The Present Scenario of Nanoparticles in the World

K.A.Khan[1] and Salman Rahman Rasel[2]
[1]Department of Physics, Jagannath University, Dhaka-1100, Bangladesh
E-mail: kakhan01@yahoo.com , Phone Number: +8801911357447
[2]Local Government Engineering Department (LGED), Fulbaria, Mymensing, Bangladesh

Abstract

Nanoparticles are particles between 1 and 100 nanometers (nm) in size with a surrounding interfacial layer. The interfacial layer is an integral part of nanoscale matter, fundamentally affecting all of its properties. The interfacial layer typically consists of ions, inorganic and organic molecules. Organic molecules coating inorganic nanoparticles are known as stabilizers, capping and surface ligands, or passivating agents. In nanotechnology, a particle is defined as a small object that behaves as a whole unit with respect to its transport and properties. Particles are further classified according to diameter.

Keywords: *Nanoparticles, Applications, Scenario, Ultrafine particles, Nanometer-sized single crystals, Single-domain ultrafine particles.*

Introduction

Nanoparticles are very important for every sector in science. It used everywhere in the field of science. Scientific research on nanoparticles is intense as they have many potential applications in medicine, physics, optics, and electronics. The U.S. National Nanotechnology Initiative offers government funding focused on nanoparticle research. It is also used in Bangladesh for some purposs. A lot of researchers are conducting research on Nanoparticles in Bangladesh now-a-days.

The term "nanoparticle" is not usually applied to individual molecules; it usually refers to inorganic materials.

The reason for the synonymous definition of nanoparticles and ultrafine particles is that, during the 1970s and 80s, when the first thorough fundamental studies with "nanoparticles" were underway in the USA (by Granqvist and Buhrman) and Japan, (within an ERATO Project) they were called "ultrafine particles" (UFP). However, during the 1990s before the National Nanotechnology Initiative was launched in the USA, the new name, "nanoparticle," had become more common. Nanoparticles can exhibit size-related properties significantly different from those of either fine particles or bulk materials. Nanoclusters have at least one dimension between 1 and 10 nanometers and a narrow size distribution. Nanopowders are agglomerates of ultrafine particles, nanoparticles, or nanoclusters. Nanometer-sized single crystals, or single-domain ultrafine particles, are often referred to as nanocrystals.

II. Methods and Materials

II A. Classifications of Nanoparticles:

(1).Ultrafine particles are the same as nanoparticles and between 1 and 100 nm in size.
(2).Fine particles are sized between 100 and 2,500 nm.
(3).Coarse particles cover a range between 2,500 and 10,000 nm.

II. B. Applications of Nanoparticles :

(1)Carbon Nanotubes:

Carbon materials have a wide range of uses, ranging from composites for use in vehicles and sports equipment to integrated circuits for electronic components. The interactions between nanomaterials such as carbon nanotubes and natural organic matter strongly influence both their aggregation and deposition, which strongly affects their transport, transformation, and exposure in aquatic environments. In past research, carbon nanotubes exhibited some toxicological impacts that will be evaluated in various environmental settings in current EPA chemical safety research. EPA research will provide data, models, test methods, and best practices to discover the acute health effects of carbon nanotubes and identify methods to predict them.

(2) Cerium oxide:
Nanoscale cerium oxide is used in electronics, biomedical supplies, energy, and fuel additives. Many applications of engineered cerium oxide nanoparticles naturally disperse themselves into the environment, which increases the risk of exposure. There is ongoing exposure to new diesel emissions using fuel additives containing CeO2 nanoparticles, and the environmental and public health impacts of this new technology are unknown. EPA's chemical safety research is assessing the environmental, ecological, and health implications of nanotechnology-enabled diesel fuel additives.

(3) Titanium dioxide:
Nano titanium dioxide is currently used in many products. Depending on the type of particle, it may be found in sunscreens, cosmetics, and paints and coatings. It is also being investigated for use in removing contaminants from drinking water.

(4) Nano Silver:
Nano silver is being incorporated into textiles, clothing, food packaging, and other materials to eliminate bacteria. EPA and the U.S. Consumer Product Safety Commission are studying certain products to see whether they transfer nano-size silver particles in real-world scenarios. EPA is researching this topic to better understand how much nano-silver children come in contact with in their environments.

(5) Iron:
While nano-scale iron is being investigated for many uses, including "smart fluids" for uses such as optics polishing and as a better-absorbed iron nutrient supplement, one of its more prominent current uses is to remove contamination from groundwater. This use, supported by EPA research, is being piloted at a number of sites across the country.

(6) Laser applications:
The use of nanoparticles in laser dye-doped poly(methyl methacrylate) (PMMA) laser gain media was demonstrated in 2003 and it has been shown to improve conversion efficiencies and to decrease laser beam divergence. Researchers attribute the reduction in beam divergence to improved dn/dT characteristics of the organic-inorganic dyedoped nanocomposite. The optimum composition reported by these researchers is 30% w/w of SiO_2 (~ 12 nm) in dye-doped PMMA.

(7) Medicinal applications:
Liposome, Dendrimer, Iron oxide nanoparticles, Nanomedicine, Polymer-drug conjugate, Polymeric nanoparticle.

