CHAPTER I
INTRODUCTION

Meeting our expanding energy demands with sustainability in mind is imperative. in today's fast-paced world. While the Earth's crust still holds abundant coal reserves, overexploitation of this finite resource poses a severe threat to our climate. Furthermore, the production of crude oil has peaked, leading to a growing global need for cleaner, renewable energy sources (Yamada et al., 2010; Zeng et al., 2020). In this context, lithium-ion (Li-ion) batteries stand out as one of the most advanced and enduring energy storage solutions available. Renowned for their high energy density and portability, Li-ion batteries have become a staple in consumer electronics (Swiderska-Mocek and Naparstek, 2016).

Currently, lithium-ion batteries (LIBs) are crucial for portable devices, electric vehicles, and energy storage. However, their flammable liquid electrolytes pose safety risks in the event of damage. Additionally, increasing energy density within existing designs remains a challenge, especially in electric vehicles (EVs) (Xiao, Miara, Wang, and Ceder, 2019). Enhancing the performance of lithium-ion batteries (LIBs) can be achieved by improving the quality of cathode materials, which play a pivotal role in determining the energy storage capacity of LIBs at their maximum potential. Traditionally, lithium-ion battery electrodes have predominantly utilized crystalline materials. However, progress in cathode material development has been impeded due to the cost and complexity associated with high-capacity crystalline solids. These materials, while offering substantial capacity, are both expensive and challenging to manufacture, rendering the creation of crystalline cathode materials a complex endeavor (Afyon, Krumeich, Mensing, Borgschulte, and Nesper, 2014; Wei et al., 2018). The electrochemical properties of amorphous electrode materials often outperform their crystalline counterparts. Amorphous electrodes exhibit a short-range ordered structure, a substantial surface area, and free volume, allowing for lattice distortions without causing significant macroscopic phase transitions, ultimately enhancing kinetics.

Lithium borate-based glass has gained attention as a potential electrode material for rechargeable batteries due to its unique electronic and electrochemical properties. These borates are known for their high capacity and conductivity (Zeng et al., 2020). Borates have higher theoretical capacities than other types of inorganic salts (Yang, Xue, and Guo, 2021). Lithium-metal borate ($LiMBO_3$) offers a higher specific capacity of 200 mAh/g, outperforming the well-known lithium iron phosphate ($LiFePO_4$), which provides 170 mAh/g (Yamada et al., 2010). To enhance these capacities, various elements have been introduced into lithium borate glass, including transition metal oxides like cobalt, nickel, and manganese oxides. These metals are key in lithium-ion batteries and offer promising specific capacities. Transforming lithium nickel manganese cobalt oxide cathode material ($Li_xNi_yMn_zCo_{1-y-z}O_2$, $0 < x,y,z < 1$, abbreviated NMC) (high specific capacity of over 160 mAh/g) into an amorphous material using Li_2O-B_2O_3 glass as a base offers the potential for novel cathode materials for lithium-ion batteries. However, detailed information about lithium-borate-based glasses doped with Ni-rich $LiNi_xMn_yCo_zO_2$ (NMC) ($x > y, z$) materials is still limited and unclear (Liu et al., 2016).

This study is primarily focused on conducting a comprehensive, systematic examination of the physical and structural properties of samples derived from sample preparation melt quenching method, each of which involves distinct production procedures. The aim is to identify the most efficient and simple procedure for achieving optimal performance.