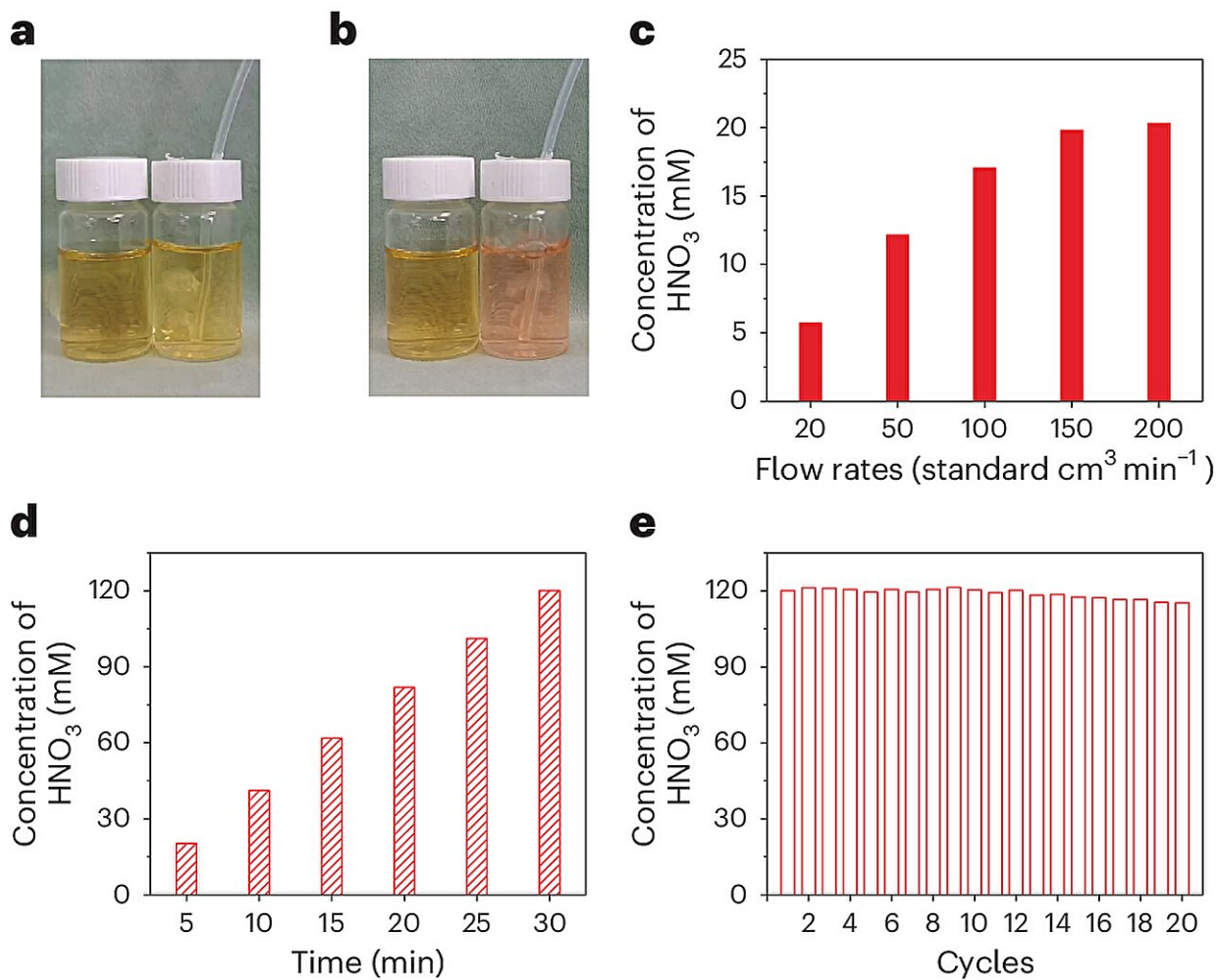


# Research team makes hydroxylamine from air and water

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**a,b**, Photographs of the pristine absorbent (**a**) and the absorbent after absorbing

