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Supplemental Information

Ammonia-free synthesis of lithium manganese iron phosphate cathodes via a co-precipitation reaction

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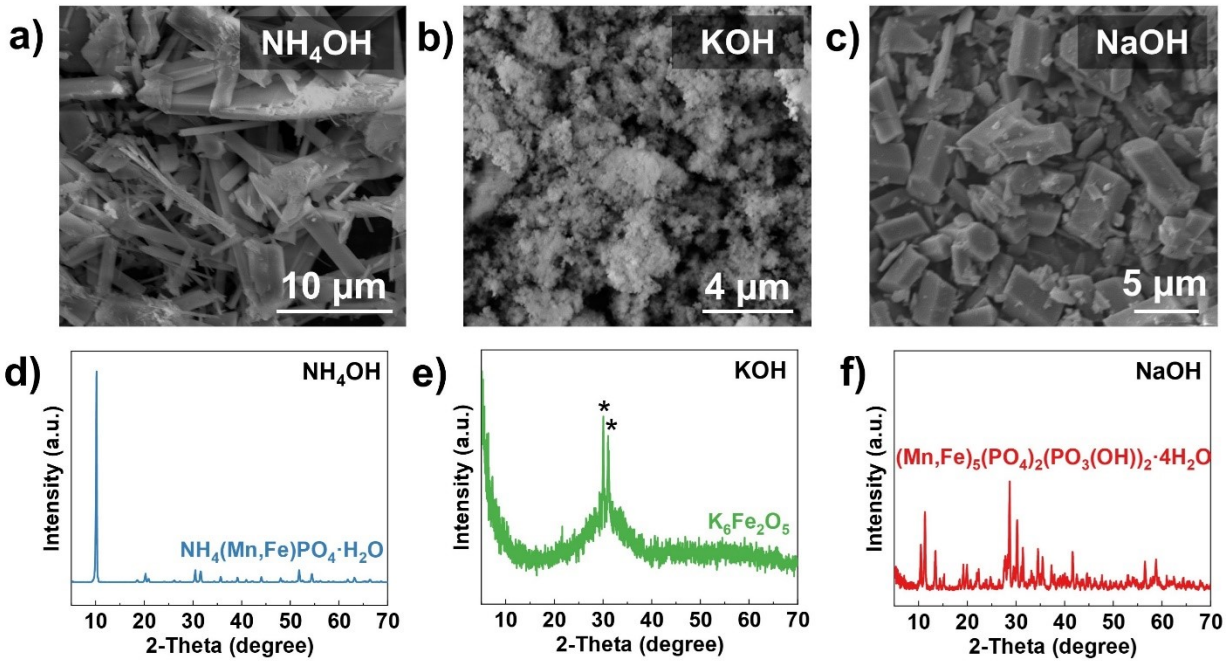

Fig. S1 Morphological and structural analysis of the precursors obtained with different basic solutions, including (a, d) NH4OH, (b, e) KOH, and (c, f) NaOH.

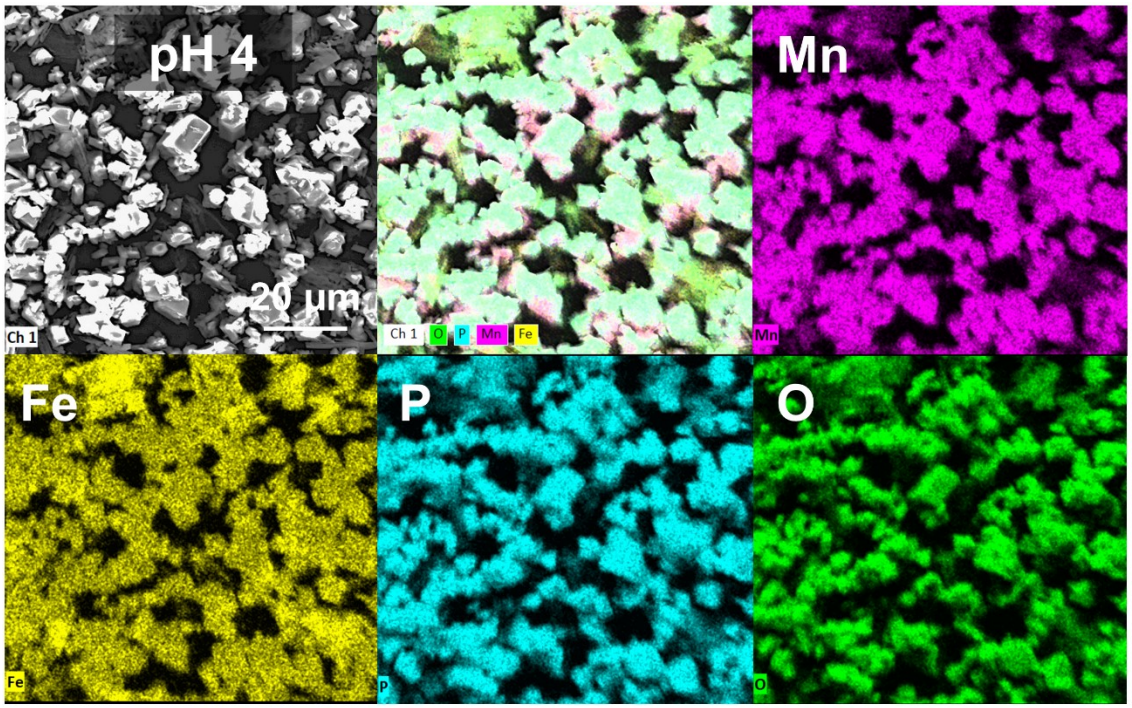

Fig. S2 SEM-EDS images of the MFP precursors obtained at pH = 4, where the mapping shows the distribution of each element, including Mn, Fe, P, and O.

