Scalable Synthesis of Zeolite for Use as Separators in High Performance Lithium-Ion Batteries

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Abstract

The goal of this project is to develop a commercially viable fire-safe lithium-ion battery by replacing the traditional polymer separator with a silica-based zeolite separator. This research aims to scale up the production of zeolites so that these fire-safe batteries can be produced on a larger scale. Several zeolites of different geometries will be synthesized in different quantities and then tested in a lithium-ion battery. These zeolite separators show higher wettability to the battery's electrolyte, and allow the formation of a more stable SEI (Solid Electrolyte Interface) layer on the electrodes.

Background

- Lithium-Ion batteries have become the preferred means of energy storage for new technologies such as cell phones and electric vehicles.
- Current lithium-ion batteries use flammable electrolytes and combustible, polymeric separator, which has led to instances of fires and explosions.
- Zeolites are microporous silicate materials
- Inorganic zeolite separators can be used with a high salt concentrated LiFSi electrolyte to prevent the growth of dendrites, which can short the battery and cause safety risks
- Zeolites offer higher porosity and increased thermal stability over traditional polymer separators, allowing for a more uniform flux of Lithium ions

Results

- Both zeolites were analyzed using SEM imaging to determine their geometry and length to thickness aspect ratio
- Zeolites were also analyzed using XRD to determine their crystal structure

