

## OPTIMIZATION OF LITHIUM IRON ORTHOSILICATE ELECTRODES SYNTHESIZED VIA VARIOUS METHODS

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**Abstract** - Lithium iron orthosilicate ( $\text{Li}_2\text{FeSiO}_4$ ) has attracted tremendous attention from the researchers due to its high theoretical capacity (234 mAh  $^{-1}$  for one Li<sup>+</sup> and 332 mAh  $^{-1}$  for two Li<sup>+</sup> per formula unit), excellent safety and environmental benignity. It is considered as a promising alternative cathode material for lithium-ion batteries [1]. Lithium iron orthosilicate cathode material was obtained by four different methods viz., solid state, polyol, sol-gel, and co-precipitation. The XRD pattern of the as-prepared cathode material by aforementioned methods has been observed. It can be seen that some of the peaks belonging to  $\text{Li}_2\text{FeSiO}_4$  and some impurities have been detected. By using RAMAN analysis, the presence of D and G bands has been confirmed. The surface morphology of synthesized material has been studied by scanning electron microscopy. From these different routes, sample obtained via the Polyol route possess good crystallites with negligible impurity among other samples studied. However, Polyol route is a low temperature process, which is able to control some parameters of nucleation of nano-particles such as size, shape and uniformity, etc. Therefore, it is revealed that polyol is the best method to synthesize lithium iron orthosilicate.

**Key Words:** solid state method; sol-gel method; lithium iron orthosilicate; polyol method; cathode material.

### 1. INTRODUCTION

Lithium-ion batteries (LIBs) have been widely used in daily life such as mobile phones, laptops, etc. Cathode materials play a consistent role in improving electrochemical performance and for reducing the cost of the whole cell. For practical applications, new kinds of cathode materials with high capacity, large energy density, and low toxicity are required [2-3]. Lithium-ion batteries mostly rely on lithium transition metal oxide, such as  $\text{LiCoO}_2$ ,  $\text{LiNiO}_2$ , and  $\text{LiMn}_2\text{O}_4$ . However, some issues including safety, toxicity and cost of these materials inhibit their further use in price sensitive and large-scale applications, such as hybrid electric vehicles. Therefore, many efforts have been made to find alternate cathode materials for lithium-ion batteries [4]. Regarding this, lithium transition metal orthosilicate ( $\text{Li}_2\text{MSiO}_4$ , M = Fe,

Co, Mn, Ni, etc.) have been successfully synthesized and characterized as potential cathode materials for lithium ion batteries (LIBs). Different from lithium transition metal phosphate which has only one lithium ion per formula unit,  $\text{Li}_2\text{MSiO}_4$  has two lithium ions per formula unit, suggesting a higher theoretical capacity than phosphates [5, 6]. However, as a polycrystalline cathode material,  $\text{Li}_2\text{FeSiO}_4$  also suffers from the low ionic/electronic conductivity and the slow diffusion of lithium ion. Therefore, tremendous efforts have been made to solve this problem, such as carbon incorporation, particle size reducing, and metal ion doping to improve electrochemical property of  $\text{Li}_2\text{FeSiO}_4$  [7-9]. In this paper, lithium iron orthosilicate cathode material was obtained by four different methods like, solid state, polyol, sol-gel, and co-precipitation. The as prepared cathode materials were characterized by XRD, FTIR, RAMAN, and SEM.

### 2. EXPERIMENTAL

The cathode materials were synthesized by various methods, they are Solid state reaction, Sol-gel method, Polyol technique, and Co-Precipitation method.

#### 2.1 Solid state reaction:

The stoichiometric amounts of lithium carbonate, iron oxide, silicon dioxide and Citric acid monohydrate were used as the starting materials. The starting materials were ground for 1 hour using mortar and pestle. Then the precursor was calcined at 800 °C for 24 hour under Ar atmosphere. Finally we obtain the final product of the material.

#### 2.2 Sol-gel method:

The  $\text{Li}_2\text{FeSiO}_4$  was prepared by sol-gel method based on citric acid. Analytical reagents  $\text{CH}_3\text{COOH}$ ,  $\text{Fe}(\text{NO}_3)_3$ , tetraethyl orthosilicate, and citric acid in a molar ratio of 2:1:1:3 were used as starting materials.  $\text{CH}_3\text{COOH}$  and  $\text{Fe}(\text{NO}_3)_3$  were first dissolved in distilled water, A saturated

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two particle spectroscopy in studying ordered surfaces and disordered samples Throughout the book the material is analyzed using rather qualitative arguments and the results of more sophisticated theories serve the purpose of endorsing the suggested physical scenarios The foundations of some of these theories have been presented in a corresponding volume entitled *Concepts of Highly Excited Electronic Systems* 3 527 40335 3 **Acta Physica Polonica** ,2005

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