

## **A systematic review of protective encapsulation for hydrogen storage materials: inorganic barriers and organic matrices**

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Table S1 Inorganic encapsulation strategies enhance the performance of hydrogen storage composites.

Hydrogen storage composites	Synthesis method	Air stability	Hydrogen storage capacity	Hydrogen adsorption and desorption performance	Quantitative retention after air exposure	Ref
Mg-cGNR	Chemical reduction	6 months	7.1~7.29 wt.%	$E_a$ (hydrogenation): 90 kJ·mol <sup>-1</sup> $E_a$ (dehydrogenation): 140 kJ·mol <sup>-1</sup>	Not mentioned	43
Mg-rGO	Chemical reduction	3 months	7.56 wt.%	$E_a$ (hydrogenation): 60.8 kJ·mol <sup>-1</sup> $E_a$ (dehydrogenation): 92.9 kJ·mol <sup>-1</sup>	Not mentioned	45
La(Ni <sub>0.95</sub> Fe <sub>0.05</sub> ) <sub>5</sub> -rGO/EC	Ultrasonic dispersion-solvent evaporation	20 days	1.30 wt.% (by total mass)	$\Delta H$ (hydrogenation): 31.95 kJ·mol <sup>-1</sup> $\Delta H$ (dehydrogenation): 35.81 kJ·mol <sup>-1</sup> $E_a$ (hydrogenation): 31 kJ·mol <sup>-1</sup> $E_a$ (dehydrogenation): 43 kJ·mol <sup>-1</sup>	Not mentioned	50
MgH <sub>2</sub> -3D activated carbon	Chemical reduction	2 weeks	6.63 wt.%	$\Delta H$ (hydrogenation): 49.1 kJ·mol <sup>-1</sup> $\Delta H$ (dehydrogenation): 46.9 kJ·mol <sup>-1</sup> $E_a$ (hydrogenation): 64.1 kJ·mol <sup>-1</sup> $E_a$ (dehydrogenation): 107.2 kJ·mol <sup>-1</sup>	Not mentioned	52
Mg-carbon	Hydrogen plasma metal reaction	3 months	6.3 wt.%	$E_a$ (hydrogenation): 64.1 kJ·mol <sup>-1</sup> $E_a$ (dehydrogenation): 107.2 kJ·mol <sup>-1</sup>	Not mentioned	55
Mg <sub>60</sub> Al <sub>40</sub> -graphite	Ball milling	2 years (non-inactivated)	3.67 wt.%	$E_a$ (dehydrogenation): 129.7 kJ·mol <sup>-1</sup>	Not mentioned	56
MgH <sub>2</sub> -NGNSs	Hydrogenation deposition	3 months	6.5 wt.%	Hydrogenation: 6.5 wt.% H <sub>2</sub> (200 °C, 0.4 h) Dehydrogenation: 5.5 wt.% H <sub>2</sub> (300 °C, 0.5 h)	Capacity loss: 1.0 wt. %	58
NaAlH <sub>4</sub> -GOF	Wet impregnation-thermal hydrogenation	7 days	1.01 wt.% (by total mass)	$E_a$ (dehydrogenation): 47.13 kJ·mol <sup>-1</sup> (NaAlH <sub>4</sub> ) and 108.45 kJ·mol <sup>-1</sup> (Na <sub>3</sub> AlH <sub>6</sub> )	Capacity loss: 32%	59
Mg <sub>2</sub> NiH <sub>4</sub> -MgO	Hydrogen chemical vapor deposition	Several months	Not mentioned	$E_a$ (dehydrogenation): 31.2 kJ·mol <sup>-1</sup>	Not mentioned	66

MgH <sub>2</sub> -CeO <sub>2</sub>	High-energy ball milling	168 h	5.3 wt.%	$E_a$ (dehydrogenation): 79 kJ·mol <sup>-1</sup>	Capacity: 4.7 wt.% $E_a$ (dehydrogenation): 82 kJ·mol <sup>-1</sup>	73
Al-Bi	High-energy ball milling	2 months	Not mentioned	Hydrogen production rate in water: 287 (55 °C) and 713 (70 °C) mL/(min · g)	Not mentioned	83
MgH <sub>2</sub> -NbF <sub>5</sub>	Ball milling	24 h	5.0 wt.%	$E_a$ (dehydrogenation): 98 kJ·mol <sup>-1</sup>	Capacity: 5.0 wt.% $E_a$ (dehydrogenation): 144 kJ·mol <sup>-1</sup>	88

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Table S2 Organic polymer encapsulation strategies enhance the performance of hydrogen storage composites.

