MOU ACTIVITIES OF EEE DEPARTMENT

S.No	Name of the Activity	Academic Year	Duration	Department
1	Submission of research project	2017 - 18	3 Months	EEE
2	Alternative energy using stored water	2017-18	1.5Year	EEE

Synthesis and Characterization of Novel Metal Organic Frame work Nano Particles as Electrodes for Al-Ion Rechargeable Batteries.

File No : TAR/2018/001115 (Ver-1)

Submitted By : Aruna Bharathi Mathangi

Submission Date : 04-Apr-2018

Proposal Details

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Principal Investigator	Mentor
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Details of Post Doctorate

Qualifying Degree :	Ph.D.
Date of Degree Awarded :	24/06/2015
Thesis Title :	: “Synthesis, Characterization And Computational Analysis Of Lithium Ion Batteries With Nano Materials"
Subject :	Electrical Engineering
Name of Research Supervisor/Guide :	Dr.M.Sushama,professor in Electrical and Electronics engineering-supervisor Dr.K. VenkateswaraRao, professor in Nano technology -co supervisor
Name of the awarding University/Institution :	Jawaherlal Nehru Technological University,JNTUH,TS

Brief details of Thesis work :

The development of renewable energy resources together with more efficient technologies for energy conversion and storage is one of mankind’s key challenges. The enhancement of energy conversion and storage technologies (fuel cells, solar cells, batteries, super capacitors, etc.) needs to be improved to enable better use of intermittent renewable electricity sources and to develop sustainable transport solutions associated with a modern society. The fact that output power of renewable energy sources such as solar and wind power plants depends on meteorological conditions. The performance of the battery is improved by developing the high power density cathode materials at Nano level. Batteries with Nano scale materials develop more power quickly with less heat. This work explains the synthesis of most interesting cathode materials with Lithium Manganese Spinel and its derivatives like transition metal oxide using various eco-friendly chemical methods, Nano particles were characterized by XRD, FESEM,EDAX,HRTEM, UV, electro chemical characterization(CV,) and (TGA/DTA) Thermal methods then compare the experimental results with computation details from first principle calculations with Material Studio and Quantum wise software’s.

Proposed Research Details

Scheme : Teachers Associateship For Research Excellence (TARE)

Broad Area : Engineering Sciences

Sub Area : Electrical Electronics & Computer Engineering

Project Summary :

The development of renewable energy resources together with more efficient technologies for energy conversion and storage is one of mankind's key challenges. The enhancement of energy conversion and storage technologies (fuel cells, solar cells, batteries, super capacitors, etc.) needs to be improved to enable better use of intermittent renewable electricity sources and to develop sustainable transport solutions associated with a modern society. The fact that output power of renewable energy sources such as solar and wind power plants depends on meteorological conditions, therefore electricity generated through RESs need to be stored in batteries for later use . The performance of the battery is improved by developing the high energy density cathode materials at Nano scale. Batteries with Nano scale materials develop more power quickly with less heat. The functional objective of nanotechnology is to model, simulate, design and manufacture nano structures and nano devices with extra ordinary properties and assemble them economically into a working system with revolutionary functional abilities.

In recent years, research and development of battery technology has primarily been focused on small-scale to large- scale applications, such as electronic devices, electric vehicles & backup systems, in which the specific energy and energy density are of great importance. It is proposed to prepare various nano structured materials. It is planned to study the cell charge and discharge properties of the rechargeable battery in which we use nano structured metal organic frame work materials with carbon material.

Here in our proposed work a novel battery fabrication involves a low cost, safe and sustainable nano structured metal organic frame works with conductive carbon, a mixture of 1-ethyl-3- methylimidazolium chloride and AlCl3 (1 : 2 molar ratio) as an electrolyte in order to improve operating voltage, energy density, life cycle and efficiency.

Keywords : Metal – organic frame works, nano particles, solvo-thermal synthesis, Hydro thermal synthesis, cyclic voltammetery, Energy density.

Objective :

• •To prepare MOFs by using solvothermal, Hydrothermal synthesis methods and layer by layer methods
•To obtain Structural, topological, thermal, spectroscopic Characterizatiosn of these nano materials by XRD,FESEM,HRTEM,TG/DTA,FTIR and RAMAN respectively.
•To prepare cell in Organ glove box and testing it in electrochemical work station
•To study charge-discharge curves and various electrochemical characterizations including impedance analyzer.
•To evaluate and analyze the results and apply the propose Al-ion battery in backup systems to built localized power plants.
Main objective is to prepare noval metal organic framework nanoparticles as electrode for Aluminum Ion Batteries to increase its operating voltage and life cycle for energy harvesting applications.

Expected Output and Outcome of the proposal :

To improve the performance of the battery, a new class of energy storage devices is developed using Metal-organic frameworks, a class of porous polymeric material, consisting of metal ions linked together by organic bridging ligands are used as electrodes in Aluminium batteries.
The proposed project involves Synthesis and characterization of novel Al-ion rechargeable battery with low cost, safe and sustainable with nano structured metal organic frame works as electrode. The expected efficiency is more than 95% with increase in performance rate and energy density as well as life cycle. Electrodes with MOFs are proposed to give huge surface area, high porosity, controllable structure and tunable pore size to improve operating voltage of the cell.

Is Ethical Clearance Certificate Required in the proposed research ? :

No

Is Certificate from Institutional Biosafety Committee Required in the proposed research ? :

No

Suitability of the proposed work in the major national initiatives of the Government :

Make in India

Theme of Proposed Work :

Energy

SCIENCE AND ENGINEERING RESEARCH BOARD
TEACHERS ASSOCIATESHIP FOR RESEARCH EXCELLENCE
Other Technical Details

Summary of the project:

The development of renewable energy resources together with more efficient technologies for energy conversion and storage is one of mankind's key challenges. The enhancement of energy conversion and storage technologies (fuel cells, solar cells, batteries, super capacitors, etc.) needs to be improved to enable better use of intermittent renewable electricity sources and to develop sustainable transport solutions associated with a modern society. The fact that output power of renewable energy sources such as solar and wind power plants depends on meteorological conditions, therefore electricity generated through RESs need to be stored in batteries for later use. In order to satisfy such demands and maintain a normal operation localized power plants have been built with energy storage devices. The performance of the battery is improved by developing the high energy density cathode materials at Nano scale. Batteries with Nano scale materials develop more power quickly with less heat. The functional objective of nanotechnology is to model, simulate, design and manufacture nano structures and nano devices with extra ordinary properties and assemble them economically into a working system with revolutionary functional abilities.

In recent years, research and development of battery technology has primarily been focused on small-scale to large- scale applications, such as electronic devices, electric vehicles & backup systems, in which the specific energy and energy density are of great importance. It is proposed to prepare various nano structured materials. It is planned to study the cell charge and discharge properties of the rechargeable battery in which we use nano structured metal organic frame work materials with carbon material.

Here in our proposed work a novel battery fabrication involves a low cost, safe and sustainable nano structured metal organic frame works with conductive carbon, a mixture of 1-ethyl-3-methylimidazolium chloride and $AlCl_3$ (1 : 2 molar ratio) as an electrolyte in order to improve operating voltage, energy density, life cycle and efficiency. The phases involved in the fabrication of stable metal-organic framework nano particles as electrodes for Aluminum Ion Batteries are as follows:

Phase 1:

Procurement of raw materials and infrastructure for the preparation of metal – organic frame work nano particles by synthesis techniques like Solvothermal and hydrothermal synthesis methods.

Phase 2:

Ball milling of the metal precursors with organic polymer / ligands to obtain fine nano sized metal organic frame works.

Phase 3:

Characterization of these nano particles by X-ray diffraction techniques, TG/DTA, SEM, UV-Vis spectroscopy, FTIR spectroscopy and particle analyzer and Electrochemical impedance spectroscopy.

Phase 4:

The obtained metal organic frame work cubic structured nano particles are further mixed with carbon to prepare electrode materials. Studying the properties of electrodes prepared by metal – organic frame works with XRD, SEM and UV-Vis spectroscopy.

Phase 5:

Fabrication of the cell assembly using MOF electrodes and electrolyte to study the battery properties. Inexpensive electrolytes like Aluminum nitrates are to be used in this methodology. To study the electrochemical properties of above prepared cells with battery testing equipment.

2. Objectives

To prepare noval metal organic framework nanoparticles as electrode for Aluminum Ion Batteries to increase its operating voltage and life cycle for energy harvesting applications.

