For Teachers

Phosphorus Recovery from Wastewaters

Module 1

Objective: Extraction of struvite

Introduction

Urine, a product of human excretion, is a component of urban wastewaters. Urine is one of the richest and most accessible sources of **phosphorus** and **nitrogen** to make struvite. The mineral could be obtained by a precipitation reaction at basic pH, helped by magnesium dependence (see reaction below).

Reaction of precipitation of the struvite:

$$Mg^{2+} + NH_4^+ + H_2PO_4^- \rightarrow MgNH_4PO_4 \cdot 6H_2O \downarrow + 2H^+$$

Laboratory practice will help pupils to develop skills for the correct and safe use of scientific equipment, make observations, take measurements and perform well-defined scientific procedures. It will also promote the student's ability to cooperate effectively with others in performing complex tasks, to participate in project work, to take on different roles at different times and to contribute and respond to ideas.

Necessities

List of materials/tools

- Beaker 500 mL
- Spatulas
- Funnel
- Erlenmeyer flask 500 mL
- Precision balance (accuracy: 0.01g)
- Magnetic stirrer
- Magnetic anchor
- Universal pH indictor/ pH meter
- Filter paper
- Protective glasses and gloves

Phosphorus Recovery from Wastewaters

Reagents	Formula		Quantity (g) or Concentration (M)
Sodium hydroxide	NaOH		0.5 M
Urea	CH_4N_2O		10 g
Sodium bicarbonate	$NaHCO_3$		1.05 g
Sodium sulphate decahydrate	$Na_2SO_4.10H_2O$		1.60 g
Ammonium chloride	NH_4Cl		0.65 g
Sodium chloride	NaCl		2.60 g
Potassium dihydrogen phosphate	KH_2PO_4		0.48 g
Potassium hydrogen phosphate	K_2HPO_4		0.60 g
Calcium dihydrate chloride	$CaCl_2.2H_2O$		0.19 g
Distilled or demineralized water			
Magnesium sulphate	$MgSO_4$		0.25 g/L

Procedure

I. Preparation of synthetic urine

1. 10 g of urea are transferred into a 500 mL beaker and 100 mL of distilled or demineralized water is added;
2. Place the beaker on the magnetic stirrer, setting between 100 and 300 rpm of velocity;
3. Add the reagents on indicated order and values, stirring;
4. Add almost 400 mL of water and wait until a complete solubilisation;

*The indicated quantities are those necessary to prepare nearly 500 mL of wastewater synthetic

II. Preparation of struvite

5. Weigh the magnesium sulphate and add it to the solution;
6. Control the pH with a pH meter or an universal pH indicator; eventually add 1/2 drops of NaOH 0.5 M till pH = 8 and continue stirring;

   The range of pH needed to obtain an optimal precipitation is pH = 8.0 - 8.5.

   Leave the solution in agitation at least one or two hours to foster the precipitation of the struvite.

The precipitation starts after nearly 3 hours;

7. Filter the solution with the filter paper in order to restore the precipitate and leave it then dry at room-temperature;
8. Pick up the struvite in a clean and dry container (Figure 1).

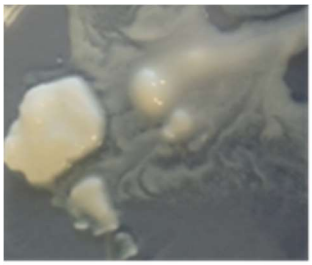

Figure1. Struvite obtained after the precipitation reaction at alkaline pH and in presence of Mg^{2+}

Additional Safety Notes

Be careful when using NaOH.

Conclusions

- Check the pH before and after the addition of NaOH. The optimal pH is in the range 8-8.5.
- Check the visual appearance of the precipitate before filtering because it should appear as an amorphous white solid (see Figure 1).
- Check the precipitate appearance after drying. It has to be a homogeneous white powder.

Video Tutorial

A video tutorial of this experiment can be found at the following YouTube link:
https://youtu.be/9fOs9uVqx0o

Questions

1. **Which aspect does the precipitate take after the drying?**
   a. The struvite appears as a white solid.

2. **Why do you think it was used the magnetic stirrer?**
   a. The stirrer is used to better solubilise the reagents and maintain the blending for a rather long time, helping the coming.

3. **Which function does NaOH have?**
   a. Sodium hydroxide is used to regulate the solution pH in order to obtain the ideal precipitate pH.