Dr. Adarsh Kumar Pandey

Mailing Address
Senior Research Fellow/Senior Lecturer
Research Centre for Nano-Materials and Energy Technology (RCNMET), School of Science and Technology, Sunway University, Selangor, Malsysia
Email (s): adarsh.889@gmail.com; adarshp@sunway.edu.my
Google scholar: https://scholar.google.com.my/citations?user=FbozkbcAAAAJ&hl=en
Cell: +60-1123125146; **Tel:** +603-74918622 Ext.7600
Fax: +603-56358633

EDUCATIONAL QUALIFICATION

- ***Ph.D. in Energy*** *from* School of Energy Management, College of Engineering, Shri Mata Vaishno Devi University, Katra, Jammu, J&K State, India**.**
  Nov. 2009-April 2013
- Post Graduate Diploma in Rural (Renewable) Energy Technology (PGD-IRET)
  2007-2008
- M. Sc.**(**Physics)
  2003 – 2005
- B.Sc. (Physics, Maths, Chemistry)
  2000-2003

PROFESSIONAL EXPERIENCE

22nd March 2018 Till Date	Senior Research Fellow/Senior Lecturer Research Centre for Nano-Materials and Energy Technology (RCNMET), Sunway University, Selangor, Malaysia
26th August 2016 10th March 2018	Research Fellow/Lecturer UMPEDAC, University of Malaya, Malaysia
15th August 2014 To 25th August 2016	Post Doctoral Research Fellow (PDF) UMPEDAC, University of Malaya, Malaysia
24th May 2013 to	Post Doctoral Fellow (PDF)

01st August 2014	SSS-National Institute of Renewable Energy, Kapurthala-144601 (Punjab) India
August 2013 to May 2014	Visiting Faculty Babasaheb Bhimrao Ambedkar University (Central University), Lucknow, Uttar Pradesh, India
01 January 2011 to 12 April 2013	Senior Research Fellow Ministry of New and Renewable Energy, Govt. of India New Delhi, India and SMVD University, Katra, India
01 January 2010 to 31 Dec. 2010	Junior Research Fellow Ministry of New and Renewable Energy, Govt. of India New Delhi, India and SMVD University, Katra, India
12th May 2008 to 15th Nov. 2009	Project Fellow National Institute of Solar Energy, Ministry of New and Renewable Energy Gwalpahari, Gurgaon, India

RESEARCH FIELD & ACTIVITIES

Extensive multidisciplinary research experience, which can be summarized in the following specializations:

- Hybrid Solar Photovoltaic (PV/T) systems
- Phase Change Materials
- Nano-Enhanced Phase Change Materials (NEPCMs)
- Dye sensitized solar cells
- Self cleaning of PV modules
- Energy and Exergy Analysis of Renewable Energy Systems

RESEARCH PROJECTS ONGOING/COMPLETED (Around total of 1.2 Million Ringgits)

- **Title:** Investigation on thermophysical properties of nano-enhanced phase change materials for concentrated photovoltaic thermal (CPVT) systems.
  PI: Dr. Adarsh Kumar Pandey
  Amount Granted : **RM 424,000**
  Project Code : **STR-RMF-MRU-004-2019**

