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The Challenges of Vanadium-based Alloys toward Applications for Hydrogen Storage

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Hydrogen storage in solid-state materials presents a safer and more compact alternative to compressed or liquid hydrogen. Vanadium (V)-based alloys, which typically crystallize in a body-centered cubic (BCC) structure, demonstrate high hydrogen storage capacities under ambient conditions—surpassing those of commercial AB_5 and AB_2-type alloys. However, the practical deployment of V-based alloys faces challenges such as limited cycling stability, high raw material cost, and difficulties in scaling up production. To address cycling stability, we propose the alloy designs that minimize initial lattice distortion. Furthermore, a novel ferrovanadium master alloy with strictly controlled impurity elements (e.g., Fe, Al, Si) has been developed to replace expensive pure vanadium, reducing raw material costs by over 90%. This approach enabled the development of a V–Ti–Cr–Fe quaternary alloy that achieves a reversible hydrogen capacity exceeding 2.6 wt.%, retains over 90% of its capacity after 2000 cycles and could be produced from the low-cost raw materials. Finally, a production line with an annual capacity of 100 tons has been established based on floating melting technology, demonstrating a viable path toward large-scale manufacturing.

References:

[1] H.-Y. Kong, Q.-F. Xie, C.-L. Wu, Y. Wang, Y.-G. Chen, H.-W. Li, Y.-G. Yan, Vanadium-based alloy for hydrogen storage: a review, Rare Metals (2024) 43(12):6201–6232.
[2] H. Y. Kong, Q. W. Huang, C. L. Wu, Y. Wang, Y.G. Chen, Y. Yan, Unraveling the intrinsic origins of defect formation in V-based alloys during hydrogen sorption cycles: Nano-scale hierarchical structures induced by lattice distortion, Nano Research, 2025, 18, 94907566.

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Born 14. 02. 1980 in Hubei Province, China. Dr. Yan completed his doctorate in materials science at Sichuan University in 2007. He worked as JSPS research fellow in IMR, Tohoku Unversity in 2008. He joined Empa, Swtizerland, as a senior scientist in 2011 and worked a postdoct in Aarhus Unversity, Denmark, in 2016. He returned to Sichuan University as a Research Fellow in 2018 and led the group of Materials and System Integration for Hydrogen Energy. He was a co-founder of Chengdu H_2-Store Technology Co., Ltd in 2023.