Faculty and Postdoc

Understanding the electrochemical performance of $LiNi_{0.5}Mn_{1.5}O_4$ coated with Yttria and distributed over graphene nanosheets as cathode in li-ion batteries

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Introduction

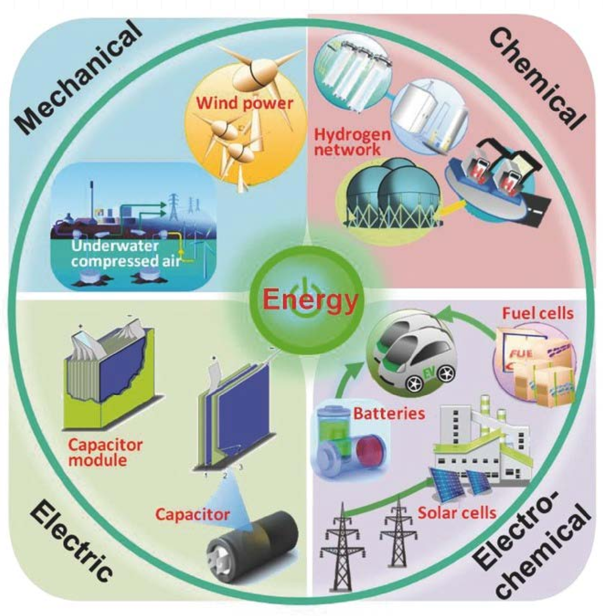
Abstract

- $LiNi_{0.5}Mn_{1.5}O_4$ is a promising cathode material for lithium-ion batteries with a high-voltage spinel structure.
- Microwave-assisted chemical co-precipitation method was used to synthesize Y_2O_3 coated quasi-spheres of $LiNi_{0.5}Mn_{1.5}O_4$.
- The material has an initial capacity of 133 mAh g^{-1} at C/10 with a retention of 98% after 100 cycles.
- In addition, cathode samples show a good capacity of 132 g^{-1} after 20 cycles at higher temperatures (55 °C).
- The material synthesis approach may successfully be applied to various electrode materials.

Synergistic Approach

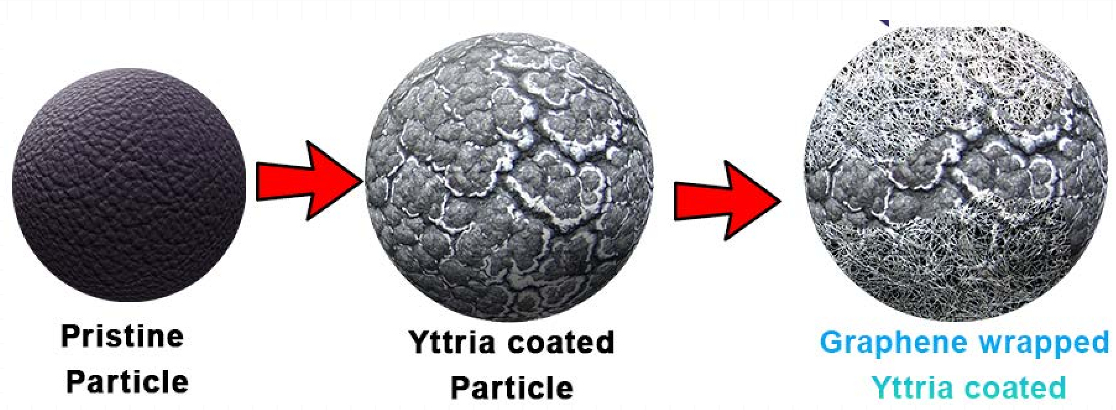
- Coating of Y_2O_3 and subsequent wrapping of quasi-spheres in graphene nanosheets does not alter the volume or promote the formation of unwanted phases.
- Oxide coatings protect the particles from ionic leaching but limit the electrical conductivity of the materials.
- However, graphene enhances the conductivity of the synthesized material and wraps active particles in a conductive channel.
- Synergistic design of the material and the robust manufacturing technique, parasitic reactions are suppressed without affecting the electrical conductivity.

