Chemists develop nanocatalysts for continuous biofuel synthesis

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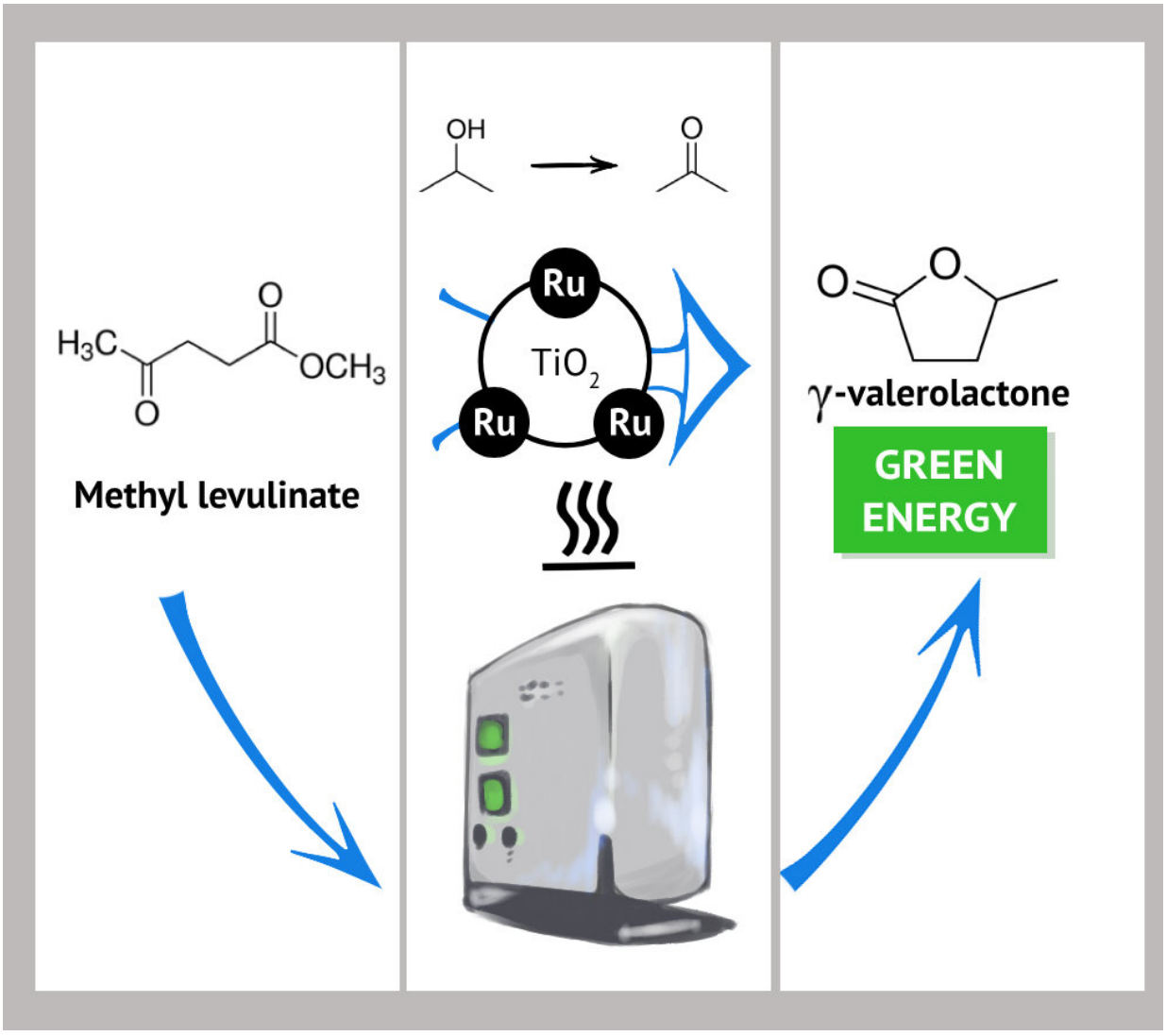

Scheme of gamma-valerolactone production. Credit: RUDN University

A chemist from RUDN synthesized new catalysts with ruthenium (Ru) nanoparticles for producing biofuel from organic biowaste. Nanocatalysts support more intensive and sustained reactions than the compounds currently available in the market. The results of the study were published in the *ChemSusChem* journal.

Rafael Luque, an external specialist from RUDN, works on the synthesis of gamma-valerolactone (GVL) together with his Chinese and Spanish colleagues. This colorless liquid can be obtained from food waste or harvesting leftovers. GVL may be used as a safe solvent or an additive to gasoline or may be distilled into hydrocarbons, "green fuel" for internal combustion engines.

Industrial use of GVL is hindered by two main issues. First of all, its manufacture involves expensive catalysts. Current market supply consists of substances based on precious metals such as ruthenium. Second, the available catalysts are unable to support a sustained reaction.

The authors of the article in *ChemSusChem* suggested a solution for both issues. They synthesized four new catalysts based on titanium dioxide crystals with 1 percent, 2 percent, 3 percent and 5 percent share of ruthenium nanoparticles (currently, the catalyzers contain over 5 percent). In a series of experiments, chemists looked for not only the most active, but also the most stable catalyst able to support a reaction for a long time.

The researchers prepared GVL from hydrogenation of levulinic acid or methyl levulinate in the presence of different catalysts, both new (titanium dioxide-based) and previously known. They also tested the catalytic activity of pure titanium dioxide, trying out each substance in all possible conditions. The scientists changed the temperature, volume of catalyst, concentration of the initial substance in the solvent, and the speed of inflow into the reactor.

Pure titanium dioxide turned out to have no catalytic activity. GVL was synthesized from initial substances only in the presence of ruthenium nanoparticles. All titanium dioxide-based catalysts synthesized by the scientists were active, but the variation with the highest (5 percent) content of nanoparticles showed maximum efficiency. In its presence, the reaction took place in 98 percent of the initial substance, and 97 percent of it was used to synthesize the target product (GVL).

Despite the same share of ruthenium, the results of previously known catalysts were considerably lower and experiments never employed methyl levulinate biowaste. For example, in the presence of a carbon-based ruthenium catalyst the reaction took place in 83 percent of levulinic acid, and only 52 percent was allocated to GVL synthesis.

High stability of the new catalysts was an even more important discovery. While traditional catalysts lost their activity two hours after the start of the reaction, titanium dioxide-based substances improved their results within this time period. The catalyst with a 5 percent share of ruthenium nanoparticles bested the others once again: GVL kept synthesizing continuously for over 24 hours.

"A traditional way of GVL synthesis involves short-term reactions in batch reactors," says Rafael Luque, professor of the Center for Molecular Design and Synthesis of Innovative Compounds for Medicine, and an external specialist of RUDN. "Therefore, there were no catalysts for continuous GVL production. We managed to create a relatively cheap, highly efficient, and very stable catalytic system based on titanium dioxide crystals. The potential of the new catalysts is not limited to GVL synthesis - we plan to use them in other studies."

More information: Chunping Xu et al. Highly Active Catalytic Ruthenium/TiO2 Nanomaterials for Continuous Production of γ-Valerolactone, *ChemSusChem* (2018). DOI: 10.1002/cssc.201800667

Provided by RUDN University