Supplementary Information

Investigation on the Air Stability of P2-Layered Transition Metal Oxides by Nb Doping in Sodium Ion Batteries

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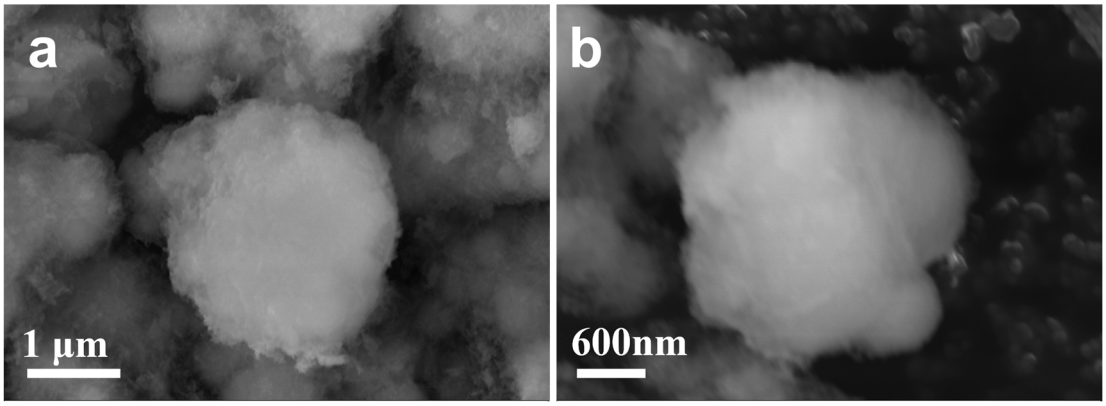


Fig. S1(a) The precursor SEM of P2-$Na_{0.67}$MN and P2-$Na_{0.67}$MNNb. (b) The precursor SEM of P2-$Na_{0.67}$MN and P2-$Na_{0.67}$MNNb.

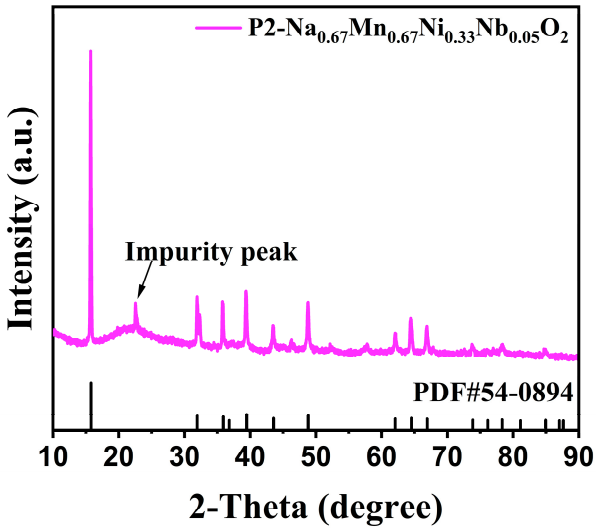


Fig. S2 The XRD patterns of P2-$Na_{0.67}Mn_{0.67}Ni_{0.33}Nb_{0.05}O_2$.

After mixed with Nb_2O_5, $Na_{0.67}Mn_{0.67}Ni_{0.33}Nb_{0.03}O_2$ had no impurity peak, but $Na_{0.67}Mn_{0.67}Ni_{0.33}Nb_{0.05}O_2$ had impurity peak generation, indicating redundant niobium had not been into the bulk phase. When the doping amount of Nb was 0.05, the impurity peak in 22.5° can be labeled as Na_3NbO_4.

