Dr. Dipanwita Majumdar

Assistant Professor, Chemistry

M.Sc. , Ph.D.

Education Details

2005 B.Sc. B. Sc. (CHEMISTRY HONOURS) from The University of Burdwan

2007 M.Sc. M. Sc. In CHEMISTRY (INORGANIC CHEMSTRY SPECIAL) from The University of Burdwan

2011 Ph.D. Ph. D. from Jadavpur University, Research work carried out at Indian Association for the Cultivation of Science, Jadavpur, Kolkata-700032

Experience Details

28-May-09 - 22-Feb-18	Lecturer, and Assistant Professor at Barasat Govt College	Assistant Professor
23-Feb-18 - Till Date	Chandernagore College, Chandannagar, Hooghly	Assistant Professor

Project

2014 - 2016	Completed	UGC MRP project titled Synthesis, Characterization and Electrochemical Studies Of Graphene-Manganese Dioxide Composites worth Rs. 5 Lakhs

Journal Publications

2009 Observation of microwave plasmons in one-dimensional conjugated polymer chain.' B Mondal, D Majumdar and S K Saha Appl. Phys. Lett. 94 (2009) 183109.

2009 'Mechanism of Ultrasonic Energy-Assisted Formation of V-, Y-Shaped Nano-Structures in Conjugated Polymers' D Majumdar R P Maity,S Basu, and S K Saha J. Nano Sc. & Nanotech. 9 (2009)6896-6901.

2010 'Graphene quantum sheet: A new material for spintronic application.' S K Saha, M Baskey, D Majumdar. Adv. Mater. 22 (2010) 5531

2010 'Observation of ferroelectric response in conjugated polymer nanotubes.' D Majumdar and S K Saha Appl. Phys. Lett., 96 (2010) 183113

2010 'Poly(3-hexylthiophene) nanotubes with superior electronic and optical properties. D Majumdar and S K Saha Chem. Phys. Lett., 489 (2010) 219

2010 Synthesis of single crystalline micron-sized rectangular silver bar.' B Mondal, D Majumdar and S K Saha, J. Mater. Research. 25 (2010) 383.

2011 Nanotechnology: Its current scope and prospect ' Dipanwita Majumdar Acad. J Aureole Vol 3(2), (2011) 114-119

2011 'Epitaxial growth of crystalline polyaniline on reduced graphene oxide D Majumdar M Baskey, S K Saha Macromol. Rapid Commun. 32 (2011) 1277

2013 Graphene and its composites as "supercaps". Dipanwita Majumdar Acad. J Aureole 4, (2013) 11-16

2014 Reduced Graphene Oxide: An Efficient Supercapacitor Material'.Dipanwita Majumdar Academic J. Aureole, 5 (2014) 42-46

2015 Graphene-MnO2 Composite as Electrocatalyst for Oxygen Reduction Reactions. Dipanwita Majumdar Academic J. Aureole, 6&7(1) (2015-16) 31-37

2015 'Charge Transport in Polypyrrole Nanotubes.'Dipanwita Majumdar, S.K.SahaJ. Nanosci. Nanotechnol. 15 (2015) 9975-9981

2016 Synthesis, characterization and electrochemical study of hydroxy-functionalized graphene/MnO2 nanocomposite D Majumdar, SK Bhattacharya Materials Today: Proceedings 3 (10), 3872-3877

2016 "Graphene-Polyaniline nanocomposites as Proficient Energy Storage Material-An Overview" Dipanwita Majumdar Innovative Energy & Research 5(2016)2

2016 "Sonochemically Synthesized Beta-Cyclodextrin Functionalized Graphene Oxide and its Efficient Role in Adsorption of Water Soluble Brilliant Green Dye."Dipanwita Majumdar J Environ Anal Toxicol 6 (2016) 5.

2016 Hydroxy functionalized Graphene: A Proficient Energy Storage Material, Dipanwita Majumdar and Sujata Pal,J Fundam. Renewable Energy Appl., 6 (2016) 209

2016 'Microwave-assisted synthesis of Mn2O3 porous balls as bifunctional electrocatalyst for oxygen reduction and evolution reaction' Dipanwita Majumdar, et al Catal. Sci. Technol., 6(5) (2016) 1417-1429

2017 Sonochemically synthesized hydroxy-functionalized graphene–MnO2 nanocomposite for supercapacitor applications.Dipanwita Majumdar, and Swapan K BhattacharyaJ Appl Electrochem 47 (2017) 789–801

2017 Proficiency of graphene oxide in adsorption and removal of methylene blue from water: An overview.Dipanwita Majumdar J Environ Chem Toxicol 1 (2017) 4-8

2017 Detoxification of Heavy Metal ion-contaminated Drinking Water by Green Technology - A Short Overview.Dipanwita Majumdar Current Green Chemistry 4 (2017) 38-44

2017 Functionalized Graphene-MnO2 nanocomposite in Fuel Cell Applications Dipanwita Majumdar Asian Journal of Science and Technology, 8(3),(2017) 4394-4398

2017 Ultrasound assisted formation of reduced graphene oxide-copper (II) oxide nanocomposite for energy storage applications Dipanwita Majumdar, Nirmal Baugh, and Swapan K Bhattacharya Colloids and Surfaces A: Physicochem. Eng. Aspects 512 (2017) 158–170.