3. Importance of the proposed project in the present context of research in the proposed area of the project

The proposed project ***"Synthesis and characterization of Novel Metal- organic framework nano particles as electrodes for Aluminum Ion Rechargeable Batteries"***. It is important to make energy storage devices of high performance. To overcome the disadvantages in commercial lead acid batteries, lithium ion batteries were developed with high operating voltage(4volts) and life cycle(30,000cycles) but LIBs are toxic, explosive and expensive, hence these are not suitable for commercial applications. In order to replace existing rechargeable batteries such as lithium ion batteries, lot of research work is going on Aluminum ion batteries even though its operating voltage is very less (2.6volts). Relative to Al, only lithium has a slightly higher electrochemical equivalent. Furthermore, the theoretical speci□c volumetric capacity of Al is the highest among the metallic fuels (8.04 A h cm^3). These advantages, as well as its low price-per-energy unit have increased interest in its use as an anode material in battery systems, speci□cally, in alkaline metal–air batteries. A major barrier to commercialization of such batteries, however, is the high rate of aluminum self-corrosion in alkaline solutions both under open-circuit conditions and during discharge. Efforts to suppress this parasitic corrosion include doping of high-purity aluminum (99.999% grade) with speci□c alloying elements4 and introducing corrosion inhibitors into its electrolyte. The ideal features like high performance rate is not achieved by Al-ion batteries. To improve the performance of the battery, a new class of energy storage devices is developed using Metal-organic frameworks, a class of porous polymeric material, consisting of metal ions linked together by organic bridging ligands are used as electrodes in Aluminum batteries. With these, very high absorption behaviors, high porosity, excellent reversibility kinetics, high performance rate and high energy density can be achieved.

- **Pictorial representation of need for energy storage system:**

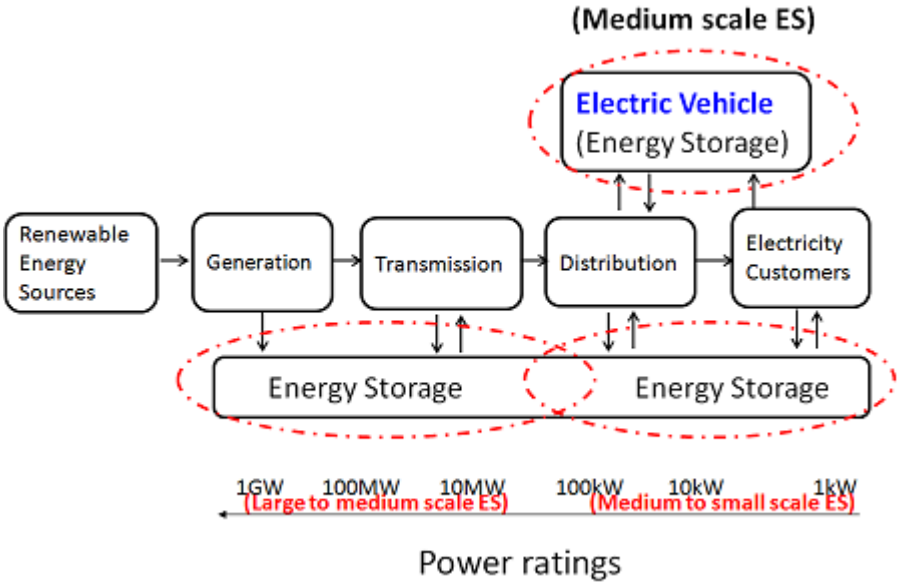

Fig: Electricity value chain – modern concepts

4. Work Plan:

4.1 Methodology:

A. Material selection:

The disadvantages of conventional lithium ion batteries are low energy density, expensive to manufacture, higher cost to energy ratio, subject to aging, even if not in use - storage in a cool place at 40% charge reduces the aging effect, Requires protection circuit to maintain voltage and current within safe limits, Not fully mature - metals and chemicals are changing on a continuing basis, Transportation restrictions - shipment of larger quantities may be subject to regulatory control. To overcome these disadvantages a new class of materials as metal organic frameworks (MOFs) represent a promising new class of porous crystalline solids because they exhibit large pore volumes, high surface areas, permanent porosity, high thermal stability, and feature open channels with tunable dimensions and topology. MOFs also provide longer life cycle, improved conductivity, reduces battery weight and safe in circuits. **Metal-organic frameworks** (MOFs) are compounds consisting of metal ions or clusters coordinated to organic ligands to form one-, two-, or three- dimensional structures. They are a subclass of coordination polymers, with the special feature that they are often porous. The organic ligands included are sometimes referred to as "struts", one example being 1, 4-benzenedicarboxylic acid (BDC).

A metal–organic framework is a coordination network with organic ligands containing potential voids. A coordination network is a coordination compound extending, through repeating coordination entities, in one dimension, but with cross-links between two or more individual chains, loops, or spiro-links, or a coordination compound extending through repeating coordination entities in two or three dimensions; and finally a coordination polymer is a coordination compound with repeating coordination entities extending in one, two, or three dimensions. In some cases, the pores are stable during elimination

of the guest molecules (often solvents) and could be used for the storage of gases such as hydrogen and carbon dioxide. Other possible applications of MOFs are in gas purification, in gas separation, in catalysis, as sensors and as super capacitors. MOFs are produced almost exclusively by hydrothermal or solvo-thermal techniques, where crystals are slowly grown from a hot solution. MOFs are constructed from bridging organic ligands that remain intact throughout the synthesis.

B. Synthesis Methods:

i) Solvothermal synthesis**:**

Solvothermal synthesis utilizes a solvent under pressures and temperatures above its critical point to increase the solubility of solid and to speed up reaction between solids. This method allows the easy control on the solubility of a solute and it leads to lowers upper saturation state which is necessary for the precipitation to happen. **Solvothermal synthesis** is a method of producing chemical compounds. It is very similar to the hydrothermal route (where the synthesis is conducted in a stainless steel autoclave), the only difference being that the precursor solution is usually not aqueous (however, this is not always the case in all literature uses of the expression). Using the solvo thermal route gains one the benefits of both the sol-gel and hydrothermal routes. Thus solvo thermal synthesis allows for the precise control over the size, shape distribution, and crystallinity of metal oxide nano particles or nanostructures. These characteristics can be altered by changing certain experimental parameters, including reaction temperature, reaction time, solvent type, surfactant type, and precursor type. Solvothermal synthesis has been used in laboratory to make nano structured titanium dioxide, graphene, carbon and other materials.

ii. Hydrothermal synthesis:

Hydrothermal synthesis includes the various techniques of crystallizing substances from high-temperature aqueous solutions at high vapor pressures; also termed "hydrothermal method". The term "hydrothermal" is of geologic origin. Geochemists and mineralogists have studied hydrothermal phase equilibrium since the beginning of the twentieth century. George W. Morey at the Carnegie Institution and later, Percy W. Bridgman at Harvard University did much of the work to lay the foundations necessary to containment of reactive media in the temperature and pressure range where most of the hydrothermal work is conducted. Hydrothermal synthesis can be defined as a method of synthesis of single crystals that depends on the solubility of minerals in hot water under high pressure. The crystal growth is performed in an apparatus consisting of a steel pressure vessel called an autoclave, in which a nutrient is supplied along with water. A temperature gradient is maintained between the opposite ends of the growth chamber. At the hotter end the nutrient solute dissolves, while at the cooler end it is deposited on a seed crystal, growing the desired crystal. In hydro thermal synthesis, the solvent is always water. It is clear that liquid water in an open container could not be raised above 100°C. But, if water is heated in a sealed container, it can be heated to temperatures above 100. It means supercritical properties of the water can be used under this condition. Hydrothermal synthesis can be defined as a method of synthesis of single crystals which depends on the solubility of minerals in hot water under high pressure. As advantage of this method can be mentioned such as provide a single phase, give enhanced permeability, mass transport capability and dissolving capacities, no post heat treatment is needed hence agglomeration will be less, after preparation no milling is required which will reduce impurities, can be synthesized any complex chemical compositions, controlling particle size or shapes, hydro thermal method crystal growth includes the ability to create crystalline phases which are not stable at the melting point. Advantages of the hydrothermal method over other types of crystal growth include the ability to

create crystalline phases which are not stable at the melting point. Also, materials which have a high vapour pressure near their melting points can be grown by the hydrothermal method. The method is also particularly suitable for the growth of large good-quality crystals while maintaining control over their composition. Disadvantages of the method include the need of expensive autoclaves, and the impossibility of observing the crystal as it grows.

Equipment for hydro thermal crystal growth:

The crystallization vessels used are autoclaves. These are usually thick-walled steel cylinders with a hermetic seal which must withstand high temperatures and pressures for prolonged periods of time. Furthermore, the autoclave material must be inert with respect to the solvent. The closure is the most important element of the autoclave. Many designs have been developed for seals, the most famous being the Bridgman seal.

iii. Mechanical Attrition (BALL MILLING):

Unlike many of the methods mentioned above, mechanical attrition produces its nanostructures not by cluster assembly but by the structural decomposition of coarser grained structures as a result of plastic deformation. Elemental powders of Al and β- SiC were prepared in a high energy ball mill. More recently, ceramic/ceramic nano composite WC-14% MgO material has been fabricated. The ball milling and rod milling techniques belong to the mechanical alloying process which has received much attention as a powerful tool for the fabrication of several advanced materials. Mechanical alloying is a unique process, which can be carried out at room temperature. The process can be performed on high energy mills, centrifugal type mill and vibratory type mill, and low energy tumbling mill. High energy mills include: Attrition Ball Mill, Planetary Ball Mill, Vibrating Ball Mill, Low Energy Tumbling Mill, and High Energy Ball Mill.

