Synergic effect of Carbon Nanotubes on Zeolitic Organic Framework catalyst for CO2 electroreduction

The electrochemical reduction of carbon dioxide (CO_2RR) into more energetic molecules, as chemicals and fuels, is becoming in the recent years an actual and promising technology that will have an important role to achieve a future zero-impact society.

In the last decade, a tremendous growth has characterize the CO_2RR technology, nevertheless the industrialization scale up is still a far goal to achieve, due to low performances and overall high costs. An often-underestimated aspect is the prize of materials employed, especially the metals typically used for the cathode and anode fabrication. If the electro-catalysis of carbon dioxide is dominated by metal/metal oxide species, a proper investigation and optimization of these metals atom should be encouraged. Confining metal atoms in an ordered and accessible porous structure, as in the metal organic framework (MOF), is considered an advanced strategy that enhances the atom efficiency and selectivity. A brand new sonochemical-synthesis of a zeolitic imidazole framework (ZIF-8), a subclass of MOF, grown on and inside of multi-walled carbon nanotubes (MWCNTs) were studied as catalyst for the CO_2RR. The strong π-π interaction between MWCNTs and the imidazole ligand prevent crystal growth during the synthesis assisted by the strong acoustic waves, leading to the formation of stable nano-particles. A deep electrochemical study of the material towards the CO_2 reduction reaction (CO_2RR) was performed in different concentrations of $KHCO_3$ aqueous solutions. The highest faradaic efficiency for CO_2RR products achieves 70.4% at -1.2 V vs the reversible hydrogen electrode (RHE) in 0.5 M $KHCO_3$ electrolyte, with a stable production rate of 0.08 mmol h^{-1} cm^{-2} in 16 hour of test, while the highest turnover frequency number (TOF) reaches a value of 453.9 s^{-1} at the same potential in 1.0 M $KHCO_3$ solution. Such approach highlight a different strategy to use metal atoms with a new and sustainable approach without losing the specific activity of their typical metal/metal oxide form.