2018 An Overview on Ruthenium Oxide Composites–Challenging Material for Energy Storage Applications D Majumdar Materials Science Research India 15(1) ,(2018) 30-40

2019 Anodic Oxidation of Butan-1-ol on Reduced Graphene Oxide -Supported-Pd-Ag-Nanoparticles/ Nanoalloy for Fuel Cell Applications Ankita Mahajan, Senjuti Banik, Dipanwita Majumdar and Swapan Kumar Bhattacharya ACS Omega, 4 (2019) 4658-4670

2019 Temperature Control Synthesis of Platinum Nanoparticle-Decorated Reduced Graphene Oxide for Electrocatalytic Oxidation of Methanol .Senjuti Banik; Ankita Mahajan; Apurba Ray; Dipanwita Majumdar; Sachindranath Das; Swapan Kumar Bhattacharya Flat Chem (2019)Flat Chem 16 (2019) 100111

2019 Synthesis and characterization of biopolymer based hybrid hydrogel nanocomposite and study of their electrochemical efficacy. Arindam Giri, Rahul Bhowmick, Chandraday Prodhan, Dipanwita Majumdar, Swapan Kumar Bhattacharya M Ali International Journal of Biological Macromolecules.123 (2019) 228–238

2019 Engineering of Gadolinium-Decorated Graphene Oxide Nanosheets for Multimodal Bioimaging and Drug Delivery.Nitya Chawda, Mainak Basu, Dipanwita Majumdar, Raju Poddar, Santosh Kumar Mahapatra, Indrani Banerjee,ACS OMEGA 4(2019) 12470-12479

2019 Optimization of physicochemical and dielectric features in the conductive copolymers of aniline and 2-aminophenol US Waware, AMS Hamouda, D Majumdar Polymer Bulletin 76 (11), 5603-5617

2019 A Review on V2O5 and Its Carbon-Based nanocomposites as Supercapacitor Electrode Materials .Dipanwita Majumdar, Manas Mandal and Swapan Kumar Bhattacharya ChemElectroChem 2019, 6, 1623. (Wiley)

2019 A Review of Recent Progress in Ruthenium Oxides based Composites for Supercapacitor Applications. Dipanwita Majumdar, Thandavarayan Maiyalagan, Zhongqing Jiang ChemElectroChem 6 (2019) 4343 (Wiley)

2019 Magnetic, pseudocapacitive and H2O2-electrosensing properties of self assembled superparamagnetic Co0.3Zn0.7Fe2O4 with enhanced saturation magnetization Rituparna Mondal,; Koyel Sarkar,; Subhrajyoti Dey,; Dipanwita Majumdar,; Swapan Bhattacharya,; Pintu; Sen, Sanjay Kumar, ACS Omega 47 (2019) 12632-12646

2019 Synthesis, characterization and physicochemical studies of copolymers of aniline and 3 nitroaniline Umesh Somaji Waware, A. M. S. Hamouda, Dipanwita Majumdar Polym. Bull. (2019). pp1-20 DOI: https://doi.org/10.1007/s00289-019-02957-y

2020 Journey from Supercapacitor to Supercapatteries: Recent advancements in electrochemical energy storage system, D Majumdar et al. Emergent Materials, Springer, ISSN : 2522-574X, https://doi.org/10.1007/s42247-020-00090-5

2020 Review on Current Progress of MnO2?based Ternary Nanocomposites for Supercapacitor Applications, D Majumdar, Chemelectrochem, Wiley, doi: https://doi.org/10.1002/celc.202001371

2020 Recent advancements of copper oxide based nanomaterials for supercapacitor applications D Majumdar, S Ghosh Journal of Energy Storage, 101995, https://doi.org/10.1016/j.est.2020.101995

2020 Recent progress in copper sulfide based nanomaterials for high energy supercapacitor applications D Majumdar Journal of Electroanalytical Chemistry, https://doi.org/10.1016/j.jelechem.2020.114825

Book Publications

2013 “Nanopesticides: A Challenging Domain of Current Research” BOOK CHAPTER by D Majumdar in the book : “Green Chemistry and Sustainable Agriculture Practices: A Step towards a better future”, Edited by Tanmoy Chattopadhyaya and Biplab Bhowmik Published by MS Academc in collaboration with Panchkot MahavidyalayaPurulia 2013. [ISBN No: 978-81-921697-3-6].

2016 “Adsorption and Removal of Soluble Methylene Blue Dye from Water by Sorbefacient Graphene Oxide”.Book Chapter by S. Pal and D Majumdar, pp 19-27.” in the book “Modern Trends in Chemical Sciences” Edited Dr. Kamala Mitra, 2016, [ISBN: 978-93-83010-31-8].

2019 POLYANILINE AS PROFICIENT ELECTRODE MATERIAL FOR SUPERCAPACITOR APPLICATIONS: PANI NANOCOMPOSITES FOR SUPERCAPACITOR APPLICATIONS. BOOK CHAPTER by Dr. Dipanwita Majumdar in the book Polymer Nanocomposites for Advanced Engineering and Military Applications edited by Noureddine Ramdani IGI Global Publishers. DOI: 10.4018/978-1-5225-7838-3.ch007

2019 POLYANILINE NANOCOMPOSITES: CHALLENGING MATERIALS FOR ENERGY STORAGE APPLICATIONS: PANI NANOCOMPOSITES FOR SUPERCAPACITOR APPLICATIONS. Book chapter by Dr. Dipanwita Majumdar in the book Polymer Nanocomposites for Advanced Engineering and Military Applications edited by Noureddine RamdaniIGI Global Publishers. DOI: 10.4018/978-1-5225-7838-3.ch008. (April, 2019) ISBN13: 9781522578383|ISBN10: 1522578382|EISBN13: 9781522578390

2019 Chemistry In Laboratory (Organic, Inorganic, Physical), Authors: Dr. Subhojit Ghosh, Dr. Madhushree Das Sharma, Dr. Dipanwita Majumdar and Dr. Swarup Manna, Santra Publications Pvt Ltd, Published in 2019, ISBN No: 978-93-86911-72-8

2019 BOOK CHAPTER: Ultrasound-Assisted Synthesis, Exfoliation and Functionalisation of Graphene Derivatives, IN THE BOOK : Graphene Functionalization Strategies, PUBLISHED BY Springer

2021 Ghosh, S. and Majumdar, D. (2021). Chemical Synthesis of Conducting Polymers Nanostructures. In Conjugated Polymer Nanostructures for Energy Conversion and Storage Applications, S. Ghosh (Ed.). https://doi.org/10.1002/9783527820115.ch2