II.C Present Research on Nanoparticles in the **World:**

Nanoparticle research is a fascinating branch of science. The strongly size-related properties of nanoparticles offer uncountable opportunities for surprising discoveries. The often unexpected and unprecedented behavior of nanoparticles bears great potential for innovative technological applications, but also poses great challenges to the scientists. They have to develop highly controllable synthesis approaches, more sensitive characterization tools and finally new models and theories to explain the experimental observations. In this review, we discuss a personal selection of papers dedicated to nanoparticle research, which we believe provide an illustrative overview of current research directions in this rapidly developing field. We have structured the text in five sections: introduction, nanoparticle synthesis, formation mechanisms, nanoparticle assembly, and applications. The chosen examples within these sections are not directly related to each other, but reflect the remarkable broadness of nanoparticle research covering historical aspects, basic and applied science as well as commercial applications.
Silver nanoparticles is in restorative industry, for example, topical salves to counteract disease against blaze and open injuries. The motivation behind the accompanying analyses was to explore the impacts of gold and silver nanoparticles on the HRP action, utilizing TMB as the substrate. Nanoparticles (NPs) interceded medication conveyance frameworks have the potential capacity to beat the natural boundaries because of EPR impact, productive medication repository, and the basic adaptability to be altered to discharge the remedial operators in the coveted site. In light of this reason shape, size and morphology of the nanoparticles can be controlled in a superior manner. In this work I took after a concoction technique Co-precipitation for the union of CdxMg1-xFe2O4 nanoparticles, which is clarified underneath. Nanomaterials (NM) are increasing expanding enthusiasm for different fields of use. They are utilized as a part of the medicinal division, in buyer items, for building materials, in PC innovation or for waste remediation. By yearly creation volumes and by number of items, silica nanoparticles. Nanoengineering empowers us to grow the surface region of silver particles notably. Silver

nanoparticles have indicated antimicrobial action against a wide exhibit of microorganisms, likely because of their various systems of antimicrobial activity.

The created nanoparticles were subjected to UV-Vis spectroscopy investigation, Atomic Force Microscopy (AFM) examination and Fourier Transform Infrared Radiation (FTIR) spectroscopy examination. In any case, their utilization for helpful reason remains a test in the field of nano and microencapsulation because of physical and concoction shakiness, proteolysis and short halflife. The examination of danger impacts of designed nanoparticles over biological community has as of late pulled in much consideration and it is frequently presumed that nanoparticles can apply cytotoxicity to creatures and plant frameworks. The boundless antibacterial, antiviral, and antifungal properties of silver nanoparticles (AgNPs) alongside their inherent reactant and optical marks make these the most prevalent and normally utilized designed nanoparticles as a part of biomedical applications, beautifying agents, attire, donning products, hardware, and of specific importance to this examination, water cleansing units, notwithstanding numerous other nano-customer items.

Selenium nanoparticles (SeNPs), which are seen as a novel Se compound, are pulling in growing thought of standard scientists on account of their extraordinary cell fortifications properties and low threat in examination with other Se-species, for instance, selenomethionine (SeMet). The advantage of MDT is the ability to direct the prescription bearing alluring particles to the tumor by the utilization of an external appealing field. Moreover, it gives the ability to keep up the particles at the looked for region, along these lines looking into concentrated on landing of the bound pharmaceutical. Starting late, there have been vital advances in the biomedical employments of nanotechnology. Sensing temperature, remotely and unequivocally, using an energetic and efficient procedure is separating to rising therapeutic and biomedical progressions. Therapeutic hyperthermia, driven either alluringly using nanosized alluring materials subjected to AC appealing fields or electromagnetically using metallic nanomaterials stimulated with appropriated light source or radiofrequency field is an imperative example of such demand.

Nanoparticles based medication conveyance methodology has tremendous clinical essentialness as showed by new nanoparticle based medication supports like pegylated liposomes of doxorubicin. Modified appropriation and slower discharge of this liposomal infusion brought about the range under bend (AUC) of doxorubicin hydrochloride liposome infusion ~2-3 times more than the AUC for comparative measurements of traditional doxorubicin hydrochloride. RNA, has as of late developed as an essential nanotechnology stage because of its unprecedented differences in structure and capacity. Little meddling RNA (siRNA), demonstrated huge potential in new sub-atomic ways to deal with down-manage particular quality expression in mammalian cells. Also nanoparticles can be misleadingly created (from designed procedures) that is particularly delivered from nanotechnologies at mechanical level to perform innovative points in different logical and modern fields. Hence the expression "nanotechnologies" alludes to the advancement and creation of materials and frameworks in the request of nanometers.

Nanoparticles are strong colloidal conveyance frameworks equipped for discharging ideal measures of medication, while evading untimely discharge. Additionally, because of their little
size, they find themselves able to be retained through the oral mucosa to reach systemic dissemination. The likelihood of utilizing biocompatible and biodegradable polymers is another point of preference, since the vehicle itself is then uprooted actually without advancing poisonous quality. Bread cook's yeast liquor dehydrogenase (ADH) and formate dehydrogenase (FDH) from Candida boidinii were immobilized on alumina nanoparticles and connected to catalyze the coupled responses for generation of n-propanol. Cofactor recovery inside of the response cycle was accomplished as a consequence of impact between protein stacked particles and free cofactor.

Nanoparticles discharged from items and applications can get specifically or in a roundabout way to the dirt. Direct soil defilement happens from intentionally applying items like biocides, manure, compost, and nanoparticles for remediation, and items which sully soil accidentally like rubbed material, some covering materials, polluted soils, and water for watering system. Item fixings coming to soils by implication then again are discharged to other ecological compartments e.g. air, water, or groundwater. Accordingly nanoparticles get traded between the natural compartments. Nanoparticles go to the dirt and abandon it through different procedures. Out of data on nanoparticles applications found in web and writing studies, an outline of nanoparticles fluxes to and from soil could be drawn. Included are just fluxes inside of the framework limit.

II D Present Situation of Nanoparticle Research in Bangladesh:
Along with other countries, Bangladesh is also getting better into researching nanoparticles. There are several works conducted by Bangladeshi researchers. One of them will be discussed here.

