

Hydroxy compounds

A-Level Chemistry

Alcohols with acyl chlorides

At A Level you meet one more reaction of an **alcohol** 醇: it reacts with an **acyl chloride** 酰氯 to make an **ester** 酯. This works faster and more completely than using a carboxylic acid. For example, ethanol and ethanoyl chloride give ethyl ethanoate, plus fumes of HCl.



An acyl chloride reacts with an alcohol faster and more completely than a carboxylic acid does, giving the ester and HCl fumes

Phenol

Phenol 苯酚 has an –OH group joined directly to a **benzene** 苯 ring. This changes the chemistry of both the –OH group and the ring.



Phenol is a low-melting solid; it slowly turns pink as it oxidises in air

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Making phenol

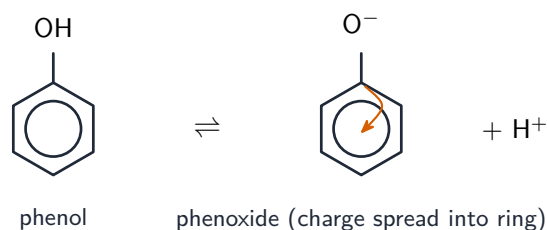
Cool **phenylamine** 苯胺 with NaNO_2 and dilute acid below 10°C to make a **diazonium salt** 重氮盐. Warming this salt with water then gives phenol (and nitrogen gas).

Reactions of phenol

- with a base such as NaOH(aq): phenol reacts to give sodium phenoxide and water. (Ordinary alcohols do **not** react with NaOH —this shows phenol is more acidic.)
- with sodium metal: gives sodium phenoxide and hydrogen.
- with a diazonium salt in NaOH(aq): forms a coloured **azo compound** 偶氮化合物 (used in dyes).
- **nitration** 硝化 with **dilute** HNO₃ at room temperature: gives a mixture of 2-nitrophenol and 4-nitrophenol.
- **bromination** 溴化 with bromine water at room temperature (no catalyst): gives a white precipitate of 2,4,6-tribromophenol.

Acidity of phenol

Phenol loses its H⁺ to form a phenoxide ion. This ion is stabilised because its negative charge is spread (delocalised) into the ring. So phenol's **acidity** 酸性 is higher than that of water or ethanol:



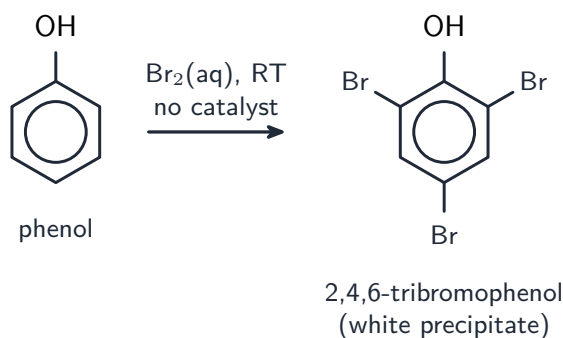
acidity: ethanol < water < phenol

Phenol is more acidic than water or an alcohol: losing H⁺ gives a phenoxide ion whose negative charge spreads into the ring, stabilising it

(Phenol is still a weak acid —weaker than a carboxylic acid.)

Why the conditions are milder than for benzene

A lone pair on the phenol oxygen is partly **delocalised** 离域 into the ring. This makes the ring more electron-rich, so it attracts electrophiles more strongly. Phenol therefore reacts faster and under much milder conditions than benzene —no catalyst is needed, and dilute reagents work at room temperature.



the ring is activated, so milder conditions than benzene

Phenol's ring is activated, so bromine water brominates positions 2, 4 and 6 at room temperature with no catalyst, giving a white precipitate

The –OH group directs new substituents to the 2-, 4- and 6-positions. The same ideas apply to other phenolic compounds, such as naphthol.



Carbolic soap contains phenol, which was one of the first antiseptics

Image: SamBlob, CC BY-SA 3.0 (commons.wikimedia.org)

Worked example. Phenol, ethanol and ethanoic acid are each shaken with aqueous NaOH and then with aqueous Na₂CO₃. Predict what happens, and order the three by acidity. Acidity depends on how well the **anion left behind** is stabilised. Ethanol's ethoxide keeps its charge stuck on one oxygen, so ethanol is weakest and reacts with **neither**. Phenol's phenoxide spreads the charge **into the ring**, making phenol acidic enough to react with the strong base NaOH but **not** with the weaker Na₂CO₃ - so no fizzing. Ethanoate spreads the charge over **two oxygens**, the most effective of the three, so ethanoic acid reacts with **both** and **fizzes** with the carbonate. Order: **ethanol < phenol < ethanoic acid**. The carbonate is the discriminating test - only a carboxylic acid fizzes, which is exactly how you tell phenol from an acid.

Exam tips

- **Phenol** is a stronger acid than alcohols (its anion is stabilised by delocalisation) but weaker than carboxylic acids —it does **not** react with carbonates.
- Phenol decolourises **bromine water** and gives a white precipitate **without a catalyst** (the ring is activated by oxygen).
- **Acyl chlorides** react with alcohols/phenols to give esters readily (better than the reversible acid route); misty HCl fumes are the observation.