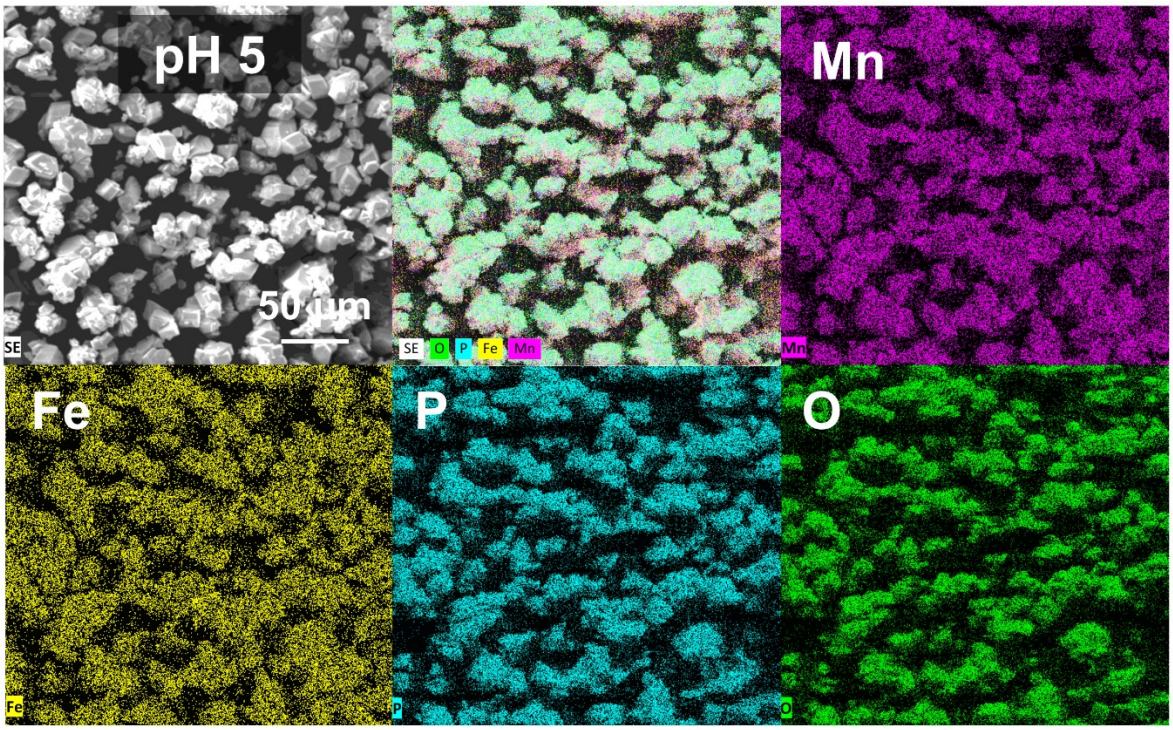

Fig. S3 SEM-EDS images of the MFP precursors obtained at pH = 5, where the mapping shows the distribution of each element, including Mn, Fe, P, and O.

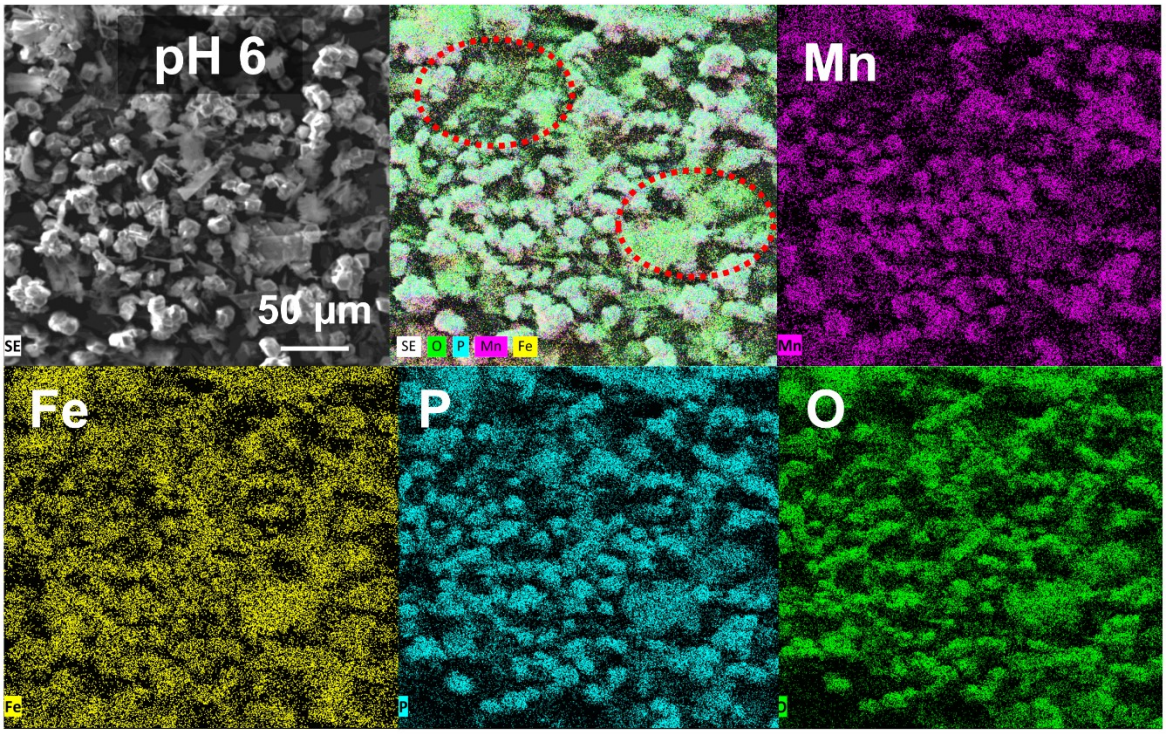

Fig. S4 SEM-EDS images of the MFP precursors obtained at pH = 6, where the mapping shows the distribution of each element, including Mn, Fe, P, and O.