Microemulsions as Nanoreactors for Preparation of Nanoparticles with Antibacterial Activity by Sakhawat Hossain, Ummul K Fatema, Md Yousuf A Mollah, M Muhibur Rahman, Md Abu Bin Hasan Susan: Nanoparticles of silver and copper have been synthesized by reduction of aqueous silver nitrate and copper chloride solutions with sodium borohydride in anionic water-in-oil (w/o) microemulsions, sodium dodecyl sulphate (SDS)/1-pentanol/cyclohexane/water. Scanning
electron microscopic (SEM) images, energy dispersive spectra (EDX) and UVspectra have been used to characterize the resultant nanoparticles. The average size of the nanoparticles has been found to be influenced by the water to surfactant molar ratio (Wo) in the microemulsions. Smaller particles are obtained at low Wo, while higher Wo yields larger particles. The antibiotic sensitivity of silver and copper nanoparticles against Escherichia coli (E. coli) was tested by zone inhibition method using nanoparticles in ethanol suspension. Both silver and copper nanoparticles showed the potential for use as antibacterial agents against E. coli with sensitivity as good as conventional antibiotics. Silver nanoparticles show higher antibacterial activity against E. coli, compared to copper nanoparticles. As the amount of the nanoparticles in the suspension decreases, antibacterial activity decreases; however the concentration dependence on antibacterial activity has been less pronounced.

II E. Present Situation of Nanoparticle Research in India:
India is one the leading countries who is getting better very fast into researching nanoparticles. There are several companies producing nanoparticles. Many of them will be discussed here.

Adnano Technologies:
Adnano Technologies is a supplier of various forms of graphene and multiwalled carbon nanotubes. They also provide analytical services like FESEM, TEM, AFM, FTIR, XRD, XPS, Contact Angle, BET, Zeta sizer and Master sizer.

Auto Fibre Craft:
AFC Powders is a company involved in manufacturing specialized nanomaterials. Currently it is manufacturing Nano-size Silver Powder for use in electronic applications for e.g. making conductive inks and pastes, RFID. This product is RoHS compliant.

AVANSA Technology & Services:
The company specializes in analytical characterization, consultancy, and synthesis of nanomaterials serving to nanotechnology-based industries, universities and institutes. They also manufacture carbon nanotubes, graphene, and various nanoparticles.

Bottom Up Technology Corporation:
The company manufactures graphene and caron nanotubes
.
Egoma Technologies:
The company specializes in producing customizable solutions to Ball Mill requirements and nanopowders. They also provide consultancy in material related industrial and research R&D related problems.
Kerala Minerals & Metals (KMML): The company manufactures various grades of titanium dioxide nanoparticles.

Nanomics Technologies:
The company manufactures a wide range of nanomaterials such as carbon nanotubes, graphene, nanoalloys, nanowires, and nanoparticle powders and suspensions.

Nano Research Elements:
A provider of nanomaterials.

Nanoshel:
Nanoshel makes more than 50 types of nanomaterials, among which the main products are nanotubes, SWCNT´s, MWCNT´s, nanoparticles.

Nanospan:
The company is active in in manufacture, supply and application of graphene related materials. They offer a range of graphene types, functionalized graphene, graphene intermediates, carbon nanotubes and nanomaterials. They provide analytical testing & engineering services for emerging nanotechnology-based products in the areas of energy storage, electronics, polymer/resin/lubricants, electronic inks and 3D printing. They also provide

nanomaterial characterization & testing services like HR-TEM, FESEM, FTIR, XRD, BET, Raman Spectroscope, AFM.

NanoXpert Technologies:
KCIL-NanoXpert Technologies is an intrapreneurial arm of KCIL (Kairav Chemofarbe Industries Ltd) India for high-tech nanoparticle business, it has a technological collaboration with National Chemical Laboratories, Pune, India, under the prestigious Prime Minister?s Fellowship Program. NanoXpert's products have been developed by experts in the field with individual experience of over a decade.

Neo-Ecosystems:
The company is specialized on researching and production of metal nanopowders.

Platonic Nanotech: The company uses its proprietary bottom-up process for the production of high quality graphene. Quantum Corporation: Quantum Corporation (QCorp) is the parent company of group of companies, head quartered in Bangalore, India. QCorp was established in 2007 with a vision to create world class Nanomaterials and Nanocomposites with strong Intellectual Property that are changing the properties of products across the globe. QCorp has developed high quality Smart Polymers, Nanomaterials and Nanocomposites as core materials for manufacturers in Telecommunications, Electronics, Drug Delivery, Conductive films, Lighting and Energy industries - without the need to change their existing processes.

Reinste Nano Ventures:
A manufacturer of nanomaterials.Sisco Research Laboratories (SRL): The company is a manufacturer and supplier of about 3500 Laboratory Chemical and Allied Products. They specialize in Molecular Biology Reagents, Biochemicals, Enzymes, Nanopowders and Carbon Nanotubes, Organic & Inorganic Intermediates, High Purity Solvents, Culture Media & BioLit™ DNA & Protein Tools for PCR and regular Molecular Biology.Smart Nanoz: The company manufactures nanoparticles.

Ultrananotech:
Manufactures nanoparticles and graphene. United Nanotech Innovations: A manufacturer of graphenes and nanocomposites.