the gaseous substances produced by the plasma discharge device for 30 s (**b**). The vials on the left and right sides were used as control and experiment groups, respectively. **c**, The concentration of  $\text{HNO}_3$  in 30 ml of absorbent under various flow rates of ambient air for a 5 min discharge. **d**, The accumulated concentration of  $\text{HNO}_3$  in 30 ml of absorbent under the flow rate of 200 standard  $\text{cm}^3 \text{min}^{-1}$  for various discharge times. **e**, Cyclic stability for the preparation of  $\text{HNO}_3$  in 30 ml of absorbent under the flow rate of 200 standard  $\text{cm}^3 \text{min}^{-1}$  at each cycle for a 30 min continuous discharge. Credit: *Nature Sustainability* (2024). DOI: 10.1038/s41893-024-01330-w

A research team led by Prof. Zeng Jie and Prof Geng Zhigang from University of Science and Technology of China (USTC) has proposed a new model for sustainable hydroxylamine ( $\text{NH}_2\text{OH}$ ) synthesis via a plasma-electrochemical cascade pathway (PECP). They achieved the green and sustainable synthesis of  $\text{NH}_2\text{OH}$  from ambient air and water at mild conditions. Their study is [published](#) in *Nature Sustainability*.

$\text{NH}_2\text{OH}$ , as an important chemical intermediate, is widely used in the fine chemical fields of medicine, pesticides, textiles, and more. The traditional production methods of  $\text{NH}_2\text{OH}$  mainly include the Raschig process, a nitric oxide reduction method, and a nitric acid reduction method. However, the Raschig process causes a large amount of nitrogen loss and [environmental pollution](#); while the other two methods give out great carbon emissions. It is therefore urgent to develop a new green, low-carbon and sustainable synthesis process for  $\text{NH}_2\text{OH}$ .

The electrosynthesis process driven by green electricity and using water as a proton source is expected to overcome the drawbacks of traditional  $\text{NH}_2\text{OH}$  [production processes](#). However, due to the thermodynamic stability of nitrogen molecules, it is difficult to achieve efficient

activation of nitrogen molecules in the direct electrocatalytic process of nitrogen.

The researchers have achieved the green and sustainable synthesis of  $\text{NH}_2\text{OH}$  using only air and water as [raw materials](#) by developing a new process that couples plasma nitrogen fixation to nitric acid production with the electrocatalytic reduction of nitric acid to  $\text{NH}_2\text{OH}$ . In addition, the team has designed a plasma discharge device with multiple parallel tips so as to enlarge the overlapping zone for the efficient activation of [nitrogen](#) gas.

First, the researchers introduced air into the plasma parallel arc discharge device and used a water solution containing methyl orange as the exhaust gas absorbent to convert the solution from neutral to acidic. By optimizing the air flow rate, they obtained a nitric acid solution with a maximum concentration of 20.3 millimoles per liter. With each reaction cycle lasting 30 minutes, the plasma discharge device maintained excellent stability over 20 cycles. The obtained nitric acid solution could be directly used for the electrocatalytic synthesis of  $\text{NH}_2\text{OH}$  after dilution and addition of electrolytes.

In addition, the team also prepared a bismuth metal thin film catalyst via magnetron sputtering and applied it to the electrocatalytic reduction of nitric acid to produce  $\text{NH}_2\text{OH}$ .

The accumulation of  $\text{NH}_2\text{OH}$  in the electrolyte during long-term electrolysis of a 100 mmol/L nitric [acid](#) solution by a bismuth thin film catalyst was investigated. After continuous electrolysis for 5 h, the highest concentration of  $\text{NH}_2\text{OH}$  reached 77.7 mmol/L. Finally, 1.887 g high-purity  $\text{NH}_2\text{OH}$  sulfate product was prepared.

This study proposes a viable way to efficiently synthesize hydroxylamine from simpler feedstock at milder conditions, which contributes to the

sustainability transformation of the chemical industry.

**More information:** Xiangdong Kong et al, Synthesis of hydroxylamine from air and water via a plasma-electrochemical cascade pathway, *Nature Sustainability* (2024). [DOI: 10.1038/s41893-024-01330-w](https://doi.org/10.1038/s41893-024-01330-w)

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