Direct Z-Scheme Heterostructure of In-situ Planted ZnO Nanorods on $g\text{-}C_3N_4$ Thin Sheets Sprayed on TiO_2 Layer: A Strategy for Ternary-Photoanode Engineering towards Enhanced Photoelectrochemical Water Splitting

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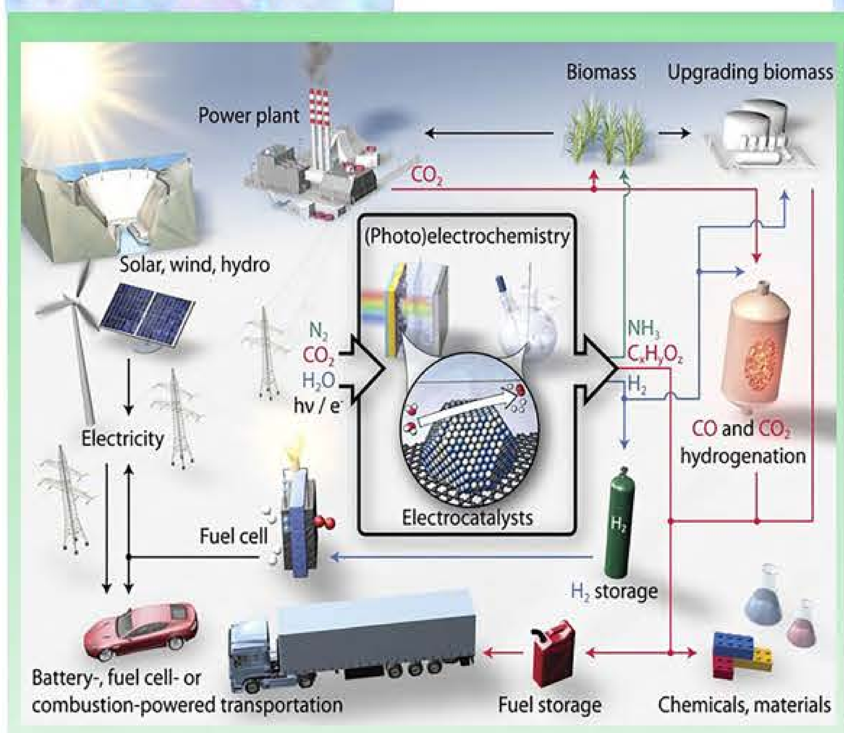
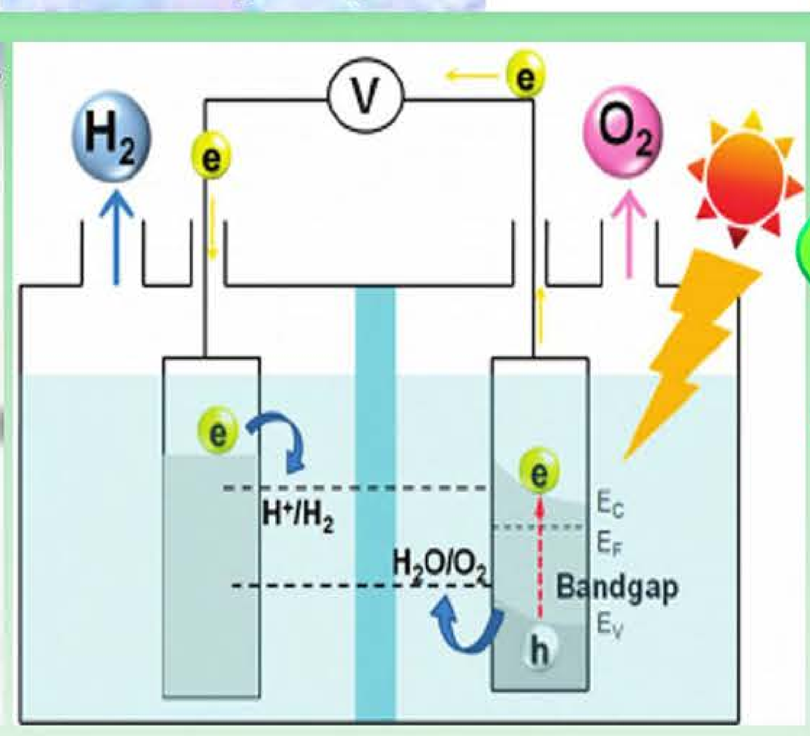
Research Focus



