Electronic Supplementary Material

Utilization of waste vanadium-bearing resources in the preparation of rare-earth vanadate catalysts for semi-hydrogenation of *α,β*-unsaturated aldehydes

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Table S1 ICP analysis of the solid waste sample.

Elements	Concentration/(ppm)
V	30676
Ni	9941
Fe	1881
Al	628
Ca	445
Mo	390
Na	382
P	131
K	118
Zn	90
Mg	72
Cr	53
Ti	48
Co	31
Sn	28

Table S2 Leaching efficiency of metals from carbon black waste by different methods.

Elemental	V	Ni	Fe
NaOH leaching method	92.3%	6.5%	9.7%
HNO_3 leaching method	95.7%	88.5%	79.2%

Table S3 ICP analysis of the hydrothermal product by using iron ions as the foreign metal cation.

Elements	Concentration/(ppm)
V	244976
Na	1035
Fe	245316

Data were obtained from the ICP test.

Table S4 ICP analysis of the hydrothermal products by using Co^{2+} as the foreign metal cation.

Elements	Concentration/(ppm)
V	281206
Na	1096
Co	996

Data were obtained from the ICP test.

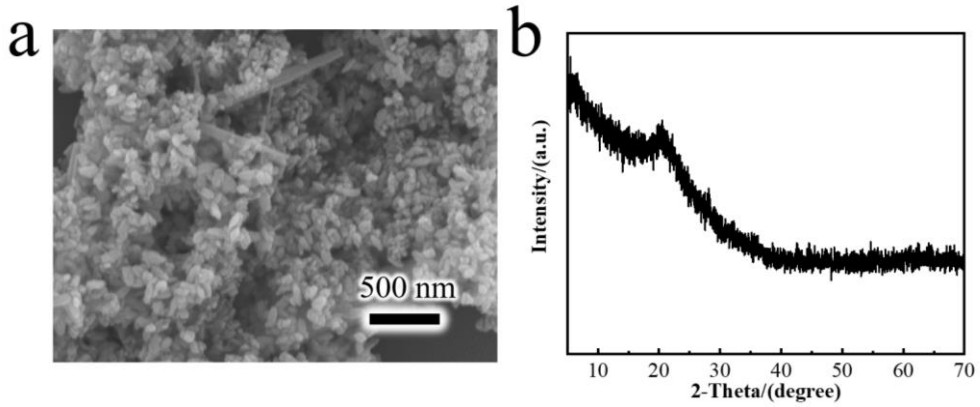

Figure S1 (a) SEM image and (b) XRD pattern of hydrothermal products with iron ions as the foreign metal cation.

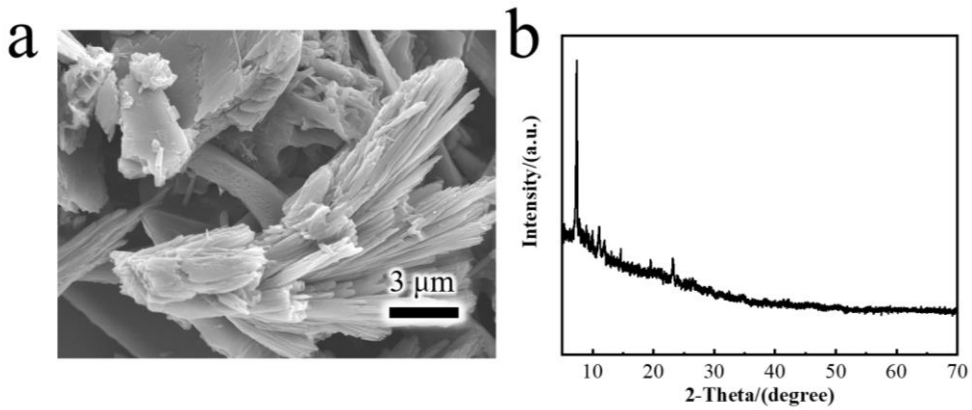

Figure S2 (a) SEM image and (b) XRD pattern of hydrothermal products with cobalt ions as the foreign metal cation.

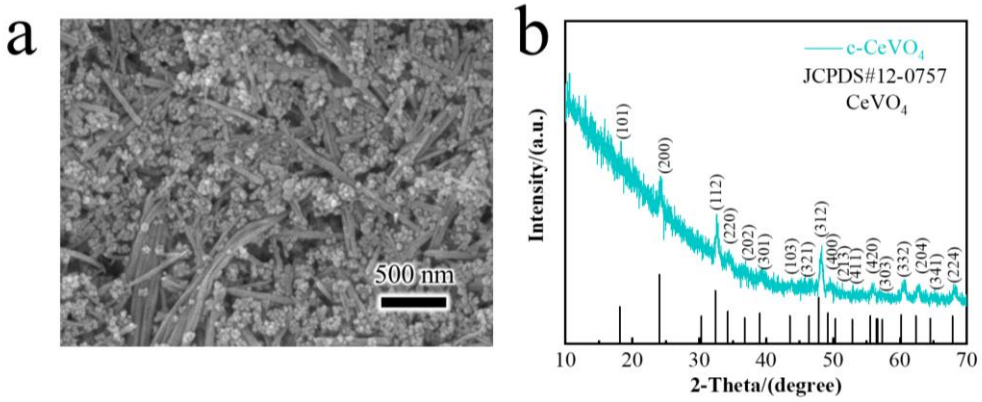

Figure S3 (a) SEM image and (b) XRD pattern of the c-$CeVO_4$ sample.

Comment: The preparation method of the c-$CeVO_4$ sample was based on a reported method with some modifications [1, 2]. First, 3.4 g of $Ce(NO_3)_3 \cdot 6H_2O$ was dissolved in 40 mL of deionized water to obtain a slightly transparent solution (solution A). Then 0.916 g of NH_4VO_3 was

dissolved in 40 mL of deionized water at 80 ℃ (solution B). Solution A was slowly added to solution B, and the mixture was stirred and heated in a water bath at 80 ℃ for 2 h. Finally, the resulting dark brown precipitate was washed with deionized water and ethanol. The product was then dried in an oven at 100 ºC for 2 h.

References

1. Zonarsaghar A, Mousavi-Kamazani M, Zinatloo-Ajabshir S. Co-precipitation synthesis of $CeVO_4$ nanoparticles for electrochemical hydrogen storage. Journal of Materials Science: Materials in Electronics, 2022, 33(9): 6549-6554
2. Ameri V, Eghbali-Arani M, Pourmasoud S. New route for preparation of cerium vanadate nanoparticles with different morphology and investigation of optical and photocatalytic properties. Journal of Materials Science: Materials in Electronics, 2017, 28(24): 18835-18841