Proceedings of the 8th World Congress on Recent Advances in Nanotechnology (RAN'23)
Lisbon, Portugal – March 23 – 25, 2023
Paper No. ICNNFC 155
DOI: 10.11159/icnnfc23.155

Nano-Lattice Engineering of Cu-Oxides via Flame Spray Pyrolysis: Challenges for Promoting Artificial Photosynthesis Performance

Areti Zindrou, Maria Solakidou, Yiannis Deligiannakis*
Lab of Physical Chemistry of Materials and Environment, Department of Physics, University f Ioannina, Greece,
nanomaterials.phyisics.uoi.gr;*ideligia@uoi.gr

Extended Abstract

The "Artificial Photosynthesis" approach aims to exploit photocatalytic technology, i.e. that is the use of solar photons to produce hydrogen (H_2) and -ideally- couple it to CO_2 reduction towards carbon-based fuels. Economically and environmentally, this is a sustainable, circular economy approach since CO_2 reduction can result in useful products such as formic acid (HCOOH), formaldehyde (HCHO), methanol (CH_3OH), methane (CH_4). Cu-oxide nanophases [CuO, Cu_2O, Cu^0] constitute highly potent nanoplatforms for the development of efficient Artificial Photosynthesis catalysts. Herein we have developed a novel Flame Spray Pyrolysis (FSP) technology[1,2] for industrial-scale synthesis of anoxic (Cu_2O, Cu^0) nanophases heterojunctioned with oxic CuO nanophase in one-step. The mechanisms of Photocatalytic H_2 production form H_2O and selective CO_2 reduction to HCOOH are discussed for mixed-phase [$Cu_2O/Cu^0/CuO$] nanojunctions [3,4]. Control of oxygen-stoichiometry in the FSP-process was screened in the range of φ=0.5 to 1.5 as a key-parameter to control the [$Cu_2O/Cu^0/CuO$] nanojunctions. We show that enhanced CO_2-reduction >2000umoles/gr/h can be achieved by proper [$Cu_2O/Cu^0/CuO$] phase composition, not pure phases. This phenomenon is discussed in the context of electron-hole life time control and photocorrosion control [5].

References

[1] Y. Deligiannakis, A.Mantzanis, A. Zindrou, S. Smykala, M. Solakidou Control of monomeric Vo's versus Vo clusters in ZrO_{2-x} for solar-light H_2 production from H_2O at high-yield (millimoles gr^{-1} h^{-1}) *Scientific Reports* 12, 15132 (2022) doi: 10.1038/s41598-022-19382-3.

[2] Teoh, W.Y., Amal, R., Mädler, L. Flame spray pyrolysis: An enabling technology for nanoparticles design and fabrication *Nanoscale* 2(8), 1324-1347(2010) doi 10.1039/c0nr00017e.

[3] Rej, S.; Bisetto, M.; Naldoni, A.; Fornasiero, P. Well-Defined Cu_2O Photocatalysts for Solar Fuels and Chemicals. *J. Mater. Chem. A* **2021**, *9*, 5915–5951, doi:10.1039/D0TA10181H.

[4] Yang, Y.; Xu, D.; Wu, Q.; Diao, P. Cu_2O/CuO Bilayered Composite as a High-Efficiency Photocathode for Photoelectrochemical Hydrogen Evolution Reaction. *Sci Rep* **2016**, *6*, 35158, doi:10.1038/srep35158.

[5] Toe, C.Y.; Scott, J.; Amal, R.; Ng, Y.H. Recent Advances in Suppressing the Photocorrosion of Cuprous Oxide for Photocatalytic and Photoelectrochemical Energy Conversion. *Journal of Photochemistry and Photobiology C: Photochemistry Reviews* **2019**, *40*, 191–211, doi:10.1016/j.jphotochemrev.2018.10.001.

H.F.R.I.
Hellenic Foundation for Research & Innovation

This research was supported by the Hellenic Foundation for Research and Innovation (H.F.R.I) under the "1st Call for H.F.R.I Research Projects to support Faculty members and Researchers" (grant HFRI-1888).