Energy Storage

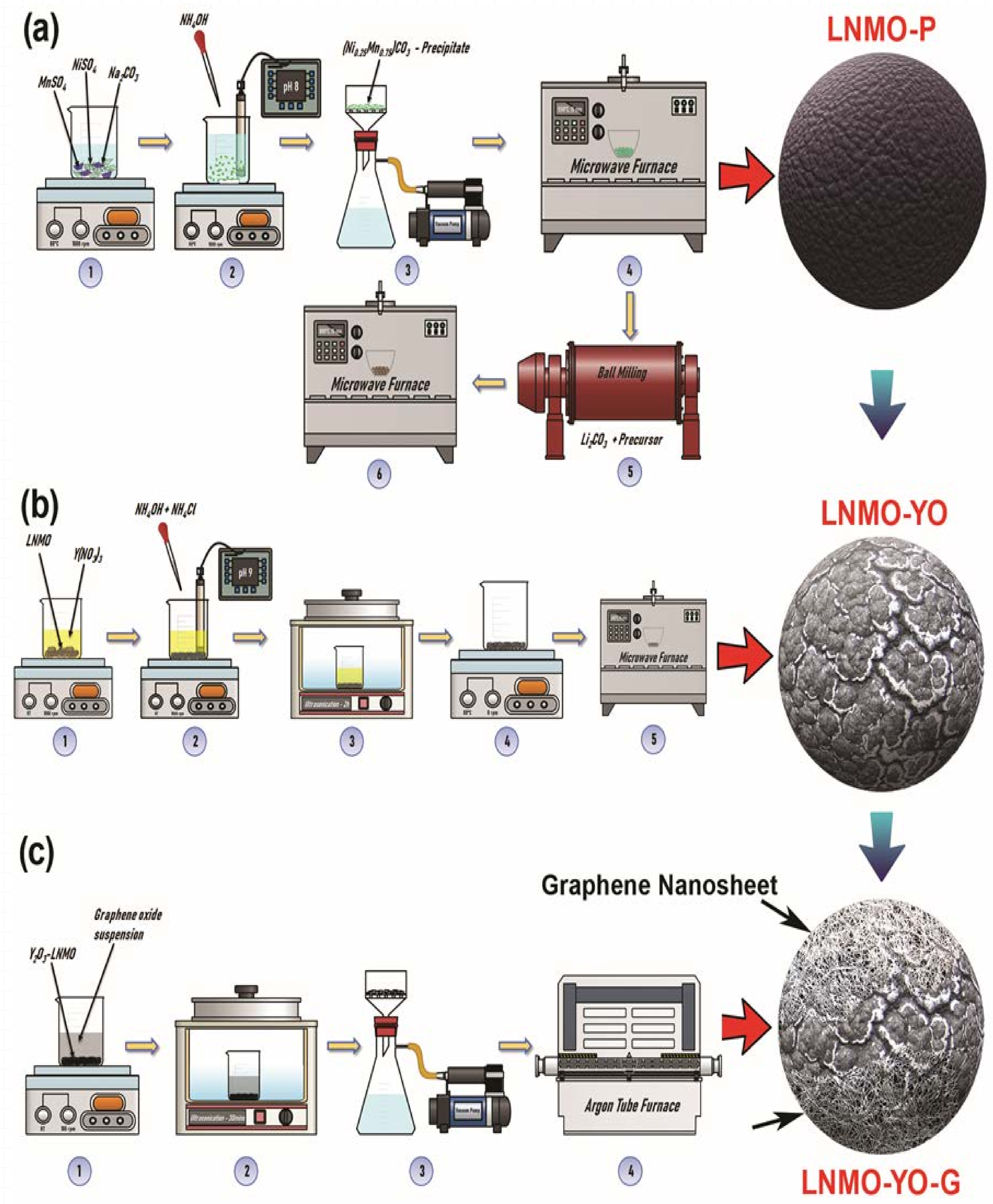


- Li-ion batteries have a better energy and power density than other technologies.

Material Design



Experimental



Results & Discussion

XRD & SEM

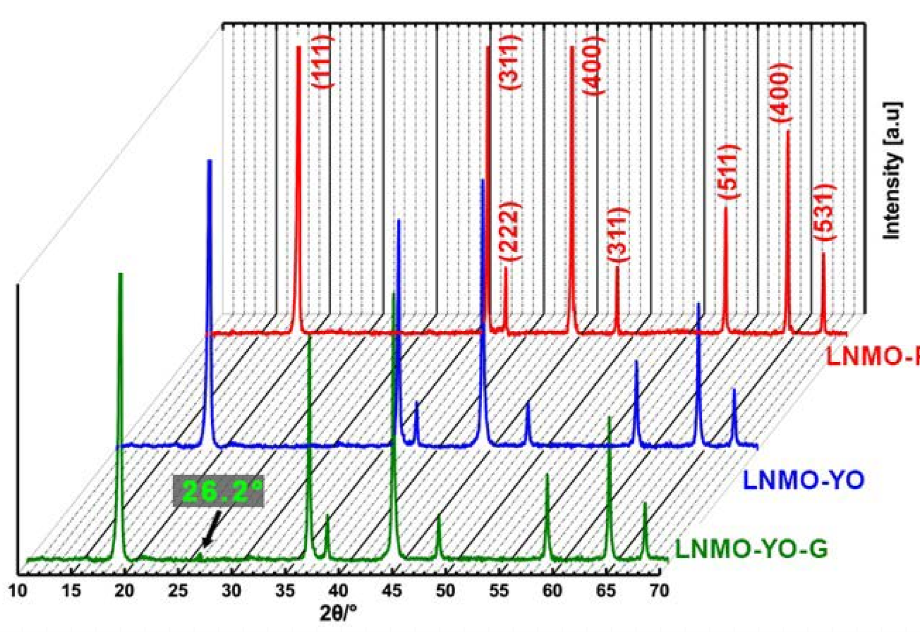


Fig. 1 XRD spectra of developed materials; LNMO-P, LNMO-YO, and LNMO-YO-G.

