Determination of soil CEC using methylene blue

Student worksheet

Principle

Cations bound to soil particles dissolve in soil water. Cations in soil water are attracted by and become bound to soil particles. This reversible process is called cation exchange. The capacity of a soil to bind cations is called its cation exchange capacity (CEC).

The singly charged cation is blue. It bonds to negative charged surfaces of, for example, clay soils. The bond is strong enough to displace almost all of the exchangeable cations bound on soil particles. The amount that bonds is a measure of soil CEC.

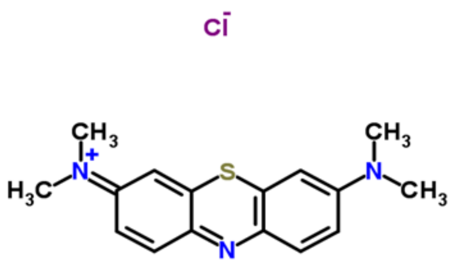

Figure Methylene blue structure.

There are a number of methods for determining CEC, but for a given sample results from different methods are not consistent. The standard method is the 'ammonium ethanoate method', but it is time consuming. However, the methylene blue method is much faster and is still widely used, despite being less reliable.

You can find the concentration of the solution of methylene blue using a colorimeter. You can also use simple colour matching although the results will be less precise.

Equipment and materials

Obtaining a calibration curve

- Burette x 2
- Test tube x 6
- Colorimeter and suitable filter (red). A methylene blue solution displays maximum absorption at 668 nm.
- Methylene blue solution containing 5×10^{-5} mol dm^{-3} methylene blue (30 cm^3)

Determining cation exchange capacity

- Balance, 2 decimal place
- 100 cm^3 conical flask with bung
- Burette
- Filter funnel and paper
- 50 cm^3 beaker
- 5 cm^3 pipette
- 100 cm^3 volumetric flask
- Colorimeter and suitable filter (red)
- Soil sample (1 g)
- Methylene blue solution, 0.01 mol dm^{-3} (10 cm^3)

Methods

Care: Wear eye protection.

Obtaining a calibration curve

1. Fill two burettes, one with 5×10^{-5} mol dm^{-3} methylene blue solution and one with deionised water.
2. Label 6 test tubes A to F and use the burettes to add the volumes of solutions shown in the table:

Test tube	Volume 5×10^{-5} mol dm^{-3} methylene blue solution (cm^3)	Volume of deionised water (cm^3)	Concentration of methylene blue (mol dm^{-3})
A	10	0	0.5×10^{-5}
B	8	2	4×10^{-5}
C	6	4	3×10^{-5}
D	4	2	2×10^{-5}
E	2	8	1×10^{-5}
F	0	10	0

3. Measure the absorbance of solutions in tubes A to F.
4. Plot a graph of absorbance (*y*-axis) against concentration of methylene blue (mol dm^{-3}) (*x*-axis) for solutions in tubes A to F. This is the calibration curve.

Determining cation exchange capacity

1. Weigh out 1 g (to the nearest 0.01 g) of soil sample and place it in a 100 cm^3 conical flask.
2. Add 10 cm^3 of 0.015 mol dm^{-3} methylene blue solution, stopper the flask with a bung and shake the mixture gently 30 minutes (use a mechanical shaker if available).
3. Use a burette to add 15 cm^3 of deionised water to the flask and mix thoroughly.
4. Filter the mixture into a 50 cm^3 beaker.
5. Pipette 5 cm^3 of filtrate into a 100 cm^3 volumetric flask. Make the volume up to 100 cm^3 with deionised water.
6. Measure the absorbance of this solution.
7. Use the calibration curve to find the concentration of this solution after shaking with the soil and diluting it.

Calculations

1. Calculate the concentration of the methylene blue solution after shaking with the soil and before it was diluted.
2. Calculate the number of moles of methylene blue in the solution added to 1 g of soil.
3. Calculate the number of moles of methylene blue in the solution after shaking with the soil.
4. Calculate the number of moles of methylene blue removed by adsorption on 1 g soil.
5. Calculate the methylene blue cation exchange capacity, CEC, as mmol of methylene blue per 100 g of soil. (1 mmol = 0.001 mole)