6.66-11.23
CJL	Light Brown to Yellow	6.88-11.18	6.88-11.55
SJM	Light Brown to Yellow	6.78-11.25	6.78-10.25

AAC: *A. auriculiformis* A. Cunn., CJL: *C. juncea* L., SJM: *S. javanica* Miq.

TABLE II: SCREENING RESULTS OF ACID-BASE TITRATION WITH EXTRACT AS INDICATOR

Indicators	Mean values of titration ± S.D. (mL)*				Indicator color changes	pH
	NaOH/HCl (Titrant/Titrand)		NaOH/CH_3COOH (Titrant/Titrand)			
	0.5M NaOH	1M NaOH	0.5M NaOH	1M NaOH		
Phenolphthalein	29.19 ± 0.06	14.56 ± 0.11	29.29 ± 0.11	14.64 ± 0.11	Colorless to Pink	8.22-10.05
AAC	29.16 ± 0.08	14.60 ± 0.09	29.10 ± 0.05	14.73 ± 0.11	Light Brown to Dark Brown	6.66-11.37
CJL	29.12 ± 0.01	14.67 ± 0.09	29.43 ± 0.13	14.81 ± 0.09	Light Brown to Yellow	6.88-11.55
SJM	28.99 ± 0.12	14.56 ± 0.04	29.26 ± 0.14	14.61 ± 0.09	Light Brown to Yellow	6.78-11.25

*All values are mean ± S.D. of 5 readings
AAC**:** *A. auriculiformis* A. Cunn., CJL: *C. juncea* L., SJM: *S. javanica* Miq.

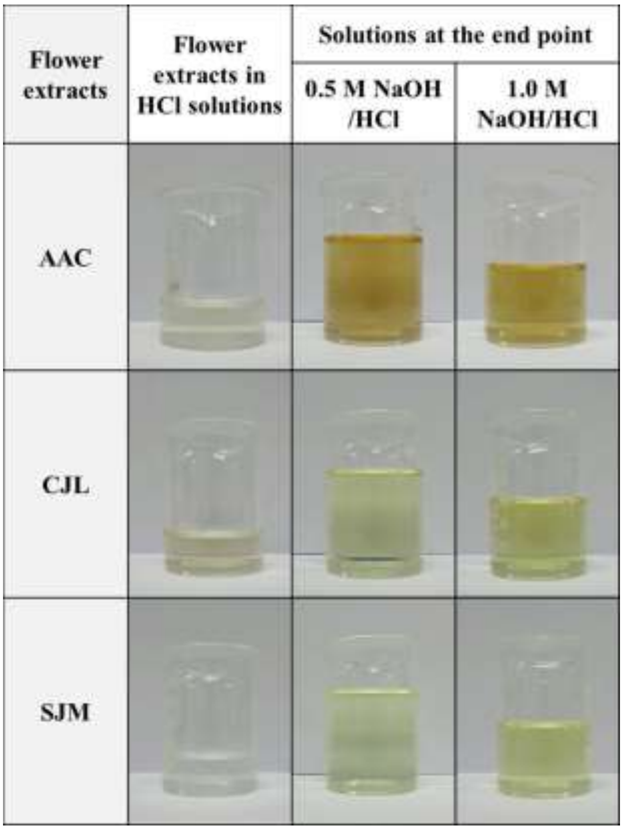

Fig. 4. Color change of strong acid – strong base titrations**.**

This study suggests the usefulness of three flower extracts in acid-base titrations, especially the case of strong acid-strong base titrations and weak acid-strong base titrations using the flower extracts as indicators that yielded a result which is very similar to that of standard indicators. Based on all above results, this study confirmed that all flower extracts can be used as acid-base indicators that can replace phenolphthalein indicator because these natural indicators are cheap, safe and easy to prepare, whereas synthetic indicators were found to be more expensive and hazardous. Therefore, this is a new application of these three flowers as local materials that can be found easily in Thailand.

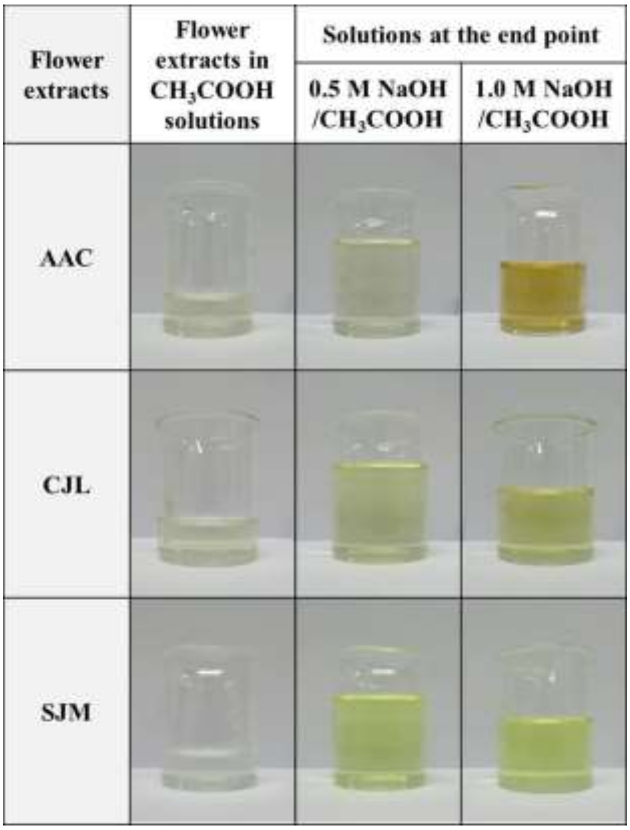

Fig. 5. Color change of weak acid – strong base titrations**.**

IV. Conclusions

Three Thai flowers, *A. auriculiformis* A. Cunn. (AAC), *C. juncea* L. (CJL) and *S. javanica* Miq. (SJM), can be used as a natural indicator according to the initial study that tested the color change in pH 1-13 of buffer solutions, pH 1-14 of HCl/NaOH solutions and pH 1-14 of CH_3COOH/NaOH solutions. Moreover, flower extracts were used in real acid-base titration, strong acid-strong base titrations and weak acid- strong base titrations in which titrants are the strong base (NaOH). The results indicate that these extracts can be used to replace the standard indicator (Phenolphthalein) because the end point is very close to the standard indicator. The increase in the strength of the strong base also increased the sharpness of color change. During titration, solutions have more basicity and the colors of solutions were changed from light brown to dark brown for ACC, and altered from light brown to yellow for CJL and SJM. Therefore, this investigation found a new application of three flowers which can be a natural indicator that is eco-friendly, easy to prepare and cheap. Finally, they can be used in the chemistry class and simply tested at home.

Acknowledgment

We appreciate the Faculty of Education and Faculty of Science and Technology, Bansomdejchaopraya Rajabhat University, for supporting chemical equipment and a laboratory.

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