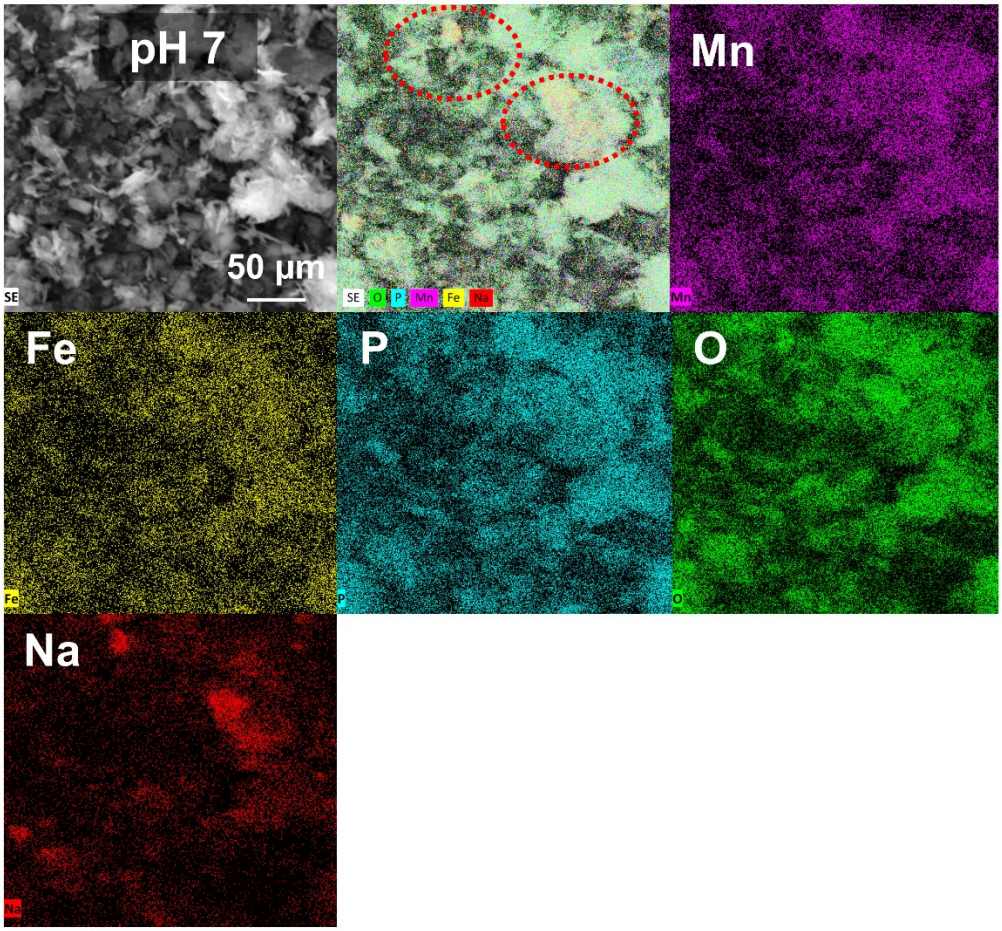

Fig. S5 SEM-EDS images of the MFP precursors obtained at pH = 7, where the mapping shows the distribution of each element, including Mn, Fe, P, O, and Na.

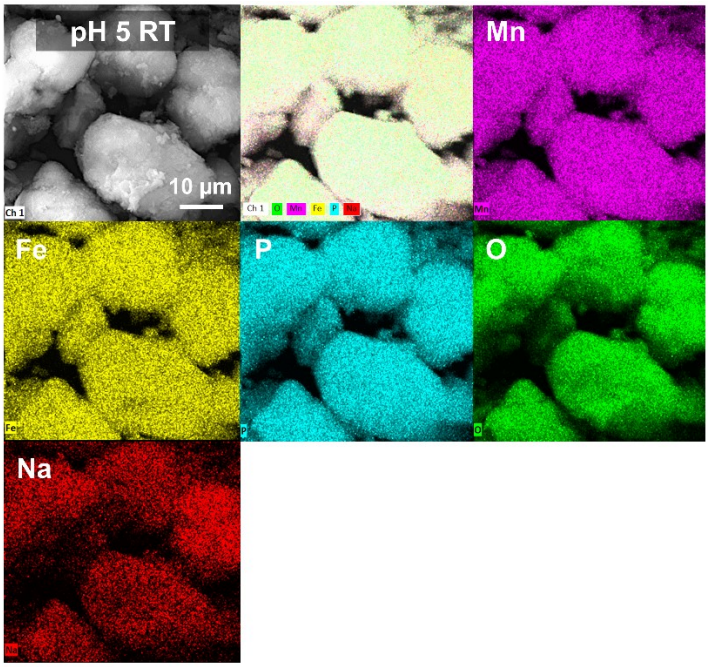

Fig. S6 SEM-EDS images of the MFP precursors obtained at pH = 5 at room temperature (25 °C), where the mapping shows the distribution of each element, including Mn, Fe, P, O, and Na.