Hydrogen storage composites	Synthesis method	Air stability	Hydrogen storage capacity	Hydrogen adsorption and desorption performance	Quantitative retention after air exposure	Ref
Mg(NH <sub>2</sub> ) <sub>2</sub> /2LiH-TPX <sup>TM</sup> 6Mg(NH <sub>2</sub> ) <sub>2</sub> /9LiH/LiBH <sub>4</sub> -TPX <sup>TM</sup>	Solution casting method	12 h	4.3 and 4.0 wt. %	Initial dehydrogenation temperature: 140 and 130 °C	Capacity loss: 0.021 wt. % per cycle and Capacity: 3.0 wt. % Not mentioned	94
Mg-PE	Chemical reduction	3 months	3.94 wt. %	Not mentioned	Not mentioned	113
NaBH <sub>4</sub> -PS	Co-precipitation	3 h	Not mentioned	Not mentioned	Weight gain: 30%	117
MgH <sub>2</sub> -PS	Organometallic hydrogenolysis	24 h	5.8 wt. %	<i>E<sub>a</sub></i> (dehydrogenation): 171.3 kJ·mol <sup>-1</sup>	Capacity loss: 30%	119
LaNi <sub>5</sub> -AES	Ball milling	17 h	0.5 wt. % (by total mass)	Not mentioned	Kinetic rate decline: 2.5 times	123
NaBH <sub>4</sub> -PABA/PEIm	Layer-by-layer assembly	24 h	Not mentioned	Not mentioned	Weight gain: < 25%	129
Mg-PMMA	One-pot reduction method	2 weeks	5.97 wt. %	<i>E<sub>a</sub></i> (hydrogenation): 24.5 kJ·mol <sup>-1</sup> <i>E<sub>a</sub></i> (dehydrogenation): 79.5 kJ·mol <sup>-1</sup>	Not mentioned	46
LaNi <sub>5</sub> -PMMA, TiMn <sub>2</sub> -PMMA, Mg <sub>2</sub> Ni-PMMA	Solution impregnation	168 h	1.30 wt. %, 1.23 wt. %, 2.85 wt. % (after exposure)	Dynamic performance slightly decreased after packaging.	Weight gain: 0.03 wt. %, ~0.00 wt. %, 0.16 wt. %	133
Mg-PMMA	Chemical reduction	3 months	6.94 wt. %	Not mentioned	Not mentioned	113
Mg-MWCNT/PMMA, Mg-PMMA	Chemical reduction	10 days, 30 days	6.7 wt. %, 5.25 wt. %	Hydrogenation: 6.7 wt. % H <sub>2</sub> (200 °C, 20 bar) Dehydrogenation: 5.5 wt. % H <sub>2</sub> (150 °C, 0 bar), Initial (de)hydrogenation temperatures: 150 and 140 °C	Not mentioned	134

NaAlH <sub>4</sub> -PEIS, NaAlH <sub>4</sub> -PEIS/MWCNT	Solution precipitation	24 h	1.1 wt.%, 1.2 wt.%	Initial dehydrogenation temperatures: 182, 185 °C Hydrogenation: 1.1, 1.2 wt.% H <sub>2</sub> (120 °C, 32 bar, 12 h)	Not mentioned	<a href="#">32</a>
NaAlH <sub>4</sub> -PANI/TiO <sub>2</sub>	Spray drying	24 h	0.95 wt.%	Initial dehydrogenation temperatures: 180 °C Hydrogenation: 0.95 wt.% H <sub>2</sub> (120 °C, 32 bar, 12 h)	Not mentioned	<a href="#">32</a>
Mg-PPy	Electrochemical deposition	1 week	Not mentioned	Initial dehydrogenation temperatures: 125 °C	Not mentioned	<a href="#">145</a>

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