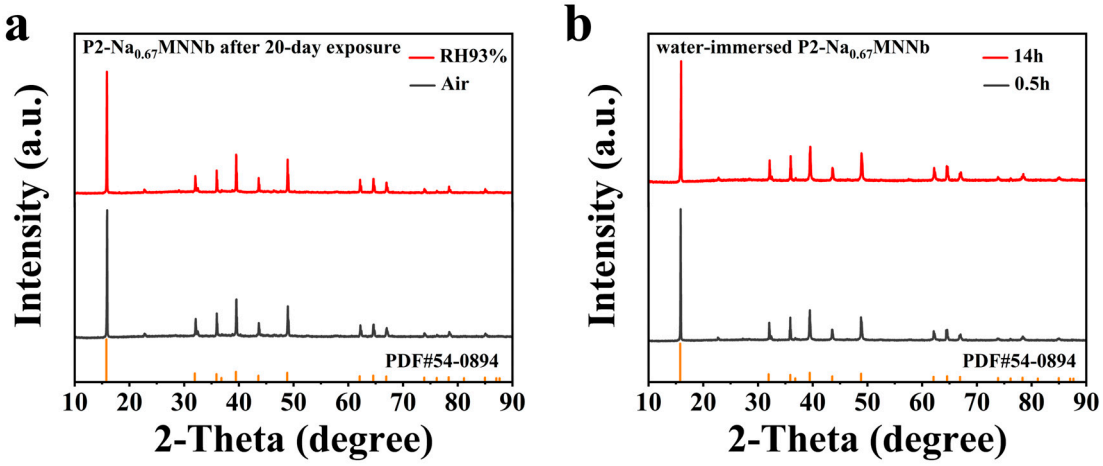


Fig. S3 (a) The XRD patterns of P2-$Na_{0.67}$MNNb sample exposed in different atmosphere after 20-day exposure. (b) The XRD patterns of water-immersed P2-$Na_{0.67}$MNNb sample.

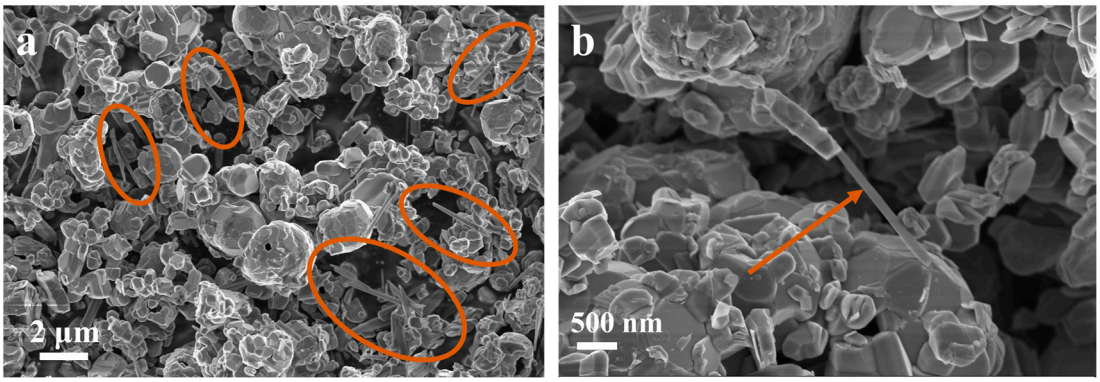


Fig. S4 (a) The SEM of P2-$Na_{0.67}MN$ after 20 days of air exposure. (b) The SEM of P2-$Na_{0.67}MN$ after 20 days of air exposure.

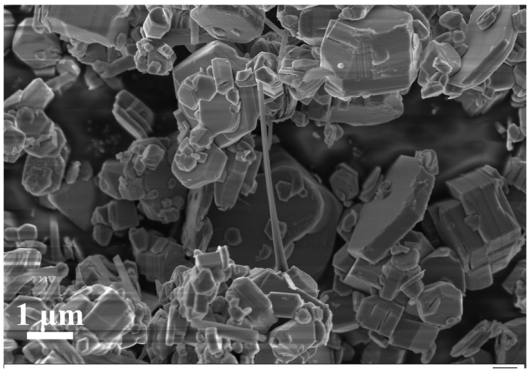


Fig. S5 The SEM of P2-$Na_{0.67}$MNNb after 20 days of air exposure.