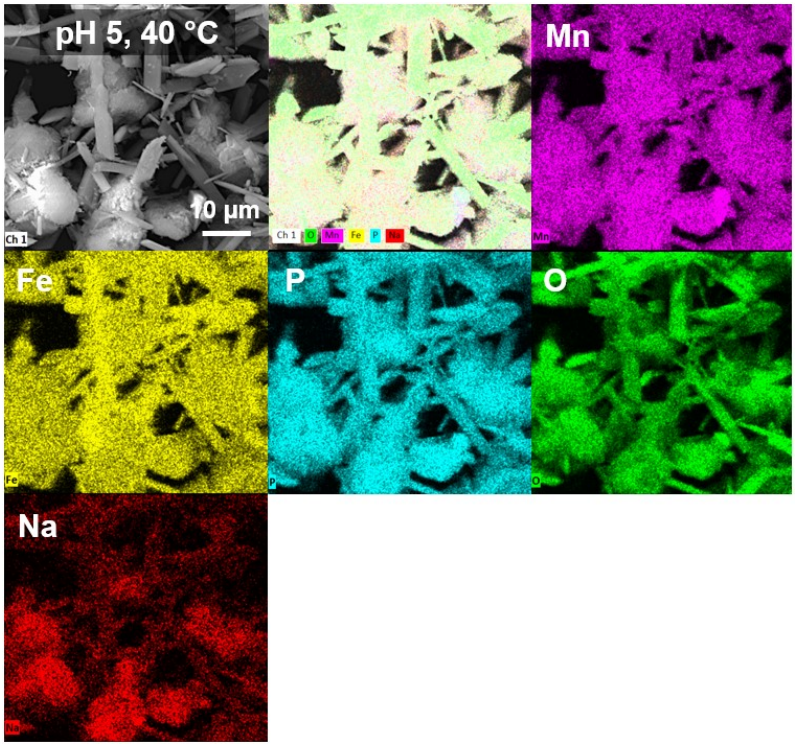

Fig. S7 SEM-EDS images of the MFP precursors obtained at pH = 5 at 40 °C, where the mapping shows the distribution of each element, including Mn, Fe, P, O, and Na.

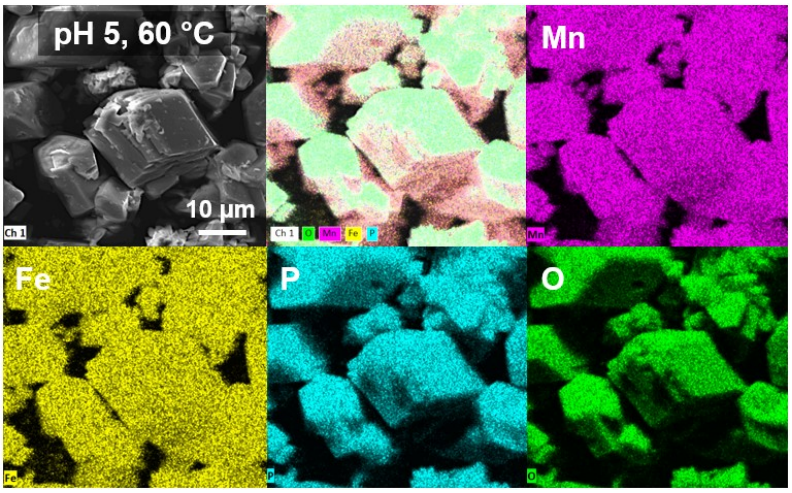

Fig. S8 SEM-EDS images of the MFP precursors obtained at pH = 5 at 60 °C, where the mapping shows the distribution of each element, including Mn, Fe, P, and O.

