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In-Situ Oxidized MXene Dopes for Energy Harvesting and Piezo-Photocatalyst

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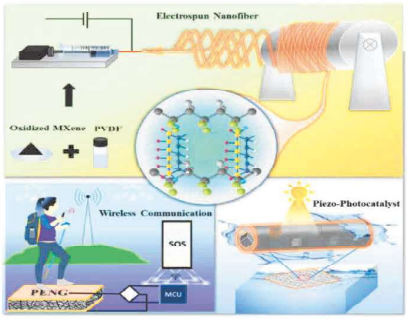
Abstract

We report partially oxidized MXene-incorporated polyvinylidene difluoride (PVDF) fibrous piezo-nanogenerators (MOP-PENG) for biomechanical energy harvesting, and piezo-assisted photocatalysis. MOP(5)-PENG, with 5 wt% MXene, achieves enhanced performance, delivering 14.4 V, 1.6 μA, and 1.5 μW cm⁻². It exhibits high tactile sensitivity (3.7 V/kPa) for digital information transmission. The addition of oxidized MXene enhances β-crystallinity, dielectric properties, and piezo-photocatalytic efficiency with 98% for Rhodamine B dye degradation. Synergistic piezoelectric and photocatalytic effects, along with a TiO_2-MXene heterojunction, improve charge separation and reaction kinetics.



Research Focus

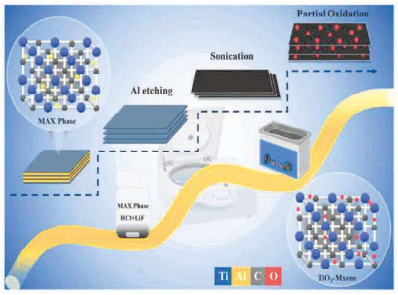


Fig. 1. Preparation process of MXene and partially oxidized MXene

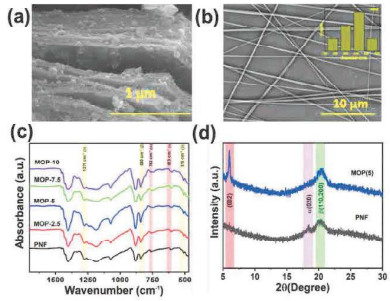


Fig. 2. FE-SEM. (a) Oxidized MXene (b) Oxidized MXene doped PVDF nanofibers (MOP(5)). (c) FTIR spectrum of PVDF and MOP NFs. (d) XRD spectra of PNF and MOP(5)

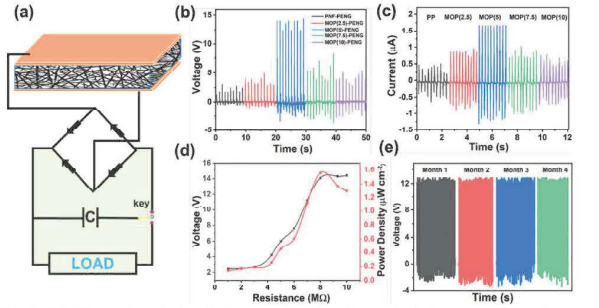


Fig. 3. (a) Illustration of circuit diagram for charging and discharging of capacitor. (b) Open-circuit voltage of PNF-PENG and MOP-PENGs. (c) Short circuit current. (d) Output voltage and power density as a function of resistance from 1 to 10 MΩ. (e) Stability and cyclic test of MOP(5)-PENG.

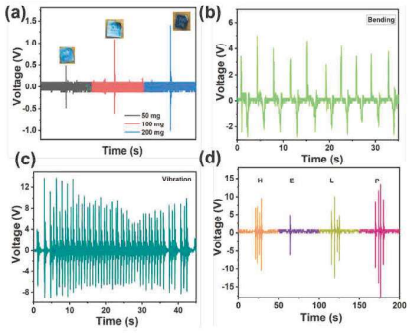


Fig. 4. (a) Sensitivity of device to various weights exerting different pressures. Biomechanical energy harvesting (b) Bending (c) Vibration (d) Transmission of signal "HELP"

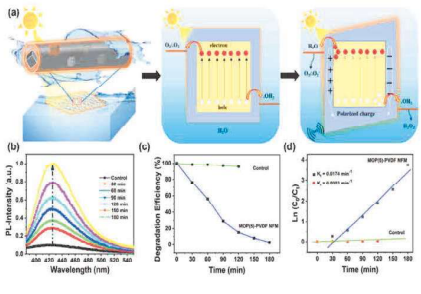


Fig 5. (a) Schematic representation of working of piezophotocatalyst (b) Fluorescent intensity of terephthalic acid solution (c) Degradation efficiency of MOP(5) and PNF (d) Rate constant for MOP(5) and PNF.

Summary

The MOP(5)-PENG demonstrates high sensitivity for energy harvesting from motions like bending, vibration, and stepping, while achieving 98% degradation of Rhodamine B dye via piezo-photocatalysis. This work paves the way for multifunctional devices in energy harvesting and environmental safety for the intelligence era.

Selected Journal Publications

1. **Jayashree Chandrasekar**, Manikandan Venkatesan, Ting-Wang Sun, Yung-Chi Hsu, Yu-Hang Huang, Wei-Wen Chen, Mei-Hsin Chen, Meng-Lin Tsai, Jung-Yao Chen, Ja-Hon Lin, Ye Zhou, Chi-Ching Kuo. "Recent progress in self-healable energy harvesting and storage devices-a future direction for reliable and safe electronics" *Mater. Horiz.*, 2024,**11**, 1395-1413.
2. **Jayashree Chandrasekar**, Manikandan Venkatesan, Ja-Hon Lin, Chi-Ching Kuo. "Purification of water using TiO_2/g-C_3N_4 nanocomposite: a visible light assisted photocatalytic activity" Zeitschrift für Physikalische Chemie,2024.
3. Manikandan Venkatesan, **Jayashree Chandrasekar**, Yung-Chi Hsu, Ting-Wang Sun, Po-Yu Li, Xuan-Ting King, Ming-An Chung, Ren-Jei Chung, Wen-Ya Lee, Ye Zhou, Ja-Hon Lin, Chi-Ching Kuo. "Rationally Improved Surface Charge Density of Triboelectric Nanogenerator with TiO_2-MXene/Polystyrene Nanofiber Charge Trapping Layer for Biomechanical Sensing and Wound Healing Application" Adv. Sci. 2024, 11, 2404019.

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