

Phenol

A-Level Chemistry ■ Topic 32

A-Level Chemistry



What we will cover

- 1 Alcohols with acyl chlorides
- 2 Phenol & its reactions
- 3 Acidity of phenol
- 4 Milder conditions



phenol oxidises pink in air

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Esters and phenol

Alcohols with acyl chlorides



An alcohol reacts with an **acyl chloride** 酰氯 to make an **ester** 酯 – **faster & more completely** than with a carboxylic acid. Ethanol + ethanoyl chloride → ethyl ethanoate + HCl.

Phenol and its reactions



Phenol 苯酚 has —OH joined to a benzene ring:

- $+ \text{NaOH} \rightarrow$ sodium phenoxide (alcohols don't react!)
- $+ \text{Na} \rightarrow \text{H}_2$
- nitration (dilute) & **bromination** 溴化 at room temp
- $+ \text{diazonium} \rightarrow$ a coloured **azo dye** 偶氮化合物

The reactions of phenol

with sodium

fizzes, giving sodium phenoxide and hydrogen – phenol is **acidic enough** for this

with NaOH(aq)

forms sodium phenoxide; but **not** with carbonate, since phenol is weaker than carbonic acid

with bromine water

decolourises it **immediately** and without a catalyst, giving 2,4,6-tribromophenol as a white precipitate

why so easy

a lone pair on the oxygen delocalises into the ring, **activating** it

with a diazonium salt

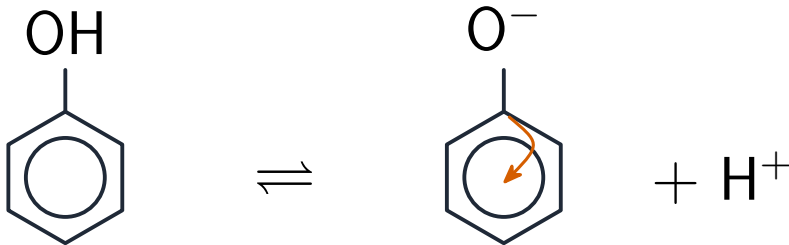
in NaOH(aq), forms a coloured **azo compound** 偶氮化合物 – the basis of many dyes

That last reaction is the whole azo-dye industry. The colour comes from the extended delocalisation across the —N=N— bridge.

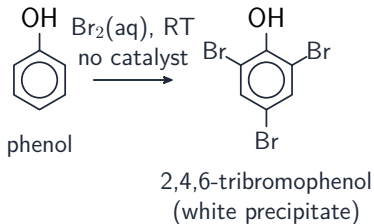
Acidity of phenol

Phenol loses H^+ to a **phenoxide** 苯氧根 ion, stabilised by spreading the charge into the ring.

So acidity is: ethanol < water < phenol (but phenol is still weaker than a carboxylic acid).



Milder conditions than benzene



the ring is activated, so milder conditions than benzene

The O lone pair is **delocalised** 离域 into the ring, making it more electron-rich and **activated**.

So bromine water brominates phenol at the 2,4,6-positions at **room temperature, no catalyst** – a white precipitate.

Where phenol's substituents go

the direction

the —OH group directs new substituents to the 2-, 4- and 6-positions

why

the oxygen's lone pair delocalises into the ring, raising electron density most at those positions

the consequence

phenol reacts **faster and under milder conditions** than benzene – bromine water needs no catalyst

the product

2,4,6-tribromophenol, a white precipitate, formed immediately

the same ideas

apply to other **phenols** and to **phenylamine** 苯胺, where the —NH_2 group activates in the same way

Activation and direction are one effect: the group that pushes electron density in also decides *where* it is highest, and therefore where the attack happens.

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.

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Recap

Worked example – which is the stronger acid?

Explain why phenol is a stronger acid than ethanol but weaker than ethanoic acid.

- All three lose H^+ from an O–H. **Stabler anion $\Rightarrow$ stronger acid.**
- Ethoxide: charge **stuck on one O** $\Rightarrow$ unstable $\Rightarrow$ very weak acid.
- Phenoxide: charge **delocalised into the ring** $\Rightarrow$ stabler $\Rightarrow$ reacts with NaOH , not Na_2CO_3 .
- Ethanoate: charge spread over **two O** $\Rightarrow$ most stable $\Rightarrow$ **fizzes with Na_2CO_3 .**

Acid strength = **anion stability**. The carbonate test separates them: only the carboxylic acid gives CO_2 .

Topic 32 – key takeaways

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Acyl chloride

+ alcohol $\rightarrow$ ester, fast & complete

2

Phenol

reacts with NaOH (more acidic than alcohol)

3

Acidity

ethanol $<$ water $<$ phenol

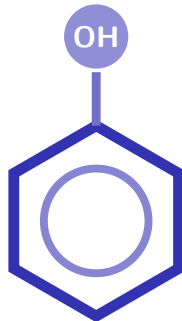
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Activated ring

brominates at room temp, no catalyst

Check yourself

- 1 What does an acyl chloride make with an alcohol?
- 2 Why is phenol more acidic than ethanol?
- 3 Does phenol react with NaOH?
- 4 What conditions brominate phenol?



Answers 1. an ester 2. the phenoxide charge spreads into the ring 3. yes
4. bromine water, room temperature, no catalyst