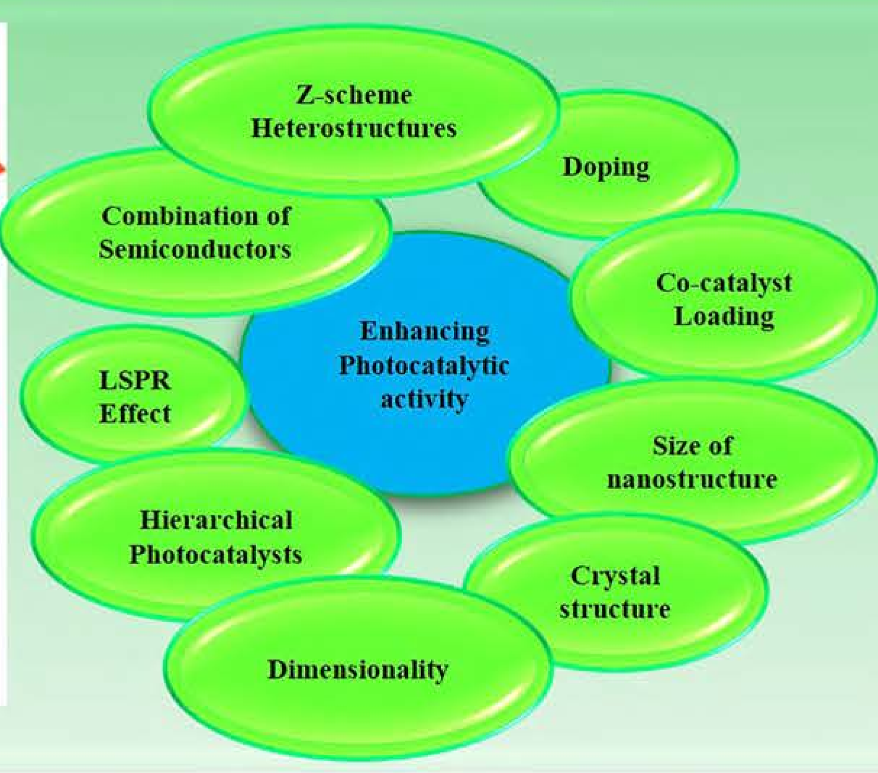
Sustainable energy future (Seh, Kibsgaard et al. 2017).