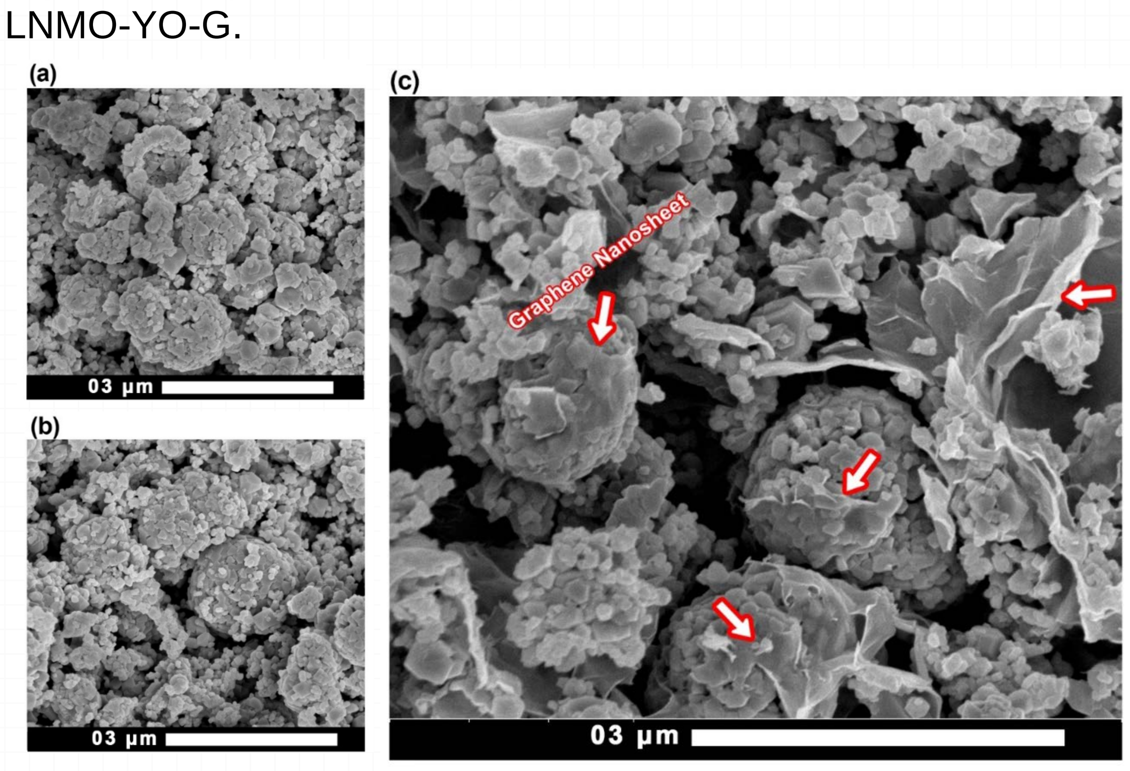


Fig. 2 FE-SEM micrographs of the prepared materials; (a) Pristine particles (b) Yttria coated particles (c) Yttria coated particles partially wrapped by graphene sheets, marked by arrows.

Cyclic Voltammetry & Rate Capability

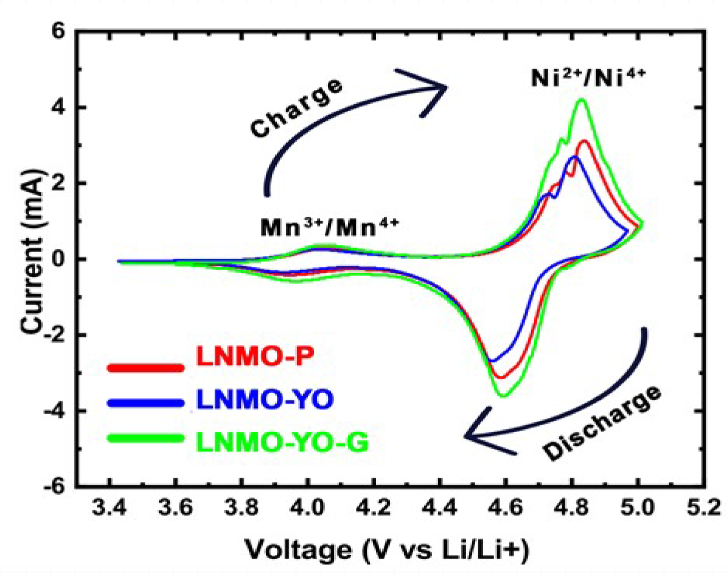


Fig. 3 Comparison of cyclic voltammetry (CV) of LNMO-P, LNMO-YO, and LNMO-YO-G scanned at 0.05 mv/s.