2021 Majumdar, D. (2021). Aqueous Electrolytes for Flexible Supercapacitors. In Flexible Supercapacitor Nanoarchitectonics (eds Inamuddin, M.I. Ahamed, R. Boddula and T. Altalhi). https://doi.org/10.1002/9781119711469.ch13

2021 D. MAJUMDAR, Chapter 26, Polyaniline Nanocomposites: Innovative Materials for Supercapacitor Applications – PANI Nanocomposites for Supercapacitor Applications (pages 579-612) IN TH BOOK Research Anthology on Synthesis, Characterization, and Applications of Nanomaterials, Information Resources Management Association (USA)ISBN13: 9781799885917|EISBN13: 9781799887362https://www.igi-global.com/book/research-anthology-synthesis-characterization-applications/271734

Paper Presentation

2010 2010: Oral Presentation: on “Formation Dynamics of V- and Y-shaped Polyaniline nanowires”.4-5th Feb, 2010 (UGC sponsored National Seminar : EMERGING CONCERNS AND ADVANCES IN CHEMISTRY) At Lady Brabourne College (Kolkata)

2011 2011: Poster presentation: l on “Epitaxial Growth of Single Crystalline Polyaniline on Reduced Graphene Oxide to grow High Quality P-N Junction”.(UGC sponsored National Level Seminar on RECENT ADVANCES IN CHEMICAL SCIENCES AND RELATED AREAS At SreeGopal Banerjee College, Bagati, Mogra, Hooghly, West Benga

2013 2013: Oral Presentation: ON THE TOPIC “Nanopesticides : A Challenging Domain of Current Research” by D Majumdar 2013.(National Conference) At Panchkot Mahavidyalaya, Purulia.

2015 2015: Poster presentation: on “Synthesis, Characterization and Comparative Electrochemical Studies of Graphite-Copper (II) Oxide and Graphene Oxide-Copper (II) Oxide composites.”on 1-2nd August, 2015.(National Conference/ National Symposium) at Indian Chemical Society, Kolkata

2015 2015: Poster presentation: NANOS 2015- International conference being organized by GITAM University during December, 14th to 17th, 2015 on the topic “Synthesis, Characterization and Comparative Electrochemical Studies of Graphite-Copper (II) Oxide and Reduced-Graphene Oxide-Copper (II) Oxide composites.”

2016 2016: Poster presentation: on the topic “Role of beta-cyclodextrin-functionalized graphene oxide in removal of organic-dye water pollutants.” (National Conference) At Department of Chemistry, Burdwan University from 4-6th February, 2016 at Burdwan

2016 2016: Poster presentation: ICMRA 2016- “Synthesis, Characterization and Electrochemical Study of Hydroxy-Functionalized Graphene/MnO2 nanocomposite” from 11-13th March, 2016 at CMR Technical Campus, Hyderabad. (International Conference)

2016 2016 Poster presentation: “Synthesis, Characterization and Electrochemical Studies of hydroxy functionalized Graphene-MnO2 Nanocomposite ” Dipanwita Majumdar INTERNATIONAL CONFERENCE ON NANOTECHNOLOGY FOR BETTER LIVING (ICNBL-2016) (25/5/2016 - 29/5/2016 NIT SRINAGAR AND IIT KANPUR AT NIT SRINAGAR, JAMMU AND KASHMIR.

2016 2016 Poster presentation:“Tuning of Charge Transport Properties in Polypyrrole Nanotubes” Dipanwita Majumdar UGC sponsored ONE DAY National Seminar 2016 RECENT ADVANCES IN LIFE SCIENCE IN THE LIGHT OF CHEMISTRY (09/09/2016)(Bethune College)

2016 2016 Poster presentation on “Adsorption and Removal of Water Soluble Methylene Blue Dye by Beta-Cyclodextrin Functionalized Graphene Oxide” Dipanwita Majumdar UGC sponsored National Seminar 2016ENTHRALLING FACETS OF MOLECULAR MANIFESTATION IN CHEMICAL SCIENCES (15.9.2016-16.09.2016)Bidhannagar College, SALTLAKE.

2016	2016 Poster presentation: Role of Sonochemically synthesized Beta-Cyclodextrin Functionalized Graphene Oxide in Adsorption of Water Soluble Brilliant Green Dye: Dipanwita MajumdarUGC sponsored National Seminar 2016on RECENT TRENDS IN CHEMICAL RESEAERCH (29.9.2016 -01.10.2016 at Sarojini Naidu College for Womenand Hiralal Mazumdar College for Women
2016	2016 Poster presentation“Adsorption and Removal of Soluble Methylene Blue Dye from Water by Sorbefacient Graphene Oxide” Dipanwita Majumdar UGC-Sponsored two day National Seminar on “MODERN TRENDS IN CHEMICAL SCIENCES” on 25-26th November, 2016 at Department of Chemistry, Narasinha Dutt College and Prasanta Chandra Mahalanobis Mahavidyalaya
2018	2018 Poster presentation: Recent Advancements of RuO2/Functionalized-Graphene Composites for Supercapacitor Applications By Dipanwita Majumdar at Recent Advances in Molecules and Materials: RA2M 2018’ 2nd– 3rd August 2018, organized by School of Applied Science & Humanities, Haldia Institute of Technology, Haldia-721657 and Indian Chemical Society (International Conference)
2019	2019 Poster presentation: Supercapatteries: A Revolution in Electrochemical Energy Storage Systems By Dipanwita MajumdarInternational Conference on Advances in Nanomaterials and Devices for Energy and Environment (ICAN-2019)27-29 January 2019 Advanced Materials and Nano-electronics Research Group of CNT Lab, in ABV-IIITM, Gwalior (International Conference)
2019	2019 Oral presentation: Supercapacitors to Supercapatteries: Renaissance in Electrochemical Energy Storage Systems By Dipanwita MajumdarInternational Conference of Emerging Technologies and Sustainable Development 2019 (ICETSD ’19) 5th and 6th March2019 Government College of Engineering and Leather Technology, Kolkata, India (International Conference)
2020	2020: National Symposium on Renewable Energy for Sustainable Future: Materials & Technology Development at Heritage Institute of Technology on 27/02/2020 on : Recent progress of supercapacitors
2020	2020: Two-Day International Seminar on “Innovation, Expansion, Impacts and Challenges in Chemical and Biological Sciences" to be held on 8-9th January, 2020

