An experiment to purify contaminated water using ion exchange

Introduction

The aim of the experiment is to prove that there are positively charged copper ions (cations) contaminating a solution, which will be passed through a column of ion resin beads, with the product being pure water (or at least a less contaminated sample). Ion resin is made up of tiny beads, about 0.3-1.2mm in diameter. It's an insoluble substance, with a highly developed structure of pores – which can either trap of release ions. This is known as ion exchange, a process of exchanging ions from two substances, an insoluble solid and a solution. An example of this process is softening hard water and water purification. When a solid is comes into contact with a solution containing ions, equilibrium is formed – meaning that the reaction can go either way, it's a reversible reaction. Ion exchange occurs when the reaction of two compounds (or elements) exchange their ions to form a new structure in a solution. An ion is a charged atom/molecule, which has either lost or gained an electron, therefore giving it a positive or negative charge. (http://en.wikipedia.org/wiki/Ion)

Hypothesis

It is expected, that it will be possible to purify contaminated water using ion exchange

Safety assessment

Goggles	Prevents from any splashes getting in the eyes.
Lab coats	Prevents staining of clothes.
Stools and bags	Should be put away, preventing trips and falls.
Pipettes	Must be handled carefully, as the tip is fragile and can break
Liquids	Care must be taken when measuring and the correct procedures must be carried out when cleaning up any spillages. Sodium Hydroxide is an irritant, so hand washing is important. Copper Sulphate and Lead Nitrate is harmful, and Nitric Acid is corrosive.
Glassware	Handle carefully. Follow procedures for cleaning any breakages.

Method

1. 4 test tubes were labelled 1-4 in a test tube rack, identifying which had what solution in it.
2. 40cm³ of the Copper Sulphate and Lead Nitrate solution was poured into a 100cm³ beaker, and from this 2cm³ was measured and put into two test tubes.
3. In the first test tube, 4 drops of the 2M Sodium Hydroxide was added, and the second test tube had 4 drops of the 1M Potassium Iodide.
4. The ion exchange tube was packed with the resin, using the flat end of a glass rod, ensuring that a 2cm gap was left at the top. This was then attached to a boss and clamp stand, with a 150cm³ beaker placed under the ion exchange tube.
5. Next, the resin was washed with 20cm³ of Nitric acid, which was the measured into a 50cm³ beaker and was then slowly poured into the ion exchange tube.
6. 30cm³ of distilled water was then passed through the tube, washing the resin.

7. Then, 5cm³ of the left over Copper Sulphate and Lead Nitrate solution was poured into the ion exchange tube, removing any of the distilled water that may still be on the resin.
8. Another boss and clamp stand was taken, and a clean test tube was placed under the ion exchange tube, so that its tip was resting on the top of the clean tube.
9. The remaining Copper Sulphate and Lead Nitrate solution was slowly poured through the resin, the filtered solution product being caught in the clean test tube.
10. The other two remaining test tube (labelled 3 and 4), had 2cm³ of the filtered solution poured into them, with 4 drops of Sodium Hydroxide in one of the tubes and Potassium iodide in the other.

Set up of the experiment

Results

	Start of experiment	End of experiment (15 minutes later)
Test tube 1: 3 – 4 drops of Sodium hydroxide and 2cm³ lead nitrate and copper sulphate solution	Clear solution	A blue precipitate had formed in the test tube. The test tube had turned a dark concentrated blue, with a chalky substance at the bottom of the tube.
Test tube 2: 3 – 4 drops of Potassium iodine and 2cm³ lead nitrate and copper sulphate solution	Clear solution	A yellow precipitate had formed in the test tube. The test tube had turned a creamy yellow colour.

The second experiment had two test tubes which contained the solution that had passed through the resin. The test tube that had the sodium hydroxide in it, turned into a transparent/clear solution. The test tube that had the potassium iodide in it, the solution turned a transparent/clear solution.

Interpretation

Going back to the hypothesis stated at the beginning it is now proven that it is possible to purify contaminated water using ion exchange. The reasons, to suspect that the water was contaminated, were that it was coloured. At the first test at the start involving the sodium hydroxide, the observations recorded were that it was gelatinous – with a blue precipitate. The gelatinous product in the test tube shows that copper is present. The white product is lead sulphate. The following equation shows that they had 'swapped partners': sodium + copper → sodium + sulphate. From the results of the experiment, it was apparent that the when the Sodium Hydroxide was added to the Lead Nitrate and Copper Sulphate solution, it wasn't able to dissolve, this gave an end result in the first test tube having a concentrated and chalky result. This is because hydroxides are insoluble in water, meaning it is unable to dissolve in water. (http://www.chemguide.co.uk/inorganic/group2/solubility.html). The second experiment involved the solution being run through the ion resin beads. The ion resin beads were used to remove the hard metals, and instead it purifies and softens the solution. The hard metals in the experiment were lead and copper. When they were passed through the resin, the nitrate and sulphate passed through and released the hydrogen ions.

Reference:

http://genchem.chem.wisc.edu/lab/CCA/STHTM/NAOH/NAOHCUS2.HTM
http://www.chemguide.co.uk/inorganic/group2/solubility.html
http://www.wikipidea.co.uk