Development of Lithium-ion Batteries for Electric Vehicle Application

Overview

Due to the depletion of the fossil energy reserves as well as alarming level of greenhouse gas emission triggered to look out for alternative clean energy sources, especially for automotive sector. The key challenge for electric vehicles is to get suitable battery to store the required amount of energy in a given volume for long driving range and speed. Lithium-ion battery (LIB) has been proven to be next generation technology to alleviate these problems. However, currently there are no manufacturers of these batteries in India. ARCI has undertaken a major task to developed LIB technology for electric vehicles by setting up a pilot plant facility for manufacturing of Lithium-ion cells and battery packs for automotive application. The objective is to establish the LIB technology using standard materials and demonstrate off-line/on-board vehicle testing. In addition high voltage/new materials will be developed indigenously. The promising materials will be optimized and scale-up for process technology.

Key Features

- Prototype cells of 10 Ah have been fabricated and they exhibited a capacity retention of >80% after 1000 cycles with a Coulombic efficiency of about 99%.
- Prototype modules of 12V, 10 Ah (120 Wh), 24V, 10 Ah (240 Wh) and 48V, 10 Ah (480 Wh) have been assembled and their performance evaluation have been carried out with appropriate loads.
- 15 Ah SS-LIB cells have been fabricated and successfully optimized the formation cycles. 48V, 15Ah (720 Wh) battery pack was assembled and its performance test with e-cycles under off-line/on-line conditions has been carried out.
- 18 Ah SS-LIB cells have been fabricated and successfully optimized the formation cycles. 48V, 18Ah (850 Wh) battery pack was assembled and its performance test with e-scooter under off-line/on-line conditions has been carried out.
- Scaled up $LiFePO_4$ by FSP process and scale-up of carbon coating technology up to 1.5 kg
- Lithium titanate was successfully synthesized and up-scaled by cost-effective high energy milling method and showed promising electrochemical performance in terms of capacity, rate capability and cyclic stability in comparison with commercial LTO.
- Fabrication of 30 m length LTO electrode using indigenous LTO materials by Li-ion pilot plant unit
- Carbon coated SnO2-nanomaterials developed by DAP method yielded a better capacity and cyclic stability compared to that of conventional SnO_2.

Potential Applications

- Two, three and four wheeler electric vehicles
- Stationary energy storage applications
- UPS

Intellectual Property Development Indices (IPDI) Level 7

- Prototype cells have been fabricated and electrochemical performance has been tested
- Assembly and testing of large format battery module/pack carried out with e-cycle and e-scooter under on-road conditions.

Major Publications

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1. S. Vasu, Moodakare B. Sahana, Chandran Sudakar, R. Gopalan, G. Sundararajan, “In-situ carbon encapsulation of LiNi1/3Co1/3Mn1/3O2 using pillared ethylene glycol trapped in the metal hydroxide interlayers for enhanced cyclic stability,” Electrochimica Acta 251, 363-377.
2. V. Rao Rikka, S. R, Sahu, R. Tadepalli, R. Bathe, T. Mohan, R. Prakash, G. Padmanabham and R. Gopalan, “Microstructure and mechanical properties of pulse laser welded SS and Al Alloys for lithium-Ion cell casings”, Journal of Materials Science and Engineering B, 6, 2016, 218-225.
3. R. Vallabha Rao, S.R. Sahu, P.V. Satyam, R. Prakash, M.S. Ramachandra Rao , R. Gopalan and G. Sundararajan, “In Situ/ex Situ Investigations on the Formation of the Mosaic Solid Electrolyte Interface Layer on Graphite Anode for Lithium-Ion Batteries”, Journal of Physical Chemistry C Vol.122 (50), p 28717-28726 , 2018
4. S.R. Sahu, V.R. Rikka, M. Jagannatham, P. Haridoss, A. Chatterjee, R. Gopalan and R. Prakash, “Synthesis of Graphene Sheets from Single Walled Carbon Nanohorns: Novel Conversion from Cone to Sheet Morphology”, Materials Research Express, Vol. 4(3), Article No. 035008, 2017.

5. S. Bhuvaneswari, U.V.Varadaraju, R.Gopalan and RajuPrakash, “Structural stability and superior electrochemical performance of Sc-doped LiMn2O4 spinel as cathode for lithium ion batteries”, Electrochimica Acta, Vol. 301, p 342-351, 2019.
6. Sasikala Natarajan, Sahana B. Moodakare, Vasu Shanmugam, Prathap Haridoss, and Raghavan Gopalan, “Infrared Spectroscopic signatures of Aluminium segregation and Partial Oxygen substitution by Sulphur in $LiNi_{0.8}Co_{0.15}Al_{0.05}O_2$”, ACS Appl. Energy Materials, Vol. 1(6), p 2536-2545, 2018.
7. V. V. N. Phanikumar, Vallabha Rao Rikka, Bijoy Das, Raghavan Gopalan, B. V. Appa Rao and Raju Prakash, “Investigation on polyvinyl alcohol and sodium alginate as aqueous binders for lithium-titanium oxide anode in lithium-ion batteries, Ionics, 2019, Volume 25, Issue 6, pp 2549–2561.
8. S. R. Sahu, D. Parimala Devi, V. V. N. Phanikumar, T. Ramesh, N. Rajalakshmi, G. Praveena, R. Prakash, B. Das, R. Gopalan, “Tamarind seed skin derived fibre-like carbon nanostructures as novel anode material for lithium-ion battery”, Ionics , volume 24, Issue 11, pp 3413–3421.

On-road demonstration of e-cycle with ARCI battery pack

On-road demonstration of e-scooter with ARCI battery pack