Mimicking Rock Chemistry for White Hydrogen Production: A Deep Dive Into Serpentinization Reaction Chemistry and Scalable White Hydrogen Generation

Alarfaj, Fatima (School: Alanjal Private School)

Hydrogen is a promising clean energy carrier, yet current production methods remain either carbon-intensive or economically unsustainable. Recently, attention has shifted to serpentinization, a natural reaction between ultramafic rocks and water that generates white hydrogen under specific geological conditions, offering carbon-free production at ~$1/kg. Despite increasing global interest, serpentinization remains poorly understood. Natural olivine, the primary reactive mineral, has inconsistent composition and limited reactivity, hindering scalability. In this novel study, a single-phase synthetic olivine was synthesized using the sol-gel method and optimized for crystallinity and $Fe^{2?}$ reactivity. It was characterized using XRD, FTIR, TGA, and SEM which confirmed >90% purity and a controlled Fe:Mg ratio.These features enabled controlled exploration of serpentinization kinetics and thermodynamics. Hydrogen production was tested under hydrothermal conditions (150°C, 24 h, 550 psi) in an autoclave reactor .Gas chromatography confirmed the formation of pure hydrogen, indicated by a pressure increase. Synthetic olivine produced 27× more hydrogen than natural olivine, attributed to increased phase purity, consistent crystallinity, and enhanced surface area due to clustered morphology. This work bridges a key knowledge gap in serpentinization chemistry and proposes a method to assess hydrogen production and purity based on mineral composition. Beyond lab success, synthetic olivine shows promise for use in depleted hydrocarbon reservoirs enabling hydrogen generation and long-term storage using existing infrastructure.This approach could make large-scale hydrogen energy more practical, affordable, and sustainable.

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