- **Attrition Ball Mill:**

  The milling procedure takes place by a stirring action of an agitator which has a vertical rotator central shaft with horizontal arms (impellers). The rotation speed was later increased to 500 rpm. Also, the milling temperature was in greater control.

- **Planetary Ball Mill:**

  Centrifugal forces are caused by rotation of the supporting disc and autonomous turning of the vial. The milling media and charge powder alternatively roll on the inner wall of the vial and are thrown off across the bowl at high speed (360 rpm).

- **Vibrating Ball Mill:**

  It is used mainly for production of amorphous alloys. The changes of powder and milling tools are agitated in the perpendicular direction at very high speed (1200 rpm).

- **Low Energy Tumbling Mill:**

  They have been used for successful preparation of mechanically alloyed powder. They are simple to operate with low operation costs. A laboratory scale rod mill was used to prepare homogenous amorphous Al30Ta70 powder by using S.S. cylinder rods. Single-phase amorphous powder of AlxTm100-x with low iron concentration can be formed by this technique.

- **High Energy Ball Mill:**

High-energy ball milling is an already established technology, however, it has been considered dirty because of contamination problems with iron. However, the use of tungsten carbide component and inert atmosphere and /or high vacuum processes has reduced impurity levels to within acceptable limits. Common drawbacks include low surface, highly poly disperse size distribution, and partially amorphous state of the powder. These powders are highly reactive with oxygen, hydrogen and nitrogen. Mechanical alloying leads to the fabrication of alloys, which cannot be produced by conventional techniques. It would not be possible to produce an alloy of Al-Ta, because of the difference in melting points of Al (933 K) and Ta (3293 K) by any conventional process. However, it can be fabricated by mechanical alloying using ball milling process.

(i) Characterization Techniques of Synthesized Compounds:

a) X-RAY DIFFRACTION (XRD):

X- ray diffraction is a powerful tool for materials characterization as well as for detailed structural elucidation. X-ray patterns are used to establish the atomic arrangements of the materials because of the fact that the lattice parameter, *d* (spacing between different planes) is of the order of x-ray wavelength. Further, X-ray diffraction method can be used to distinguish crystalline materials from nano crystalline (amorphous) materials. The structure identification is made from the x-ray diffraction pattern analysis and comparing it with the internationally recognized database containing the reference pattern (JCPDS).

b) NANO PARTICLE SIZE ANALYZER:

This is the instrument for characterization of the physical properties of samples. Depending on the configuration and application the system can be used as a particle size analyzer, or also used to measure zeta potential, molecular weight (MW) and second virial coefficient (A2). Detection of data is carried out by dynamic light scattering (DLS), which is depending on the physical properties of the specimen, the dynamic range is 0.3nm–

8μm.The lower limit is influenced by concentration, how strongly the sample scatters light, and the presence of large unwanted particles. The upper limit is influenced by the density of the sample since DLS is modeled on all motion coming from Brownian motion, not gravitational settling. The instrument can measure the molecular weight of proteins, polymers, and other molecules.

c) SCANNING ELECTRON MICROSCOPY(*SEM*):

SEM is one of the common techniques used in characterization of nano materials and nanostructures. SEM can be provided topographical information as optical microscopes, chemical composition information, crystalline structure and orientation of materials making up the sample. Generally SEM has a source of electrons is focused into a beam, with having energy ranging around few hundred eV to 50KeV that is restored over the surface of the specimen by deflection coils. As the electrons strike and penetrate the surface, a number of interactions occur that result in the emission of electrons and photons from the sample, and SEM images are produced by collecting the emitted electrons on a cathode ray tube (CRT). The SEM uses a focused into a beam (by electromagnetic lenses) with high energy electrons (range from few hundred (eV) to 50(KeV)) to produce a different type of signals at the surface of solid specimens. Conventional SEM has magnification ranging from 10X to approximately 100,000X, spatial resolution of 50 to

100nm. As the electrons strike and penetrate the surface, a number of interactions occur that result in the emission of electrons and photons from the sample, and SEM images are produced by collecting the emitted electrons on a cathode ray tube (CRT).

d) UV-Vis SPECTROSCOPY:

This technique involves the absorption of near-UV or visible light. One measures both intensity and wavelength. It is usually applied to molecules and inorganic ions in solution. Broad features make it not ideal for sample identification. However, one can determine the analyze concentration from absorbance at one wavelength and using the Beer- Lambert law:

e) Fourier Transform Infra-Red (FTIR) Spectroscopy:

The FTIR spectroscopy deals with the study of the interaction of matter with Infrared (IR) radiation. The absorption of radiation by a sample requires that (1) the energy content of radiation should correspond to the energy difference between the two vibrational states (2) there should be strong coupling reaction between the sample and the radiation. This coupling interaction takes place only if there is a change in dipole moment during the absorption process. If there is no change in dipole moment during the absorption process, there will be no coupling interaction between t//he sample molecules and radiation and therefore no absorption is possible, even if the first condition is satisfied. Infrared spectra are usually plotted as percentage transmittance (%T) or absorbance (A) on a scale, linear in wave numbers. Transmittance is the ratio of the intensity of radiation transmitted by the sample (I) to that incident on the sample(I), expressed as a percentage, so that T=100(I/I) .The main advantage of FT is the rapid-scan capability, especially for the study of short-lived species. Now-a-days, computer controlled instruments are available which allow rapid data manipulation, repetitive scanning, signal averaging, background subtraction, spectral smoothing, fitting & scaling, and searching in digitized spectral libraries & databases, to identify unknown samples. Among the applications of Infrared Spectroscopy, chemical analysis (qualitative and quantitative) and the determination of molecular structure are important. The present study was performed on a Perkin Elmer paragon 500 model spectrometer in the region of 400–2000 cm-1. Comparing the results of characterization techniques and selecting the appropriate material for battery electrode applications.

ii) Preparation of MOF- derived nano structured carbon electrodes and battery cell assembly:

The obtained metal organic frame work cubic structured nanoparticles are further mixed with amorphous carbon to prepare cathode electrode materials. The large content of carbon-based organic linkers in MOFs facilitates the design of nano structured carbon using MOFs as sacrificial materials. Because MOFs inherently consist of metallic species which are an integral part of the whole structure, it is essential to remove these metallic species to get high surface area carbon. Direct carburization of Al-porous coordination polymers is used to fabricate carbon. The obtained nano porous carbon possessed an extremely high surface area over 5000m2 g_1 and a large pore volume of 4.3 cm3 g_1. It was also revealed that the carbonization temperature was critical to realize such high surface area and pore volume. Another method for preparing nano structured carbon with high porosity can be achieved by infiltrating a secondary carbon source into the cavities of MOF shard-templates. Carbonization of MOFs with secondary precursor commonly results in high surface area carbon. For example by using pristineZIF-8 to obtain the high surface area carbon, furfuryl alcohol was introduced into ZIF-8 as a secondary carbon source, which gave unexpectedly high surface area of 3405m2g_1 and a total pore volume of 2.58cm3 g_1. Besides furfuryl, some other carbon-based organics like glycerol, carbon tetrachloride, ethylenediamine, and phenolic resin have been reported for using as secondary carbon sources in MOFs

cavities for producing nano structured carbon. The properties of electrodes prepared by metal – organic frame works are characterized with the techniques (XRD, Scanning electron microscopy and UV-Vis spectroscopy) described in the section characterization of synthesized compounds.By analysing the results of characterization techniques for the electrode materials, a suitable selection of electrodes is made. With the procurement of suitable electrodes and electrolytes, battery cell assembly will be started. In this project, Inexpensive electrolytes like Sodium sulphates, sodium nitrates, lithium nitrates, potassium nitrates and ammoniates are to be used. The study of the fabricated battery cell is done by using Cyclic Voltammetry method.

iii)Study of fabricated Al-ion battery cell using cyclic voltammetry method in Electrochemical workstation:

Cyclic voltammetry is a type of potentiodynamic electrochemical measurement. In a cyclic voltammetry experiment, the working electrode potential is ramped linearly versus time. Unlike in linear sweep voltammetry, after the set potential is reached in a CV experiment, the working electrode's potential is ramped in the opposite direction to return to the initial potential. These cycles of ramps in potential may be repeated as many times as needed. The current at the working electrode is plotted versus the applied voltage (that is, the working electrode's potential) to give the cyclic voltammogram trace. Cyclic voltammetry is generally used to study the electrochemical properties of an analyte in solution. In cyclic voltammetry, the electrode potential ramps linearly versus time in cyclical phases. The rate of voltage change over time during each of these phases is known as the experiment's scan rate (V/s). The potential is applied between the working electrode and the reference electrode, while the current is measured between the working electrode and the counter electrode. These data are plotted as current (*i*) versus applied potential (*E*, often referred to as just 'potential'). During the initial forward scan (from t0 to t1) an increasingly reducing potential is applied; thus the cathodic current will, at least initially, increase over this time period assuming that there are reducible analytes in the system. At some point after the reduction potential of the analyte is reached, the cathodic current will decrease as the concentration of reducible analyte is depleted. If the redox couple is reversible then during the reverse scan (from t1 to t2) the reduced analyte will start to be re-oxidized, giving rise to a current of reverse polarity (anodic current) to before. The more reversible the redox couple is, the more similar the oxidation peak will be in shape to the reduction peak. Hence, CV data can provide information about redox potentials and electrochemical reaction rates.