Courses

2012	Orientation Program	86th Orientation Programme at Academic Staff College, The University of burdwan
2013	Refresher Course	Refreshers Course "Recent Development on Nanoscience and Technology" by Recent Development on Nanoscience and Technology School of Materials Science and nanotechnology, under ASC, Jadavpur University
2018	Refresher Course	Winter School on Environmentl Science, HRDC, The University of Burdwan, 30.01.2018 to 19.02.2018
2020	Refresher Course	Online Refresher Course in Natural Aciences, HRDC-Goa University from 15.09.2020 to 28.09.2020
2020	Short Term Course	HEALTH AND STRESS : PROBLEM AND REMEDIES, UGC-HRDC, THE UNIVERSITY OF BURDWAN, FEBRUARY 18-24, 2020

Seminar / Workshop / Lecture Attendance

2010	Seminar	UGC sponsored STATE LEVEL SEMINAR " TECHNOLOGIES OF REVOLUTION: SOCIETY, ECONOMY & POLICY" Barasat Govt. College and Paschimbanga Itihas Samsad, 4-5th March, 2010.
2011	Conference	“Celebration of the International Year of Chemistry-2011”, by Dept of Chemistry, Jadavpur University on 24-25 March 2011

2011	Seminar	UGC sponsored National SeminarEMERGING TRENDS IN PLANT SCIENCE jointly organized by PG Dept of Botany, Barasat Govt. College and Biological Sc. Dept., ISI, Kolkata on 14th &15th July, 2011.
2011	Seminar	UGC sponsored National seminar MODERN TRENDS OF RESEARCH IN CHEMISTRY organized jointly by Chemistry Dept. of Chemistry Barasat Govt. College and IACS, Kolkataon 7th & 8th Sept, 2011.
2011	Seminar	UGC sponsored National seminar on RECENT WINDOWS OF CHEMISTRY jointly organized by Chemistry Dept. of Mahadevananda Mahavidyalaya and Panihati Mahavidyalaya, on 14th December,2011
2012	Workshop	Indo-US Workshop on Frontiers of Excellence in Photovoltaics Science and Technologies at IIT Bombay on January 15-17,2012.
2013	Conference	Physical Chemistry Research: Teaching and Industrial Perspectives ,organized by Dept of Chemistry, Jadavpur University on September 28,2013
2014	Symposium	National Symposium on Recent Advances in Chemistry and Industry organized by Indian Chemical Society on 01-02 August, 2014
2015	Symposium	National Symposium on Recent Advances in Chemistry and Industry organized by Indian Chemical Society on 01-02 August, 2015
2015	Symposium	One day symposium on Medicinal Chemistry and its perspectives, Dept of Zoology, Calcutta University on 17th November,2015
2016	Conference	Higher Edu. Dept. Govt of WB Sponsored Satyasundar Barman Memorial Lecture On “Policies For Higher Education In Backward Region Of WB” at Barasat Govt. College, on 25/2/2016
2017	Conference	Quantum Physics and Consciousness: conducted by Bhaktivedanta Institute on 4-5th Feb, 2017
2017	Workshop	Science Academies Lecture Workshop On Recent Trends In Chemistry And Biology By Science Forum, Mrinalini Dutta Mahavidyapith, Birati-700051 on 4-6 March,2017
2017	Workshop	Workshop on Research-Based Pedagogical Tools (RBPT) @ IIT Gandhinagar, Gujrat in collaboration with IISER Pune and Sheffield Hallam University, UK from 10.12.2017 to 13.12.2017
2018	Conference	ACS Publications and the Indian Academy of Sciences joint meeting “Expanding Frontiers in Chemical Sciences”@ BHU, Varanasi, on 01.11.2018
2018	Seminar	National Seminar on Energy Storage and Conversion (NSESC-2018) at Department of Instrumentation Science, Jadavpur University on 06.12.2018
2019	Workshop	Workshop on “PROMOTION UNDER CAREER ADVANCEMENT SCHEME” organized by IQAC, Bejoy Narayan Mahavidyalaya on July 19, 2019
2020	Workshop	“One Week Online National Faculty Development Program on E-Contents and ICT Tools for Innovative and Effective Teaching & Learning Process” Organized by Roorkee College of Management & Computer Applications, Roorkee from 8 August to 14 August, 2020.
2020	Seminar	‘RECENT TRENDS IN BIOLOGICAL AND CHEMICAL SCIENCE TO FIGHT AGAINST COVID-19 organized by Department of Zoology, Chemistry and Botany In collaboration with IQAC, Kabi Nazrul College, Murarai, Birbhum 731219, WB, India on 26.07.2020

2020	Seminar	Two Days State Level Webinar held on 7-8th August, 2020 organized by Dept. of Zoology and Dept. of Botany, supported by IQAC, Kalna College, Kalna, Purba Bardhaman, West Bengal, entitled “Covid-19: Molecular aspects and its possible managements”

