From Nitrate Pollution to Ammonium: A Solar Photocatalyst for Water Remediation

THE INVENTION

We propose a solar-driven photocatalytic technology for the selective conversion of nitrate contaminants in water into valuable ammonium that is able to operate under mild conditions, offering a promising route for both water remediation and sustainable ammonia production.

Innovative aspects and advantages

- **A dual-purpose tool to valorize wastewater:** simultaneously treats nitrate-rich water and generates ammonia, obtaining a valuable fertilizer from the treatment process.
- **High efficiency**: over 97% nitrate degradation with up to 80% ammonium selectivity.
- **Simple, low-cost preparation and operation:** obtained by mechanically mixing commercially available TiO_2 with CuO at ambient temperature and pressure, and using solar or UV irradiation, and operated at under mild conditions.
- **Sustainable**: enhances overall sustainability by utilizing glycerol, a common waste byproduct of biodiesel production, as a sacrificial electron donor.

IP Rights

European priority patent application EP26382377.5 with priority date March 18th 2026

Summary

The widespread contamination of water by nitrates, driven by agricultural runoff, presents a severe environmental and public health challenge – as nitrate levels cause aquatic eutrophication and pose significant human health risks.

Conventional catalytic methods for reducing waterborne nitrates present significant limitations: they frequently struggle with poor selectivity, require harsh conditions or rely on expensive materials, making large-scale implementation economically unviable.

Additionally, conventional nitrate-removal technologies may eliminate nitrate without enabling recovery of nitrogen as a valuable product.

This photocatalytic solution uses solar energy to reduce nitrate contamination in water while converting it into ammonium, a valuable fertilizer.

The system employs a simple physical mixture of commercially available TiO_2 and CuO, avoiding complex synthesis steps or expensive noble metals. Operating under anoxic conditions at ambient temperatures, the process relies on glycerol as sacrificial electron donor. When exposed to solar radiation, the catalyst drives a consecutive reaction pathway that selectively reduces nitrate to ammonium through a nitrite intermediate.

The process is highly sustainable, leveraging renewable solar irradiation and glycerol, a common biodiesel byproduct.

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Current state of development

- **TRL 5:** the technology has been successfully validated at pilot plant scale under solar radiation, including tests in real well-water matrices with controlled nitrate concentrations.
- The process was tested in a CPC solar photoreactor at 25 L scale under anoxic conditions and real solar irradiation, demonstrating operation in a relevant environment.
- Under solar irradiation, it achieved >97% nitrate removal from an initial concentration of 40 mg/L, with up to ~79% selectivity toward NH_4^+ after 300 minutes.

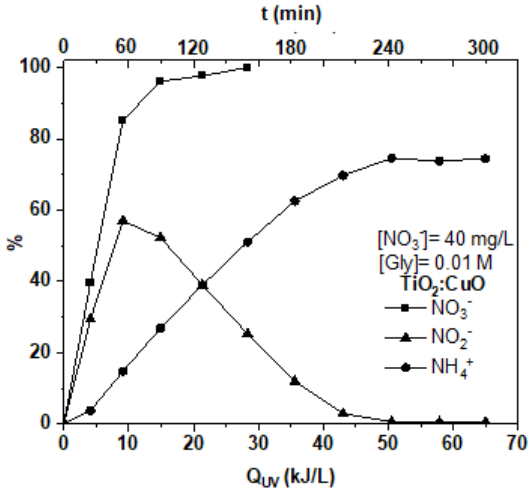

Fig. 1. Photocatalytic nitrate conversion rate (%) and yields (%) towards ammonium and nitrite production, tested at pilot plant scale.

Next steps

- Optimize operating conditions for real well-water matrices.
- Demonstrate continuous operation, catalyst reuse and long-term stability.

Scientific Team

- Led by **Dr. Gonzalo Guirado Lopez** (Universitat Autònoma de Barcelona, UAB – Electrochemistry and Green Chemistry Group) and **Dr. Sixto Malato** (CIEMAT /Plataforma Solar de Almeria– Solar Water Treatment Unit).

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