For instance, if the electron transfer at the working electrode surface is fast and the current is limited by the diffusion of analyte species to the electrode surface, then the peak current will be proportional to the square root of the scan rate. This relationship is described by the Cottrell equation. In this situation, the CV experiment only samples a small portion of the solution, i.e., the diffusion layer at the electrode surface. Cyclic voltammetry (CV) has become an important and widely used electro analytical technique in many areas of chemistry. It is often used to study a variety of redox processes, to determine the stability of reaction products, the presence of intermediates in redox reactions, reaction and electron transfer kinetics, and the reversibility of a reaction.CV can also be used to determine the electron stoichiometry of a system, the diffusion coefficient of an analyte, and the formal reduction potential of an analyte, which can be used as an identification tool. In addition, because concentration is proportional to current in a reversible, the concentration of an unknown solution can be determined by generating a calibration curve of current vs. concentration.

Experimental setup:

CV experiments are conducted on a solution in a cell fitted with electrodes. The solution consists of the solvent, in which are dissolved electrolyte and the species to be studied.

The cell:

A standard CV experiment employs a cell fitted with three electrodes: reference electrode, working electrode, and counter electrode. This combination is sometimes referred to as a three-electrode setup. Electrolyte is usually added to the sample solution to ensure sufficient conductivity. The solvent, electrolyte, and material composition of the working electrode will determine the potential range that can be accessed during the experiment.

The electrodes are immobile and sit in unstirred solutions during cyclic voltammetry. This "still" solution method gives rise to cyclic voltammetry's characteristic diffusion-controlled peaks. This method also allows a portion of the analyte to remain after reduction or oxidation so that it may display further redox activity. Stirring the solution between cyclic voltammetry traces is important in order to supply the electrode surface with fresh analyte for each new experiment. The solubility of an analyte can change drastically with its overall charge; as such it is common for reduced or oxidized analyte species to precipitate out onto the electrode. This layering of analyte can insulate the electrode surface, display its own redox activity in subsequent scans, or otherwise alter the electrode surface in a way that affects the CV measurements. For this reason it is often necessary to clean the electrodes between scans.

Common materials for the working electrode include glassy carbon, platinum, and gold. These electrodes are generally encased in a rod of inert insulator with a disk exposed at one end. A regular working electrode has a radius within an order of magnitude of 1 mm. Having a controlled surface area with a well-defined shape is necessary for being able to interpret cyclic voltammetry results. To run cyclic voltammetry experiments at very high scan rates a regular working electrode is insufficient. High scan rates create peaks with large currents and increased resistances, which result in distortions. Ultra micro electrodes can be used to minimize the current and resistance. The counter electrode, also known as the auxiliary or second electrode, can be any material that conducts current easily and will not react with the bulk solution. Reactions occurring at the counter electrode surface are unimportant as long as it continues to conduct current well. To maintain the observed current the counter electrode will often oxidize or reduce the solvent or bulk electrolyte.

Solvents:

CV can be conducted using a variety of solutions. Using typical electrodes, solvents dissolve not only the analyte, often at mM levels, but also electrolyte, generally at much higher concentrations. For aqueous solutions, these requirements are trivial, but for non aqueous solutions, the choices of suitable solvents are fewer.

Electrolyte:

The electrolyte ensures good electrical conductivity and minimizes IR drop such that the recorded potentials correspond to actual potentials.. In non aqueous solvents, the range of electrolytes is more limited, and a popular choice is tetra butyl ammonium hexa fluoro phosphate ("TBAF").

4.2 Time Schedule of activities giving milestones through BAR diagram.

S.No	Activity/Mile Stone	1st Year		2nd Year		3rd Year	
		1-6M	6-12M	13-18M	19-24M	25-30M	31-36M
A1	Procurement of raw materials and infrastructure.						
A2	Preparation of metal – organic frame work nano particles by solvothermal method and hydrothermal method.						
A3	Ball milling of the metal precursors with organic polymer / ligands to obtain fine nano sized metal organic frame works.						
A4	Characterization of these nano particles by XRD,TG/DTA, SEM, UV-Vis spectroscopy, FTIR spectroscopy and Particle Size analyzer.						
A5	Cell preparation and testing using Organ glove box and electrochemical work station.						

f) Justification for proposing the host institute / mentor

- Since the host institute (CSIR-IICT) has well equipped synthesis lab, all the required characterization facilities and battery testing equipment, it will be easy to carry out experimentation and testing of proposed project.
- Furthermore Dr.J.Vatsala Rani is expertise in synthesis and characterization of Aluminium ion batteries for energy harvesting applications, her technical expertise would be valuable.
- The host institute IICT is nearer to our parent institute Geethanjali College of Engineering and Technology to carry out this proposed work with collaboration under TARE research scheme of SERB

6. Key publications (SCI indexed journals) published by the Investigator

- M. Aruna Bharathi, K. Venkateswara Rao, M. Sushama"Synthesis, Characterization and Density Functional Study of $LiMn_{1.5}Ni_{0.5}O_4$ Electrode for Lithium ion Battery" Journal of Nano and Electronic physics, Vol. 6 No 1, 01005(5pp) (2014).

- M. Aruna Bharathi, K. Venkateswara Rao, M. Sushama "Structural and Electronic properties of LiMn2O4 Nano Material for Lithium Ion Battery "International Journal of Quantum Matter, American Scientific Publishers (ASP)-USA Volume 5, Number 3, June 2016, pp. 365-368(4)

7. Bibliography

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8. List of Projects submitted/implemented by the Investigator in last five year, if any

(List out details of the Projects submitted, implementing and/or completed)

S. No.	Title	Cost in lakhs	Month of submission	Role as PI / Co-PI	Agency	Status
1	**"Fabrication Of Quantum Dots In Perovskite Materials For Green Power Applications".** Reference No : **202016000621**	50.8	November 2017	PI	SERB Empowerment and Equity Opportunities for Excellence in Science Scheme	Not Recommended

9. List of facilities being extended by host / parent institution(s) for the project implementation.

9.1 Infrastructural Facilities at host / parent institute

S. N.	Infrastructural Facility	Yes / No / Not required Full or sharing basis	
		Host institute	**Parent institute**
A.	Workshop Facility	Yes	Yes
B.	Water & Electricity	Yes	Yes

C.	Laboratory Space/ Furniture	Yes	Yes
D.	Power Generator	Yes	Yes
E.	AC Room or AC	Yes	Yes
F.	Telecommunication including e-mail & fax	Yes	Yes
G.	Transportation	Yes	Yes
H.	Administrative/ Secretarial support	Yes	Yes
I.	Information facilities like Internet/Library	Yes	Yes
J.	Computational facilities	Yes	Yes
K.	Animal/Glass House	Not required	Not required
L.	Any other special facility being provided	Not required	Not required

9.**2 Equipment available with the mentor / Institute/ Group/ Department/Other Institutes available for the project:**

Equipment available with	**Generic name of Equipment**	**Model, Make & year of purchase**	**Remarks including accessories available and current usage of equipment**
With mentor	Electrochemical workstation	Biologic Science instruments, BCS-815,France, 2018	Currently in Use
	4 Probe Resistivity meter	SES instruments,Roorkee,2016	Currently in Use
	Organ Glove Box	M Braun(Unilab),Germany,2016	Currently in Use
	Vacuum Oven	Ham co-Hindustan inst.co,2016	Currently in Use
	Conductivity meter	Karfischea-metrohm 860Kf thermoprep,2017	Currently in Use
	Viscometer	Brookfield Viscometer DV2T,2016	Currently in Use
With host institute	X-Ray Diffractometer	PANalytical Empyrean XRD,2011	Currently in Use
	Field Emission Scanning Electron	FESEM, JEOL JSM-7610F,2012	EDAX, Elemental Detection from Boron onwards.