PEC Water Splitting

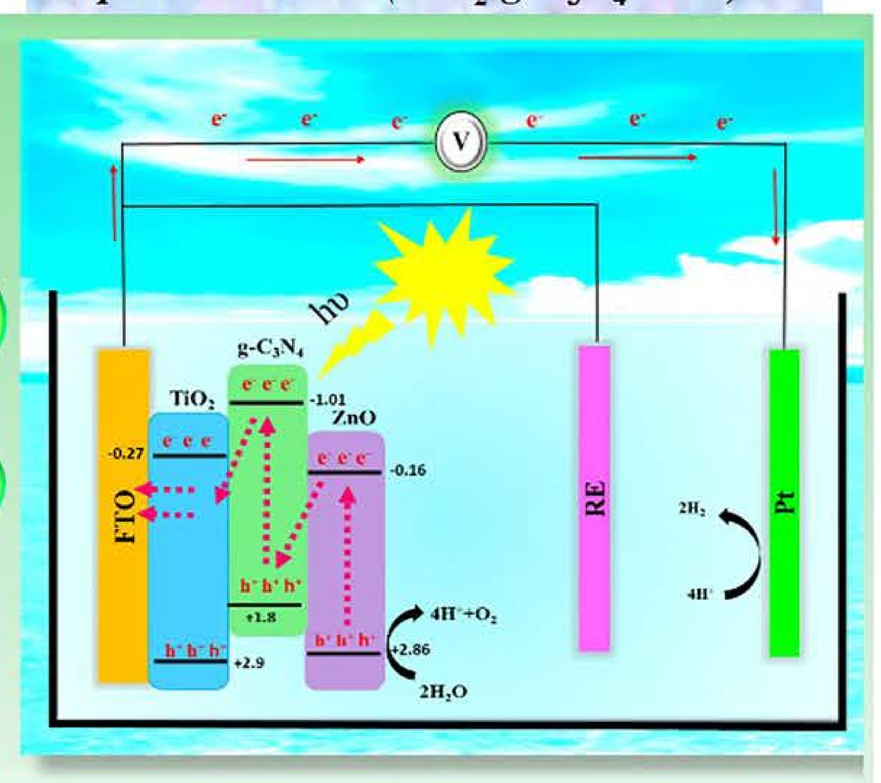


Energy diagram of PEC water splitting (Chen, Chen et al. 2012)

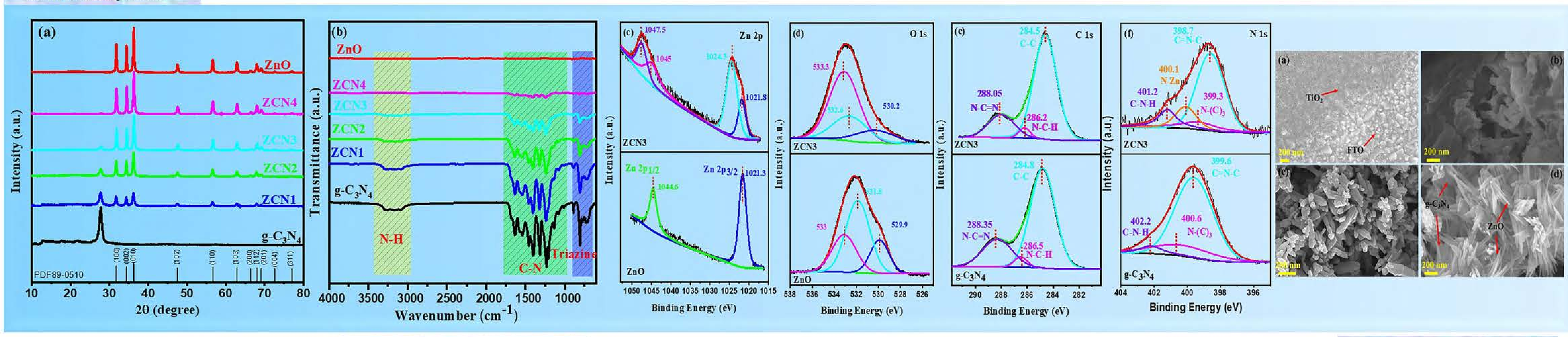
Photocatalysis Enhancement



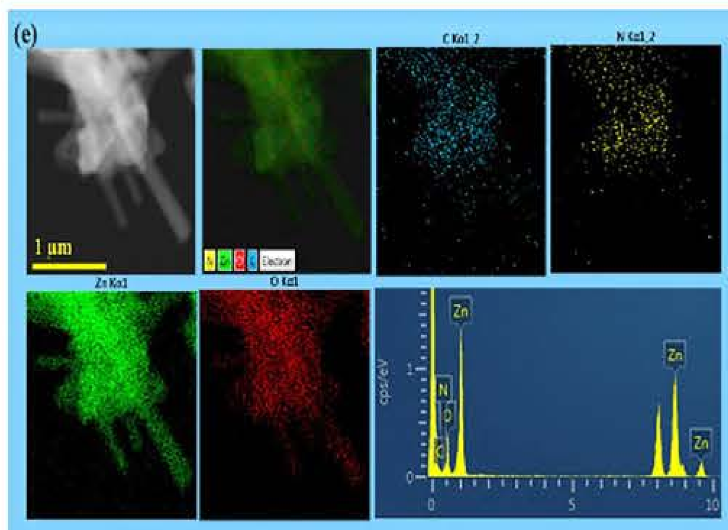
Graphical Abstract ($TiO_2/g\text{-}C_3N_4/ZnO$)



