The linear dynamic range of the new generation Cary 4000, 5000 and 6000i spectrophotometers

Data Sheet

Introduction/Theory

The photometric accuracy and linearity of a spectrophotometer define its ability to measure an absorbance that can be directly related to a standard solute of known absorptivity or concentration. Photometric accuracy and linearity are vital for quantitative measurements, as the ability to measure the correct photometric response for a given concentration is the essential requirement of any analytical measurement. Of similar importance is the dynamic range over which the spectrophotometer remains linear. This is known as the linear dynamic range and is defined as the concentration range over which absorbance and concentration remain directly proportional to each other. A wide linear dynamic range permits the analysis of a wide range of sample concentrations (optical densities), and reduces sample preparation (dilution) requirements.

Cary 4000, 5000 and 6000i instruments provide excellent linear dynamic range

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Materials

- Cary 4000, 5000 or 6000i spectrophotometer with cell base installed. A Cary 4000 was used to obtain the results in this experiment.
- UV-Vis neutral density and blue attenuation filter kit, part number 9910047700, which includes the following parts:
  - Neutral density screens (0.5, 1.1, 1.5 absorbance)
  - Filter assembly BG25 blue (x3)
  - Filter holder (2x V- holder)
  - Instructions for use
- Extra 1.5 absorbance screen in Neutral Density Filter Kit, part number 0218006500
- Quartz cuvettes (10 mm pathlength), part number 6610000800
- Standard potassium permanganate solutions (0.1, 1, 10, 100 and 500 mg/L; freshly prepared from AR Grade $KMnO_4$)

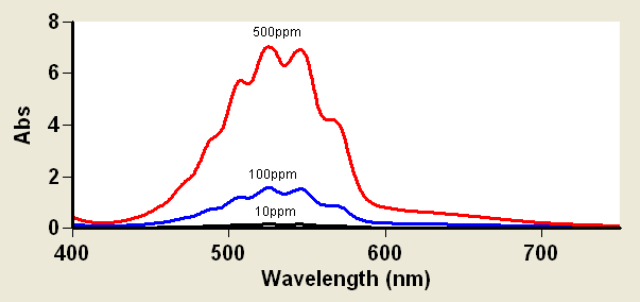
Method

1. Warm up the Cary spectrophotometer for at least 1h prior to use.
2. Recalibrate the instrument by running the Auto-calibrate feature in the Validate Application.
3. Perform instrument performance tests on the instrument using the Validate application. The instrument must pass all tests.
4. Place a cell holder in the sample beam and a V-holder in the reference beam.
5. Set the instrument up as follows:
   - Wavelength range: 750–400 nm
   - Scan rate 60.0 nm/min with a data interval of 1.000 nm and a signal averaging time of 1.000 s.
   - SBW: 2.0 nm
   - Zero/Baseline correction: ON
   - All other parameters as Default
6. Perform a Zero/Baseline correction on H_2O with no rear beam attenuation. Measure the 0.1, 1 and 10 mg/L $KMnO_4$ solutions sequentially using the same quartz cuvette.
7. Place a 1.5 absorbance rear beam attenuation (RBA) screen in the reference beam and perform another Zero/Baseline correction. Using the same quartz cuvette as above, measure the 100 mg/L $KMnO_4$ solution.
8. Repeat Step 4, this time using 4.1 absorbance RBA in the reference beam (i.e., 1.5 + 1.5 + 1.1 absorbance), and scan the 500 mg/L $KMnO_4$ solution.

Note: Rinse the cuvette with each solution between measurements, making sure the optical faces are dry and free from fingerprints before each measurement. Use lint-free tissues.

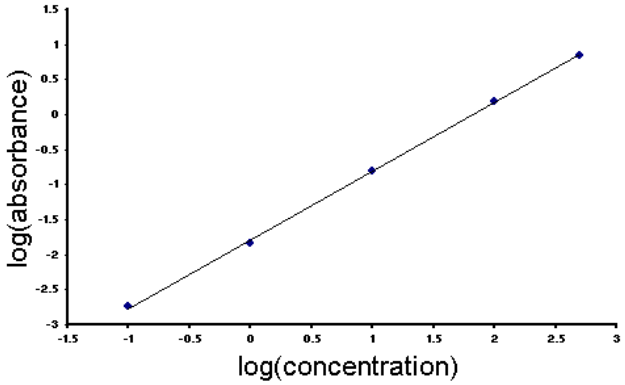
9. Construct a calibration curve by plotting the logarithm of the absorbance versus the logarithm of the concentration.
10. To confirm the linear dynamic range of your Cary spectrophotometer, perform a linear regression on your data and calculate the coefficient of determination (r^2). This gives an indication of the 'goodness of fit' of your data to a straight line, and hence the dynamic range and linearity of the instrument.

Results



The plot of log absorbance vs log concentration (mg/L) below highlights the wide dynamic range and inherent linearity (r^2 = 0.9996) of the Cary spectrophotometers,

and confirms that quantitative analysis of permanganate from 0.1 – 500 mg/L is quite feasible at the peak absorption wavelength of 525 nm.



Conclusion

The quantitative analysis of aqueous potassium permanganate demonstrates the excellent photometric accuracy and wide linear dynamic range of the Cary instruments.

The neutral density and blue attenuation filter (part number 9910047700) permits rear beam attenuation and measurement of photometric range in the visible spectrum.

References

1. UV-Vis Filter Kit instructions, part number 8510063900

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