Chemistry 254
Experiment 11
Spectrophotometrical determination of the pK_A of methyl red

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Abstract

In this practical the acid dissociation constant of methyl red was determined using spectrophotometry.

Contents

1 Introduction

In this practical we determine the acid dissociation constant (pK_A) of the indicator methyl red using spectrophotometry.

First two calibration solutions were made, for both the ionised and non-ionised forms of methyl red. The absorbance was measured at 520 nm and 425 nm for the ionised and non-ionised forms respectively, at various concentrations. From this we are able to obtain a calibration curve by taking linear regressions, the slope of the regression line allowes for the calculation of the relative concentrations of the acid and base forms of methyl red present in our test solutions. From this we calculate pK_A values for each test solution, of which the pH was also measured.

We compare these pK_A values against one obtained by taking the linear regression of pH against $log\left(\frac{[MR^-]}{[MRH]}\right)$. This use of the Henderson-Hasselbalch equation means, the intercept of our regression line will give the value of the pK_A. Furthemore providing a more accurate value then simply taking the mean of the values for each test solution.

2 Results

Figure 1, and figure 2 show the absorbance for MRH and MR^- at 520 $nm$and 425 nm respectively, at various concentrations, with the regression line.

Figure 3 shows pH against $log\left(\frac{[MR^-]}{[MRH]}\right)$ for the test solutions, with regression line.

Our average pK_A value of 6.630 has a standard deviation of 0.354. The value calculated from the linear regression shown in figure 3 is 5.903.

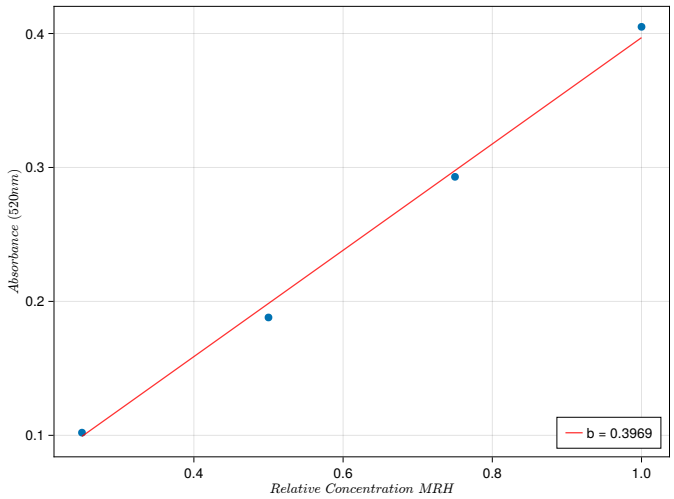

Figure 1: Absorbance at 520 nm

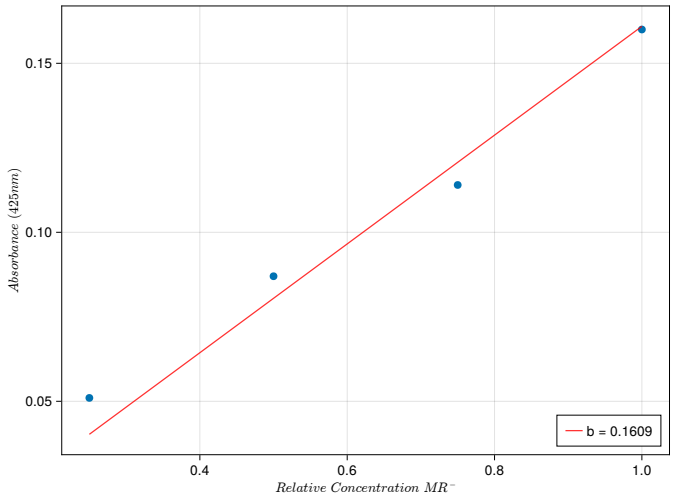

Figure 2: Absorbance at 425 nm

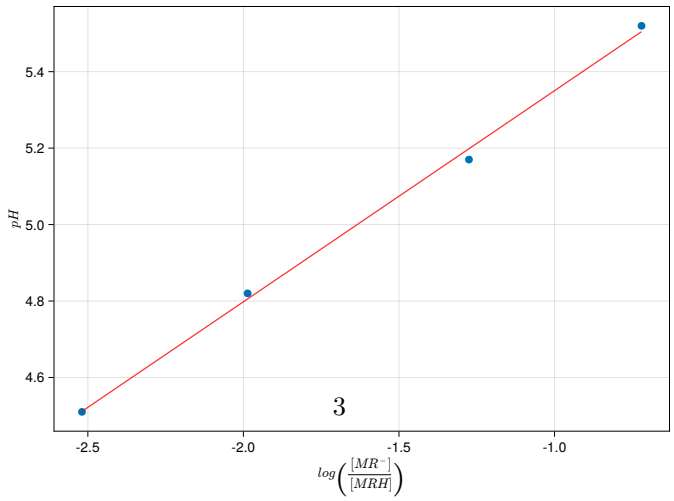

Figure 3: pH over $log\left(\frac{[MR^-]}{[MRH]}\right)$

A static export of the notebook containing all analysis and figures is availible at `https://adammenne.github.io/chemistry_254/practical_3/notebook.html`. With full source code availble at `https://github.com/AdamMenne/chemistry_254/tree/master/practical_3`

3 Discussion

The value for pK_A detrmined by linear regression is notably lower than the mean value of the test solutions, and is closer to values referenced in the literature

However, both of these values deviate significantly from values referenced in the literature which range from 4.8 to 5.1. This is most likely due to the build up of various errors in the preparation of the calibration and test solutions. And possibly the influence of factors not taken into account by the procedure.

Appendix A Questions

1. In the Henderson–Hasselbalch equation we take the log of the ratio of two concentrations, as such the exact values have no impact, only the value of this ratio.

2. Probably, notably

3. Most likely, however it is hard to say without knowing the actual concentration of the original methyl red solution. As, at high enough concentration, electrostatic interactions will begin to impact the absorbance, leading to values that deviate from what is expected according to the Beer-Lambert law.

Appendix B Flow Diagram

A - Standard, acid, and base solutions

1. Prepare standard solution of 10 cm^3 add 125cm^3 96% C_2H_5OH, make up with distilled water
2. Prepare solution A with 50 cm^3 of the standard solution and 50 cm^3 0.1 M HCl, make up with water
3. Prepare solution B with 50 cm^3 of the standard solution and 100 cm^3 0.04 M CH_3COONa, make up with water

B - Calibration solutions

1. Acid form
   (a) Dilute solution A to 0.75, 0.5, and 0.25 with 0.1 M HCl in 10 mL volumetric flasks.
   (b) Measure absorbance at 520 nm.
2. Base form
   (a) Dilute solution B to 0.75, 0.5, and 0.25 with 0.04 M CH_3COONa in 10 mL volumetric flasks.
   (b) Measure absorbance at 425 nm.

C - Test solutions

1. Prepare test solutions in 100 mL volumetric flasks according to the table at the bottom of page 54 of the practical guide.
2. Measure absorbance at 520 nm and 425 nm of each solution.
3. Measure pH of each solution.

Appendix C MSDS

Methyl red

- Health hazard, environmental hazard

- suspected of being carcinogenic

- if exposed, seek medical advice

- avoid release to the environment

Hydrochloric acid

- Harmful, corrisive

- may cause skin burns, eye damage and respiratory irritation, do not inhale

- if in contact with skin or eyes wash for several minutes

Sodium acetate

- Low concern