Supplementary Information for

## Rapid room-temperature synthesis of ultrasmall cubic Mg-Mn spinel

## cathode materials for rechargeable Mg-ion battery

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Fig. S1. Mn K-edge XANES spectra of MMO and MMO-G.



Fig. S2. dQ/dV curves of MMO and MMO-G cathodes.



Fig. S3. Mn *K*-edge XANES spectra of MMO-G electrode after 1st and 10th charge.

Particle	Electrolyte	Discharge	Current	Ref.
size		capacity	density	
Not	Mg(TFSA) <sub>2</sub> /CsTFSA	150 mAh g <sup>-1</sup>	$13.5 \text{ mA g}^{-1}$	[12]
indicated	(150°C)	200 mAh g <sup>-1</sup>	$5.4 \text{ mA g}^{-1}$	
200 nm	$0.2 \text{ M Mg(Ac)}_2$	102 mAh g <sup>-1</sup>	Not	[15]
	$+ 0.1 \text{ M AlCl}_3/PC$		indicated	
17 nm	0.5 M Mg(ClO <sub>4</sub> ) <sub>2</sub>	120 mAh g <sup>-1</sup>	10 µA	[16]
	/EC-DEC			
11 nm	0.5 M Mg(TFSA) <sub>2</sub>	220 mAh g <sup>-1</sup>	27 mA g <sup>-1</sup>	[18]
	+ 0.5 M DPGDME/AN	$80 \text{ mAh } \text{g}^{-1}$	135 mA g <sup>-1</sup>	
31 nm	0.5 M Mg(TFSA) <sub>2</sub>	70 mAh g <sup>-1</sup>	27 mA g <sup>-1</sup>	[18]
	+ 0.5 M DPGDME/AN	$50 \text{ mAh g}^{-1}$	135 mA g <sup>-1</sup>	
40 nm	0.5 M Mg(ClO <sub>4</sub> ) <sub>2</sub> /AN	100 mAh g <sup>-1</sup>	$4 \text{ mA g}^{-1}$	[19]
120 nm	Mg(TFSA) <sub>2</sub> /EC-PC	225 mAh g <sup>-1</sup>	$1 \text{ mA g}^{-1}$	[23]
5 nm	0.5 M Mg(ClO <sub>4</sub> ) <sub>2</sub> /AN	230 mAh g <sup>-1</sup>	$10 \text{ mA g}^{-1}$	This
		150 mAh g <sup>-1</sup>	190 mA g <sup>-1</sup>	work
	Particle size Not indicated 200 nm 17 nm 11 nm 31 nm 40 nm 120 nm 5 nm	Particle sizeElectrolyteNotMg(TFSA)2/CsTFSAindicated $(150^{\circ}C)$ 200 nm0.2 M Mg(Ac)2 + 0.1 M AlCl3/PC17 nm0.5 M Mg(ClO4)2 /EC-DEC11 nm0.5 M Mg(TFSA)2 + 0.5 M DPGDME/AN31 nm0.5 M Mg(TFSA)2 + 0.5 M DPGDME/AN40 nm0.5 M Mg(ClO4)2/AN120 nmMg(TFSA)2/EC-PC5 nm0.5 M Mg(ClO4)2/AN	Particle size Electrolyte Discharge capacity   Not Mg(TFSA)_2/CsTFSA 150 mAh g <sup>-1</sup> indicated $(150^{\circ}C)$ 200 mAh g <sup>-1</sup> 200 nm 0.2 M Mg(Ac)_2 102 mAh g <sup>-1</sup> + 0.1 M AlCl_3/PC 120 mAh g <sup>-1</sup> 17 nm 0.5 M Mg(ClO_4)_2 120 mAh g <sup>-1</sup> /EC-DEC 120 mAh g <sup>-1</sup> 11 nm 0.5 M Mg(TFSA)_2 220 mAh g <sup>-1</sup> + 0.5 M DPGDME/AN 80 mAh g <sup>-1</sup> 31 nm 0.5 M Mg(TFSA)_2 70 mAh g <sup>-1</sup> + 0.5 M DPGDME/AN 50 mAh g <sup>-1</sup> 40 nm 0.5 M Mg(ClO_4)_2/AN 100 mAh g <sup>-1</sup> 120 nm Mg(TFSA)_2/EC-PC 225 mAh g <sup>-1</sup> 120 nm 0.5 M Mg(ClO_4)_2/AN 230 mAh g <sup>-1</sup> 5 nm 0.5 M Mg(ClO_4)_2/AN 230 mAh g <sup>-1</sup>	Particle sizeElectrolyteDischarge capacityCurrent densityNotMg(TFSA)_2/CsTFSA150 mAh g^{-1}13.5 mA g^{-1}indicated(150°C)200 mAh g^{-1}5.4 mA g^{-1}200 nm0.2 M Mg(Ac)_2102 mAh g^{-1}Not+ 0.1 M AlCl_3/PC102 mAh g^{-1}10 $\mu$ A17 nm0.5 M Mg(ClO_4)_2120 mAh g^{-1}10 $\mu$ A/EC-DEC11 nm0.5 M Mg(TFSA)_2220 mAh g^{-1}135 mA g^{-1}31 nm0.5 M Mg(TFSA)_270 mAh g^{-1}27 mA g^{-1}40 nm0.5 M Mg(ClO_4)_2/AN50 mAh g^{-1}135 mA g^{-1}120 nmMg(TFSA)_2/EC-PC225 mAh g^{-1}1 mA g^{-1}5 nm0.5 M Mg(ClO_4)_2/AN230 mAh g^{-1}10 mA g^{-1}5 nm0.5 M Mg(ClO_4)_2/AN230 mAh g^{-1}10 mA g^{-1}

Table S1. Comparison of the cathode performances for MgMn<sub>2</sub>O<sub>4</sub> with anhydrous electrolytes.