Co-doped carbon anode material for high-performance seawater batteries

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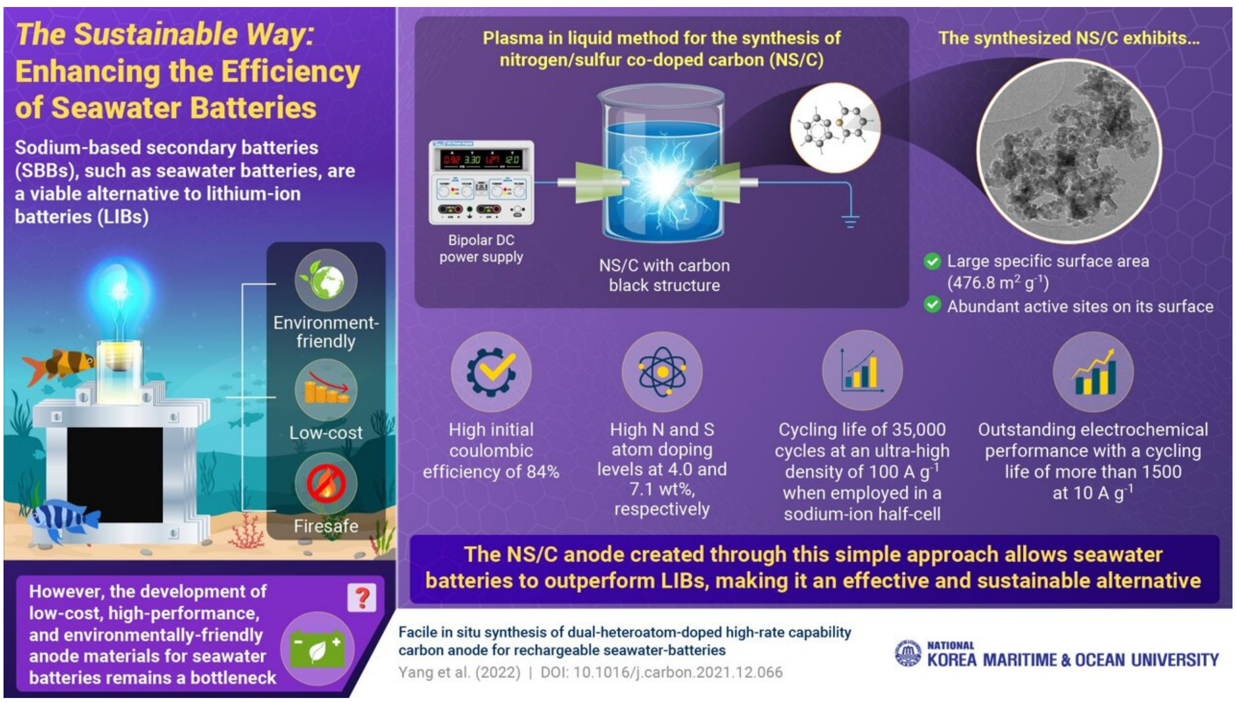

Credit: Korea Maritime & Ocean University

Despite the many potential applications of seawater batteries (SWBs), the limited performance of available materials has hindered their commercialization. To tackle this issue, scientists from Korea Maritime and Ocean University have developed a novel co-doped carbon material for the anode of SWBs. Their straightforward synthesis route and the high performance of the developed anode material will pave the way for the widespread adoption of SWBs, which are safer and less expensive than lithium-ion batteries.

Lithium-ion batteries have taken the world by storm thanks to their remarkable properties. However, the scarcity and high cost of lithium has led researchers to look for alternative types of rechargeable batteries made using more abundant materials, such as sodium. One particularly promising type of sodium-based battery is seawater batteries (SWBs), which use seawater as the cathode.

Though SWBs are environmentally benign and naturally firesafe, the development of high-performance anode materials at a reasonable cost remains a major bottleneck that prevents commercialization. Traditional carbon-based materials are an attractive and cost-efficient option, but they have to be co-doped with multiple elements, such as nitrogen (N) and sulfur (S), to boost their performance up to par. Unfortunately, currently known synthesis routes for co-doping are complex, potentially dangerous, and don't even yield acceptable doping levels.

In a recent study, a team of scientists from Korea Maritime and Ocean University led by Associate Professor Jun Kang have found a way out of this conundrum. Their paper, which was made available online on December 22, 2022 and published in Volume 189 of *Carbon* on April 15, 2022, describes a novel synthesis route to obtain N/S co-doped carbon for SWB anodes.

Termed 'plasma in liquid,' their procedure involves preparing a mixture of precursors containing carbon, N, and S and discharging plasma into the solution. The result is a material with high doping levels of N and S with a structural backbone of carbon black. As proved through various experiments, this material showed great potential for SWBs, as Dr. Kang remarks: "The co-doped anode material we prepared exhibited remarkable electrochemical performance in SWBs, with a cycling life of more than 1500 cycles at a current density of 10 A/g."

The potential maritime applications of SWBs are many, since they can be safely operated while completely submerged in seawater. They can be used to supply emergency power in coastal nuclear power plants, which is difficult when using conventional diesel generators in the event of a disastrous tsunami. Additionally, they can be installed on buoys to aid in navigation and fishing. Perhaps most importantly, SWBs could be literally life-saving, as Dr. Kang explains: "SWBs can be installed as a power source for salvage equipment on passenger ships. They would not only supply a higher energy density than conventional primary batteries, but also enable stable operation in water, thereby increasing survival probabilities."

More information: Hyeon-Su Yang et al, Facile in situ synthesis of dual-heteroatom-doped high-rate capability carbon anode for rechargeable seawater-batteries, *Carbon* (2022). DOI: 10.1016/j.carbon.2021.12.066

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