Green nanomaterials engineering for water splitting reactions

Salvo Mirabella
Luca Bruno, Giacometta Mineo, Elena Bruno
University of Catania, CNR-IMM, Via Santa Sofia 64, Catania, Italy
salvo.mirabella@dfa.unict.it

Abstract

The design of highly efficient and sustainable electrocatalysts for water splitting is a key issue for alternatives to conventional carbon-based energy sources. Hydrogen and oxygen evolution reactions (HER and OER) needs to be optimized in proper electrolytes with fast kinetics and efficient material utilization. Indeed, very different electrocatalytic performances appear in literature and without an appropriate investigation of mass activity and overpotential a fair comparison is unmanageable. Nanotechnology could help in boosting water electrolysis still the stability remains an open issue. Here, we will review recent progress in low-cost nanostructures of transition metal oxides (NiO, WO_3, CuO, ZnO) for improving HER and OER in acidic and alkaline conditions. Decoration with mono or bimetallic nanoclusters will also be discussed. Well established metrics (overpotential, TOF, Tafel slope) will be used to asses solid and comparable electrocatalytic performances of nanostructures. Physically based models will be proposed to explain catalytic activity with respect to electronic energy bands of semiconductors. WO_3 nanoneedles with optimized hexagonal/monoclinic phase junctions shows HER overpotential of 170 mV for 10 mA/cm^2 in acidic electrolyte [1]. NiO microflowers, composed of very thin sheets (20 nm thick) intertwined like petals of a desert rose, exhibit an overpotential of only 314 mV at current density of 10 mA/cm^2 under alkaline conditions, with promising intrinsic activity of catalyst (Tafel plot as low as 40 mV/dec and turnover frequencies of 0.01 or 6.98 /s^1 for bulk or redox determination, respectively) [2]. NiO nanoplates decorated with ultralow amount of Pt nanoclusters show a HER overpotential of only 66 mV at current density of 10 mA/cm^2 in alkaline media. A cell for water electrolysis fully based on Ni nanostructures shows a low potential of 1.57 V to afford a current density of 10 mA/cm^2 and a good long-term stability [3].

References

[1] G. Mineo, et al., ACS Applied Energy Materials, (2022) in press
[2] L. Bruno, et al., Sust. Energy & Fuels, (2022), accepted
[3] L. Bruno, et al., Int. J. Of Hydrogen Energy, (2022), accepted

Figures

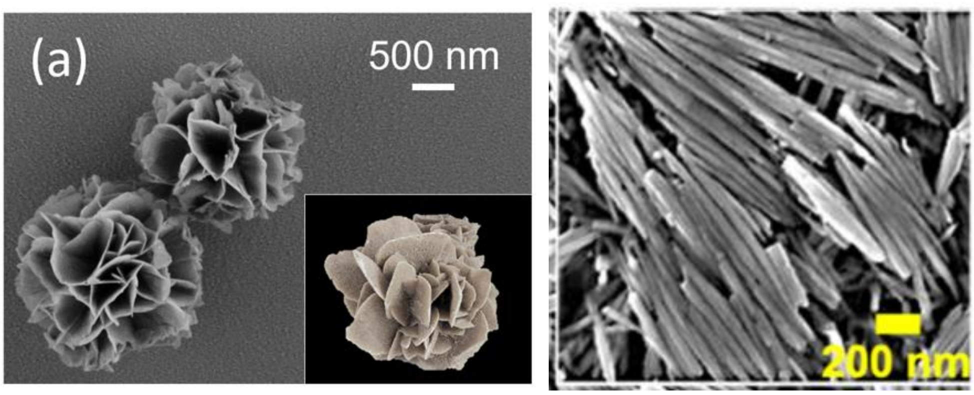

Figure: [left] NiO microflowers dispersed on GP (desert rose in the inset). [right] Bundles of WO_3 nanoneedles.