

Study of *Melastoma malabathricum* Fruit Dye as Green Alternative to Synthetic Indicators in Acid-Base Titration

Dr. Ponchami Sharma

Assistant Professor, Department of Chemistry, Haflong Government College, Dima Hasao, Assam, India

Email: [ponchi.du\[at\]gmail.com](mailto:ponchi.du[at]gmail.com)

Abstract: The growing concern over the environmental and health impacts of synthetic acid-base indicators has intensified the search for sustainable and eco-friendly alternatives. In this study, the feasibility of using *Melastoma malabathricum* fruit extract as a natural acid-base indicator was systematically evaluated. Aqueous and ethanolic extracts of the fruit dye were prepared and employed in various acid-base titrations. The pH dependent colour transition of the extracts, exhibiting red hues in acidic media and blackish blue in alkaline conditions enables clear end point detection. Titrimetric analyses involving weak acid-strong base ($\text{CH}_3\text{COOH-NaOH}$) and strong acid-weak base ($\text{HCl-NH}_4\text{OH}$) systems produced end points comparable with those obtained using standard synthetic indicators such as phenolphthalein and methyl orange. However, the extracts showed limited applicability in strong acid-strong base (HCl-NaOH) titrations. The results demonstrate that *Melastoma malabathricum* fruit extract serves as an effective, non-toxic and biodegradable indicator for selected acid-base titrations, offering a viable green alternative to conventional synthetic indicators. This study highlights the potential of locally available plant resources in promoting sustainable practices in analytical chemistry.

Keywords: Natural indicators, Plant Dyes, Acid-Base Titration, Green Chemistry, *Melastoma malabathricum*

1. Introduction

In analytical chemistry, acid-base indicators play a crucial role in titrimetric analysis by signaling the equivalence point through a visible colour change (Maqsood et al., 2025). Conventionally, synthetic indicators such as phenolphthalein, methyl orange etc. have been extensively used due to their sharp transition ranges and ease of availability (Samuel et al., 2024). However, these synthetic indicators are harmful to health and environment (Maqsood et al., 2025). In contrast, plant derived natural pigments are biodegradable, non-toxic and obtained from renewable biological sources, aligning with green chemistry principles and reducing the chemical footprint of routine analyses (Maqsood et al., 2025, Samuel et al., 2024). Recent research has demonstrated that natural dye extracts can exhibit reliable pH dependent colour changes and therefore they have potential utilization as green alternative of synthetic indicators in acid-base titration (Patrakar et al., 2010, Leshe & Baye, 2020, Gwarzo et al., 2023, Maqsood et al., 2025).

Melastoma malabathricum is a shrub widely available in the reserves of Assam (Figure 1). It is locally known as *futuka*. The fruits are used as food and have attractive purple colour. The pigment contains mainly two anthocyanins; namely cyanidine-3-glucoside and cyanidine-3, 5-diglucoside (Figure 2) (Singh et al., 2013). The anthocyanins are pH sensitive and changes colour in to blackish blue in basic solution and red in acidic solution. Due to this pH sensitivity, it was hypothesized that fruit extract could be utilized as an indicator for different types of acid-base titrations. This study evaluates the efficiency of *Melastoma malabathricum* dye as an indicator for various types of acid-base reaction.

2. Experimental

2.1 Materials

Fresh ripe fruits of *M. malabathricum* were collected from Dima Hasao, Assam, India. Analytical grade NaOH, CH_3COOH , NH_4OH , HCl, phenolphthalein and methyl orange were used throughout the study.

2.2 Method

The fruits were washed with distilled water and sun dried. The dried fruits were grinded in a mixture grinder to make fine powder. 10 g of this powder was then magnetically stirred with 50 mL water. A deep purple coloured dye solution was obtained. It is then filtered and the filtrate was stored in a clean bottle. The procedure was repeated with another 10 g of fruit powder using ethanol. The acid-base titrations were performed with different types of acids and bases using the dyes as indicators (Table 1). Similar titrations were performed using commercially available indicators.

