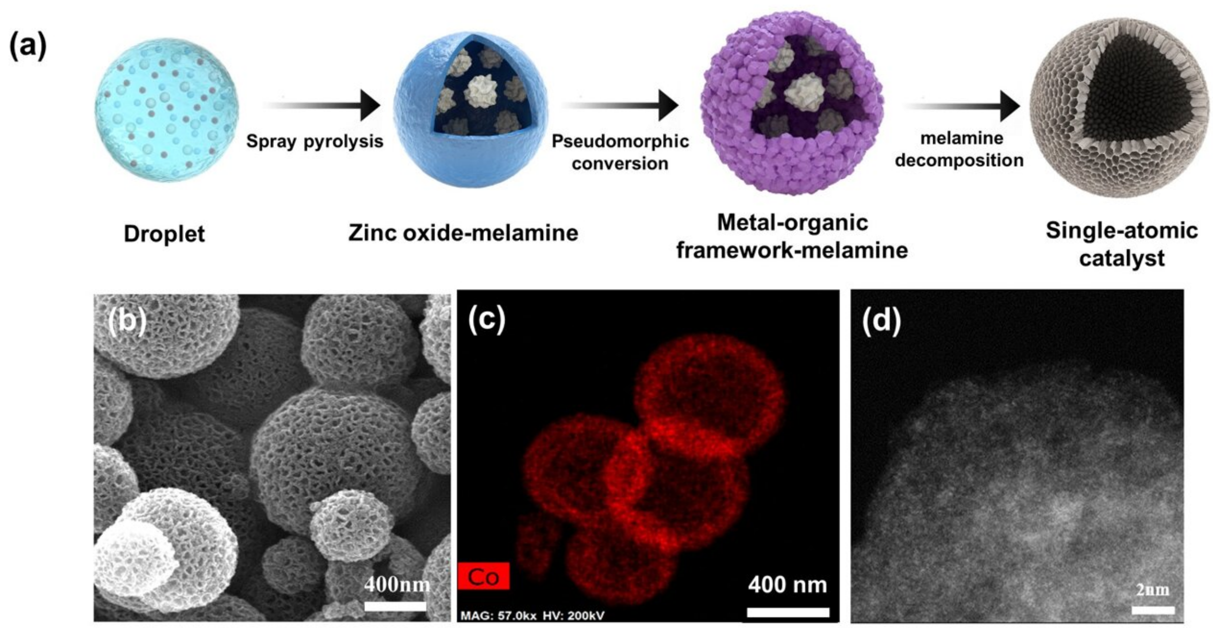
Development of high-durability single-atomic catalyst using industrial humidifier

May 13 2022



(a) single-atomic catalyst synthesis process using humidifier method, (b) SEM image, (c) cobalt element mapping image, (d) high-resolution STEM image of cobalt single-atomic catalyst. Credit: Korea Institute of Science and Technology (KIST)

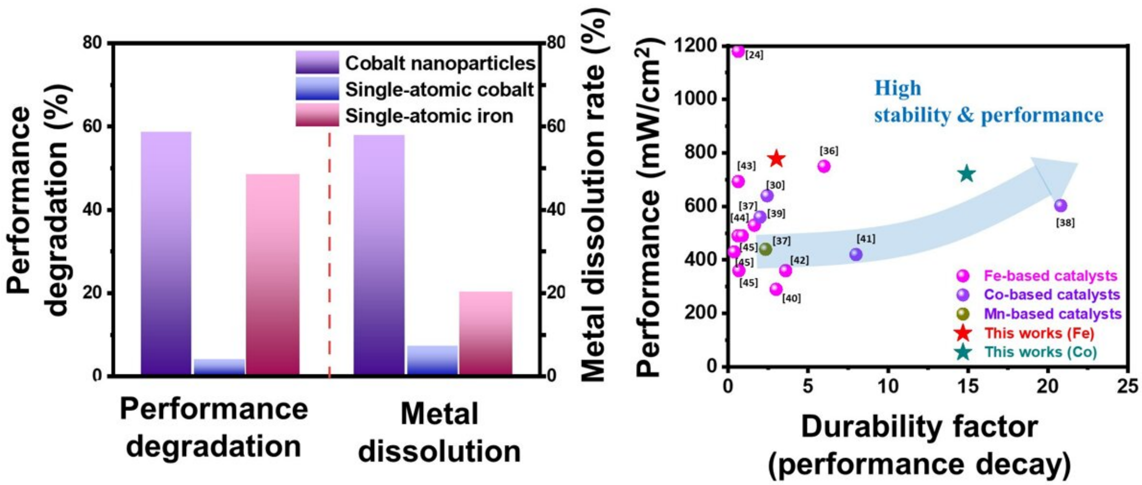
Fuel cell electric vehicles (FCEVs) are an eco-friendly means of transportation that will replace internal combustion locomotives. FCEVs offer several advantages such as short charging time and long mileage.