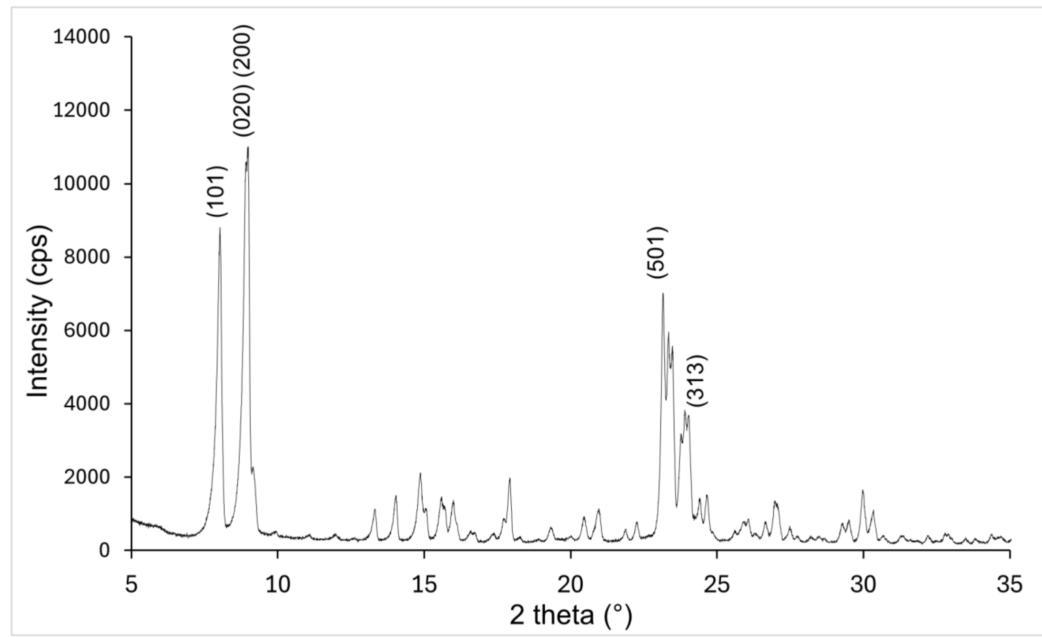

Figure 1: XRD of high aspect ratio zeolite

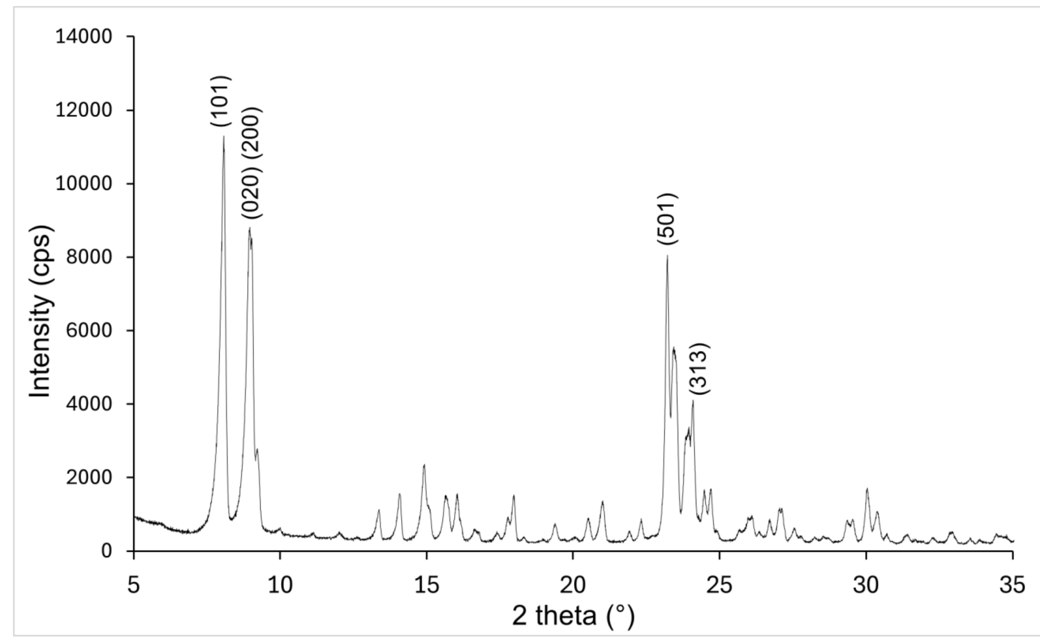

Figure 2: XRD of low aspect Ratio zeolite

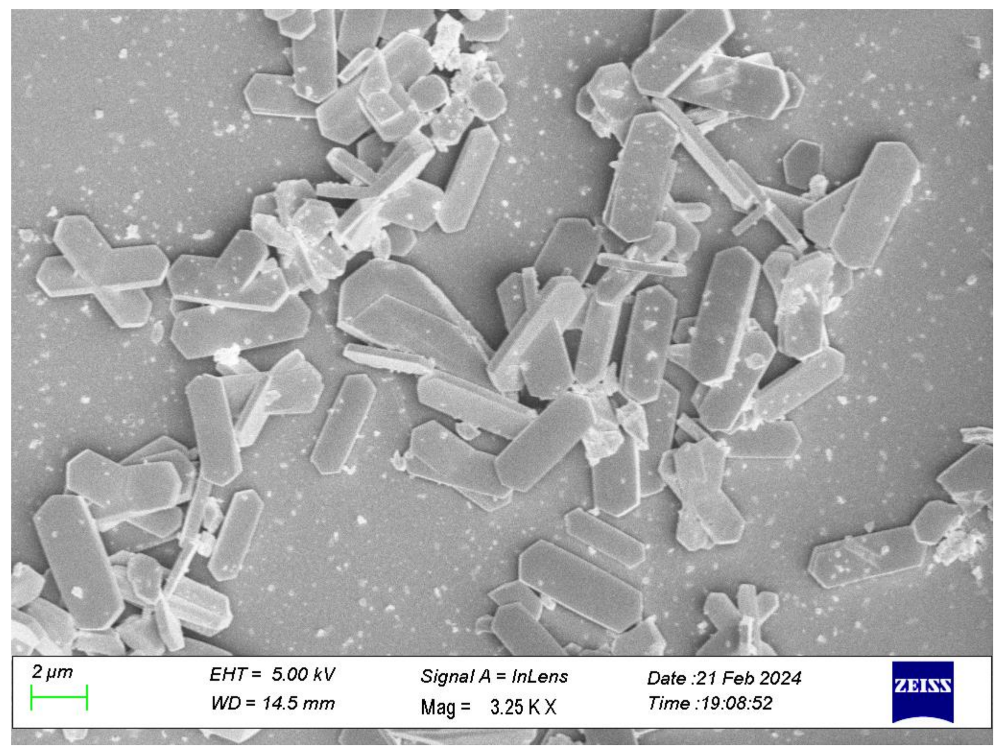

Figure 3: High aspect ratio zeolite

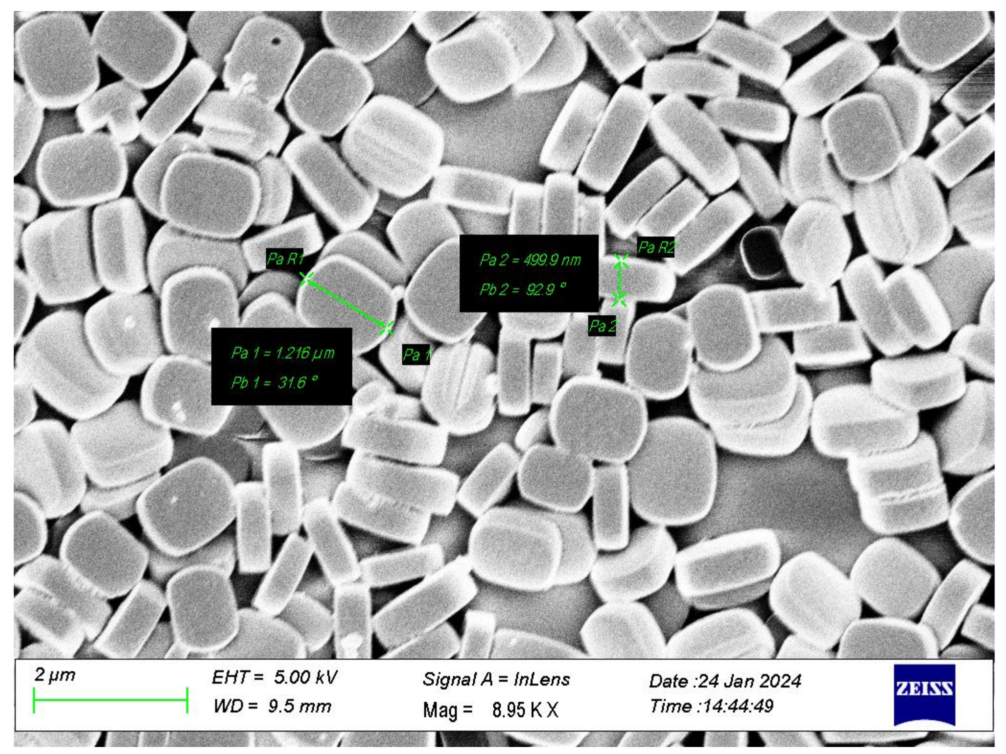

Figure 4: Low aspect Ratio zeolite

	TEOS (g)	TPAOH (g)	DI water (g)	Autoclave Temperature (°C)	Autoclave Time (h)	Typical Particle Length (µm)	Typical Particle Thickness (µm)
Low aspect ratio silicate	10	12	202	130	8	1.0-1.2	0.5
High aspect ratio silicate	10	4	170	155	10	5-6	0.5

Table 1: Zeolite synthesis conditions and dimensions

Objectives

- Synthesize zeolites in a scalable manner, so that these zeolites can later be used to construct fire safe batteries
- These zeolite separators are more porous than polymeric separators, and can be used with higher concentrated electrolytes and nonflammable solvents

Future Goals

- The current zeolite synthesis is performed in an 80 mL autoclave. To make these batteries commercially viable synthesis needs to be scaled up to synthesize larger quantities of zeolite
- Test batteries with zeolite separator coated on the NMC cathode and compare the performance to that of a traditional Li-ion battery

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