II F.RePresent Situation of Nanoparticle Research in Japan:
Along with other countries, Japan is also getting better into researching nanoparticles. There are several works conducted by Japanese researchers. One of them will be discussed here.
Nanoparticles Effectively Target Rapamycin Delivery to Sites of Experimental Aortic Aneurysm in Ratsby Takuro Shirasu, Hiroyuki Koyama , Yutaka Miura, Katsuyuki Hoshina, Kazunori Kataoka, Toshiaki Watanabe: Several drugs targeting the pathogenesis of aortic aneurysm have shown efficacy in model systems but not in clinical trials, potentially owing to the lack of targeted drug delivery. Here, we designed a novel drug delivery system using nanoparticles to target the disrupted aortic aneurysm micro-structure. We generated poly(ethylene glycol)-shelled nanoparticles incorporating rapamycin that exhibited uniform diameter and long-term stability. When injected intravenously into a rat model in which abdominal aortic aneurysm (AAA) had been induced by infusing elastase, labeled rapamycin nanoparticles specifically accumulated in the AAA. Microscopic analysis revealed that rapamycin nanoparticles were mainly distributed in the media and adventitia where the wall structures were damaged. Co-localization of rapamycin nanoparticles with macrophages was also noted. Rapamycin nanoparticles injected during the process of AAA formation evinced significant suppression of AAA formation and mural inflammation at 7 days after elastase infusion, as compared with rapamycin treatment alone. Correspondingly, the activities of matrix metalloproteinases and the expression of inflammatory cytokines were significantly suppressed by rapamycin nanoparticle treatment. Our findings suggest that the nanoparticle-based delivery system achieves specific delivery of rapamycin to the rat AAA and might contribute to establishing a drug therapy approach targeting aortic aneurysm**.**

II G. Present Situation of Nanoparticle Research in USA:
USA leads the research in nanoparticles. They have the latest technologies to produce and conduct experiments on nanoparticles. Some of those aspects are discussed here. Zeta Potential for Metal Oxide Nanoparticles, A Predictive Model Developed by a NanoQuantitative Structure–Property Relationship Approach by Rasulev, Alicja Mikolajczyk, Agnieszka Gajewicz, Bakhtiyor Rasulev, Nicole Schaeublin, Elisabeth Maurer-Gardner, Saber Hussain, Jerzy Leszczynski and Tomasz Puzyn: According to Rasulev, physico–chemical characterization of nanoparticles in the context of their transport and fate in the environment is an important challenge for risk assessment of nanomaterials. One of the main characteristics that defines the behavior of nanoparticles in solution is zeta potential. "In this paper, we have demonstrated the relationship between zeta potential and a

series of intrinsic physico–chemical features of 15 metal oxide nanoparticles revealed by computational study," Rasulev said. "It was shown that zeta potential depends on spherical size of nanomaterial and electron orbital energy."Silver nanoparticles' synthesis, properties, toxicology, applications and perspectives by Quang Huy Tran, Van Quy Nguyen and Anh-Tuan Le: In recent years the outbreak of re-emerging and emerging infectious diseases has been a significant burden on global economies and public health. The growth of population and urbanization along with poor water supply and environmental hygiene are the main reasons for the increase in outbreak of infectious pathogens. Transmission of infectious pathogens to the community has caused outbreaks of diseases such as influenza (A/H5N1), diarrhea (Escherichia coli), cholera (Vibrio cholera), etc throughout the world. The comprehensive treatments of environments containing infectious pathogens using advanced disinfectant nanomaterials have been proposed for prevention of the outbreaks. Among these nanomaterials, silver nanoparticles (Ag-NPs) with unique properties of high antimicrobial activity have attracted much interest from scientists and technologists to develop nanosilverbased disinfectant products. This article aims to review the synthesis routes and antimicrobial effects of Ag-NPs against various pathogens including bacteria, fungi and virus. Toxicology considerations of Ag-NPs to humans and ecology are discussed in detail. Some current applications of Ag-NPs in water-, air- and surface- disinfection are described. Finally, future prospects of Ag-NPs for treatment and prevention of currently emerging infections are discussed.

III. Conclusion

Nanoparticles and Nanotechnology hold the future of technology. Though they have some health and safety issues, still it is quite reasonable to conduct further research into this matter to eliminate every negative or controversial issue

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References

[1] K.A.Khan, Lovelu Hassan, A K M Obaydullah, S. M. Azharul Islam, M.A. Mamun, Tanjila Akter, Mehedi Hasan, Md. Shamsul Alam,M. Ibrahim, M Mizanur Rahman and M. Shahjahan , Bioelectricity: A new approach to provide the electrical power from vegetative and fruits at off-grid region, Published in the journal of Microsystem Technologies of Springer, manuscript number: 2018MITE-D-17-00623R2, Received: 14 August 2017/Accepted: 3 February 2018, Volumes-24,Issues-3, Impact Factor: 1.195, ISSN: 0946-7076 (Print) 1432-1858 (Online), Springer-Verlag GmbH Germany, Part of Springer Nature, DOI: 10.1007/s00542-018-3808-3, 2018.

[2] Mehedi Hasan and K A Khan, Dynamic Model of Bryophyllum pinnatum Leaf Fueled BPL Cell: A Possible Alternate Source of Electricity at the Off-grid Region in Bangladesh, Published in the Microsystem Technologies (2018), Springer, manuscript number, MITE-D-18-00800R1, DOI: https://doi.org/10.1007/s00542-018-4149-y, Publisher Name: Springer Berlin Heidelberg,Print ISSN: 0946-7076,Online ISSN: 1432-1858, First Online: 28 September 2018

[3] K A Khan, M.S.Bhuyan,M. A. Mamun, M. Ibrahim, Lovelu Hassan and M A Wadud, Organic Electricity from Zn/Cu-PKL Electrochemical Cell, Published in the Springer Nature, Series Title: Advs in Intelligent Syst., Computing, Volume Number:812, Book Title: Contemporary Advances in Innovative and Applicable Information Technology,ISBN:978-981-13-1539-8, https://doi.org/10.1007/978-981-13-1540-4, 2018

[4] K A Khan, A. Rahman, M. S. Rahman, A. Tahsin, K. M. Jubyer, and S. Paul, "Performance analysis of electrical parameters of PKL electricity (An experimental analysis on discharge rates, capacity & discharge time, pulse performance and cycle life & deep discharge of PathorKuchi Leaf (PKL) electricity cell)," In Innovative Smart Grid Technologies-Asia (ISGT-Asia), 2016 IEEE, pp. 540-544. IEEE, 2016.

