New strategy achieves efficient and stable carbon dioxide electrolysis in solid oxide electrolysis cell

October 8 2021, by Li Yuan

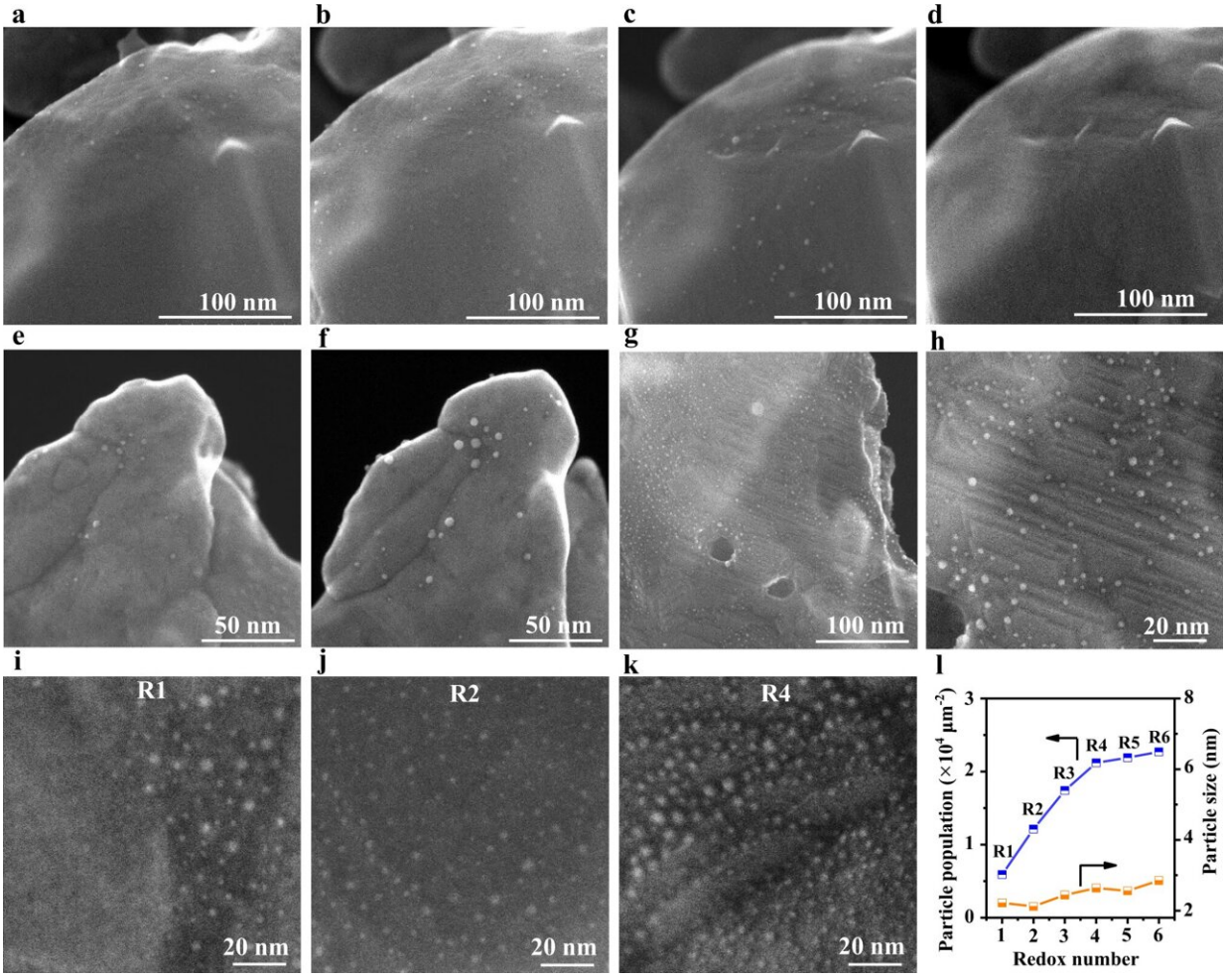

Fig. 1: Morphological study of the SFRuM catalysts. In situ secondary electron (SE)-STEM images of SFRuM after reduction at 800 °C for ~15 min (a), after reduction at 800 °C for ~30 min (b), after reoxidation at 800 °C for ~30 min (c),

and after reoxidation at 800 °C for ~40 min (d). In situ SE-STEM images of SFRuM O1 after reduction at 600 °C for ~10 min (e), after reduction at 800 °C for ~10 min (f), and after reduction at 800 °C for ~60 min (g). h Magnified image of (g). Ex situ SE-STEM images of SFRuM R1 (i), SFRuM R2 (j), and SFRuM R4 (k). l Population and size distribution of metal NPs exsolved after different redox manipulations. Credit: DOI: 10.1038/s41467-021-26001-8

Solid oxide electrolysis cell (SOEC) is promising in CO_2 conversion and renewable clean electricity energy storage. It can convert CO_2 and H_2O simultaneously into syngas or hydrocarbon fuel at the cathode, and produce high purity O_2 at the anode.

Perovskite-type oxides have the advantages of excellent doping ability, carbon deposition resistance and redox stability. However, the application of perovskite electrodes is limited due to insufficient electrocatalytic activity.

Recently, researchers led by Prof. WANG Guoxiong and Prof. BAO Xinhe from the Dalian Institute of Chemical Physics (DICP) of the Chinese Academy of Sciences and their collaborators achieved efficient and stable CO_2 electrolysis in SOEC. They found that redox cycle manipulations promoted the exsolution of high-density metal/perovskite interfaces, which improved the CO_2 electrolysis performance and stability.

This study was published in *Nature Communications* on Sept. 27.

The researchers prepared Ru-doped $Sr_2Fe_{1.4}Ru_{0.1}Mo_{0.5}O_{6-\delta}$ (SFRuM) double perovskite. They found that the repeated redox manipulations promoted the exsolution of RuFe alloy nanoparticles from 5900 μm^{-2} to 22680 μm^{-2}, where the mean particle size was between 2.2 and 2.9 nm,

thus regulating the density of the RuFe@SFRuM interfaces.

Combined with in situ atmosphere electron microscopy, elemental maps and electron energy loss spectroscopy, they revealed the formation and regeneration mechanism of RuFe@SFRuM interface under reducing and oxidizing atmosphere. "The enrichment in Ru species on the surface can promote the exsolution of high-density RuFe@SFRuM interfaces," said Prof. WANG.

What's more, in situ atmosphere electron microscopy, electrochemical impedance spectroscopy combined with density functional theory calculations confirmed that the RuFe@SFRuM interface promoted CO_2 adsorption and activation. Compared with the SFRuM cathode, the RuFe@SFRuM cathode had a 74.6 percent increase in current density for CO_2 electrolysis at 1.2 V and 800 °C, and exhibited a high stability of CO_2 electrolysis for 1000 h.

More information: Houfu Lv et al, Promoting exsolution of RuFe alloy nanoparticles on $Sr_2Fe_{1.4}Ru_{0.1}Mo_{0.5}O_{6-\delta}$ via repeated redox manipulations for CO2 electrolysis, *Nature Communications* (2021). DOI: 10.1038/s41467-021-26001-8

Provided by Chinese Academy of Sciences