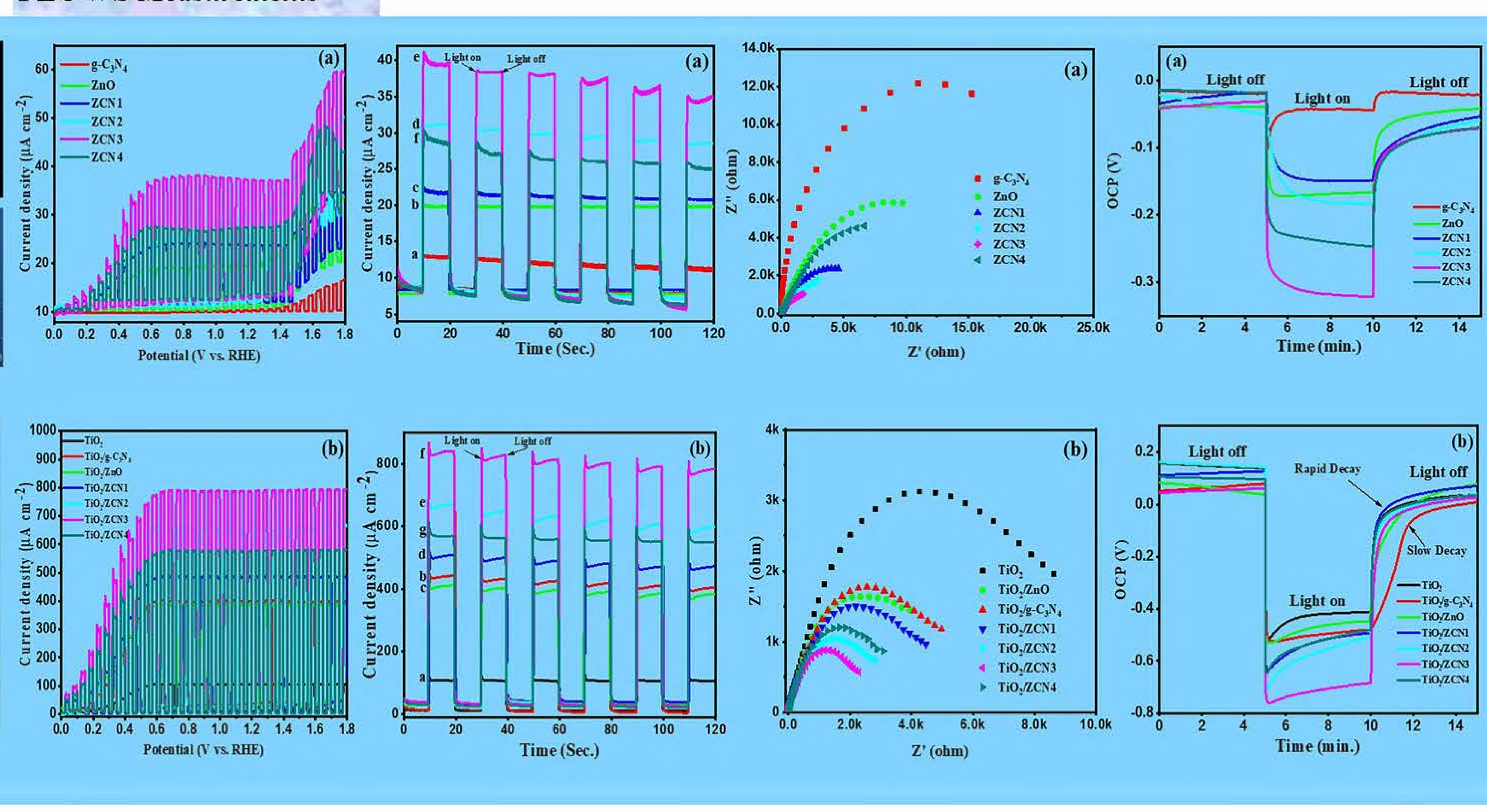
Characterization



PEC-WS Measurements

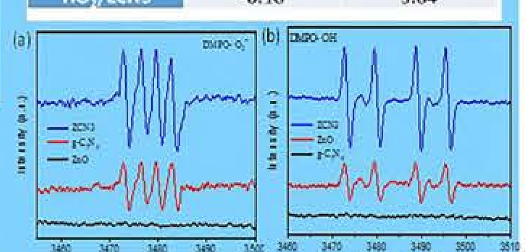


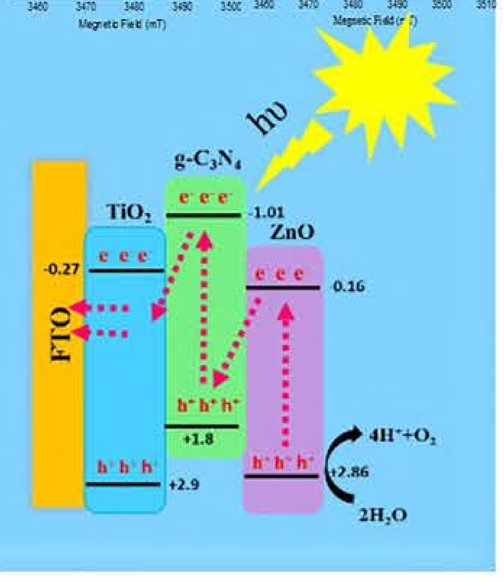
Sample	BET Surface area (m^2/g)	Pore volume (cm^3/g)	Average pore diameter (Å)
$g\text{-}C_3N_4$	13.16	0.073	220.9
ZnO	15.01	0.056	149.3
ZCN1	29.56	0.166	224.9
ZCN2	29.11	0.143	196.5
ZCN3	27.92	0.147	210.3
ZCN4	28.53	0.143	201.1



PEC-WS Mechanism

Sample	E_{fb} (V vs. RHE)	N_D (cm^{-3}) * 10^{20}
$g\text{-}C_3N_4$	-0.95	0.81
$TiO_2/g\text{-}C_3N_4$	-0.65	4.91
ZnO	-0.12	3.35
TiO_2/ZnO	-0.11	4.95
ZCN3	-0.29	1.08
TiO_2/ZCN3	-0.18	5.84





Conclusion

The current lifestyle, characterized by various environmental problems, calls for adopting sustainable and eco-friendly energy sources. Photoelectrochemical water splitting (PEC-WS) based on solar energy, in particular, is an economical and eco-friendly approach for converting sunlight into hydrogen. In this regard, we developed a fabrication method that enables the in-situ growth of ZnO nanorods on $g\text{-}C_3N_4$, resulting in a $ZnO/g\text{-}C_3N_4$ composite with an enhanced specific surface area. The composite exhibits interfacial Zn-N bonding interactions. This composite demonstrated improved efficiency for a lower charge recombination rate with a Z-scheme type charge separation. We used an airbrushing procedure under mild heating to deposit $ZnO/g\text{-}C_3N_4$ on TiO_2, leading to a ternary composite photoanode. This photoanode displayed efficient charge carriers' separation and transfer due to improved interface properties. PEC-WS measurements showed that the as-fabricated $TiO_2/g\text{-}C_3N_4/ZnO$ heterostructure produced a photocurrent about 160-, 40-, 20-, 8-, 2-, and 2-fold higher than pristine $g\text{-}C_3N_4$, pristine ZnO nanorods, $ZnO/g\text{-}C_3N_4$ composite, pristine TiO_2, TiO_2/ZnO, and $TiO_2/g\text{-}C_3N_4$, respectively, at 1.23 V vs. RHE. To our knowledge, this is the first study to use these strategies to fabricate such ternary photoanodes. Our strategy could pave the way for synthesizing various $g\text{-}C_3N_4$-based ternary composites for PEC-WS. We believe this work will be of high interest as our approach is applicable to many ternary heterostructures and could be widely used as a universal strategy to increase the photocatalytic performance of various composites toward PEC-WS.

Acknowledgments