	Microscope		Currently in Use
	High Resolution Transmission Electron Microscope	HRTEM, TALOS F200X from FEI,2013	SEAD, Selected Area Electron Diffraction. Currently in Use
	Co focal Micro-Raman Spectrometer	Horiba Jobin Yvon HR 800 UV,2009	Currently in Use
	Thermo gravimetric Analyser TGA/DTA/DSC	Hitachi High Technologies Global, 2012	Currently in Use
	Fourier Transform Infrared Spectroscopy (FTIR)	Brüker,Advance,2014	Currently in Use
With parent institute	Chemical laboratory.		Apparatus required for basic research is available.
			No major equipment

10. Name and address of experts/ institution interested in the subject / outcome of the project

a) Name and address of experts/ institution interested in the subject

(1) **Dr. R.S. Raju** Ex-Chief Scientist, CSIR-CEERI, Pilani, Rajasthan Presently : Dean R&D Geethanjali College of Engineering & Technology, Cheeryal (V), Keesar (M), Medchal Dist. Telangana state -501301 Mobile: 9413723303 E-mail: raju.ceeri@gmail.com	2) **Dr. K. VenkateswaraRao** Professor of Nanotechnology, CNST IST ,Jawaharlal Nehru Technological University Hyderabad(JNTUH)* TS -500085 Phone: +91-9440858664 kalagadda2003@gmail.com, kalagadda2003@jntuh.ac.in PDF: Raman Postdoctoral fellow School of Medicine, Radiology Dept Johns Hopkins University, Baltimore, Maryland, USA

3)**Tata Narasinga Rao** Scientist-F,ARCI, HYDERABAD, Phone (office): +91-40-24441075 Fax: +91-40-24442699 E-mail: tata@arci.res.in	**4) Dr.Vemuri Madhu** Scientist-G, Armour Design and development division, Defence metallurgical research laboratory, Kanchanbagh, Hyderabad-500 058 Telangana State, phone-9440498708, **Email: madhu.vemuri@dmrl.drdo.in**

b) Outcome of the project :

To improve the performance of the battery, a new class of energy storage devices is developed using Metal-organic frameworks, a class of porous polymeric material, consisting of metal ions linked together by organic bridging ligands are used as electrodes in Aluminium batteries

The proposed project involves Synthesis and characterization of novel Al-ion rechargeable battery with low cost, safe and sustainable with nano structured metal organic frame works as electrode. The expected efficiency is more than 95% with increase in performance rate and energy density as well as life cycle. Electrodes with MOFs are proposed to give huge surface area, high porosity, controllable structure and tunable pore size to improve operating voltage of the cell.

RESUME

Dr.M.ARUNA BHARATHI
D/O M.RATNA KISHORE
D.NO; 12-51,
BANK COLONEY,
XAVIER NAGAR,
ELURU-534007

E-mail ID:arunabharathi916@gmail.com
Contact No: 9908325596

Career Objective:

Seeking a challenging and responsible position and career in an esteemed organization where I can share and enrich my knowledge and skills for growth of the organization as well as self.

RESEARCHINTRESTS:

- Power Quality and Conditioning
- Renewable Energy sources
- Hybrid Power Systems
- Nano Technology
- Nano Materials for Energy Harvesting
- Synthesis &Characterization Techniques

EDUCATION:

Jawaharlal Nehru Technological University Hyderabad, INDIA

- Doctor of Philosophy in Electrical and Electronics Engineering, June '2015

  Thesis Title: **"Synthesis, Characterization and Computational Analysis OfLithium Ion Batteries With Nano Materials",**
- Master of Technology in Electrical Power Engineering, 2007
- Thesis Title: **"Wavelet based Power Quality Improvement by Unified Power Quality Conditioner"**

Andhra University Visakhapatnam, INDIA

- Bachelor of Technology in Electrical and Electronics Engineering,2002

  (Sir.C.R.Reddy College of Engineering College)

  Project Title: **"Closed loop Speed Control of DC Series Motor using Micro controller based Chopper Circuit"**

PROFESSIONAL EXPERIENCE:

A) TEACHING

Sir C R Reddy College of Engineering, Eluru

- Associate Professor , Dept of EEE August,2015-Present
- Assistant Professor, Dept of EEE **July, 2007 – July,2015**

St.Theresa's college for women,Eluru

- Lecturer , Dept of Electronics and Physics, Jun, 2004 – May, 2005

Sir.C.R.Reddy College for Women,Eluru

- Lecturer , Dept of Electronics, Jun, 2002 – May, 2004

B) ADMINISTRATIVE

- In-Charge Result Analysis, Dept of EEE **Jun, 2008- Present**
- In-Charge Electronic Devices and Circuits Laboratory, **Jun, 2008 – Present**
- Reviewer for BE project work
- Faculty Coordinator for NBA, Dept of EEE **Jun, 2007 – Present**
- Faculty coordinator for campus placements Dept of EEE **Jun, 2007-2009**
- Faculty co-coordinator for TECHFEST (Technical paper presentations)
- Coordinator during Inspection committees (AICTE,A.U) .
- Member in department development committee
- In-Charge for laboratory Budget proposals, Dept of EEE **Jun, 2008 - Present**
- In-Charge for department R&D activities and faculty profiles

C) EXTRA CURRICULAR

- Guiding students Hobby projects and paper Presentations
- Conducting counseling classes to students.
- Faculty advisor for college Women protection cell

PROJECTSGUIDED:

Sir C R Reddy College of Engineering, Eluru

- Under Graduate: 14
- Post Graduate : 04

COURSESHANDLED:

Sir C R Reddy College of Engineering, Eluru

U.G. Electrical and Electronics Engineering

- Performance and Design of Electrical machines I,II& III
- Electrical Machines
- Power Systems-I, II
- Control systems
- Digital Control Systems
- Power System Protection
- Power System Analysis & Stability

- Electronic Devices and Circuits
- Elements of Electrical Engineering
- Electro Magnetic Field Theory

P.G. Power Systems and Automation

- Extra High Voltage AC
- Power Quality

DETAILS OF LABORATORY WORK HANDLED :

- Power system simulation lab
- Basic Electrical Engineering
- Electrical Machines
- Networks& Measurements
- Control systems
- Electronic Devices And Circuits lab
- Power Electronics lab
- Material Synthesis lab
- Material simulation Lab

COMPUTER SKILLS:

- Expertise in Material Studio
- Expertise in Quantum wise ATK Virtual Nano Lab
- Working with PCVD software for PV Module design
- Working with Simulation software like MATLAB, PSCAD, PSPICE,
- ETAP, PLC and Tool Boxes- Wavelets.
- Expertise in application of Nano material for Energy Harvesting

FELLOWSHIP OF ACADEMIC BODIES AND PROFESSIONAL SOCIETIES:

- Life member ISTE (LM 53264)
- Membership in IEI (M-153769-5)
- Selected for Rajiv Gandhi National Fellowship RGNF- UGC
- Received memento for best presentation from CSIR-CBRI,Roorky,and International conference.

GUEST LECTURES:

1. Delivered a guest lecture on"Quantum wise ATK Virtual Nano Lab Simulation studies" at CNST, IST, JNTUH,Hyderabad on (06-07)th July'2015.
2. Delivered a lecture on " Career guidance program for rural students" organized by World Vision of India, Eluru on 24th June' 2016.

DETAILS OF RESEARCH PUBLICATIONS:

CONFERENCEPUBLICATIONS:

1. Power Quality improvement using UPQC through Wavelet Transforms ICPS (International conference on Power systems) CPRI, Bangalore March, 2008
2. Solution Combustion method to Nano Composite Particles NCONSEA-2012 (National Conference on Nano Science, Nano Engineering &Applications) CNST, JNTUH HyderabadApril, 2012.
3. Improvement of Voltage Quality and Reducing Sag/Swells In Isolated Power Systems CONCON-2012 (National Conference on Contemporary Control and Soft Computing in Electrical Engineering Andhra University, Visakhapatnam May 2012.
4. Synthesis and Analysis of Nano Composite Particles Recent Trends in Nanobiotechnology in the protection of Health & Environment Andhra Loyola College Vijayawada 1st December 2012.
5. Synthesis & Analysis of Nano composite Materials for Lithium-ion Batteries using Solution CombustionMethod International conference on Advanced Materials for Energy Efficient Buildings CSIR-Central Building Research Institute ,India Habitat Centre New Delhi 14-02-2013.
6. Structural and Electronic properties of LiMn2O4 Nano Material for Lithium Ion Battery InternationalE-Workshop OnComputational Condensed Matter Physics and Materials Science(IWCCMP-2013), IIITM Gwalior, India 27-29 Nov,2013
7. Nano structured LiMn2O4 Cathode materials of Lithium ion Batteries for Energy Storage 3rd Nano Today Conference, IBN, Biopolis, **Singapore** (07-12)th Dec 2013.
8. LIBS/STATCOM with PSO based PI controller for a grid connected Wind Energy System ,National Conference on Power system Control Operation and Maintenance 24th and 25th January 2014 ISSN 2249 – 4944.
9. M. ArunaBharathi, K. VenkateswaraRao, M. Sushama "NanoMaterial prospects of Lithium ion Battery Electrode for VehicleApplications " 2nd International Conference on Recent Advances inDesign Development and Operation of Micro Air Vehicles,ICRAMAV-21-11-2013, ISBN:9789351071693
10. Particle swarm optimization control algorithm for power quality improvement in a grid interconnected wind energy system International Conference on recent Advances in Design, Development and Operation of Micro Air Vechiles-ICRAMAV-2013, JNTUH, Hyderabad, ISBN No : 9789351071693, page nos : 170-177, 21-11-2013.
11. "Synthesis, Characterization and Computational Analysisof LiMn1.5Cu0.5O4 Cathode material for Li-ion Batteries" International Conference on Nanoscience andNanotechnology for Energy Applications (EApp-2016),SathyabamaUniversity,Chennai,(27-29)th June'2016

