Sea water electrolysis – advantages, challenges and perspectives as a cost-efficient technology for green hydrogen production

Evelina Slavcheva, A. Garbev, E. Petkucheva
"Acad. Evgeni Budevski" Institute of Electrochemistry and Energy Systems, Bulgarian Academy of Sciences
"Acad. G. Bonchev" Str., Bl.10, Sofia 1113, Bulgaria

In the last years the interest in direct seawater electrolysis as an alternative technology for green hydrogen production has increased considerably. In contrast to the advanced PEM electrolysis based on consumption of highly purified fresh-water, it uses the most abundant water resource on the Earth (almost 97 %). The sea water has high salinity, its ionic conductivity reaches 34 mS cm^{-1} at 25 °C making it an ideal electrolyte which can be easily split to hydrogen and oxygen. That is why, the sea water electrolysis is an intriguing method for sustainable energy production. However, due to the high chlorine concentration (similar to 0.5 M NaCl), a significant problem in the sea water electrolysis is the competition between the anode partial reaction of oxygen evolution known for its sluggish kinetics and the formation of Cl_2 gas (at acidic pH) or ClO (at alkaline pH). The formation of these by-products leads to severe corrosion and degradation of the anode, and in turn to lowering the system efficiency. In addition, during a long-term service the high salinity leads to precipitation of alkaline earth hydroxides and carbonates on the cathode surface which is another problem to be solved. The scientific research on the direct electrolysis of seawater deals with various aspects of this process including optimizing the electrode and catalytic materials, improving the efficiency and stability of the process, and exploring new methods to address the challenges of the high salinity.

The focus of the present study is on the synthesis of a new composite catalyst consisting of polymer matrix with appropriate conductivity and a catalytic metal incorporated in its structure. The samples under investigation are obtained by means of chemical polymerization of aniline through oxidation and introduction of both classical catalysts such as Pt and Ru and non-noble metals from the transition series (Co, Ni, Fe) aiming cost reduction of this type of electrodes.

The composition, structure, and morphology of the prepared composites are investigated using variety of spectroscopic and physicochemical methods as illustrated in Fig.1. The reaction mechanisms and kinetics of the seawater electrolysis on conventional and newly synthesized composite electrodes are studied by means of cyclic voltammetry and chronoamperometry. The performance of the electrode materials in aqueous media with varying pH and its specific response as both anode and cathode are pre-screened following the proceeding redox reactions on the electrode surface to establish the preferable more efficient application.

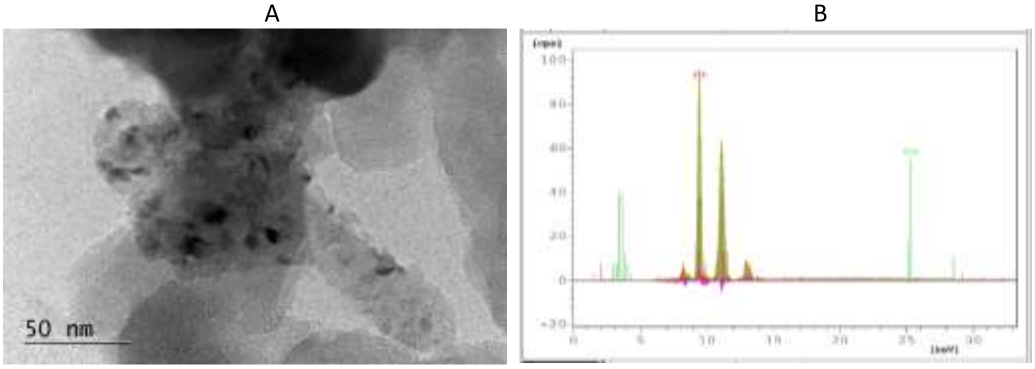

Figure 1. TEM (a) and fluorescence X-Ray (b) analysis of polymer composite with incorporated Pt

The results obtained proved the feasibility of the introduced method of synthesis. The electrochemical investigation of the obtained composite catalysts showed promising electrocatalytic activity and improved stability toward the aggressive chlorine effects. Although still in the initial stage, the research carried out gives credence for further ongoing experiments to elucidate deeper the mechanism of proceeding reactions, increase the electrode service life, and enhance the cost efficiency of sea water electrolysis.

Acknowledgement: The authors kindly acknowledge the financial support of project № BG05M2OP001-1.002-0014 "Center of Competence HITMOBIL - Technologies and Systems for Generation, Storage and Consumption of Clean Energy", funded by Operational Programme "Science and Education for Smart Growth" 2014–2020 and co-funded by the EU from European Regional Development Fund. The research is partly done with the assistance of the Bulgarian Ministry of Education and Science under the National ROADMAP FOR RESEARCH INFRASTRUCTURE 2017–2023 approved by DCM No354/29.08.2017, "Energy Storage and Hydrogen Energetics" (ESHER).