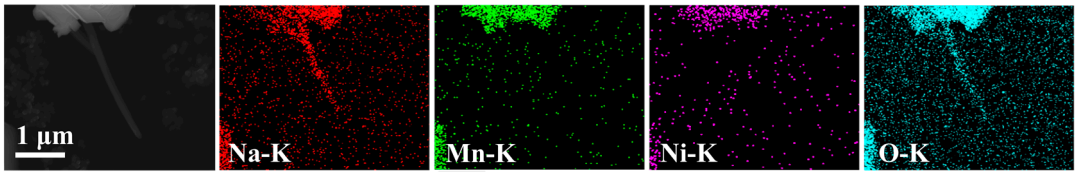
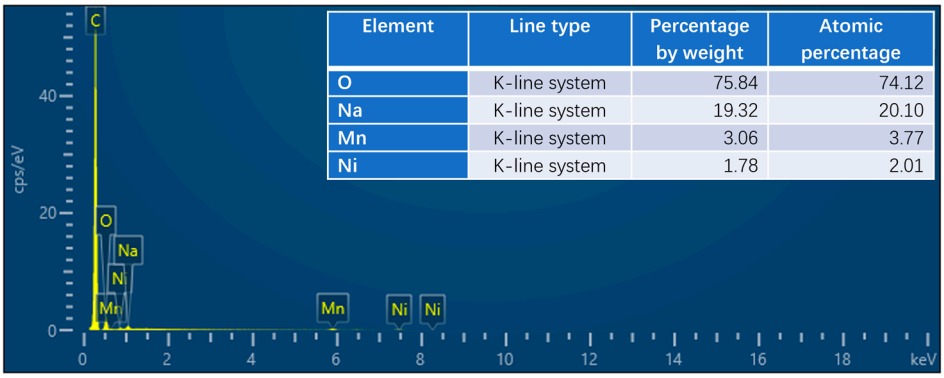


Fig. S6 SEM-EDS elemental mappings of rod-like particles in P2-$Na_{0.67}$MN sample.



Element	Line type	Percentage by weight	Atomic percentage
O	K-line system	75.84	74.12
Na	K-line system	19.32	20.10
Mn	K-line system	3.06	3.77
Ni	K-line system	1.78	2.01

Fig. S7 The spectrum diagram of total distribution diagram for SEM-EDS of rod-like particles in P2-$Na_{0.67}$MN sample.

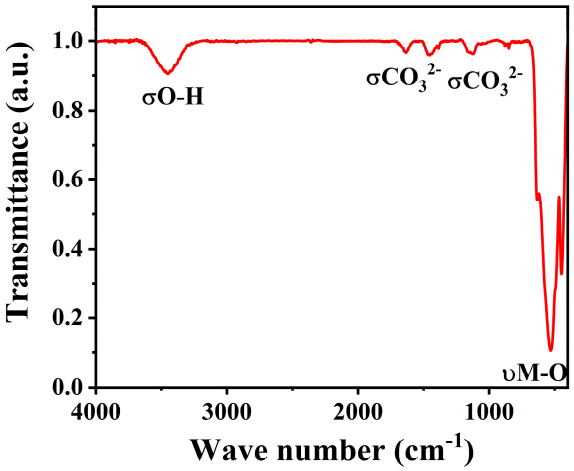


Fig. S8 The FTIR of P2-$Na_{0.67}$MN after 20 days of air exposure.