JOURNALS:

1. Synthesis Characterization and Density Functional Study of $LiMn_{1.5}Ni_{0.5}O_4$ Electrode for Lithium ion Battery Journal of Nano Electronic Physics, Sumy State University, Ukraine Vol. 6 No 1, 01005(5pp) April,(2014).
2. Lithium-Ion battery energy storage STATCOM for grid interconnected WPS International Journal of Advanced Engineering and global Technology(IJAEGT)-RSA ISSN No: 2309-4893
3. LIBS/STATCOM with PSO Based PI Controller for a Grid Connected Wind Energy System International Journal of Education and applied research IJEAR Jan - June 2014, ISSN: 2348-0033 (Online) ISSN: 2249-4944.
4. Experimental and Density Functional Study of $LiMn_{1.5}Ni_{0.5}O_4$ Electrode for Lithium ion Battery International Journal of Nano Science and Engineering, International Association for Sharing Knowledge and Sustainability, Under Review.
5. Structural and Electronic properties of $LiMn_2O_4$ Nano Material for Lithium Ion Battery International Journal of Quntum Matter, American Scientific Publishers (ASP)-USA Accepted.
6. Electro chemical performance of $LiMn_{1.5}Ni_{0.5}O_4$ Cathode of Lithium Ion Battery for Renewable Energy Storage Journal of Energy Storage-Elsevier.(Communicated)

HANDS-ON TRAINING:

Selected and attended forINUP Hands-on training on Fabrication & Characterization of Crystalline Silicon Solar Cells,held at IIT Bombay,Mumbai during Nov 17-22,2014.

WORKSHOPS:

1. Wavelets and its Application to Power System Protection A One Day workshop, Dept.of EEE, VR.SiddhrthaEngg.college, Vijayawada, September, 2007.
2. Advanced Power System Simulation& Analysis with ETAP, SPARKS, Dept.of EEE, Sir.C.R.Reddycollege of engineering, Eluru, September, 2007.
3. Introduction to Nano science,Nano Technology & Applications, INSNTA, Center for Nano Science and Technology ,JNTUH, Hyderabad, September, 2010.
4. "Applications of Nano Technology" Short Term Course UGC-Academic staff college, JNTUH, Hyderabad (10^{th} -15^{th}) June 2013.
5. Advances in X-Ray diffractometry& Scanning Electron Microscopy Three days' workshop Dept. of Metallurgical and Materials Engineering, RGUKT(IIIT), Hyderabad (15^{th} -17^{th})July 2013.
6. IEEE Xplore Digital Library User Awareness Workshop, IEEE workshop University Library, JNTUH, Hyderabad, August 2013.
7. InternationalE-Workshop OnComputational Condensed Matter Physics and Materials Science(IWCCMP-2013), IIITM Gwalior, India 27-29 Nov,2013
8. Nano Fabrication Technologies, INUP Familiarization Workshop, IIT Bombay, Mumbai, May 26-28, 2014
9. Five days short term course on "Synthesis & Characterization of Nano Materials" organized by JNTUH under TEQUIP-II,from March 14th -18th 2016.

BRIEF ABOUT PHD THESIS:

Title: "Synthesis, Characterization And Computational Analysis Of Lithium Ion Batteries With Nano Materials"

ABSTRACT: The development of renewable energy resources together with more efficient technologies for energy conversion and storage is one of mankind's key challenges. The enhancement of energy conversion and storage technologies (fuel cells, solar cells, batteries, super capacitors, etc.) needs to be improved to enable better use of intermittent renewable electricity sources and to develop sustainable transport solutions associated with a modern society. The fact that output power of renewable energy sources such as solar and wind power plants depends on meteorological conditions. The performance of the battery is improved by developing the high power density cathode materials at Nano level. Batteries with Nano scale materials develop more power quickly with less heat. This work explains the synthesis of most interesting cathode materials with Lithium Manganese Spinel and its derivatives like transition metal oxide using various eco-friendly chemical methods, Nano particles were characterized by XRD, FESEM,EDAX,HRTEM, UV, electro chemical characterization(CV,) and (TGA/DTA) Thermal methods then compare the experimental results with computation details from first principle calculations with Material Studio and Quantum wise software's.

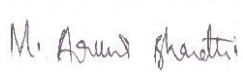
REFERENCES:

(1**) Dr.M.Sushama** Ph.D (JNTUH), MISTE, MIETE,MSSI Professor & Head , Electrical & Electronics Engineering, JNTU college of Engineering. Ph: 9848637597 Email- m73sushama@yahoo.com	2)**Dr.K. VenkateswaraRao** M.Sc, M.Tech; Ph.D Associate Professor of NanoTechnology, Addl.Controller of Examinations-II JNTUH. Ph no: 9440858664 Email- kalagadda2003@gmail.com
3)**Tata NarasingaRao** Scientist-F,ARCI, HYDERABAD Phone (office): +91-40-24441075 Fax: +91-40-24442699 E-mail: tata@arci.res.in	4)Dr.A.Srinivasa Reddy Professor & Head , Electrical & Electronics Engineering, Sir.C.R.Reddy college of Engineering,Eluru 534007 Ph no: 9440070075 Email - srinivasareddyalla@yahoo.co.in

- **Personal profile:**

Name	: Dr.M. ArunaBharathi
Father's name	:M. Ratna Kishore
Date of Birth	: 01-06-1978.
Age	: 38Years
Experience	: 12 academic years
Designation	: Associate Professor
Qualification	: PhD

I hereby declare that the particulars given above are true to the best of my knowledge and belief.



Place: ELURU
Date: 30-06-2016

SIGNATURE OF THE CANDIDATE

BOARD OF SECONDARY EDUCATION
ANDHRA PRADESH

J 376173

SECONDARY SCHOOL CERTIFICATE

PC/11/006652370

Certified that ARUNA BHARATHI MATHANGI bearing

R.No. 0187641 Son/Daughter of RATNA KISHORE

and belonging to A P S W R H S ARUGOLANU appeared

at the SSC EXAMINATION held in MARCH, 1993 and PASSED the EXAMINATION in

FIRST division with TELUGU as the medium of instruction.

The Date of Birth of the Candidate is

DATE OF BIRTH	DAY		MONTH	YEAR			
01/06/1978	ZERO	ONE	JUN	ONE	NINE	SEVEN	EIGHT

The Candidate Secured the following Percentage of marks

FIRST LANG.	MARKS	THIRD LANG.	MARKS	MATHEMATICS	MARKS
TELUGU SANSKRIT	66	ENGLISH	69	MATHEMATICS	77
GENERAL SCIENCE	77	SOCIAL STUDIES	82	TOTAL (in figures)	371

TOTAL (in words) * THREE HUNDRED AND SEVENTY ONE *

SECOND LANGUAGE (HINDI * SEVENTY THREE *) 73

Marks of Identification
1. A mole on the left side of the neck.
2. A mole on the right side of the lower jaw

Head of Institution

Date of Issue 10/05/1993

HYDERABAD

PRINCIPAL
A.P.S.W.R. SCHOOL FOR BOYS
ARUGOLANU - 534 152
(Via) Prathipadu-T.P.Gudem Mdl
WEST GODAVARI DT.

SECRETARY
BOARD OF SECONDARY EDUCATION

Any corrections in the Certificate will not be entertained after three years from the date of issue.
Any unauthorised correction in the certificate will result in cancellation of certificate.
The marks with the asterisk indicates the marks secured in the Previous Examinations.

Phone : 9533791618
Fax : +91-40-24220320
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Geethanjali

Geethanjali College of Engineering and Technology

AUTONOMOUS

(Accredited by NBA, Approved by AICTE, New Delhi)

Sy.No. 33 & 34, Cheeryal (V), Keesara (M), Medchal District. - 501 301.

CERTIFICATE FROM THE INVESTIGATOR

I, Dr. M. Aruna Bharathi (Name) Professor (Designation) Geethanjali College of Engineering & Technology (University / college / institute) agree to undertake the following, if I am offered the SERB –TARE, research grant.

1. I shall abide by the rules and regulations of SERB during the entire tenure of the grant.
2. I shall also abide by the rules, discipline of the institutions where I will be implementing my grant.
3. I shall devote adequate time to fulfil the requirements of the programme to execute the research work during the tenure of the grant.
4. I shall prepare the progress report at the end of each year and communicate the same to SERB duly certified by the mentor.
5. I shall send two copies and one soft copy (PDF file) of the consolidated progress report duly certified by the mentor at the end of the grant.