However, the excessive cost of platinum used as a fuel cell catalyst leads to limited supply of FCEVs. There has been extensive research on non-precious metal catalysts such as iron and cobalt to replace platinum; however, it is still challenging to find substitutes for platinum due to low performance and low stability of non-precious metal catalysts.

A research team led by Dr. Sung Jong Yoo of the Hydrogen Fuel Cell Research Center at Korea Institute of Science and Technology (KIST) conducted joint research with professor Jinsoo Kim of Kyung Hee University and professor Hyung-Kyu Lim of Kangwon National University; they announced that they have developed a single atomic cobalt-based catalyst with approximately 40% improved performance and stability compared to contemporary cobalt nanoparticle catalysts. Their research is published in *Applied Catalysis B: Environmental*.

Conventional catalysts are typically synthesized via pyrolysis, wherein transition metal precursors and carbon are mixed at 700–1000℃. However, due to metal aggregation and a low specific surface area, the catalysts obtained through this process had a limited activity. Accordingly, researchers have focused on synthesizing single-atomic catalysts; however, previously reported single-atomic catalysts can only be produced in small quantities because the chemical substances and synthesis methods used varied depending on the type of the synthesized catalyst . Therefore, research has focused on performance improvement of the catalyst rather than the manufacturing process.

To address this problem, the spray pyrolysis method was implemented using an industrial humidifier. Droplet-shaped particles were obtained by rapidly heat-treating the droplets obtained from a humidifier. This can enable mass production through a continuous process, and any metals can be easily produced into particles. The materials used for the synthesis of metal particles should be water-soluble because the particles are made through an industrial humidifier.



(Left) Catalyst performance reduction rate and metal dissolution rate after 100-h evaluation; (right) comparison with existing literature of cobalt- and iron-based catalysts. Credit: Korea Institute of Science and Technology (KIST)

It was confirmed that the cobalt-based single-atomic catalysts developed through this process exhibit excellent stability as well as fuel cell performance and are 40% superior compared to conventional cobalt catalysts. Cobalt-based catalysts also cause side reactions in fuel cells; however, computational science has shown that catalysts manufactured via spray pyrolysis lead to forward reactions in fuel cells.

Dr. Yoo clarified, "Through this research, a process that can enable considerable improvement in the mass production of cobalt-based single-atomic catalysts has been developed, and the operating mechanism of cobalt-based catalysts has been elucidated via close analyses and computational science. These results are expected to serve as indicators for future research on cobalt catalysts." They also added, "We plan to expand the scope of future research to explore not only catalysts for fuel cells, but also environmental catalysts, water electrolysis, and battery fields."

More information: Kyungmin Im et al, Design of Co-NC as efficient electrocatalyst: The unique structure and active site for remarkable durability of proton exchange membrane fuel cells, *Applied Catalysis B: Environmental* (2022). DOI: 10.1016/j.apcatb.2022.121220

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