[5] M. K. A. Khan, S. Paul, M. S. Rahman, R. K. Kundu, M. M. Hasan, M.Moniruzzaman, and M. A. Mamun, "A study of performance analysis of PKL electricity generation parameters:(An experimental analysis on voltage regulation, capacity and energy efficiency of pathorkuchi leaf (PKL) electricity cell)," In Power India International Conference (PIICON), 2016 IEEE 7th, pp. 1-6. IEEE, 2016.

[6] M. K. A. Khan, M. S. Rahman, T. Das, M. N. Ahmed, K. N. Saha, and S. Paul,"Investigation on Parameters performance of Zn/Cu Electrodes of PKL, AVL, Tomato and Lemon juice based Electrochemical Cells: A Comparative Study,"In Electrical Information and Communication Technology (EICT), 2015 3rd International Conference on, pp. 1-6. IEEE, 2017.

[7] K A Khan, Akhlaqur Rahman, Md Siddikur Rahman, Aniqa Tahsin, Kazi Md Jubyer, and Shuva Paul. "Performance analysis of electrical parameters of PKL electricity (An experimental analysis on discharge rates, capacity & discharge time, pulse performance and cycle life & deep discharge of Pathor Kuchi Leaf (PKL) electricity cell)." In Innovative Smart Grid Technologies-Asia (ISGT-Asia), 2016 IEEE, pp. 540-544. IEEE, 2016.

[8] M K A Khan, Shuva Paul, Md Siddikur Rahman, Ripon Kumar Kundu, Md Mahmudul Hasan, Mohammad Moniruzzaman, and Mohammad Al Mamun. "A study of performance analysis of PKL electricity generation parameters:(An experimental analysis on voltage regulation, capacity and energy efficiency of pathor kuchi leaf (PKL) electricity cell)." In Power India International Conference (PIICON), 2016 IEEE 7th, pp. 1-6. IEEE, 2016.

[9] M K Alam Khan, "Copper Oxide Coating for use in Linear Solar Fresnel Reflecting Concentrating Collector",Published in the journal. of Elsevier, Renewable Energy, An International Journal, WREN(World Renewable Energy Network), UK, RE: 12.97/859,1998

[10] Muhammad Riazul Hamid, Characterization of a Battery cell fueled by Bryophyllum Pinnatum sap, International Journal of Scientific & Engineering Research, Volume 4, Issue 3, ISSN 2229-5518, March-2013.

[11] Muhammad Riazul Hamid, Akib Yusuf, Abu Md. Abdul Wadud, and Md. Mosfiqur Rahaman, Design and Performance Test of a Prototype of a 12 Volt DC Battery Fueled by Bryophyllum Pinnatum Sap and Improvement of Its Characteristics, Department of Electrical and Electronic Engineering, Ahsanullah University of Science and Technology, Dhaka, Bangladesh, Email: {drhamidbd, shohan933}@gmail.com, {akib147, sshaon95}@yahoo.com, International Journal of Electronics and Electrical Engineering Vol. 4, No. 5, October 2016.

[12] K A Khan, " Electricity Generation form Pathor Kuchi Leaf (Bryophyllum pinnatum) " , Int. J. Sustain. Agril. Tech. 5(4): 146-152, July 2009.

[13] K A Khan and Md. Eyashir Arafat, "Development of Portable PKL (Pathor Kuchi Leaf) Lantern", Int. J. SOC. Dev. Inf. Syst. 1(1): 15-20 January 2010.

[14] K. A. Khan and Ranen Bosu, "Performance study on PKL Electricity for Using DC Fan", Int. J. SOC. Dev. Inf. Syst. 1(1): 27-30, January 2010

[15] K A Khan and Md. Imran Hossain," PKL Electricity for Switching on the Television and Radio",Int. J. SOC. Dev. Inf. Syst. 1(1): 31-36, January 2010

[16] Shuva Paul, K A Khan, Kazi Ahad Islam, Baishakhi Islam and Musa Ali Reza, "Modeling of a Biomass Energy based (BPL) Generating Power Plant and its features in comparison with other generating Plants ",IPCBEE vol. 44 (2012) @ (2012) IACSIT Press, Singapore DOI: 10.7763/ IPCBEE. 2012. V44. 3

[17] K. A. Khan, Shuva Paul, Md. Adibullah, Md.Farhat Alam, Syed Muhammad Sifat, Md. Rashed Yousufe, " Performance Analysis of BPL/PKL Electricity module ", International Journal of Scientific & Engineering Research Volume 4, Issue3, March-2013 1 ISSN 2229-5518

[18] K A Khan, Shuva Paul,Asif Zobayer,Shiekh Saif Hossain, A Study on Solar Photovoltaic Conversion, International journal of Scientific and Engineering Research ,Volume-4,Issue-3,March-2013,ISSN2229-5518, 2013

[19] Tania Akter, M H Bhuiyan, K A Khan and M H Khan, "Impact of photo electrode thickness and annealing temperature on natural dye sensitized solar cell", Published in the journal. of Elsevier. Ms. Ref. No.: SETA-D-16-00324R2, 2017

[20] K A Khan, Inventors, Electricity Generation form Pathor Kuchi Leaf (PKL), Publication date 2008/12/31, Patent number BD 1004907,2008

[21] K A Khan, Technical note "Copper oxide coatings for use in a linear solar Fresnel reflecting concentrating collector", Publication date 1999/8/1, Journal Renewable energy, Volume 17, Issue 4, Pages 603-608, Publisher – Pergamon, 1999

[22] K A Khan, Shuva Paul, A analytical study on Electrochemistry for PKL (Pathor Kuchi Leaf) electricity generation system, Publication date 2013/5/21, Conference- Energytech, 2013 IEEE, Pages 1-6, Publisher, IEEE,2013

[23]T.A.Ruhane, M.Tauhidul Islam, Md. Saifur Rahaman, M.M.H. Bhuiyan, Jahid M.M. Islam, M.K.Newaz, K A Khan, Mubarak A. Khan, "Photo current enhancement of natural dye sensitized solar cell by optimizing dye extraction and its loading period" , Published in the journal of Elsevier : Optik - International Journal for Light and Electron Optics, 2017.