Date: 04-04-2018

M. Aruna Bharathi

Signature of the applicant

DIAMOND JUBILEE YEAR
1942-2002

भारतीय रासायनिक प्रौद्योगिकी संस्थान

हैदराबाद - 500 007

INDIAN INSTITUTE OF CHEMICAL TECHNOLOGY

(वैज्ञानिक तथा औद्योगिक अनुसंधान परिषद)

(COUNCIL OF SCIENTIFIC & INDUSTRIAL RESEARCH)

TARNAKA, UPPAL ROAD, HYDERABAD - 500 007. (A.P.) INDIA.

दिनांक / Dated: 3/4/18

ENDORSEMENT CERTIFICATE FROM THE HOST INSTITUTE

This is to certify that:

I. The applicant, Dr. Aruna Bharathi.M Will assumes full responsibility for implementing the project. Dr. Vatsala Rani.J, Senior Scientist, (designation) can act as mentor for the applicant in case the project proposal is approved for funding.

II. The associateship will start from the date on which the faculty member joins University / Institute where he / she implements the grant. The mentor will send the joining report to the SERB. SERB will release the funds on receipt of the joining report.

III. Institute will issue a mandatory 90 days attendance certificate upon completion by the candidate every year for release of fellowship.

IV. The applicant, if selected as a TARE grantee, will be governed by the rules and regulations of the Universities / Institute and will be under administrative control of the University / Institute for the duration of the grant.

V. The grant-in-aid by the Science & Engineering Research Board (SERB) will be used to meet the expenditure on the project and for the period for which the project has been sanctioned as indicated in the sanction letter/ order.

VI. No administrative or other liability will be attached to the Science & Engineering Research Board (SERB) at the end of the Research grant.

VII. The Institute will provide basic infrastructure and other required facilities to the investigator for undertaking the research objectives.

VIII. The Institute will take into its books all assets received under this sanction and its disposal would be at the discretion of Science & Engineering Research Board (SERB).

IX. The Institute assume to undertake the financial and other management responsibilities of the project.

X. The Institute shall settle the financial accounts to the SERB as per the prescribed guidelines within the three months from the date of termination of the Research grant.

Signature of the Mentor

वैज्ञानिक / SCIENTIST
फ्लोरो कार्बनिक प्रभाग
FLUOROORGANIC DIVISION
आई आई सी टी, हैदराबाद - 500 007.
IICT, Hyderabad - 500 007.

Signature of the Head of the Institute / Registrar

प्रभारी निदेशक / Incharge Director
सी.एस.आइ.आर-भारतीय रासायनिक प्रौद्योगिकी संस्थान
CSIR-Indian Institute of Chemical Technology
विज्ञान और प्रौद्योगिकी मंत्रालय, भारत सरकार
Ministry of Science & Technology, Govt. of India.
हैदराबाद/Hyderabad-500 007, तेलंगाना/Telangana, भारत/India.

दूरभाष / TELEPHONE : 27160123 - 40 (18 लाइनें / 18 LINES)
ई-मेल /E- mail : रूट@सीएस आईआईसीटी.रेन.आई.एन.आई.सी.इन / root@csiict.net.inic.in
टेलिग्राम / Telegram: रिसर्च / "RESEARCH" हैदराबाद / HYDERABAD. निदेशक टेलिफैक्स /Director Fax: 91-40-27160387
व.प्र.नि. टेलिफैक्स /Sr. COA Telefax: 91-40-27193198

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info@gcet.edu.in

Geethanjali

Geethanjali College of Engineering and Technology

AUTONOMOUS

(Accredited by NBA, Approved by AICTE, New Delhi)

Sy.No. 33 & 34, Cheeryal (V), Keesara (M), Medchal District. - 501 301.

ENDORSEMENT CERTIFICATE FROM THE PARENT INSTITUTE

This is to certify that:

I. The applicant **Dr. M. Aruna Bharathi** is working as a professor (designation) in this institute. We welcome her participation in the Project titled: *"Synthesis and Characterization of Novel Metal Organic Frame Work Nano Particles as Electrodes for Al-Ion Re-chargeable Batteries"* .

II. The applicant is in regular position as defined by the term "Regular" in the ECRA eligibility (Please refer www.serb.gov.in).

III. The applicant, Dr. M. Aruna Bharathi., will assume full responsibility of implementing the project as Principal Investigator.

IV. She will be allowed to work in the host institute CSIR-Indian Institute of Chemical Technology (CSIR-IICT) to fulfil the 90 days/year mandatory attendance period required for the research grant.

V. The date of commencement of the grant starts from the date on which the University/Institute receives the bank draft/cheque from the Science & Engineering Research Board (SERB).

VI. The grant-in-aid by the Science & Engineering Research Board (SERB) will be used to meet the expenditure on the project and for the period for which the project has been sanctioned as indicated in the sanction letter/ order.

VII. No administrative or other liability will be attached to the Science & Engineering Research Board (SERB) at the end of the Research grant.

VIII. The University/ Institute will provide basic infrastructure and other required facilities to the investigator for undertaking the research objectives.

IX. The University/ Institute will take into its books all assets received under this sanction and its disposal would be at the discretion of Science & Engineering Research Board (SERB).

X. University/ Institute assume to undertake the financial and other management responsibilities of the project.

XI. The University/ Institute shall settle the financial accounts to the SERB as per the prescribed guidelines within the three months from the date of termination of the Research grant.

Dated: March 28, 2018

Signature of the Head of Institute

Seal of the Institute

PRINCIPAL
Geethanjali College of Engg. and Tech.
Cheeryal (V), Keesara (M), Medchal Dist.(T.S.)-501 301.

Curriculum vitae

VATSALA RANI . J

Fluoro Organics Division,

Indian Institute of Chemical Technology,

Tarnaka, Hyderabad - 500 007,

AP, INDIA

Phone: 91-(040)-27193171 (off.)

91-(040)-27206068 (Res)

Email: vatsala@iict.res.in, vatsala.iict@gov.in

Mobile: 9010822191

DOB : 21 July1967

Education

Ph.D 1997 Electrochemistry **Osmania University , Hyderabad**

MSc . 1989 Organic Chemistry **Osmania University , Hyderabad**

Honours and Awards

Winner in DST- Lockeed Martin sponsored India Innovation Growth programme in 2015 and

Winner in visit to USA – Taxes University, Stanford University and Silicon valley .

For Innovating – Futuristic Eco –friendly Rechargeable Mg –ion battery

Work Experience

- 1997 : Research Associate ,Defence Research & Development laboratory, Hyd.,Telangana.
- 2002: Appointed Scientist, Central Electrochemical Research Institute,Karaikudi,T.N.
- 2008 to till date, Senior Scientist , India Institute of Chemical Technology, Hyd, Telangana.

Sponsor Research Project as PI (on going)

No.	Title	Funding Agency	Amount (Rupees)
1.	Synthesis of Novel layered nanosheet composites for polyvalent ion-treansfer type batteries (2015 to 2018)	**DST**	**38 lacs**
2	Development of Magnesium ion battery for defence application (2017 -2018)	**DRDO**	**65 lacs**
3	Development and commercialisation of Mg-ion battery (2017 -2019)	**AOST(Inc)**	**1.2 crores**

Patent (filed = 1, granted = 1)

Title: A Novel rechargeable magnesium battery with fluorinatedgraphite cathode and ionic liquid based gelatinized electrolyte. Copy right : CSIR-IICT.
Patent Application no: 1253DEL2014

Journal Publications (Total = 20) representative

1. **J. Vatsalarani** ,D.C.Trivedi, K. Ragavendran and P.C. Warrier. Effect of polyaniline coating on shape change phenomenon of porous zinc electrode. J. Electrochem. Soc. 152(10) A1974-A1978 (2005)

2. **J.Vatsalarani**, S.Geetha, D.C. Trivedi, P.C.Warrier. Stabilization Of Zinc Electrodes with a conducting polymer. J. of Power Sources 158 (2006) 1484-1489.

3. **Vatsalarani** .J. N. Kalaiselvi & R. Karthikeyan Effect of mixed cations in synergizing the performance characteristics of PVA-based polymer electrolytes for novel category Zn/AgO polymer batteries—a preliminary study. J.,Ionics (2009) 15:97–105.

4. V. S. Vidhya, **J. Vatsala Rani**, A. Ratheesh Kumar, R. Thangamuthu K. R. Murali, M. Jayachandran, Electrodeposition and properties of nanocrystalline ZnO films prepared in the presence of anionic surfactant SDS and ionic liquid 1-butyl-3-methylimidazolium methylsulfate J Mater Sci: Mater Electron 05/2012; 22(9):1460-1465.

