Abstract

Developing alternate energy storage systems for transportation are motivated by a combination of socio-economic issues like environmental conservation to combat global warming, fast diminution of conventional non-renewable energy sources, rising cost of fossil fuel and concern for sustainable energy. Electrochemical energy storage may be considered as an important strategy while addressing the increasing demand for clean energy. In this complex situation Lithium-ion battery has come up as a potential alternative energy source that can be used in number of areas. However, the energy density of Li-ion battery is still much lower than that of fossil fuel. Therefore, at present the major challenge for the Li-ion battery research is focused on to increase the energy density along with power density to fulfil the demand for energies required for electric vehicles and high-end portable electronics. Now to satisfy the requirement of higher energy and power density, improved LIB materials are required with better electrochemical performance along with safety.

Cathode materials are the primary component responsible for increasing the energy and power density of rechargeable Li-ion batteries. The olivine structured $LiMPO_4$ (where M = Fe, Mn, Ni, or Co) has a great potential to serve this purpose. Among the various cathode materials, $LiFePO_4$ and the materials derived from $LiFePO_4$ are most widely used positive electrodes in LIBs. Along with $LiFePO_4$, $LiMnPO_4$ is also gradually becoming attractive due to its high energy density (700 $Whkg^{-1}$), higher operational voltage at 4.1 V vs. Li, stability of traditional electrolyte solutions at this voltage electrochemically, improved safety due to existing strong P–O covalent bond, low cost and its environmentally benign nature. Having 20% higher redox potential compare to $LiFePO_4$, $LiMnPO_4$is considered as a potential cathode material while replacing $LiFePO_4$ in LIB. However,

the cyclic stability and rate performance of $LiMnPO_4$ are somewhat restricted due to its lower electronic and Li^+ ion conductivity.

In this work, $LiMnPO_4$ olivine structured cathode material at optimum pH condition with optimum content of conducting carbon in cathode material has been successfully prepared by low temperature (180°C) hydrothermal method. Optimum percent of La dopant in carbon containing cathode material is obtained based on electrochemical performance of the material. Physical and morphological characterization shows the structure and phase purity and their nano size morphology. Substitution of Mn^{2+} with La^{3+} in $LiMnPO_4$ improves the bulk conductivity as well as electronic mobility of the material than that of pure $LiMnPO_4$.

During the past two decades, the development of lithium-ion battery research has been focused on exploring and improving the electrode materials and electrolytes. However, the separator, an indispensable component of Li-ion battery is not studied extensively. In general, a separator has major two functions, i.e., preventing the electronic connection between positive electrode and negative electrodes while providing transport pathways for Li^+ ion movements. Commercial separators for Li-ion batteries are usually made of polyolefin materials having two major drawbacks viz. low thermal stabilities and poor electrolyte wettability.

The development of advanced separator has been a major concern, in recent years for rechargeable lithium-ion batteries for varying areas of applications like portable electronics, electric vehicles and power grids. Having served the role of a physical barrier against the electronic conduction between cathode and anode in order to prevent electrical short circuiting, separator also holds the liquid electrolyte which acts as a vehicle for Li^+ ions transport during charge/discharge cycles of Li-ion battery. The performance of Li-ion battery is largely dependent on the materials and structure of the separators.

In the present work, we have synthesized Boehmite (γ-AlO.OH) nanorods (length 90-140 nm; dia. ~15 nm) by a simple low-temperature (180^{o}C) hydrothermal method and coated onto both sides of surface modified polypropylene (Celgard). The prepared composite separator has been tested in $LiFePO_4$//Li half cells as well as in $LiFePO_4$//MCMB full cells in coin cell configuration for understanding the influence of this separator on electrochemical performance. It is found that composite separator results in improved cell kinetics due to better electrolyte uptake and formation of a Li^+ ions buffer reservoir facilitating fast ion transport at high current rates.