

Chemical Properties of Phenol

In this lab we are going to look at some of the properties of phenol and compare them to those of ethanol. It will be interesting to see how the benzene ring influences the behaviour of the – OH group, and vice versa. The reactions you will investigate are with the following reagents: water, NaOH, NaHCO₃, Na, Br_{2(aq)}, conc. HNO₃, neutral FeCl_{3(aq)}, HNO₃, H₂SO₄

Purpose

To observe the effect of the benzene ring on the behaviour of the hydroxyl group, and vice versa.

Materials & Apparatus

test tubes, test tube rack, forceps, universal indicator solution, moist blue litmus paper, hot-water bath, 2 M NaOH_(aq), conc. HCl, NaHCO_{3 (s)}, Br_{2(aq)}, Na metal, , conc. H₂SO₄, FeCl_{3(aq)}, Na₂CO_{3(aq)}, HNO₃

Safety

Both bromine and phenol attack the skin and give off irritating vapours. Sodium is dangerously reactive with water. Sodium hydroxide solution is very corrosive, even when dilute it can damage your eyes. Glacial acetic acid emits a strong odour, has dangerous fumes and burns the skin. Conc. HNO₃ is very corrosive and reacts violently with water. KMnO_{4(aq)} stains the skin. Na₂Cr₂O_{7(aq)} is a powerful oxidant and can damage the skin.

Procedure

1. Solubility in water

- Pour ~ 5 cm³ of water into a tt and add ~ 1.5 g of phenol. Cork and shake the tt. Record whether phenol dissolves in water.
- Add a further 2 - 4 g of phenol, shake and note your observations.
- Place the tt in a beaker of hot water for a few minutes, shake the tt and note your observations.
- Allow the solution in the tt to cool and note your observations.
- Add a few drops of universal indicator solution to the phenol-water mixture in one tt and distilled water in another.

2. Reaction with sodium hydroxide

- Pour 5 cm³ of 2 M NaOH_(aq) into a tt and add ½ a spatula-measure of phenol. Cork and shake the tt.
- Add ~ one more spatula of phenol, cork and shake. Compare the solubility of phenol in water from reaction 1 above. Note your observations.
- Drop by drop, add 2 cm³ of con. HCl. Shake the tt and note your observations.

3. Reaction with NaHCO₃

- Into a tt pour 1 cm³ of water and add 2-3 small crystals of phenol. Cork and shake until the phenol has dissolved.
- Add about 0.5 g of solid NaHCO₃ and note your observations.

4. Reaction with Sodium

- In the fume cupboard, heat ~ 100 cm³ of water in a beaker to about 60 °C.
- Put a small spatula measure of phenol in a dry tt, and stand it in the hot water until the phenol melts.
- Using forceps, pick up a 1 mm cube of sodium and remove the excess oil from its surface on a piece of filter paper. Use a tt holder to remove the tt from the hot water bath and, drop the sodium into the molten phenol. Test the gas with a lighted splint.

5. Reaction with Bromine Water

- Into a tt pour 5 cm³ of water and add ½ a spatula- measure of phenol.
- Cork and shake until the phenol has dissolved.
- Pour half the solution into another tt for Reaction 6 below.
- Add ~ 6 drops of Br_{2(aq)} to the aqueous phenol, shaking the tt after the addition of each drop. Note your observations.

6. Reaction with neutral FeCl_{3(aq)}

- Into a tt, pour ~ 1 cm³ FeCl_{3(aq)}. Add Na₂CO_{3(aq)}, drop-by-drop, until a **trace** of the brown precipitate **just** remains after shaking.
- Add a few drops of this 'neutral' FeCl_{3(aq)} to the solution prepared in Reaction 5 above. Note your observations.
- Add a few drops of 'neutral' FeCl_{3(aq)} to 2 cm³ of ethanol. Note the difference between ethanol and phenol in this test.

7. Reaction with HNO₃

To ½ measure- spatula of phenol add 6M HNO₃, note the appearance of dense yeollow oil. Repeat with conc. HNO₃

8. Reaction with H₂SO₄

To ½ measure- spatula of phenol add conc. H₂SO₄, note your observations.

Discussion Questions

- What does the smell of phenol remind you of?
- How does the solubility and pH of phenol compare with ethanol? Explain the difference.
- In the reaction with sodium, what bond has been broken C – O or O – H? How does this compare with ethanol?
- Which tests distinguish between ethanol and phenol?
- Explain why phenol is more soluble in NaOH than in water.
- Which tests indicate that phenol is a stronger acid than ethanol?
- Which tests indicate that phenol is a weaker acid than dilute mineral acids such as HCl, H₂SO₄ and HNO₃?
- How do you account for the fact that phenol decolorises bromine water and forms a white precipitate whereas ethanol does not?
- a) Does the presence of the OH group activate or deactivate the ring w.r.t electrophilic substitution.
b) Into which ring positions does the OH group direct the electrophiles which attack phenol?
- Give three tests to distinguish between an alcohol and a phenol. For each test, state clearly how the test distinguishes the phenol from the alcohol by stating how each of them reacts when subjected to the test.
- Write the systematic name and structural formula of the compound commonly known as TCP.
- Two substances, A and B, have the same molecular formula, C₇H₈O, and both structures contain a benzene ring. Both compounds effervesce with sodium metal. Refluxing A with acidified K₂Cr₂O_{7(aq)}, results in a complex mixture but B yields C, C₇H₆O₂. Iron (III) chloride gives a violet colour with A only. When treated with ethanoic acid in the presence of H₂SO₄, only B produces a pleasant - smelling compound, D. Suggest possible structures for the compounds A to D and elucidate reactions where possible.