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Flower-Like Single Atom Lanthanum Doped 2D-Layered MXene for Electrocatalytic and Photocatalytic Applications

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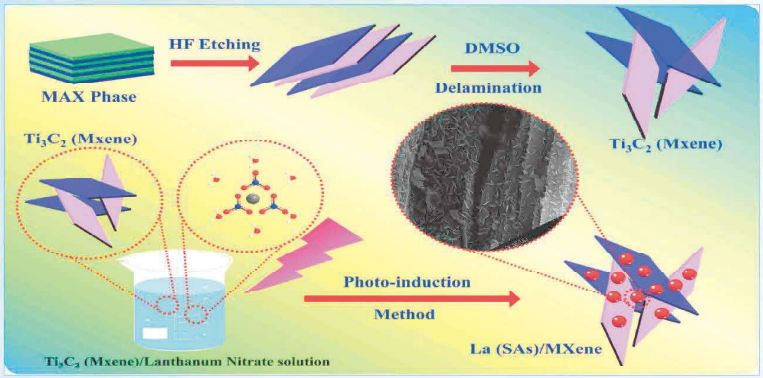
Abstract

Towards worldwide energy crisis and environmental pollution, scientists have sought excellent electrocatalysts for oxygen evolution reaction (OER) and photocatalysts to eliminate environmental pollutants. In this research, we synthesize and design rare-earth lanthanum (La) single atoms (SAs) doped on 2D-MXene as the active center for electrocatalysis/photocatalysis towards OER and diphenylamine (DPAH) degradation. The La-1 SAs/MXene electrocatalyst has a low overpotential of 160 mV at 10 mA/cm^2 and a Tafel potential of 63 mV/dec, respectively. The La SAs/MXene have excellent photocatalytic activity with higher degradation efficiency of 99 % within 70 min of treatment time. Additionally, the possible photocatalytic reaction mechanisms have been discussed. Our finding exhibited that La SAs/MXene-related materials will be suitable for environmental applications with outstanding performance.

Experimental



Results and Discussion

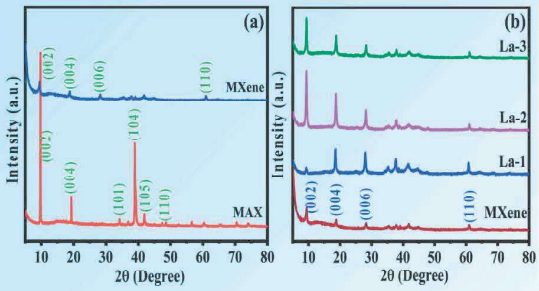


Fig.1 XRD patterns of the (a) MAX phase & MXene and (b) LA SAs/MXene

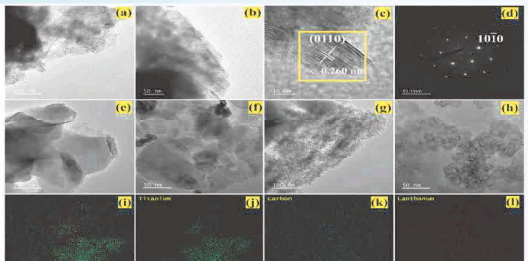


Fig. 2 (a & b) TEM images for La-1, (c) HRTEM images of La-1, (d) SAED patterns of La-1, (e & f) La-2 TEM images, (g & h) La-3 TEM images, (i) La/MXene overall EDX color mapping, (j) Ti, (k) C, and (i) La.

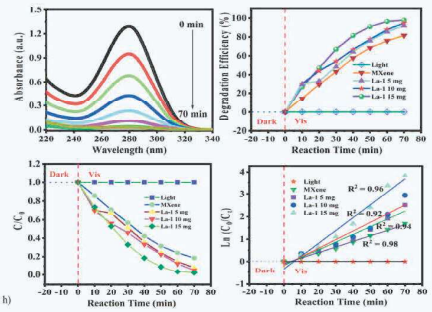


Fig.5 (a) UV-Vis absorbance spectra for DPAH concerning treatment time, (b & c) Degradation efficiency of DPAH for effect catalysis dosage, and (d) kinetic study for DPAH degradation concerning the effect of catalyst dosage.

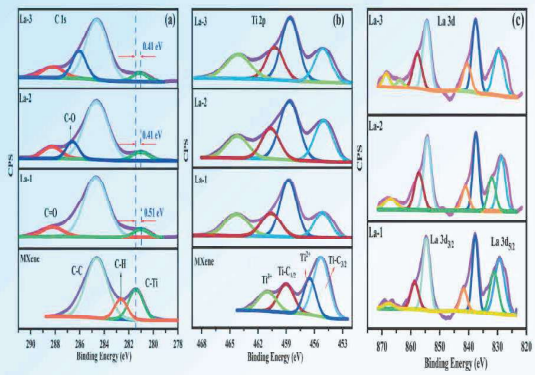


Fig.3 (a) XPS C1s spectra for Mxene and La doped Mxene, (b) XPS Ti 2p spctra for all samples, and (c) XPS La 3d spectra for La doped Mxene

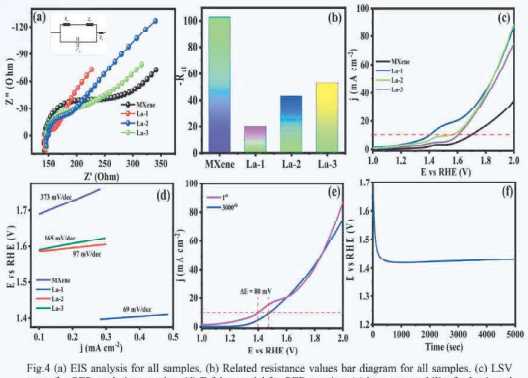


Fig.4 (a) EIS analysis for all samples, (b) Related resistance values bar diagram for all samples. (c) LSV curve for OER evolution reaction, (d) Tafel potential for OER reaction, (e) long-term stability for La-1, and (f) i-t curve for La-1 cyclic stability.

Conclusion

The proposed La SAs/MXene showed enormous electrocatalytic ability towards OER with a low overpotential of 160 mV at 10 mA cm^{-2} and a Tafel potential of 65 mV/dec, respectively. Moreover, the electrocatalyst exhibits long-term stability or durability during the OER activity. As prepared materials photocatalytic ability is evaluated towards degradation of DPAH. Overall, this research could provide a new approach for the rare-earth SAs related to 2D MXene catalysts for energy evolution and degradation of harmful environmental pollutants.