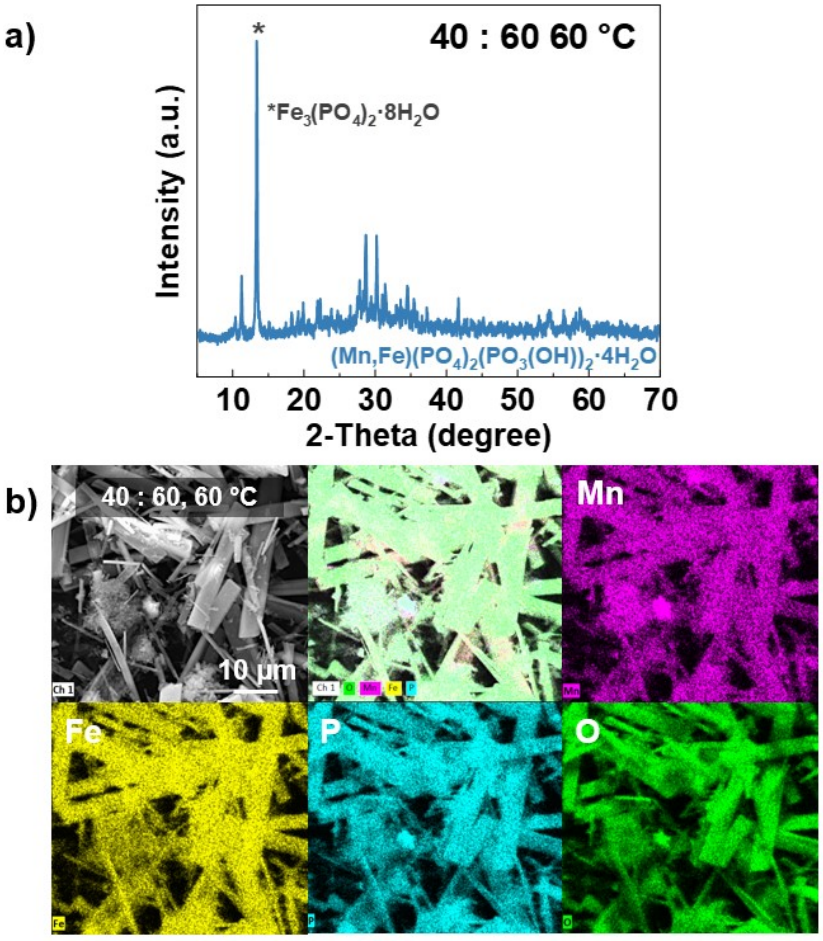

Fig. S9 Morphological and structural analysis of the MFP precursor with an Mn : Fe ratio of 40 : 60 at 60 °C: (a) XRD pattern and (b) SEM-EDS mapping of each element, including Mn, Fe, P, and O.

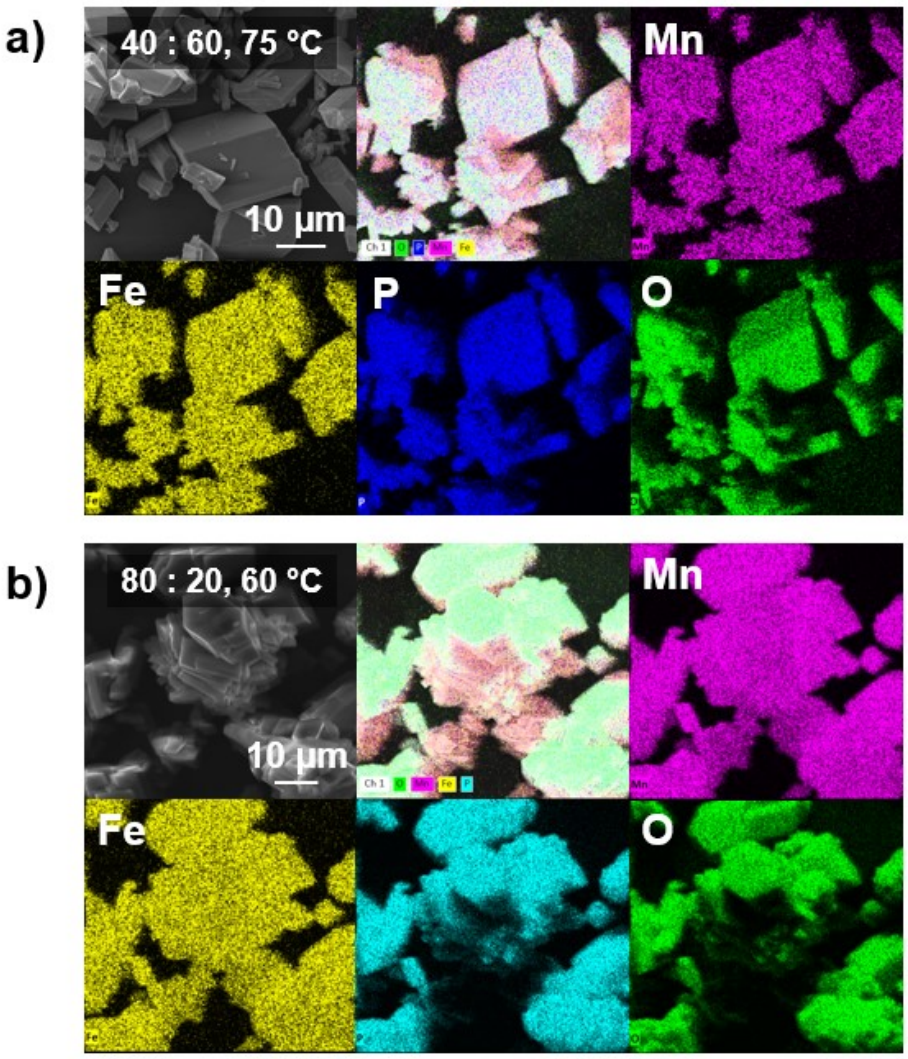

Fig. S10 SEM-EDS mapping showing the distribution of each element, including Mn, Fe, P, and O for (a) Mn : Fe = 40 : 60 at 75 °C and (b) 80 : 20 at 60 °C.

