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IAPME Seminar

Plasma Engineered Chloride-resistant Electrocatalysts for Seawater-based batteries

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Seawater-based electrochemical devices are promising large-scale energy storage devices and are highly compatible with offshore ocean locations or large-scale maritime applications. However, the complexity of the seawater components, in particular, chloride anion (Cl^-) blocks the metal surface and hinders the oxygen reduction reaction (ORR) and oxygen evolution reaction (OER). In particular, platinum or metal-based electrocatalysts often suffer a severe reduction of the catalytic activity due to the strong adsorption effect of the Cl^- on the catalyst surface. As a result, the ORR/OER electrocatalyst /active sites must be prevented from Cl^- adsorption during reactions. For instant, our group has designed a negative-charged surface of Nitrogen-doped graphene (NG) coated on cobalt electrocatalyst to repel Cl^- selectively in seawater electrolyte. [1] Our DFT model successfully demonstrated the near-surface charge transfer at the interface of cobalt core and pyridinic-N graphene (Co (*fcc*)/N-Gr) strongly contributed to advanced catalytic activity and selectively Cl^- repulsion in seawater electrolyte. Experimentally, the structure of a few layered (NG) encapsulated cobalt (Co 4mmol-N/C) showed superior performance in a rechargeable seawater battery with an extremely low overpotential (0.56 V) at 0.1 mA and presented superior stability over 100 hours. Therefore, it has been proved that the enhanced surface electric charge could repel negative Cl^- and increase the chemical tolerance by preventing the adsorption of Cl^- on the catalyst surface. Similarly, we employed plasma engineering to anchor Fe Quantum dots (QDs) on a negative charge-mediated surface composed of nitrogen-doped graphene (NG) on $Ti_3C_2T_x$ MXene. The negative fluorine and hydroxyl groups on MXene and NG induced strong negative-charged surface with a build-in electric field to repel Cl^-, effectively protected the Fe QDs active sites from the seawater electrolyte. As a result, the cathode electrocatalysts demonstrated high ORR catalytic activity in seawater electrolytes and achieved a high-power density output of 53.6 mW/cm^2 and rate performance of 0.8 V at 50 mA/cm^2 in Al-air seawater batteries. [2] Our group has applied similar electrocatalyst design for a novel Mg-air seawater batteries with simultaneous carbon dioxide (CO_2) neutralization. The Mg-air seawater battery achieved a maximum 36 mW/cm^2, as well as a stable discharge voltage of 1V and continuous CO_2 reduction of 0.8 g/Wh. In addition, the electrocatalyst protected with N-doped carbon showed significant enhancement in durability, which can continuously light up LED for several tens of hours. Overall, our works provide a new insight to design highly stable electrocatalyst for practical seawater-based batteries in near future.

Professor Li graduated with her Ph.D from McMaster University, Canada in 2010 and proceeded as an assistant professor at Nagoya University, Japan. In 2017, she has moved to Pusan National University and is currently an associate professor in the School of Materials Science and Engineering. Her major researches including design plasma chemistry and reaction for catalytic material synthesis. She has successfully designed various plasma reactions to synthesize functional materials in the field of green energy applications, including plasma synthesis of heteroatom-doped carbon bi-functional oxygen catalyst for fuel cell, hybrid metal-carbon catalysts for metal-air battery, surface treatment of carbon and silica acid catalyst for biomass upgrade. She has published over 80 SCI papers, including *App. Catal. B, Nano-miro Letts., Chem. Eng. J., Mater. Chem. A., Green Chem.*, etc. She has 10 patents registered in Korea/Japan.

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