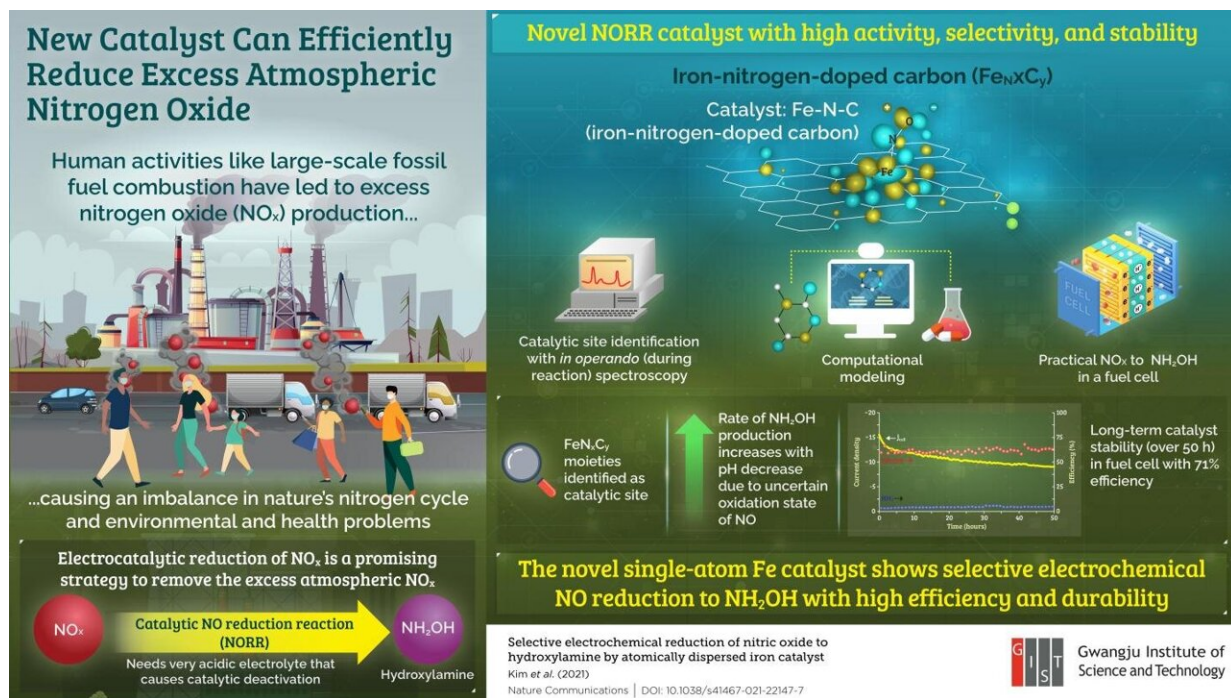


Clearing the air: A reduction-based solution to nitrogen pollution with a novel catalyst

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A new iron catalyst helps preferentially reduce nitric oxide to hydroxylamine, opening doors to pollution control and clean energy. Credit: Gwangju Institute of Science and Technology (GIST)

Our reliance on fossil fuels as a primary energy source has pushed air pollution to an all-time high, resulting in several environmental and health concerns. Among the major pollutants, nitrogen oxide (NO_x) accumulation can cause severe respiratory diseases and imbalance in the

Earth's nitrogen cycle. Reducing NO_x accumulation is, therefore, an issue of utmost importance.

Recently, the conversion of NO_x into harmless or even useful nitrogen products has emerged as a promising strategy. Particularly appealing to scientists is the reduction of NO_x to hydroxylamine (NH_2OH), which can be utilized as a renewable source of energy.

The 'make-or-break' step that determines the formation of hydroxylamine is the catalytic electrochemical reduction of nitric oxide (NO), which can either yield hydroxylamine or nitrous oxide (N_2O), depending on the electrolyte pH and electrode potential. Studies show that for hydroxylamine formation to dominate over N_2O formation, very acidic electrolytes with a pH less than 0 are required. However, such a harshly acidic environment rapidly degrades the [catalyst](#), limiting the reaction. "The development of a new catalyst with [high activity](#), selectivity, and stability is the next challenge," says Prof. Chang Hyuck Choi from the Gwangju Institute of Science and Technology (GIST) in Korea where he works on the catalysis of electrochemical reactions.

In a recent study published in *Nature Communications*, Prof. Choi and his colleagues from Korea and France investigated NO reduction in the presence of a new iron-nitrogen-doped carbon (Fe-N-C) catalyst made of isolated FeN_xC_y moieties bonded to a carbonaceous substrate. The catalyst was chosen for its high selectivity for the NH_2OH pathway as well as its resistance to extremely acidic conditions.

The team performed in operando (i.e., during the reaction) spectroscopy and electrochemical analysis of the catalyst to determine its catalytic site and the pH dependence of NH_2OH production.

They identified the active site of the catalyst as the ferrous moieties bonded to the carbon substrate where the rate of NH_2OH formation

showed a peculiar increase with decreasing pH. The team attributed this peculiarity to an uncertain oxidation state of NO. Finally, they achieved efficient (71%) NH_2OH production in a prototypical NO- H_2 fuel cell, establishing the catalyst's practical utility. Moreover, they found that the catalyst exhibited long-term stability, showing no signs of deactivation even after operating for over 50 hours!

The approach not only reduces harmful air pollutants, but also provides a useful byproduct that may find use in ushering in a renewable energy society. "Apart from the applications of hydroxylamine in the nylon industry, it can also be used as an alternative hydrogen carrier. Thus, the new catalyst will not only help reduce the amount of NO_x pollutants in our atmosphere but also lead us to a renewable energy future," Prof. Choi explains.

We can breathe easy knowing that the team's findings take us a few steps closer to a pollution-free renewable energy society.

More information: Dong Hyun Kim et al, Selective electrochemical reduction of nitric oxide to hydroxylamine by atomically dispersed iron catalyst, *Nature Communications* (2021). [DOI: 10.1038/s41467-021-22147-7](https://doi.org/10.1038/s41467-021-22147-7)

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