

# Synthesis of $\text{Li}_4\text{Ti}_5\text{O}_{12}$ and Design for Hybrid Capacitors

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## 1. Introduction

Electrochemical capacitors (ECs), also called super-capacitors or ultra-capacitors, are charge storage device with capacities intermediate between those of electrolytic capacitors and rechargeable batteries. ECs store charge at the electrode/electrolyte interface either through conventional non-Faradic means, by forming an electric double layer (called electrochemical double layer capacitors, EDLCs), or by a limited Faradic reaction (pseudocapacitors). In addition, more recently, researchers have begun to explore the combination of both Faradic and non-Faradic processes in the same hybrid device to overcome the limits of conventional EDLCs. The combination of an electric double-layer electrode, usually activated carbon (AC), with a battery electrode has drawn a considerable amount of research attention, for example, AC/Ni(OH)<sub>2</sub> with an aqueous electrolyte and AC/Li<sub>4</sub>Ti<sub>5</sub>O<sub>12</sub> (LTO) with a non-aqueous electrolyte. This is because the high working voltage and energy density of the battery electrode afford significantly higher overall energy density than that possible with EDLCs. In particular, there has been considerable interest in the combination of AC positive electrodes with nanostructured LTO negative electrodes in organic or Li salt electrolytes. In this study, We investigated the electrochemical properties of the hybrid capacitor by applying this synthesis of LTO material.

## 2. Experimental

LTO was prepared by the sol-gel process from LiOH (Sigma-Aldrich) and tetra titanium isopropoxide (TTIP; Sigma-Aldrich) using ultrasonication. Briefly, LiOH and TTIP solutions were first individually prepared in 2-methoxy ethanol, and then the latter was added drop-wise to the former, followed by stirring for 2 h. The Li/Ti molar ratio was adjusted to 4.5:5. The mixture was ultrasonicated for 5 h, and then the solvent was removed by drying at 110°C in vacuum overnight. The obtained precursor was sintered at 850 °C for 5 h in an Ar atmosphere and finally cooled to room temperature to afford a white powder.

## 3. Result & Discussion

The XRD patterns of the prepared LTO matched all of the peaks in JCPDS file no. 26-1198, confirming that pure LTO was obtained. Furthermore, the redox characteristics and specific capacity of LTO were measured in an electrochemical test. Reversible redox peaks were observed from 1.45 to 1.75 V due to the redox reactions of Ti<sup>3+</sup> and Ti<sup>4+</sup> in cyclic voltammetry curves. In addition, LTO exhibited a very flat charge-discharge curve with a specific capacity of approximately 127 mAh g<sup>-1</sup> from charge-discharge curves. Potential driving of the negative electrode and the positive electrode was measured by charge and discharge process forms an over potential on the positive electrode side according as cell voltage increases, which is a result of a characteristic of the material. The positive electrode forming an electric double layer does a linear behavior, and the LTO inducing redox reaction forms the over position on the positive electrode side in relation to the potential by a flat response, which affects the poor cycle characteristics [4].

## References

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