5. **J. Vatsala Rani,** S. Bhavana Rushi, V. Kanakaiah, and S. Palaniappan, Green Fluorination of Natural Graphite and its Application in Rechargeable Magnesium Ion Transfer Battery. J. Electrochemi. Soc., 158 (9) A1031-A1035 (2011).

6**. J. Vatsala Rani**, V. Kanakaiah, Tulshiram Dadmal, M. Srinivasa Rao, S. Bhavanarushi . Fluorinated Natural Graphite Cathode for Rechargeable Ionic Liquid Based Aluminum–Ion Battery.J. of Electrochem. Soc., 160 (10) A1781-A1784 (2013)
Paper Cited in Nature - doi:10.1038/nature14340, reference '6'

7) V. Kanakaiah, M. Latha, B. Sravan, Aruna Palanisamy, **J. Vatsala Rani**. Rechargeable Magnesium Carbon-Fluoride Battery with Electrolyte Gel of Ionic Liquid and Low Molecular Weight Gelator. J. Electrochem. Soc., 161 (10) A1586-A1592 (2014)

Thesis supervised – Ph.D.2; M.Sc: 10

MANDAL REVENUE OFFICE - TENALI

GUNTUR DISTRICT, A.P - 0

SSID : 0732-0000-5030-0201 **Appl. No:** 2001 163 **Date:** 04-05-2001

COMMUNITY, NATIVITY AND DATE OF BIRTH CERTIFICATE

1) This is to certify that Sri/Smt/Kum **-Aruna Bharathi Mathangi*****
Son / daughter of Sri **-Rathnakishore Mathangi*****
of Village/Town **-GUDIVADA (H.No. 6-24/A)*****
Mandal **-TENALI*****
District **-GUNTUR*****
of the state of Andhra Pradesh belongs to **-MALA*****
Community which is recognised as **-SC (GROUP-C)***** under

The Constitution (Scheduled Castes) Order 1950
The Constitution (Scheduled Tribes) Order 1950

G.O.Ms. No. 1793, Education, dated 25 - 9 - 1970 as amended from time to time (B.Cs) S.Cs , S.Ts , list (Modification) Order, 1956 S.Cs and S.Ts (Amendment) Act. 1976

2) It is certified that Sri/Smt/Kum **-*****
is a native of **-*****
Village/Town **-*****
Mandal **-*****
District **-*****
of Andhra Pradesh.

3) It is certified that the place of birth of Sri / Smt / Kum **-*****
is **-*****
Village/Town **-*****
Mandal **-*****
District of Andhra Pradesh.

4) It is certified that the date of birth of Sri/ Smt/ Kum **-Aruna Bharathi Mathangi*****
is
Day **-1*****
Month - **6*****
-June***
Year - **1978*****
(in words)- **One*****
- One Nine Seven Eight*
as per declaration given by his/her father/mother/guardian and as entered in the school records where he/she studied.

(Seal)

Signature:

Date: 4.5.01

Name:

Mandal Revenue Officer
TENALI

Designation:

4.5.01

0732200100091

GEETHANJALI COLLEGE OF ENGINEERING AND TECHNOLOGY (Autonomous)

Project Title: **Alternate Energy using Stored Water**
(Inhouse project)

Service Provider : Mr Lolla Srinivasa Murthy
Bio Electrical and Energy Systems (BEES)
76 Prashant Nagar, Malakpet, Hyderabad – 500 036
Mobile: 98498-57173
E-mail <lolla@ieee.org>, <lsmurthy32@hotmail.com >

Principal Investigator: Dr. R.S. Raju

Objective : To design and develop alternate energy system using stored water.

Sanctioned amount : Rs 7.00 Lakhs

Project period : 1-1/2 years (starting 10-02-2018)

Work done : An alternate energy system has been developed to generate electrical power using stored water. The functionality of the system has been demonstrated. The project has been completed in January 2020; however, improvements are being made to enhance the efficiency.

Outcome : The functionality of system is demonstrated. This was aimed to generate electricity by passing part of the college water line through the system so that electricity is generated. The outgoing water will be used for wetting college lawns and plants.

Benefit to college : The design methodology is established which would be useful in developing a similar type of clean **energy systems** to the nearby villages for generating electricity as per their needs.

S.N.	Contents
01	MoU dated 06-02-2015
02	Scheme of implementation of project
03	Minutes of meetings
04	Completion certificate
05	Benefit to college
06	Financial statement

30/7/2021

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Geethanjali College of Engg. and Tech.
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Geethanjali
College of Engineering and Technology
... Striving towards Perfection
An Autonomous Institution
Approved by AICTE and Permanently Affiliated to JNTUH
ISO 9000:2008 Certified

BEES

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Date: January 27, 2020

Completion Certificate

Reference: Agreement, dated February 25, 2018

Subject : Inhouse project "*Alternate Energy system using Stored Water*" – Phase-I.

The above project was jointly taken up by Geethanajali College of Engineering and Technology (GCET), Hyderabad and Bio-electrical & Energy Systems (BEES), Hyderabad with a motive to address energy issues. As an alternate to Government supplied energy, and also to lessen the burden on distribution transformers, this activity on stored energy was taken up to generate additional power.

The work was successfully completed in terms of developing: (i) torque module, (ii) guided turbine with stored water, (iii) generator module using permanent magnets, (iv) load balancing and power management unit and (v) display monitoring panel with all safely features. The basic functionality of the the system was demonstrated to the fully satisfactory in terms of power generation.

A paper titled "*exploring alternative energy sources to supplement and cover the downtime of wind and solar to improve the resilience of smart grids*" was accepted for presentation in "International Conference ISUW-2020", scheduled during March 03-07, 2020 in New Delhi.

(Lolla Srinivasa Murthy)
CEO, Bio-electrical & Energy Systems (BEES)
76, Prashant Nagar (West), Hyderabad -500 036

CEO
Bio Electrical & Energy Systems
76, Prashanth Nagar Colony West,
Malakpet, Hyderabad-500036,
Telangana State, INDIA.

(Dr Udaya Kumar Susarla)
Principal
Geethanjali College of Engineering
and Technology, Hyderabad

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Geethanjali College of Engineering & Technology
Sy. No. 33 & 34
Cheeryal Village
Keesara Mandal
Medchal Dist.

PRINCIPAL
Geethanjali College of Engg. and Tech.
Cheeryal (V), Keesara (M), Medchal Dist.(T.S.)-501 301.

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GEETHANJALI COLLEGE OF ENGINEERING AND TECHNOLOGY

Minutes of Meeting on "Alternate Energy System", held on July 10, 2019 in Director's chamber

Title of project: **Development of Alternate Energy System using Stored Water**

Agenda: Integration of system in the shed, constructed recently.

The following members were present:

S.N.	Name	Designation	E-mail	Mobile No
1.	Dr S Udaya Kumar	Principal	uksusarla@gmail.com	9866308257
2.	Dr RS Raju	Dean, R&D	raju.ceeri@gmail.com	94137 23303
3.	Mr L Srinivasa Murthy	CEO, BEES	lolla@ieee.org, murthy@bees-consulting.net	9849857173, 79012 87173

Minutes of Meeting:

1. Principal reviewed the progress made on the above project. Dr Raju briefed that the shed is ready for shifting the modules. Mr Murthy wanted extra amount, primarily, due to the prolongation of the project. He expressed his views as following:

a) Progress of shed construction work:
It is observed that the construction work is completed with all necessary things to move in the system modules for further system integration, Machinery erection, installation and commissioning. Staff also updated and confirmed that the plinth, electrical points, door, window slides and separate earth pit exclusively for the system are provided.

b) The need for Extra budget:
The initial projected cost is Rs 4.4 Lac and the time duration is around 6 to 9 months. Amount already disbursed is Rs 4.0 Lac. The present requested amount is another 3.0 Lac having 12 week time bound execution task period.
BEES is requested to provide detailed expenditure incurred, costs involved in procuring and processing to customize the various system modules with enough documentation and bills for further discussion in the committee at the institution level.

Shifting of modules: Mr Murty expressed that he will start the shifting work and will take up integration activity after the above payment is made to him.

Action points:
1. Payment to BEES: sending the proposal to management →action Dr Raju
2. (a) Shifting of modules, (b) integration of system and (c) testing of system →action Mr Murthy, and members of the project team..

RSRaju 10/7/2019
(RS Raju), Dean, R&D

Copy to: 1. Chairman and Principal
2. All Members of the meeting.

The project cost, as incurred by BEES, has been increased due to (a) increased period of time and (b) certain needed features incorporated. principal is requested to approve this additional amount of Rs 3.0 Lac so that the remaining work could be completed soon

RSRaju 18/7/2019

Principal:
Rs 3.00 Lac may pl. be released to BEES (Two Lac)
RSRaju 9/8/2019
To A/C Sec on 09/08/19

PRINCIPAL Geethanjali College of Engg. and Tech. Cheeryal (V), Keesara (M), Medchal Dist. (T.S.) 501 301

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