New Materials for Green Hydrogen Fuel Production from Seawater Electrolysis

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For prevention of exhaustion of fossil fuels and uranium, renewable energy fuels should supplied to meet the demand of the whole world. We are proposing hydrogen fuel for the use of renewable energy. Intermittent electricity generated by solar cell on deserts or wind turbine in on and/or offshore regions will be converted to hydrogen by seawater electrolysis nearby sea or desert coasts. The produced hydrogen can be used directly as a fuel in internal combustion engine, an energy carrier in fuel cells, a key component in many industrial applications and/or converted to methane by reaction with carbon dioxide for preventing global warming. We are creating the key materials, cathode and anode, necessary for seawater electrolysis process. For industrialization of green hydrogen technology based on seawater electrolysis, enormous evolution of toxic chlorine, which generally occurs on anode, is not allowed. In addition, cheap and durable cathode and anode materials with very low overpotentials during electrolysis process are requested. Finally, optimum electrolyzer design with very low energetic loss is crucial.

We succeeded in tailoring durable oxygen evolving anodes, without formation of environmentally harmful chlorine, during electrolysis of acidic seawater. The anodes were deposited from 0.2M Mn^{2+}-0.003M Mo^{6+}-*xM* N (N is either transition or rare earth metal cations) solutions of pH 0.5~-0.1 at 600 Am^{-2} on electroconductive substrate by direct, pulse and repeated anodic current deposition. Our best anode showed 100% and 97% oxygen evolution efficiency, with no loss in weight, after about 3000 and 7000 h of electrolysis, respectively, at 1000Am^{-2}. This anode is considered to be the best ever known oxygen evolving anode during seawater electrolysis. We also succeeded in developing NiMoC and NiMoFeC alloys as new durable cathode materials for hydrogen evolution reaction during alkaline seawater electrolysis. The alloys were electrodeposited on both expanded iron and nickel substrates by direct and pulse current deposition. The new electrodes showed higher activity and durability for hydrogen evolution reaction than carbon steel, expanded Ni and platinized titanium electrodes.
The technical objective of the work is to further improve the performance of our new materials to meet the requirements of international standards and US Department of Energy (DOE) for producing green hydrogen fuel with reasonable price from forecourt sized electrolyzer. This goal shall be reached through:

1. The employment of advanced tools for fine nanoscale control for the development of new nanostructure electrode materials.
2. Utilization of cheap components in the catalyst layer and underlying substrate of the electrodes.

Development and optimization of the basic engineering and cost indicators of an efficient and ecologically safe prototype single and multiple cell stacks of PEM electrolyser for seawater electrolysis.