Experiment 4

Synthesis of Ferrate(VI) Ions

Student Handout

Purposes

1. To prepare ferrate(VI) ions.
2. To study the environmental applications of ferrate(VI) ions.

Background

Ferrate(VI) (FeO_4^{2-}) consists of iron in the +6 oxidation state. It is an environmental-friendly but powerful oxidising and disinfecting agent. It can oxidise harmful organic and inorganic species such as phenol, hydrazine, cyanide, ammonia, as well as bacteria and viruses. The standard potentials of the Fe(VI)/Fe(III) couple in acidic and basic media are shown below:

$$FeO_4^{2-}(aq) + 8\ H^+(aq) + 3e^- \rightleftharpoons Fe^{3+}(aq) + 4\ H_2O(l) \qquad E^\ominus = +2.20V$$
$$FeO_4^{2-}(aq) + 4\ H_2O(l) + 3e^- \rightleftharpoons Fe(OH)_3(s) + 5\ OH^-(aq) \qquad E^\ominus = +0.72V$$

In this experiment, you will prepare FeO_4^{2-} ions with OCl^- ions and perform simple tests to study their environmental applications.

Safety

Handle all chemicals with great care. Avoid direct contact of chemicals with skin. Dispose of chemical waste, broken glassware and excess materials according to your teacher's instruction. Safety information on the chemicals used in the investigation can be found in the Material Safety Data Sheet (MSDS). Consult your teacher for details.

EYE PROTECTION
MUST BE WORN

Pay special attention when handling concentrated base and oxidising agents.

Materials and Apparatus Available

NaOH powder 

2 M H_2SO_4 solution 

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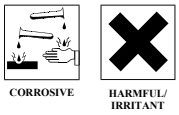
0.3 M $FeCl_3$ solution 

Ethanol 

Bleaching water
Test tubes
100-cm^3 Beakers

Droppers
Cotton wool

Experimental Procedure

Photos of the experiment are available at http://www.chem.cuhk.edu.hk/ssc.htm.

Part A: Preparation of FeO_4^{2-}

1. Add 10 cm^3 of bleaching water in a 100-cm^3 beaker.
2. Grind NaOH pellets into powder and add 3 g of it to the beaker with stirring.
3. When most of the NaOH powder dissolves and the mixture remains hot, add 5 drops of 0.3 M $FeCl_3$ solution with stirring for a few seconds.
4. Add 2 g of NaOH powder into the reaction mixture.
5. Allow the reaction mixture to cool down.
6. Place a small amount of cotton wool into a dropper. Filter the reaction mixture through the dropper with cotton wool. Salt of FeO_4^{2-} synthesised shows purple colour in the filtrate.

Part B: Oxidation of organic and inorganic pollutants

Test 1: Add ~2 cm^3 of absolute or normal ethanol to a test tube containing 2 cm^3 of the filtrate collected in Part A. Record your observations.

Test 2: Add a few drops of the filtrate collected in Part A to a test tube containing 2 cm^3 of 2 M H_2SO_4 solution. Record your observations.

Questions for Further Thought

1. Write out the chemical reaction to explain why FeO_4^{2-} is unstable in acidic solution.
2. Write out the chemical equations for the reactions taking place in the following steps.
   (a) Addition of ethanol to FeO_4^{2-} solution.
   (b) Addition of FeO_4^{2-} solution to 2 M H_2SO_4 solution.

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Reference

J. G. Ibanez, M. Tellez-Giron, D. Alvarez and E. Garcia-Pintor, *J. Chem. Educ.*, 2004, **81**, 251.