Awards

2005	Qualified in nationally competitive examination, JAM -2005, conducted by Indian Institute of Technology (IIT), All India Rank-162
2006	Qualified in nationally competitive examination, CSIR-UGC NET - 2006, conducted jointly by Council of Scientific and Industrial Research (CSIR) and University Grants Commission (UGC), Govt. of India, 2006, December for lectureship and research fellowship. Selected for SPM interview under CSIR.
2006	Qualified in nationally competitive examination, GATE -2006, conducted by Indian Institute of Technology (IIT), All India Rank-281
2007	Qualified in nationally competitive examination, GATE -2007, conducted by Indian Institute of Technology (IIT), All India Rank-12
2011	2011: Poster award for the presentation: l on “Epitaxial Growth of Single Crystalline Polyaniline on Reduced Graphene Oxide to grow High Quality P-N Junction”.(UGC sponsored National Level Seminar on RECENT ADVANCES IN CHEMICAL SCIENCES AND RELATED AREAS At Sree Gopal Banerjee College, Bagati, Mogra, Hooghly, West Benga
2016	2nd best poster presentation at International Conference on Materials Research and Applications (ICMRA-2016) fom 11-13 March 2016 @ CMR TECHNICAL CAMPUS, Kandlakoya (V), Medchal (M), RR Dist, Telangana, India-501401,(Approved by AICTE, New Delhi, Affiliated to JNTU, Hyderabad.)
2016	3rd Young Women Scientist paper presentation at International Conference on Nanotechnology for Better Living, 2016 jointly organized by IIT Kanpur and NIT Srinagar at Srinagar, J&K, India on 25-29th May, 2016.
2021	InSc Research Excellence Award-2021, InSc (Institute of Scholars), Bangalore, Regd. under Ministry of MSME, Govt. Of India and ISO 9001:2015 certified.
2021	InSc Young Researcher Award-2021 InSc (Institute of Scholars), Bangalore, Regd. under Ministry of MSME, Govt. Of India and ISO 9001:2015 certified.

Memberships

1	Editorial Board Member of Peer-reviewed International Journal : Materials Science Research India for 2017 and 2018
2	Moderator and Question Paper Setters of UG and PG Level CHEMISTRY COURSES IN various reputed Universities in India.
3	Life Member at Indian Physical Society
4	Life member of Indian Association for the Cultivation of Science,Jadavpur
5	Reviewer of many reputed International peer-reviewed journals (Springer, Elsevier, Wiley)
6	InSc Professional Member, Institute of Scholars, Department of Awards, Muddhinapalya Bengaluru-560091, Karnataka, India

Review | Published: 13 May 2020

Journey from supercapacitors to supercapatteries: recent advancements in electrochemical energy storage systems

Dipanwita Majumdar, Manas Mandal & Swapan Kumar Bhattacharya

Emergent Materials **3**, 347–367(2020)

Abstract

Generation, storage, and utilization of most usable form, viz., electrical energy by renewable as well as sustainable protocol are the key challenges of today's fast progressing society. This crisis has led to prompt developments in electrochemical energy storage devices embraced on batteries, supercapacitors, and fuel cells. Vast research and development are being executed worldwide on each of these systems. Although fuel cells and batteries possess higher energy density but excessive installation cost, bulkiness, low power capabilities, and short life time are major limitations till date. The performances of supercapacitors at present lie in-between these batteries and conventional capacitors, hence serve as supporting or secondary devices for uninterrupted power supply systems. Nonetheless, supercapacitors

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Recent advancements of copper oxide based nanomaterials for supercapacitor applications

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ARTICLE INFO

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Supercapacitors
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Specific energy

ABSTRACT

Copper oxides (CuO and Cu_2O) have been established as technologically important materials due to their unique advantages of low cost, high chemical stability and remarkable electrochemical performance, particularly, in the fields of catalysis, photovoltaics and energy storage applications. Specifically, promising capacitance availability, noticeable electrochemical response and facile fabrication of copper oxides have driven enormous attention for high energy supercapacitors to meet the high rising demands for efficient electrochemical energy storage systems. This review summarizes the recent advancements of various copper oxide based nanosystems employed to design better electrode materials for advanced supercapacitors. Special emphasis has been given on correlating their capacitive behavior with varying morphology obtained via different synthetic procedures. Electrochemical responses of varied copper oxides nanostructures have been comprehensively discussed. To overcome the issue of high rates of agglomeration, low conductivity and poor electrochemical stability of pristine copper oxides nanomaterials, they have been successfully combined with suitable pseudocapacitive materials like metal oxides, chalcogenides, etc., as well as several carbon-based systems such as conducting polymers, carbon nanotubes and functionalized graphene systems, etc. to fabricate binary/ternary/quaternary nanocomposites with superior features for advanced energy storage applications, have also been outlined. In the course, merits/ demerits of these assorted nanocomposites have been highlighted to delineate clearly the current challenges faced that may promote better strategic designing of smarter nanomaterials for high performance supercapacitor electrodes in the near future.

1. Introduction

Uninvited and adverse ecological impacts imposed by uncontrolled consumption of non-renewable fossil fuels have triggered serious concerns among scientists to develop renewable and sustainable energy generation processes as well as look over their efficient storage and conversion phenomena [1,2]. This has urged rapid advancements in electrochemical energy storage (EES) devices such as batteries, supercapacitors, fuel cells, etc. to convene high rising demands of non-stop supply of energy [3,4]. Till date, massive and voluminous batteries are considered as major electrochemical energy storage systems due to their high energy density (energy stored per unit volume) and specific energy (energy accummulated per unit mass) (30–300 $Whkg^{-1}$) [4–6]. However, poor life duration, low specific power (energy supplied per unit time per unit mass) and power density (energy furnished per unit time per unit volume), eco-toxicity and safety problems especially related to their recycling and disposal after life-end are the foremost practical limitations. Nevertheless, lack of suitable substitutes for existing batteries has been the main ground for disregarding their drawbacks. As an alternative, fuel cells provide promising energy conversion rate as well as low CO_2 emissions but suffer from bulky size, large installation costs and insufficient fuel storage capability. On the contrary, conventional capacitors though display inferior specific energy, yet can deliver energy at ultrafast rate along with long cycle life. The above points stimulated researchers to assemble and integrate all the good qualities of each type of the above EES systems to fabricate novel devices with enhanced energy delivering capabilities in the form of supercapacitors, also popularly named as electrochemical capacitors or ultracapacitors [6,7].