3. Results and Discussion

In order to evaluate the potential for the use of the dyes as indicators in acid-base titrimetry, a number of titrations were conducted. The end points of the titrations using 4 to 5 drops of the dyes are reported in table 1. The end points of the acid-base titrations using commercially available indicators are also reported in the table.

The results in the table 1 show that the end points obtained with the aqueous and ethanol extracts of *M. malabathricum* in 0.1M solutions of acetic acid and sodium hydroxide (i. e. weak acid-strong base) and hydrochloric acid-ammonium hydroxide (i. e. strong acid-weak base) are comparable to those obtained using traditional indicators (methyl orange

and phenolphthalein). The end points obtained using the extracts of *M. melabathricum*, in titrations involving 0.1M hydrochloric acid and 0.1M sodium hydroxide solutions (i. e. strong acid/strong base) are not comparable to the end points obtained using the commercial indicators. This suggests that the aqueous and ethanol extracts of *M. melabathricum* are suitable indicators in weak acid-strong base and strong acid-weak base titrations, but not so suitable for strong acid-strong base titrations.

4. Conclusion

From this study it is seen that application of the aqueous and ethanolic extract of *M. melabathricum* fruit as acid-base indicator give comparable results with commonly used commercial indicators for weak acid-strong base and strong acid-weak base titrations. Therefore, this dye can be used as a nontoxic and natural alternative for the available synthetic indicators for these two types of titrations.

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Table and Figures

Table 1: Titration end points (10.00ml of 0.1M of the base was titrated against 0.1M solution of the acid in each case)

Indicators	HCl / NaOH	CH ₃ COOH / NaOH	HCl / NH ₄ OH
Methyl orange	11.6	**	7.2
Phenolphthalein	11.1	7.2	**
<i>M. melabathricum</i> (aqueous extract)	12.9	7	7.3
<i>M. melabathricum</i> (ethanol extract)	13.9	6.9	7.3
** = not evaluated			

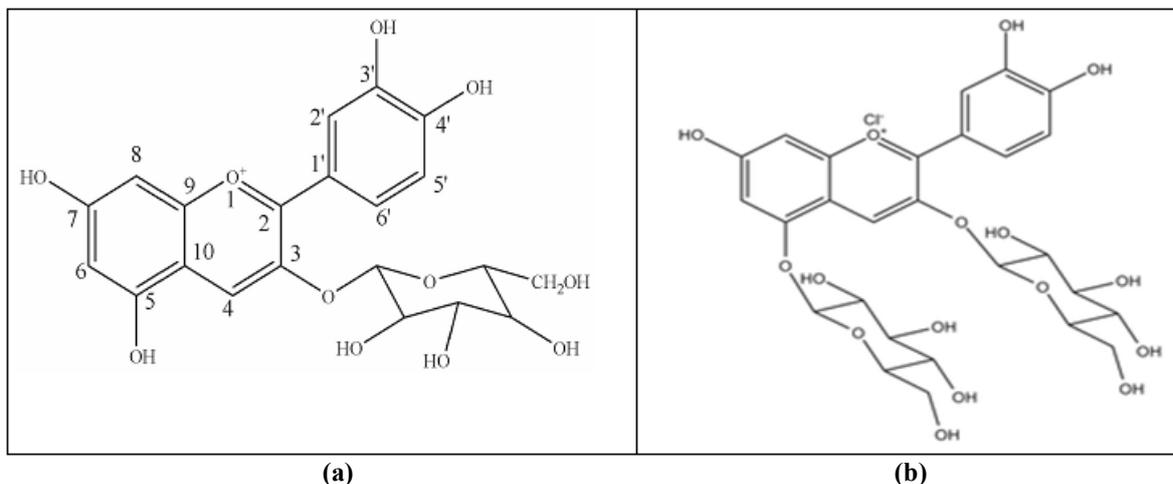


(a)



(b)

Figure 1: (a) *Melastoma malabathricum* plant (b) *Melastoma malabathricum* fruit



(a) (b)
Figure 2: (a) Cyanidin-3-glucoside (b) Cyanidin-3, 5-diglucoside