In Situ Piezodeposited Noble-Metal Schottky Junctions on Laponite/ZnO for Enhanced Piezocatalytic Hydrogen Evolution

Talha Kuru[a, b]*, Emre Aslan[c], İmren Hatay Patır[a]

[a] Selcuk University, Department of Biotechnology, 42030, Konya, Türkiye e-mail: talha59510@gmail.com

[b] YEO Technology R&D Center, 34870, İstanbul, Türkiye

[c] Selcuk University, Department of Biochemistry, 42030, Konya, Türkiye

Piezocatalysis is an emerging energy-conversion process in which mechanical stimuli, such as vibration and ultrasonication, induce electrical polarization in non-centrosymmetric materials and generate charge carriers capable of driving surface redox reactions. In piezocatalytic hydrogen production, mechanically generated electrons reduce protons to H_2, while holes participate in oxidation reactions. However, rapid electron–hole recombination and slow surface reduction kinetics continue to limit the efficiency of this process. Laponite, a synthetic layered silicate nanoclay, possesses negatively charged sheets, a high surface area, and localized structural charge imbalances. Although it is not intrinsically piezoelectrically active, its layered structure can serve as a supporting scaffold and charge-transfer mediator for piezoelectric semiconductors. In this study, the optimized Laponite/ZnO nanocomposite containing 15 wt% ZnO (LZO15) was modified with Pt through an in situ piezodeposition approach. Pristine LZO15 exhibited a piezocatalytic hydrogen evolution rate of 1198 µmol g^{-1} h^{-1} and a mechanical-to-hydrogen efficiency of 0.41%. Noble-metal deposition enhanced hydrogen evolution by 1.8-fold for Pt/LZO15, corresponding to estimated rate of 2156. Assuming an unchanged mechanical-energy input, the corresponding MTH efficiency increased proportionally to approximately 0.74%. The enhancement originates from the integration of two complementary interfacial strategies. First, Si–O–Zn bonds formed between Laponite and ZnO create a rapid charge-transfer pathway, suppress ZnO aggregation, and promote the directional migration of piezo-induced electrons. Second, noble-metal/ZnO Schottky junctions act as electron-trapping interfaces, inhibit charge back-transfer, and provide efficient proton-reduction sites. These findings demonstrate that combining clay-bond engineering with piezodeposited Schottky junctions is a promising strategy for improving mechanical-energy conversion and sustainable hydrogen generation.

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