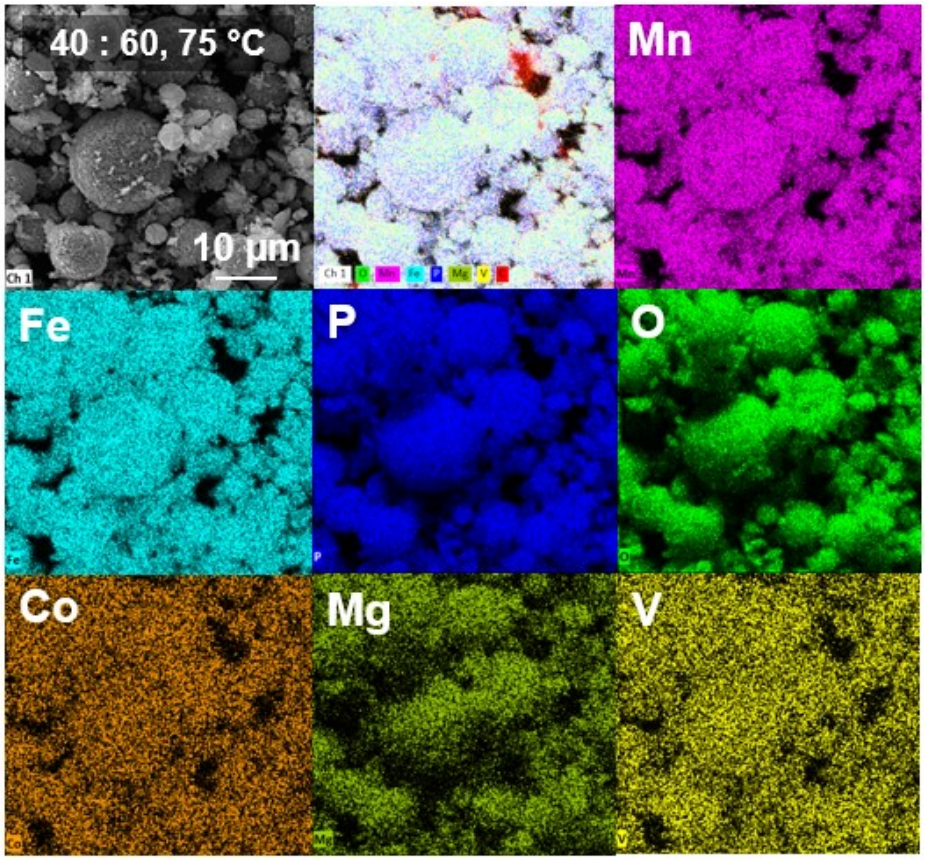

Fig. S11 SEM-EDS mapping of the LMFP cathode with a Mn : Fe ratio of 40 : 60 at 75°C to examine the distribution of each element, including Mn, Fe, P, O, Co, Mg, and V.

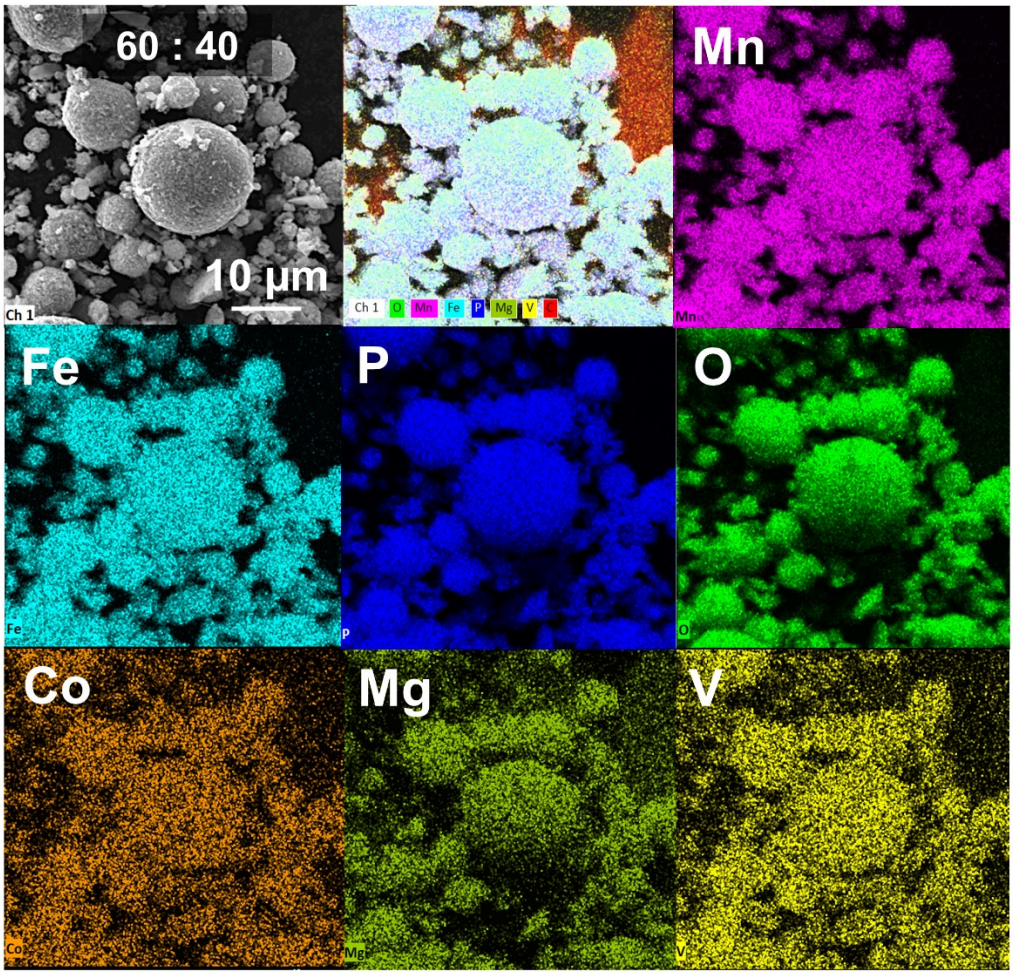

Fig. S12 SEM-EDS mapping of the LMFP cathode with a Mn : Fe ratio of 60 : 40 to examine the distribution of each element, including Mn, Fe, P, O, Co, Mg, and V.

