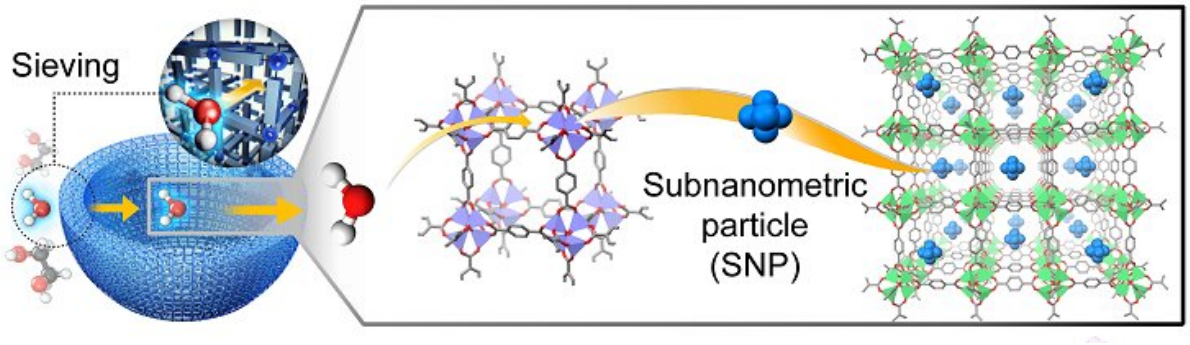
Energy storage using oxygen to boost battery performance

June 17 2020



Credit: The Korea Advanced Institute of Science and Technology (KAIST)

Researchers have presented a novel electrode material for advanced energy storage device that is directly charged with oxygen from the air. Professor Jeung Ku Kang's team synthesized and preserved the sub-nanometric particles of atomic cluster sizes at high mass loadings within metal-organic frameworks (MOF) by controlling the behavior of reactants at the molecular level. This new strategy ensures high performance for lithium-oxygen batteries, acclaimed as a next-generation energy storage technology and widely used in electric vehicles.

Lithium-oxygen batteries in principle can generate ten times higher energy densities than conventional lithium-ion batteries, but they suffer

from very poor cyclability. One of the methods to improve cycle stability is to reduce the overpotential of electrocatalysts in cathode electrodes. When the size of an electrocatalyst material is reduced to the atomic level, the increased surface energy leads to increased activity while significantly accelerating the material's agglomeration.

As a solution to this challenge, Professor Kang from the Department of Materials Science and Engineering aimed to maintain the improved activity by stabilizing atomic-scale sized electrocatalysts into the sub-nanometric spaces. This is a novel strategy for simultaneously producing and stabilizing atomic-level electrocatalysts within metal-organic frameworks (MOFs).

Metal-organic frameworks continuously assemble metal ions and organic linkers.

The team controlled hydrogen affinities between water molecules to separate them and transfer the isolated water molecules one by one through the sub-nanometric pores of MOFs. The transferred water molecules reacted with cobalt ions to form di-nuclear cobalt hydroxide under precisely controlled synthetic conditions, then the atomic-level cobalt hydroxide is stabilized inside the sub-nanometric pores.

The di-nuclear cobalt hydroxide that is stabilized in the sub-nanometric pores of metal-organic frameworks (MOFs) reduced the overpotential by 63.9% and showed ten-fold improvements in the life cycle.

Professor Kang said, "Simultaneously generating and stabilizing atomic-level electrocatalysts within MOFs can diversify materials according to numerous combinations of metal and organic linkers. It can expand not only the development of electrocatalysts, but also various research fields such as photocatalysts, medicine, the environment, and petrochemicals."

This study was reported in *Advanced Science*, titled "Autogenous Production and Stabilization of Highly Loaded Sub-Nanometric Particles within Multishell Hollow Metal-Organic Frameworks and Their Utilization for High Performance in Li-O_2 Batteries."

More information: Won Ho Choi et al. Autogenous Production and Stabilization of Highly Loaded Sub-Nanometric Particles within Multishell Hollow Metal–Organic Frameworks and Their Utilization for High Performance in Li–O 2 Batteries, *Advanced Science* (2020). DOI: 10.1002/advs.202000283

Provided by The Korea Advanced Institute of Science and Technology (KAIST)