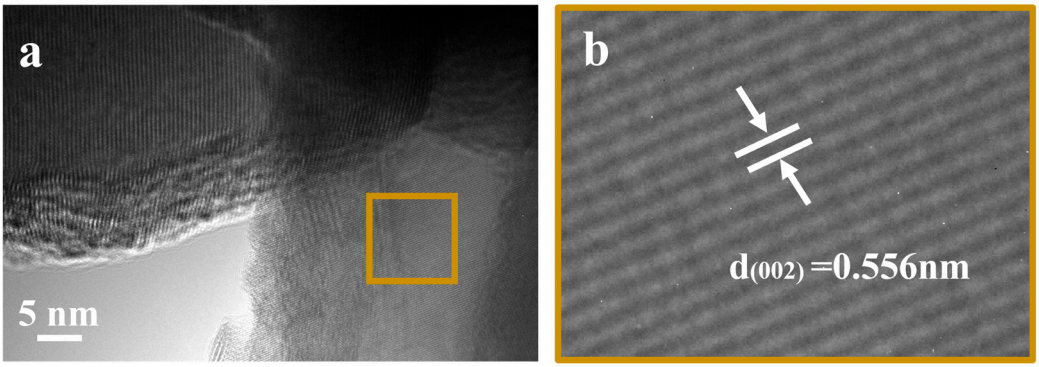


Fig. S9 (a) The TEM images of P2-$Na_{0.67}MN$. (b) The TEM images of P2-$Na_{0.67}MN$.

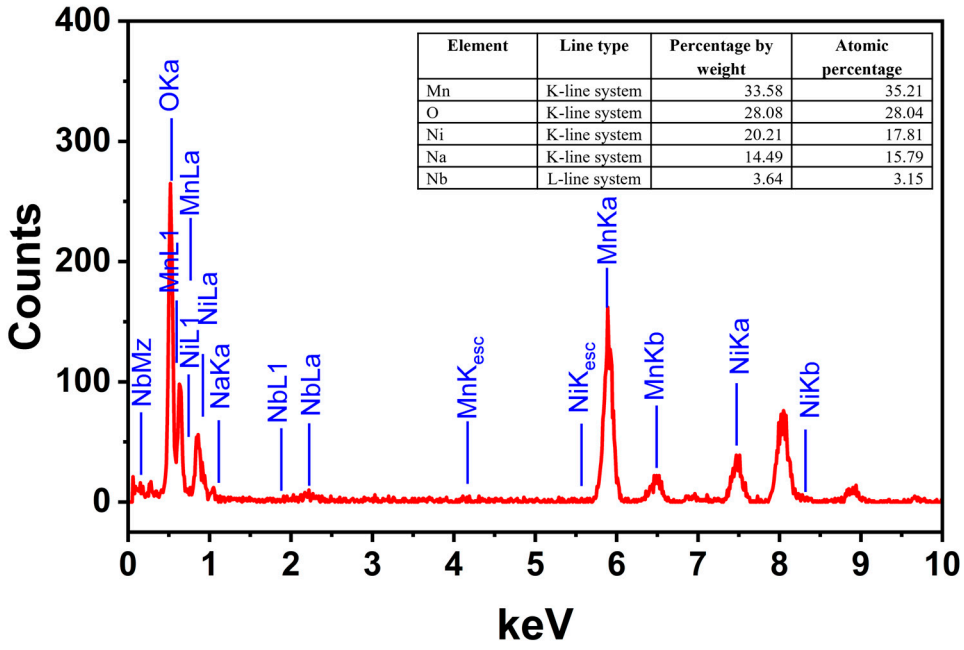


Fig. S10 The spectrum diagram of total distribution diagram for HADDF-EDS of P2-$Na_{0.67}$MNNb.