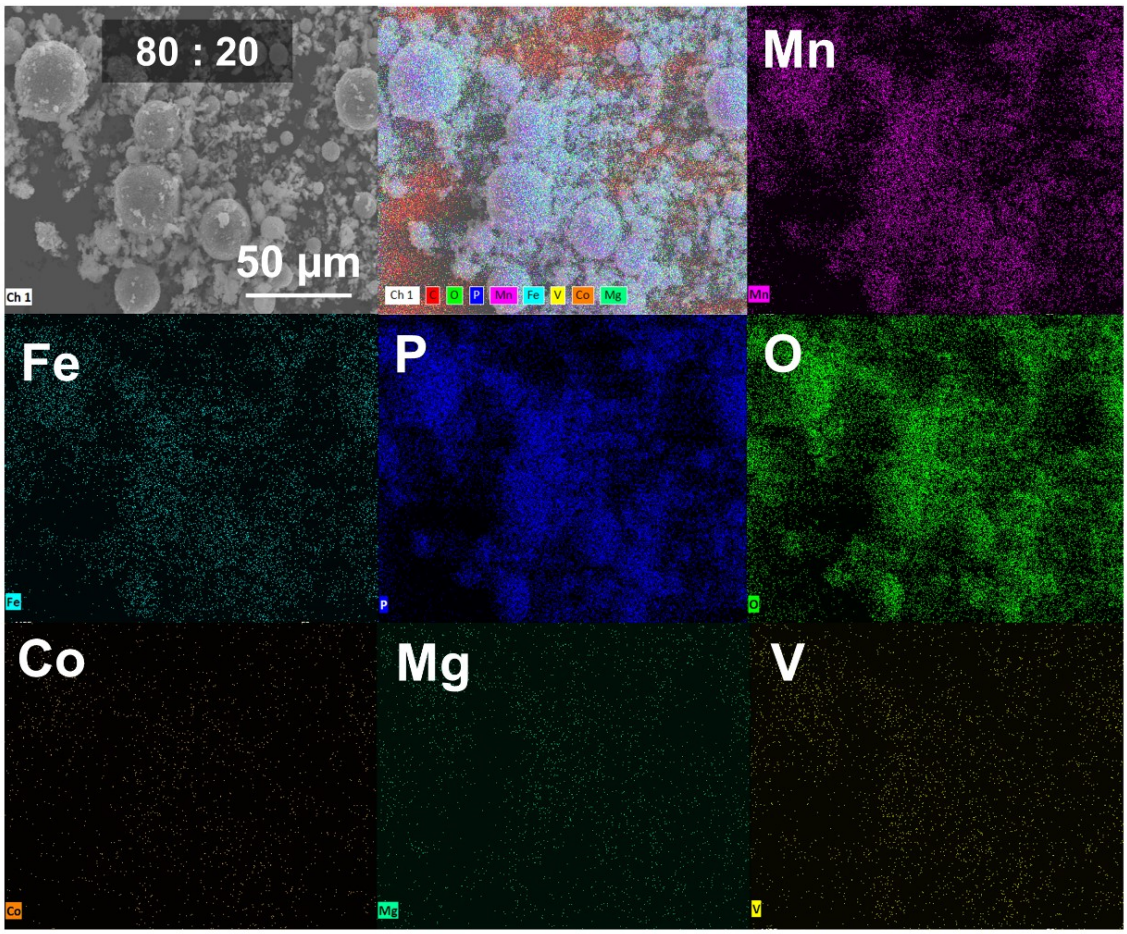

Fig. S13 SEM-EDS mapping of the LMFP cathode with a Mn : Fe ratio of 80 : 20 to examine the distribution of each element, including Mn, Fe, P, O, Co, Mg, and V.

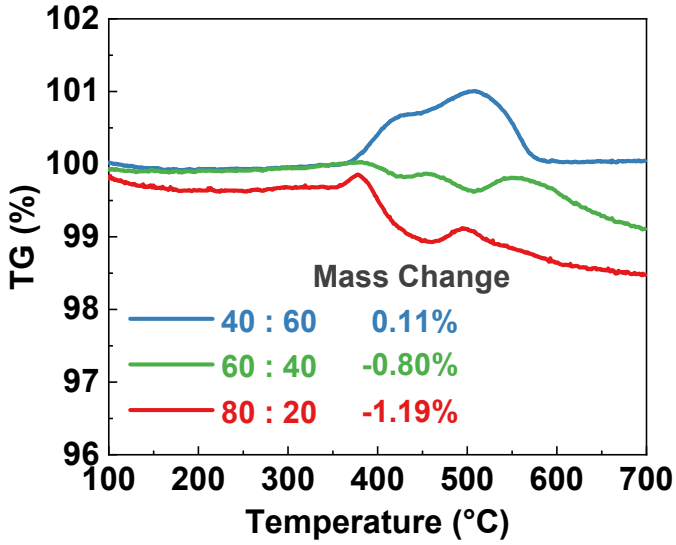

Fig. S14 TGA profiles of the LMFP cathodes, showing the amount of carbon content for the 40 : 60, 60 : 40, and 80 : 20 samples

