

# Modulation of the redox properties of solid-state materials for energy storage: low temperature electrodeless reactions in a microwave reactor

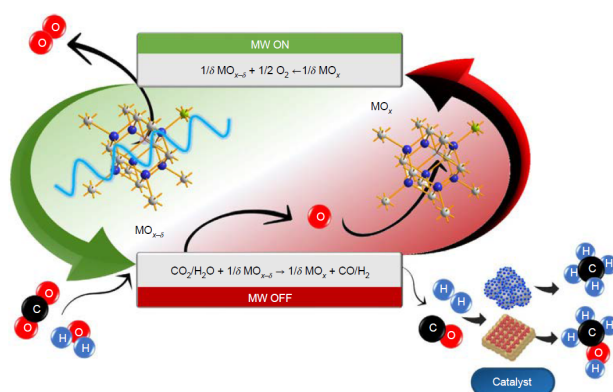
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The modulation of redox properties in solid-state materials plays a crucial role in enhancing their performance for energy storage applications. By tailoring oxidation states and defect chemistry, materials can achieve improved charge storage capacity, stability, and reversibility. In this work, we explore novel strategies to control redox behavior through electrodeless microwave-assisted reactions at low temperatures, performed in an ad-hoc microwave cavity. Unlike conventional electrochemical approaches, microwave-driven processes enable rapid and selective activation of redox-active sites, facilitating ion mobility. We investigate the impact of microwave irradiation on the structural and electronic properties of metal oxides and other functional materials, demonstrating significant enhancements in redox kinetics and energy storage capabilities. Additionally, we examine key reactions such as hydrogen and oxygen evolution, carbon monoxide production from CO<sub>2</sub> reduction, and selective oxidation processes. [1-3] These findings provide insights into alternative pathways for tuning redox properties, directly contributing to the electrification of chemical processes by reducing reliance on fossil-fuel-based thermal activation and enabling decentralized, on-demand reaction control. This study paves the way for new energy storage and catalytic technologies, promoting more sustainable and electrified chemical manufacturing.



Schematic illustration of the microwave-induced redox cycle. [1]

## References

- [1] J. M. Serra et al., Hydrogen production via microwave-induced water splitting at low temperature *Nat. Energy*, **2020**, 5, 910–919.
- [2] J. M. Serra et al., Modulating redox properties of solid-state ion-conducting materials using microwave irradiation *Mater. Horiz.*, **2023**, 10, 5796–5804.
- [3] A. Domínguez-Saldaña et al., Enhanced Hydrogen Production in Microwave-Driven Water-Splitting Redox Cycles by Engineering Ceria Properties, *Adv. Energy Mater.*, **2024**, 10, 2470165.