[24] K A Khan, M S Alam, M A Mamun, M A Saime & M M Kamal, Studies on electrochemistry for Pathor Kuchi Leaf Power System, Ppublished in the Journal of Bangladesh J. Agric. And Envirin. 12(1): 37-42, June 2016

[25] Mehedi Hasan, Lovelu Hassan, Sunjida Haque, Mizanur Rahman, K A Khan, A Study to Analyze the Self-Discharge Characteristics of Bryophyllum Pinnatum Leaf Fueled BPL Test Cell, Published in the Journal of IJRET, Vol-6 Iss-12, Dec-2017

[26] J. Sultana, K A Khan, and M.U. Ahmed. "Electricity Generation From Pathor Kuchi Leaf (PKL) (Bryophillum Pinnatum)." J.Asiat Soc. Bangladesh Sci., 2011, Vol. 37(4): P 167-179

[27] M. Hasan, S. Haque and K A Khan, "An Experimental Study on the Coulombic Efficiency of Bryophyllum pinnatum Leaf Generated BPL Cell",IJARIIE, ISSN(O)-2395-4396, Vol-2, Issue-1, 2016

[28] MM Hasan, MKA Khan, MNR Khan and MZ Islam, "Sustainable Electricity Generation at the Coastal Areas and the Islands of Bangladesh Using Biomass Resources", City University Journal, Vol. 02, Issue. 01, P. 09-13, 2016.

[29] M Hasan and K A Khan, "Bryophyllum pinnatum Leaf Fueled Cell: An Alternate Way of Supplying Electricity at the Off-grid Areas in Bangladesh" in Proceedings of 4th International Conference on the Developments in Renewable Energy Technology [ICDRET 2016], P. 01, 2016. DOI: 10.1109/ICDRET.2016.7421522

[30] M Hasan, KA Khan, MA Mamun, "An Estimation of the Extractable Electrical Energy from Bryophyllum pinnatum Leaf", American International Journal of Research in Science, Technology, Engineering &Mathematics (AIJRSTEM), Vol. 01, Issue. 19, P. 100-106, 2017.

[31] M K A Khan, M. S. Rahman, T. Das, M. N. Ahmed, K. N. Saha, and S. Paul, "Investigation on Parameters performance of Zn/Cu Electrodes of PKL, AVL, Tomato and Lemon juice based Electrochemical Cells: A Comparative Study,"In Electrical Information and Communication Technology (EICT), 2017 3rd International Conference on, pp. 1-6. IEEE, 2017. DOI: 10.1109/EICT.2017.8275150,IEEE, Khulna, Bangladesh, Bangladesh, 7-9 Dec. 2017.

[32] Md. Afzol Hossain, M K A Khan, Md. Emran Quayum,''Performance development of bio-voltaic cell from arum leaf extract electrolytes using zn/cu electrodes and investigation of their electrochemical performance'', International Journal of Advances in Science Engineering and Technology, ISSN: 2321-9009, Vol-5, Iss-4, Spl. Issue-1, Nov-2017

[33] K A Khan , M. A. Wadud , A K M Obaydullah and M.A. Mamun, PKL (Bryophyllum Pinnatum) electricity for practical utilization, IJARIIE-ISSN(O)-2395-4396, Vol-4, Issue-1, Page: 957-966

[34] M. M. Haque, A.K.M.A. Ullah, M.N.L Khan, A.K.M.F. F. Kibria and K A Khan,"Phyto-synthesis of MnO2 Nanoparticles for generating electricity," In the International conference on Physics-2018, Venue-Department of Physics, University of Dhaka, Dhaka-1000,Bangladesh, Organizer-Bangladesh Physical Society(BPS, 08-10 March, 2018.

[35] Lovelu Hasan,Mehedi Hasan, K A Khan and S.M. Azharul Islam, "SEM Analysis of Electrodes and measurement of ionic pressure by AAS data to identify and compare the characteristics between different bio-fuel based electrochemical cell, " In the International conference on Physics-2018, Venue-Department of Physics, University of Dhaka, Dhaka-1000,Bangladesh, Organizer-Bangladesh Physical Society(BPS, 08-10 March, 2018.

[36] Mehedi Hasan and K A Khan, "Identification of BPL Cell Parameters to Optimize the Output Performance for the Off-grid Electricity Production, " In the International conference on Physics-2018, Venue-Department of Physics, University of Dhaka, Dhaka-1000,Bangladesh, Organizer-Bangladesh Physical Society(BPS, 08-10 March, 2018.