However, the energy-power efficiency of first-generation supercapacitors are far below to the expectations and thus, handy, portable,

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Review

Recent progress in copper sulfide based nanomaterials for high energy supercapacitor applications

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Supercapacitors
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Specific power
Specific energy

ABSTRACT

Copper sulfides (Cu_xS, x = 1–2), have been recognized as industrially significant materials with diverse applications in exotic technological fields of electronics, sensors, catalysis, photovoltaics, energy storage, etc. Their promising electrochemical performance, ease of availability, and low production cost have motivated enormous interest in fabricating high-performance supercapacitors to meet the sky-rising demands for proficient electrochemical energy storage devices. Various copper sulfide nanostructures obtained via different synthetic methodologies to design superior electrode materials for high-energy supercapacitors have been briefly outlined here. The variations in capacitive behavior with diverse copper sulfides morphologies have been compared and elaborated. As pristine metal chalcogenides nanomaterials often suffer a high rate of agglomeration, irreversible volume change during large electrochemical cycles in addition to poor charge transport features, their commercial usage gets severely restricted. Accordingly, to overcome the aforesaid limitations and bring about superior material qualities, copper sulfides have been intimately blended with a range of other electro-active materials like inorganic semiconductors including metal oxides, hydroxides, chalcogenides, carbides, etc., conducting polymers including polyaniline, polypyrrole, derived polythiophenes, etc. as well as with diverse carbon-based systems in the form of activated carbons, carbon nanotubes and functionalized graphene systems, etc., to furnish varieties of exquisite binary, ternary and quaternary nanocomposites. These materials have exhibited improved features, especially, in terms of capacitance, energy, and power efficiencies besides offering good mechanical flexibility and environmental stability to be applied in various energy-seeking fields of global technology. To the best of knowledge, very few review reports are available in the literature that highlights systematic as well as comprehensive discussion on the extent of progress of supercapacitive applications of different copper sulfide nano-systems and their nanocomposites. Besides, this study also outlines the current challenges faced as well as figures out some prospective ways that may promote better strategic sketching of smarter copper sulfides-based nanomaterials for high-performing supercapacitors in the upcoming days.

Contents

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Recent Progress in Ruthenium Oxide-Based Composites for Supercapacitor Applications

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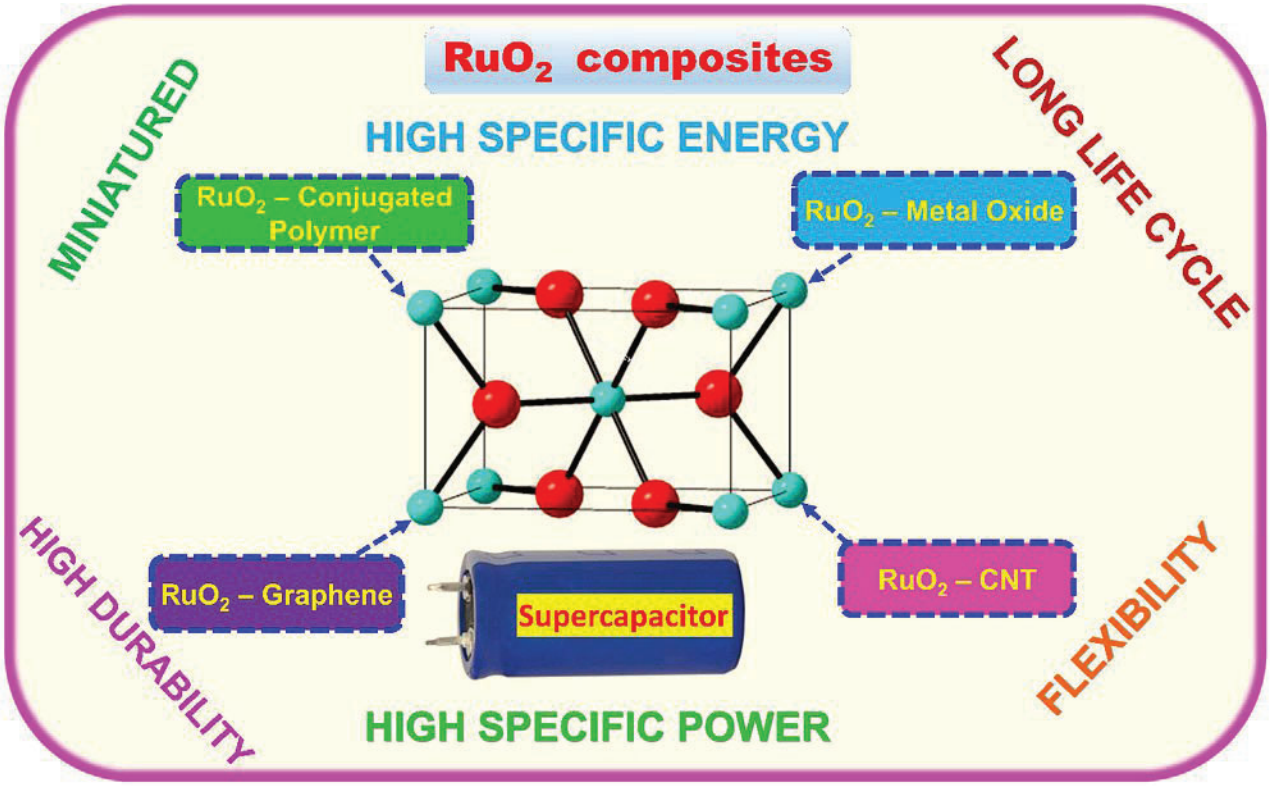

Electrochemical energy storage has emerged as one of the principal topics of present-day research to deal with the high energy demands of modern society. Accordingly, besides fuel cells and battery technologies, interesting and challenging results have been observed in the recent past, during the materialization of "supercapacitors" or "ultracapacitors", which have provoked a sharp increase in research inclination to revisit this aspect of renewable and sustainable energy storage. Supercapacitor performances are largely dependent on electrode materials, the nature of the electrolyte used, and the range of voltage windows employed. Carbon-based electrode materials have tunable properties such as electrical conductivity, extensive surface area, and faster electron transfer kinetics with low fabrication costs. But their specific capacitances are found to be too low for commercialization. Ruthenium dioxide (RuO_2), owing to its high theoretical specific capacitance value (1400–2000 $F g^{-1}$), has been extensively recognized as a favorable material for supercapacitor devices, but high production cost and agglomeration effects stand as high barriers preventing marketable usage. Consequently, RuO_2-based nanocomposites have been widely studied to optimize the material cost, with simultaneous improvement in the electrochemical performances. This Review describes comprehensively the recent progress in terms of the fabrication and design, electrochemical performance, and achievements of RuO_2 and its nanocomposites as electrode materials for supercapacitors, which will be beneficial for further research designing high-performance supercapacitor devices.