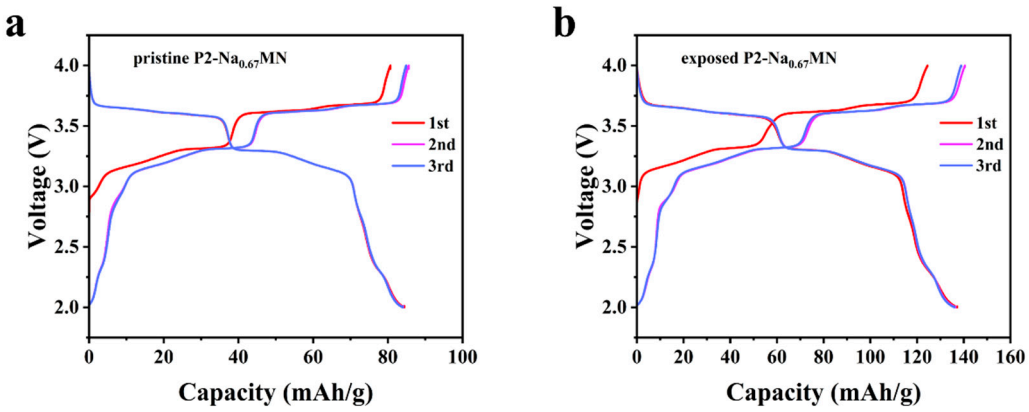


Fig. S11 Galvanostatic charge/discharge voltage profiles of (a) the pristine P2-$Na_{0.67}$MN and (b) exposed P2-$Na_{0.67}$MN at the first three cycles at 0.2 C in the voltage range of 2-4 V (exposed P2-$Na_{0.67}$MN refers to exposing pristine P2-$Na_{0.67}$MN to RH93% humid environment for 20 days).

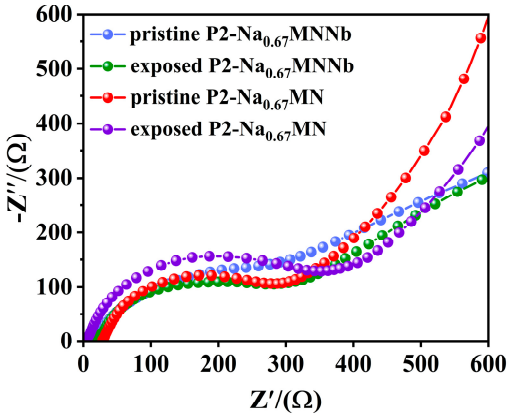


Fig. S12 Nyquist plot of the coin cells that based on pristine P2-$Na_{0.67}$MN, exposed P2-$Na_{0.67}$MN, pristine P2-$Na_{0.67}$MNNb and exposed P2-$Na_{0.67}$MNNb electrode materials.

Table. S1 The ICP date of P2-$Na_{0.67}MN$ and P2-$Na_{0.67}MNNb$ cathode materials.

ICP results (mol mL^{-1})	Na	Mn	Ni	Nb
$Na_{0.67}Mn_{0.67}Ni_{0.33}O_2$	0.67	0.67	0.33	
$Na_{0.67}Mn_{0.67}Ni_{0.33}Nb_{0.03}O_2$	0.67	0.67	0.30	0.03

Table. S2 Crystallographic parameters of P2-$Na_{0.67}$MNNb refined by the Rietveld method.

Atoms	Wycoff position	X	Y	Z	Occupancy
Na1	2b	0	0	0.25000	0.30
Na2	2d	0.66670	0.333330	0.25000	0.37
Ni	2a	0	0	0	0.31
Mn	2a	0	0	0	0.67
O	4f	0.66670	0.33330	0.07950	1
Nb	2a	0	0	0	0.03

Space group: $P6_3/mmc$ (space group no. 194), a=2.88749 Å, c=11.16065 Å, Rwp=4.32%.

Table. S3 Crystallographic parameters of P2-$Na_{0.67}MN$ refined by the Rietveld method.

Atoms	Wycoff position	X	Y	Z	Occupancy
Na1	2b	0	0	0.25000	0.36
Na2	2d	0.66670	0.33330	0.25000	0.31
Ni	2a	0	0	0	0.33
Mn	2a	0	0	0	0.67
O	4f	0.66670	0.33330	0.05180	1

Space group: $P6_3/mmc$ (space group no. 194), a=2.88504 Å, c=11.15540 Å, Rwp=5.62%.