[37] K A Khan, M.S.Bhuyan,M. A. Mamun,M.Ibrahim,Lovelu Hassan and M A Wadud, "Organic electricity from Zn/Cu-PKL electrochemical cell ", Published in the Souvenir of First International Conference of Contemporary Advances in Innovative & Information Technology(ICCAIAIT) 2018,organized by KEI, In collaboration with Computer Society of India(CSI), Division-IV(Communication). The proceedings consented to be published in AISC Series of Springer,2018

[38] M K A Khan , A K M Obaydullah, M.A. Wadud and M Afzol Hossain, "Bi-Product from Bioelectricity", IJARIIE-ISSN(O)-2395-4396, Volume-4, Issue-2, Page-3136-3142 , 2018

[39] M K A Khan and A K M Obaydullah , "Construction and Commercial Use of PKL Cell", IJARIIE-ISSN(O)-2395-4396, Volume-4, Issue-2, Page-3563-3570, 2018

[40] M K A Khan, "Studies on Electricity Generation from Stone Chips Plant (Bryophyllum pinnatum)", International J.Eng. Tech 5(4): 393-397, December 2008

[41] K A Khan, M Afzol Hossain, A K M Obaydullah and M.A. Wadud, "PKL Electrochemical Cell and the Peukert's Law ", Vol-4 Issue-2, 2018 IJARIIE-ISSN(O)-2395-4396,Page: 4219 – 4227

[42] K A Khan, M.A.Wadud, M Afzol Hossain and A.K.M. Obaydullah, "Electrical Performance of PKL (Pathor Kuchi Leaf)Power", Published in the IJARIIE-ISSN(O)-2395-4396,Volume-4, Issue-2, Page-3470-3478 ,2018.

[43] K A Khan, M Hazrat Ali, M. A. Mamun, M. Mahbubul Haque, A.K.M. Atique Ullah, Dr. Mohammed Nazrul Islam Khan, Lovelu Hassan, A K M Obaydullah, M A Wadud, "Bioelectrical Characteristics of Zn/Cu-PKL Cell and Production of Nanoparticles (NPs) for Practical Utilization'' , 5th International conference on 'Microelectronics, Circuits and Systems', Micro2018, 19th and 20th May,2018,Venue: Bhubaneswar, Odisha, India, Organizer: Applied Computer Technology, Kolkata, West Bengal, India, Page: 59-66, www.actsoft.org , ISBN: 81-85824-46-1, In Association with: International Association of Science, Technology and Management, 2018

[44] M.M. Hassan, M. Arif and K A Khan, "Modification of Germination and growth patterns of Basella alba seed by low pressure plasma", Accepted in the " Journal of Modern Physics", Paper ID: 7503531,2018

[45] K.A.Khan, S.M.Maniruzzaman Manir, Md. Shafiqul Islam, Sifat Jahan, Lovelu Hassan, and M Hazrat Ali. "Studies on Nonconventional Energy Sources for Electricity Generation" Internation Journal of Advance Research And Innovative Ideas In Education , Volume 4 Issue 4 2018 Page 229-244

[46] K A Khan, Mahmudul Hasan, Mohammad Ashraful Islam, Mohammad Abdul Alim, Ummay Asma, Lovelu Hassan, and M Hazrat Ali. "A Study on Conventional Energy Sources for Power Production" Internation Journal Of Advance Research And Innovative Ideas In Education, Volume 4 Issue 4 2018 Page 214-228

[47] M K A Khan ; Md. Siddikur Rahman ; Tanmoy Das ;Muhammad Najebul Ahmed ; Kaushik Nandan Saha ; Shuva Paul, Investigation on parameters performance of Zn/Cu electrodes of PKL, AVL, Tomato and Lemon juice based electrochemical cells: A comparative study, Publication Year: 2017, Page(s):1-6, Published in: 2017 3rd International Conference on Electrical Information and Communication Technology (EICT), Date of Conference: 7-9 Dec. 2017, Date Added to IEEE Xplore: 01 February 2018, ISBN Information: INSPEC AccessionNumber: 17542905,DOI: 10.1109/EICT.2017.8275150,Publisher: IEEE,Conference Location: Khulna, Bangladesh

[48] K A Khan and M. M. Alam, " Performance of PKL (Pathor Kuchi Leaf) Electricity and its Uses in Bangladesh", Int. J. SOC. Dev. Inf. Syst. 1(1): 15-20, January 2010.

[49] K A Khan, M. H. Bakshi and A. A. Mahmud, "Bryophyllum Pinnatum leaf (BPL) is an eternal source of renewable electrical energy for future world", American Journal of Physical Chemistry 2014;3(5):77-83,published,online,November10,2014(http://www.sciencepublishinggroup.com/j/ajpc)doi:10.11648/j.ajpc.20140305.15,ISSN:2327-2430 (Print); ISSN: 2327-2449(Online),2014.

[50] M K A Khan, An Experimental Observation of a PKL Electrochemical Cell from the Power Production View Point, Presented as an Invited speaker and Abstract Published in the Conference on Weather Forecasting & Advances in Physics, 11-12 May 2018, Department of Physics, Khulna University of Engineering and Technology (KUET), Khulna, Bangladesh.

[51] Bapy Guha, Fakhrul Islam and K A Khan ,Studies on Redox Equilibrium and Electrode Potentials, IJARIIE-ISSN(O)-2395-4396, Volume-4, Issue-4, Page-1092-1102 , 2018

[52] Fakhrul Islam, Bapy Guha and K A Khan , Studies on pH of the PKL Extract during Electricity Generation for day and night time collected Pathor Kuchi Leaf , IJARIIE-ISSN(O)-2395-4396, Volume-4, Issue-4, Page-1102-1113 , 2018

[53] K A Khan, Mohammad Lutfor Rahman, Md. Safiqul Islam, Md. Abdul Latif, Md. Afzal Hossain Khan, Mohammad Abu Saime and M Hazrat Ali, Renewable Energy Scenario in Bangladesh, Published in the journal of IJARII, Volume-4,2018, Issue-5, page : 270-279, ISSN(O)-2395-4396.

[54] K A Khan and Salman Rahman Rasel, Prospects of Renewable Energy with Respect to Energy Reserve in Bangladesh, Published in the journal of IJARII, Volume-4,2018, Issue-5, page : 280-289, ISSN(O)-2395-4396.

