**A review on hydrogen production using decorated metal-organic frameworks by electrocatalytic and photocatalytic water splitting**

Rana Adeel Mehmood, Awais Ali Aslam, Muhammad Javid Iqbal, Ali Hamza Sajid, Ameer Hamza, Hina Fatima Tahira, Izaz Ul Islam,\* , Erdal Yabalak\*

**Abstract:**

As global energy demands surge, hydrogen production through sustainable water splitting techniques has become a focus of extensive research. Electrocatalytic and photocatalytic water splitting using earth-abundant materials presents a promising approach for generating clean hydrogen by utilizing only water and renewable energy sources. Among the diverse catalysts studied, metal–organic frameworks (MOFs) have recently emerged as a transformative category due to their tunable porosity, crystallinity, and customizable molecular structures. This comprehensive review presents a comparative analysis of electrocatalytic and photocatalytic MOF systems for hydrogen evolution reaction (HER) and oxygen evolution reactions (OER), emphasizing the structure–activity relationships that drive catalytic performance. Electrocatalytic water splitting harnesses electrical energy to drive the chemical reaction that splits water into hydrogen and oxygen and photocatalytic water splitting utilizes light energy (photons) to initiate the chemical reaction. It explores molecular-level engineering principles that enhance bifunctional activity for overall water splitting by modifying metal clusters and organic linkers in MOFs. To improve efficiency, stability, and scalability, framework doping, defect engineering, and nanocomposite design are presented. Additionally, this review critically examines current limitations and offers perspectives on translating these advances into scalable, practical technologies for hydrogen production.