1. Introduction

1.1. Supercapacitors as Proficient Electrochemical Energy Storage (EES) Devices

Electrochemical energy storage (EES) systems comprising of fuel cells, batteries and supercapacitors are quickly emerging as one of the blazing issues of research to cope up with high energy demands of the modern society. Among these various electrochemical energy storage systems, supercapacitors (SCs) designing and fabrication technology are fast growing ever since the last decade, especially to meet the exceeding needs of miniature, portable criteria besides high lifetime, elevated power densities, flexibility, wide operating temperature range, low maintenance costs and light weight not only to supplement the former ones to but to replace them in many high energy-seeking sectors.[1–2] Supercapacitors are often popularly called as ultracapacitors or electrochemical capacitors, because of their superior designing so as to attain appreciably higher capacitances, large energy densities at large power densities compared to conventional capacitors. SCs are often treated as battery-complementary devices for high power demanding applications as they show higher power density compared to batteries although much improvements in energy densities are still in progress.[3] Besides, their applications are rapidly emerging in the fields of computers and memory storage devices. Furthermore, combination of supercapacitors and other renewable energy generating sources such as wind mills, solar cells, fuel cells are targeted for maximized energy storage and rapid charging capabilities with improved charge/discharge cycle performance of the hybrid as well as electric-vehicles for public transits.[3] Supercapacitor applications are getting popular by days in various uninterrupted power supply seeking areas of public securities, electronic gadgets, heavy machineries, biomedical, space and military applications.[4] Further, it is realized that assembling one supercapacitor electrode with suitable battery-type (hybrid systems) can considerably boost the energy density of the device. Thus, it's not far that commercially viable, flexible, maintenance-free, standalone supercapacitor-battery (termed as supercapatteries) will be readily available in the market.[5]

1.2. Essential Facts Related to State-of-the-Art Supercapacitors

Generally, "typical supercapacitors (EDLCs)" employ two large-surface-area-based electrodes separated by an insulating separator and submerged in electrolyte within a sealed jacket, as depicted in Figure 1.

Electrochemical energy storage (EES) device's efficacy is indicated by two crucial parameters, namely, specific energy/ energy density and specific power/ power density, respectively expressed by Equations (1) and (2):[1,6]

$$\text{Specific Energy } (E) = \frac{1}{2m} C_s (\Delta V)^2 \quad (1)$$

$$\text{Specific Power } (P) = (E/\Delta t) \times 3600 \quad (2)$$

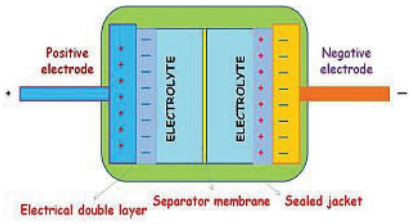

Figure 1. A typical two-electrode supercapacitor setup.

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Review on Current Progress of MnO_2-Based Ternary Nanocomposites for Supercapacitor Applications

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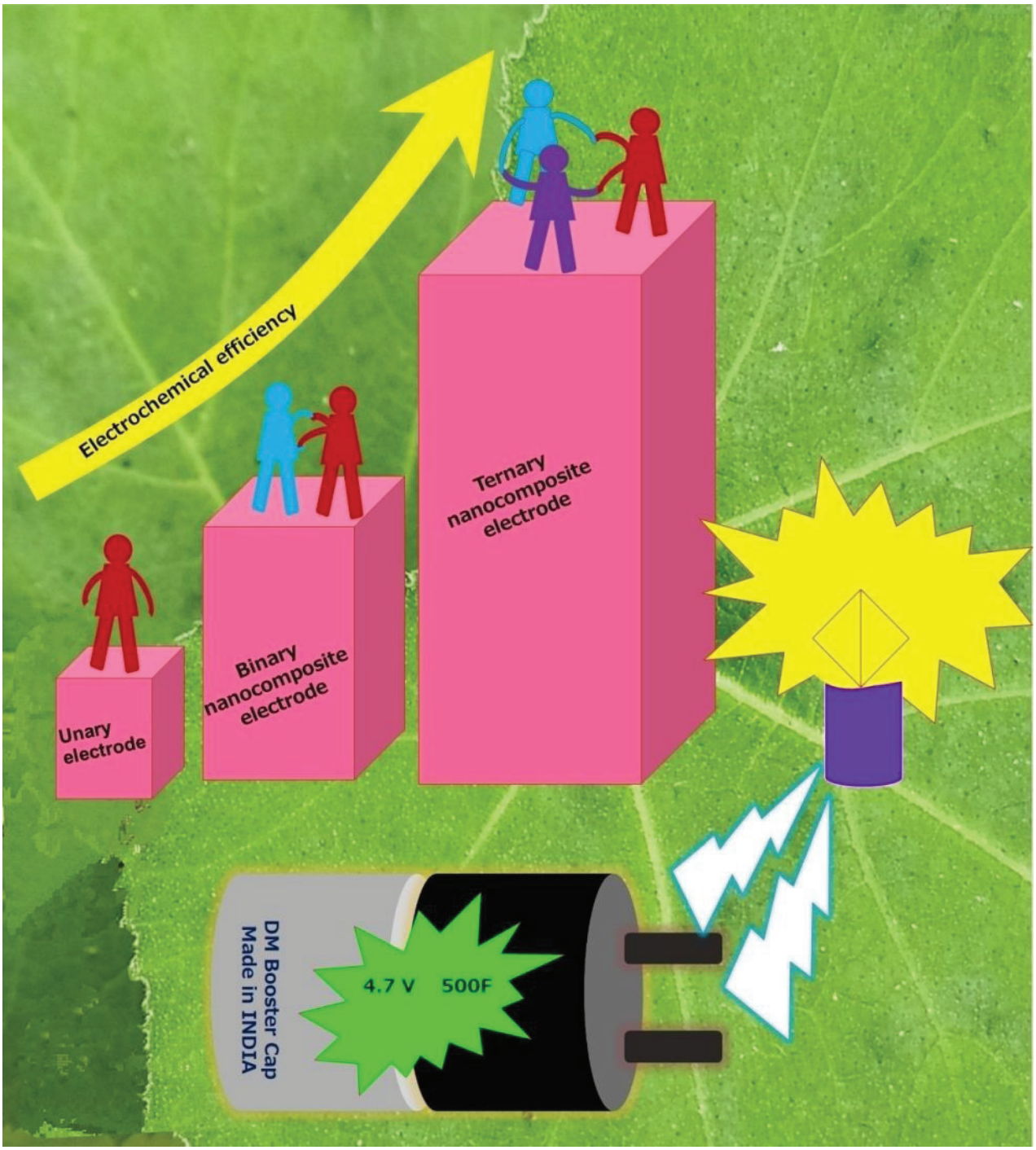