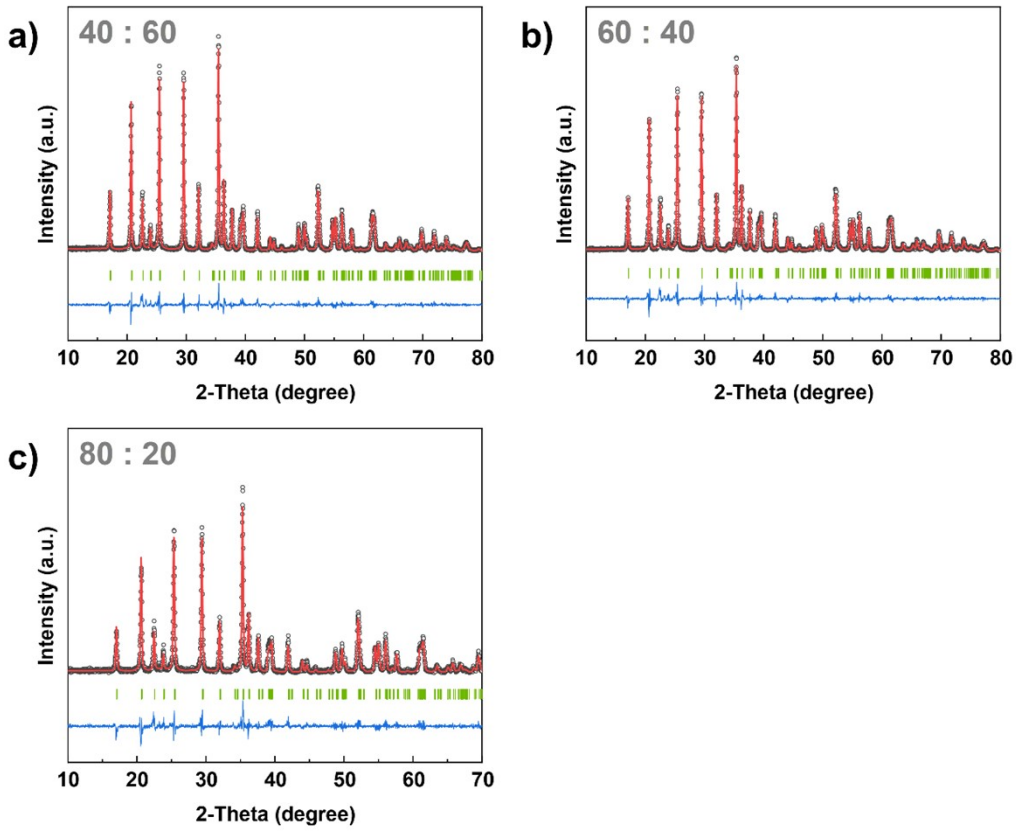

Fig. S15 Rietveld refinement profiles of the LMFP cathodes with a Mn : Fe ratio of (a) 40 : 60, (b) 60 : 40, and (c) 80 : 20 with respect to the LMFP pattern (COD#2300354) as the reference pattern.

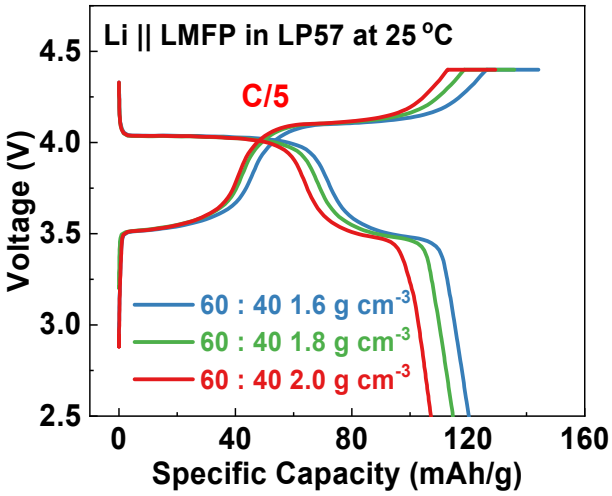

Fig. S16 Charge-discharge profiles of the first cycle at C/5 rate for the Mn : Fe = 60 : 40 sample with different packing densities.

Table S1 Elemental ratios of the precursors synthesized by the co-precipitation method as obtained from ICP-OES analysis with $FePO_4$ as the reference

Sample	Mn	Fe	P
Target Ratio	**0.600**	**0.400**	**0.67 for $M_2(PO4)_3$ phase 0.80 for $(Mn, Fe)_5(PO_4)_2(HPO_4)_2 \cdot 4H_2O$ phase 1.00 for NH_4MPO_4 phase**
$FePO_4$ (Reference)	0.001	0.999	1.057
MFP-NH_4OH	0.608	0.392	1.030
MFP-KOH	0.593	0.407	0.805
MFP-NaOH	0.661	0.339	0.818
MFP-pH 4	0.679	0.321	0.850
MFP-pH 5	0.617	0.383	0.841
MFP-pH 5-CA	0.704	0.296	0.844
MFP-pH 7	0.606	0.394	0.711
MFP-pH 5-RT	0.588	0.412	0.746
MFP-pH 5-40 °C	0.524	0.476	0.722
MFP-pH 5-60 °C	0.620	0.380	0.828

Table S2 Crystallographic data of LMFP (COD#2300354) used for performing the Rietveld refinement analysis

Parameter	$LiMn_{0.5}Fe_{0.5}PO_4$
Space Group	-P 2ac 2n (62)
a-axis (Å)	10.4072
b-axis (Å)	6.06188
c-axis (Å)	4.73357
α=β=γ (°)	90.00
V (Å^3)	298.628
Radiation	Cu $K\alpha_1$ (1.5405 Å)

Table S3 Structural information of LMFP (COD#2300354) used for performing the Rietveld refinement analysis

Element	Label	x	y	z	B	Occupancy
Li	Li1	0	0	0	0	0.996
Fe	Fe1	0.2828	0.25	0.9705	0	0.498
Mn	Mn1	0.2828	0.25	0.9705	0	0.498
P	P1	0.0952	0.25	0.4169	0	1
O	O1	0.0939	0.25	0.731	0	1
O	O2	0.4495	0.25	0.2062	0	1
O	O3	0.1604	0.0537	0.2778	0	1
Fe	Fe2	0	0	0	0	0.002
Mn	Mn2	0	0	0	0	0.002
Li	Li2	0.2828	0.25	0.9705	0	0.004