[55] K A Khan, Md.Shahadat Hossain, Md.Mostafa Kamal,Md.Anisur Rahman and Isahak Miah ,Pathor Kuchi Leaf : Importance in Power Production, IJARIIE-ISSN(O)-2395-4396 , Vol-4 Issue-5, 2018

[56] K A Khan, M.Hazrat Ali, M. A. Mamun, M. Ibrahim,A K M Obaidullah, M. Afzol Hossain and M Shahjahan, PKL Electricity in Mobile Technology at the off-grid region, Published in the proceedings of CCSN-2018, 27-28 October, 2018 at Kolkata, India.2018

[57] K A Khan and Afzol Hossain, Off-grid 1 KW PKL Power Technology: Design, Fabrication, Installation and Operation, Published in the proceedings of CCSN-2018, 27-28 October, 2018 at Kolkata, India,2018
[58] K A Khan, M. A. Mamun, M. Ibrahim, Mehedi Hasan, Md. Ohiduzzaman A K M Obaidullah, M.A Wadud and M Shajahan, PKL electrochemical cell for off-grid Areas: Physics, Chemistry and Technology, Published in the proceedings of CCSN-2018, 27-28 October, 2018 at Kolkata, India.2018
[59] K A Khan, and Salman Rahman Rasel. "Studies on Wave and Tidal Power Extraction Devices" International Journal of Advance Research And Innovative Ideas In Education Volume 4 Issue 6 2018 Page 61-70
[60] K A Khan, Sultan Mahiuddin Ahmed , Mousumi Akhter , Md Rafiqul Alam , and Maruf Hossen . "Wave and Tidal Power Generation" Internation Journal Of Advance Research And Innovative Ideas In Education Volume 4 Issue 6 2018 Page 71-82
[61] K A Khan, Md. Atiqur Rahman, Md. Nazrul Islam, Mahmuda Akter, and Md. Shahidul Islam. "Wave Climate Study for Ocean Power Extraction" Internation Journal Of Advance Research And Innovative Ideas In Education Volume 4 Issue 6 2018 Page 83-93
[62] K A Khan, Md.Sujan Miah, Md. Iman Ali, Sujan Kumar Sharma, and Abdul Quader. "Studies on Wave and Tidal Power Converters for Power Production" Internation Journal of Advance Research And Innovative Ideas In Education Volume 4 Issue 6 2018 Page 94-105
[63] K.A.Khan , and Farhana Yesmin. "PKL Electricity- A Step forward in Clean Energy" Internation Journal Of Advance Research And Innovative Ideas In Education Volume 5 Issue 1 2019 Page 316-325
[64] K.A.Khan, M Hazrat Ali, A K M Obaydullah, M A Wadud, "Candle Production Using Solar Thermal Systems ",1st International Conference on 'Energy Systems, Drives and Automations', ESDA2018, Page: 55-66.
[65] K.A.Khan and Farhana Yesmin, "Cultivation of Electricity from Living PKL Tree's Leaf" International Journal Of Advance Research And Innovative Ideas In Education Volume 5 Issue 1 2019 Page 462-472
[66] S. J. Hassan & K. A. Khan, "Determination of Optimum Tilt angles of Photovoltaic panels in Dhaka, Bangladesh."International J. Eng. Trach 4 (3): 139-142, December 2007. Webiste : www. Gsience. Net , 2007
[67] S.J.Hassan & K. A. Khan, "Design, Fabrication and performance study of Bucket type solar candle machine", International J. Eng. Trach 4 (3), December 2007. Webiste : www. Gsience. Net, 2007
[68] Md. Kamrul Alam Khan, "Studies on Electricity Generation from Stone Chips Plant (Bryophyllum pinnatum)", International J.Eng. Tech 5(4): 393-397, December 2008
[69] Saiful Islam, K.A. Khan, A.K. Sadrul Islam & M. Junab Ali, "Design, Fabrication & performance study of a Paraboloidal Solar Medical Sterilizer" , Bangladesh J.Sci. Res. 18(2): 211-216, 2000 (December)
[70] Md Shahidul Islam and Md. Kamrul Alam Khan, Performance Studies on Single Crystal Solar PV Modules for Practical Utilisation in Bangladesh, International J.Eng. Tech 5(3): 348-352, September 2008
[71]Md.Kamrul Alam Khan, Studies on Fill Factor(FF) of Single Crystal Solar PV Modules For Use In Bangladesh, International J.Eng. Tech 5(3): 328-334, September 2008
[72] Md. Kamrul Alam Khan, Performance Studies of Monocrystallinne PV module considering the shadow effect, International J.Eng. Tech 5(3): 342-347, June 2008
[73] Md Shahidul Islam and Md.Kamrul Alam Khan, Study the Deterioration of a Monocrystal Solar silicon PV module Under Bangladesh Climate, International J.Eng. Tech 5(2):26 3-268, June 2008.
[74] K.A.Khan, Salman Rahman Rasel and Md. Ohiduzzaman, "Homemade PKL Electricity Generation for Use in DC Fan at Remote Areas",1st International Conference on 'Energy Systems, Drives and Automations', ESDA2018, Page: 90-99.
[75] K.A.Khan , and Farhana Yesmin. "Solar Water Pump for Vegetable field under the Climatic Condition in Bangladesh" Internation Journal Of Advance Research And Innovative Ideas In Education Volume 5 Issue 1 2019 Page 631-641
[76] K.A.Khan , and Salman Rahman Rasel. "Solar Photovoltaic Electricity for Irrigation under Bangladeshi Climate" Internation Journal Of Advance Research And Innovative Ideas In Education Volume 5 Issue 2 2019 Page 28-36