Manganese dioxide (MnO_2) has proved itself as a popular pseudocapacitive material with low fabrication cost, high availability, low toxicity, and improved handling safety compared to many other inorganics or carbon-based systems existing in the market. However, the specific capacitance reported to date has been far inferior to that of the theoretically predicted value (ca. 1370 Fg^{-1}), which is mainly attributed to the issues associated with poor conductivity, nanostructure agglomeration, low porosity, rapid electrolyte-mediated dissolution, and so forth, which have considerably limited its commercial effectiveness. Thus, to bring about improvement in the electrochemical performance of MnO_2-based supercapacitors, novel designs of MnO_2 nanomaterials through composite formations with other substances, such as nanocarbons, conducting polymers or inorganic materials, namely metal oxides and sulfides, have been comprehensively explored. Extensive studies on these MnO_2 binary nanocomposites revealed significant improvement in the electrochemical features compared to pristine phases; nevertheless, the achieved state is still far below practicability. Hence, scientists have opted for MnO_2-based ternary nanocomposites achieved by blending appropriate proportions the three components (MnO_2 nanostructures being one of the constant components) that would promote synergism to attain suitable dimensions, crystallinity, crystal structure, conductivity, mass loading, and electrolyte selectivity so as to confer superior capacitance, charge transfer kinetics, better utilization of electroactive materials, energy and power densities, as well as improved mechanical stability and environmental adaptability. Herein, recent developments and advancements in the research of various MnO_2-based ternary nanocomposites employed for supercapacitor applications have been discussed and are compared with binary analogs with special emphasis on correlating their composition, morphology, and the electrochemical properties that are noticeably modified upon introduction of the third component. The associated challenges encountered in their progress toward commercialization and the probable ideas of persuading better strategic designs of these ternary systems for high-performance supercapacitor applications have also been delineated.

1. Introduction

Over the past few years, the demand for renewable energy generation technologies has achieved tremendous worldwide research consideration to effectively resolve the issues of fast exhausting fossil fuels and their adverse environmental consequences.[1] However, their usage has not been commonly accepted partially due to high installation costs and the failure to provide good energy solutions during off-source periods. Thus to successfully drive these green technologies, explorations in the field of energy storage systems have intensified with the urge to develop smart gadgets that can efficiently storage as well as deliver energy economically as well as profitably at the time of requirement.[2] These fundamental objectives have channelized scientific interests to design superior electrochemical energy storage (EES) devices to meet the sky-high needs of uninterrupted power supply.[3,4] Among the EES, the gigantic, voluminous batteries are currently considered as the premier and commonest energy supporting systems as they have championed in high specific energy (energy stored per unit mass) values irrespective of poor term-life, inferior specific power (energy delivered per unit time per unit mass), environmental-toxicity and safety troubles particularly associated with their recycling and after-life disposal uncertainties.[4–6] These obvious drawbacks have been deliberately overlooked due to the lack of suitable alternative energy storage systems available today. Conventional capacitors although capable of delivering high power and long cycle life, display inferior energy density and thus, have restricted industrial applications. This knowledge has urged in devising novel EES systems that may balance the fine qualities of batteries as well as capacitors to counter the immediate energy problems.[6–7] Eventually, this led to the establishment of 'supercapacitors' or 'ultracapacitors' that possess unique features of portability, robustness, high specific power with appreciable life expectancy, and low maintenance expenses to replace the popular low-lasting bulky batteries shortly.[7]

However, the specific capacitance and energy density values of generation-I supercapacitors have been far away from the theoretical expectations and thus, flexible, upgraded versions with high energy performances are in the immediate demand for smarter energy solutions in the near future. Rigorous investigations have revealed that the electrode materials take a major role in assigning the efficiency of these EES, and consequently wide varieties of nanomaterials including inorganic compounds such as metallic oxides, chalcogenides, carbides, etc.; conducting polymers and their derivatives; various nano-carbons; etc. have been fabricated for achieving the desired goal.[8] Several nanocomposites based on these substances have also been formulated for realizing high electrochemical efficiency in these devices. Nonetheless, the so-far obtained standards are considerably inferior to the much-needed targets for commercialization.[9] Accordingly, dedicated scientific minds are persistently engaged in the task of designing novel and intelligent electrode ingredients for witnessing a better tomorrow.[10]

The current review, in this perspective, comprehensively discusses the state of the art of research of various MnO_2-based ternary nanocomposites employed for supercapacitor applications, with special emphasis on correlating their electrochemical properties with composition and morphology that have rewarded them higher priority in respect to their binary analogs. Such systematic assessment might promote well-judged, productive formulations of an improved class of

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