Potassium ions improve the efficiency of converting nitrogen to ammonia

An international team of researchers which included a senior researcher of Siberian Federal University found that gold nanoparticles grown on an organic matrix containing potassium ions show a significantly greater efficiency of electrochemical conversion of nitrogen into ammonia. Their work has been published in the Journal of Materials Chemistry A in the HOT Papers section.

Ammonia is one of the most widely produced inorganic chemicals. The greater part of the modern industry and agriculture is based on the use of ammonia which is an important raw material for the production of plastics, fibers, dyes, explosives, resins, pharmaceuticals and fertilizers, with the share of fertilizers of 80 % and more.

On an industrial scale, ammonia is synthesized by the most common Haber-Bosch process: a mixture of nitrogen and hydrogen is passed through a heated catalyst (400–600 °C) under high pressure (150–350 atm.) However, such a process is energy-intensive and eats up to 2 % of the world's annual energy consumption. Therefore, large-scale production of ammonia is accompanied by high production costs. Hydrogen for this process is produced from natural gas, which leads to the release of large amounts of CO_2 (at least 450 million tons per year), exacerbating the greenhouse effect.

In recent years, researchers have begun to pay attention to the possibility of producing ammonia using the electrochemical nitrogen reduction reaction. Such a process can be driven by electricity from solar and wind power, and the entire conversion process can flow under normal conditions. Many catalysts have been investigated over the past few years, but their desired efficiency is still at the initial stage as it is difficult to simultaneously achieve high ammonia output and current efficiency.

“Our partners from China managed to experimentally prepare catalysts based on ultradispersed gold nanoparticles embedded in an organic matrix containing potassium ions. These catalysts have shown high stability and simultaneous ammonia yield and current efficiency. To explain the mechanism of the work of the catalyst, we created models and performed a number of calculations. The presence of potassium cations has been found to have a double effect. On the one hand, it prevents the approach of H3O+ to the surface of gold due to the repulsion from the positively charged coordination sphere of the K+ complexes, which leads to the suppression of the undesirable competing reaction of hydrogen evolution. And on the other hand, at the same time, the transferred charge enhances the interaction between the bound nitrogen molecule and the surface of gold, which leads to a decrease in the limiting stage,” explained **Artyom Kuklin**, co-author of the research, senior researcher at the Laboratory of Nonlinear Optics and Spectroscopy, SibFU.

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