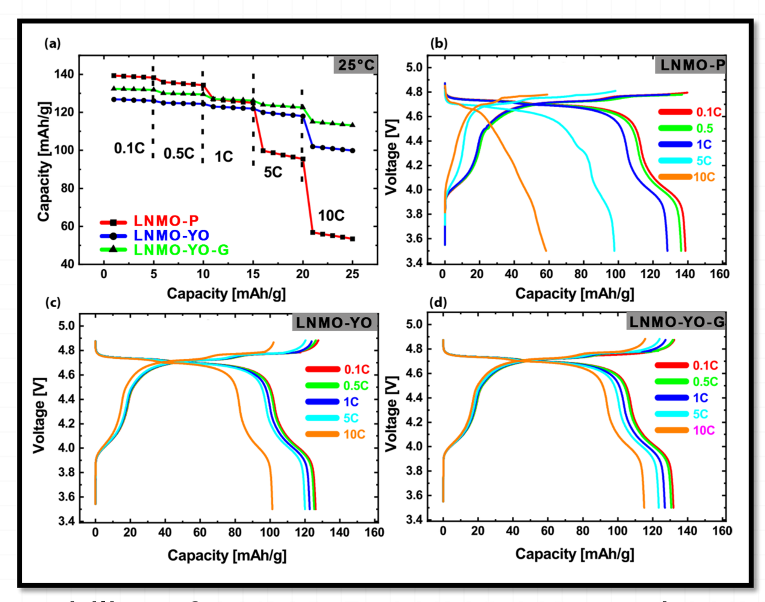


Fig. 4 Rate capability of LNMO-P, LNMO-YO, and LNMO-YO-G at 25°C, Galvanostatic charge/discharge curves at different C-rates of (b) LNMO-P (c) LNMO-YO (d) LNMO-YO-G.

EIS

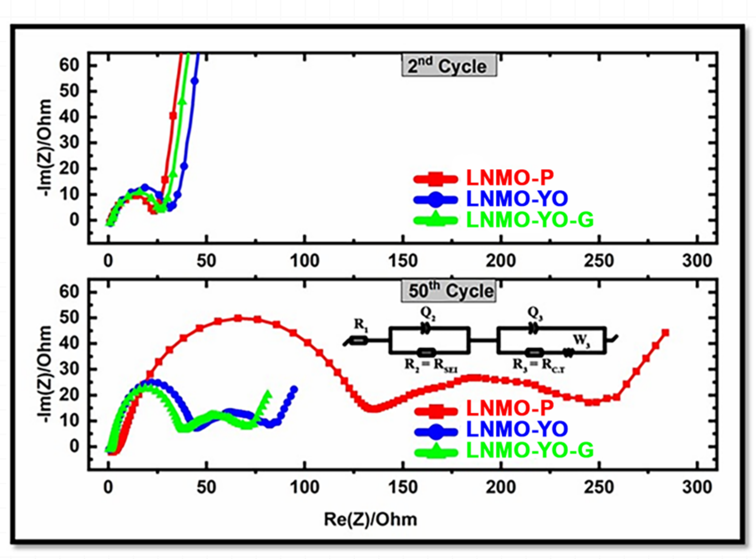


Fig. 5 The Nyquist plot of LNMO-P, LNMO-YO, and LNMO-YO-G samples obtained after 50 cycles under constant current charge-discharge between 3.4 V to 4.9 V at C/10 rate at 25 °C.

Conclusion

- Microwave-assisted chemical co-precipitation was used to create quasi spheres comprising of pristine particles, Y_2O_3 coated particles, and Y_2O_3 coated wrapped in graphene nanosheets..
- The presence of Y_2O_3 coating and the wrapping of graphene nanosheets significantly increases the electrochemical performance of the material.
- This improvement electrochemical performance is due to (i) circumvention of the parasitic reactions between the electrolyte and active electrode material (ii) slow development of an unfavorable SEI layer (iii) prevention of Mn^{3+} dissolution due to the Jahn Teller effect, and (iv) improvement in the kinetics of charge transfer.

Acknowledgment

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