Duration : 1st September 2019 – 31st August 2021

- **Title:** Improving specific heat capacity and thermal conductivity of molten salt based nano-fluids for for solar energy harvesting in concentrated solar power systems
  Investigator: Prof. Saidur Rahman
  Co-Investigator : Dr. Adarsh Kumar Pandey
  Amount Granted : RM212,500
  Duration : 2019-2021
- **Title:** Characterizing of MXene for solar applications **(Budget RM 76,500)**
  Investigator: Prof. TS. DR. Md. Mustafizur Rahman
  Co-PI: Dr. Adarsh Kumar Pandey
  Project Code: RDU192208
  Duration: 01/09/2019 - 31/08/2022
- **Title:** Design and modification of FDM based 3D printer for enhanced printed material properties. **(Budget RM 79,250)**
  Investigator: Prof. TS. DR. Md. Mustafizur Rahman
  Co-PI: Dr. Adarsh Kumar Pandey
  Project Code: RDU192208
  Duration: 01/09/2019 - 31/08/2022
- **Title:** MXene/Conducting Polymers-Based Nanocomposites as Photocatalyst for Waste Water Treatment
  Investigator: Dr. Syed Shahabuddin
  Co-Investigator : Dr. Adarsh Kumar Pandey
  Amount Granted : RM 47,500
  Project Code : INT-2019-SST-RCNMET-02
  Duration : 1st January – 31st December 2019
- **Title:** Experimental studies on the effect of current density and magnetic field on the growth of nanowires during electrodeposition **(Budget RM 36, 500)**
  Investigator: Dr. Mahendran A/L Samykano
  External Collaborator: Dr. Adarsh Kumar Pandey
  Project Code: RDU1803176
  Duration: 30/12/2018-29/12/2020
- **Title:** Fused deposition modelling to formulate pla-metal structure for 3D-printed applications **(Budget RM 25,000)**
  Investigator: PROF. DR. MD. MUSTAFIZUR RAHMAN
  External Collaborator: Dr. Adarsh Kumar Pandey
  Project Code: RDU190350

Duration: 05/03/2019 - 04/03/2021

- **Title:** Role of acrylonitrile-butadiene-styrene (abs) to develop 3D printed components using additive manufacturing technique **(Budget RM 25,000)**
  Investigator: PROFESOR MADYA TS. DR. KUMARAN A/L KADIRGAMA
  External Collaborator: Dr. Adarsh Kumar Pandey
  Project Code: RDU190351
  Duration: 05/03/2019 - 04/03/2021
- **Title:** Development of PLA-3D printed structure using fused deposition method**(Budget RM 25,000)**
  Investigator: IR. TS. DR. MAHENDRAN A/L SAMYKANO
  External Collaborator: Dr. Adarsh Kumar Pandey
  Project Code: RDU190352
  Duration: 05/03/2019 - 04/03/2021
- **Title:** *Towards Net-Zero Energy PV/T Integrated Residential Building in Malaysia* (**Budget** RM 161,000)
  Investigators: PI- Dr. A. K. Pandey
  Funding Agency: University of Malaya Research Grant (UMRG), University of Malaya
  Status: Completed.
- **Title:** *Synthesis of conducting Polymer nanocomposites for dye sensitized solar cells and photocatalytic degradation of pollutants from waste water.*
  Investigators: PI: Dr. Syed Shahabuddin, Co-PIs: **Dr. A K Pandey**, Prof. Saidur Rahman; Dr. Norazilawati Muhamad Sarih; Associate Prof. Dr. Juan Joon Ching
  Budget: RM 40,000
  Duration: 1 Year (1st January 2018-31st Dec. 2018)
  Funding Agency: Sunway University Internal Grant
  Status: Completed.
- **Title:** *Synthesis and characterization of advanced nanocomposites phase change materials for thermal energy storage.*
  Investigators: Dr Jesbains Kaur ,Prof Saidur Rahman, Dr Samir Hassani, Dr Syed Shahabuddin ,**Dr Adarsh Kumar Pandey**, Prof Dr Noriyuki Kuwano
  Budget: RM 40,000
  Duration: 1 Year (1st January 2018-31st Dec. 2018)
  Funding Agency: Sunway University Internal Grant
  Status: Completed.

THESIS SUPERVISION

Ph.D. Completed:

1. Name of Student: Md. Shouquat Hossain

Title of Thesis:: Energy, exergy and economic analysis of Phase Change Materials encapsulated hybrid Photovoltaic/Thermal (PV/T) syatems

Status: Graduated in May 2018

2. Name of Student: Muhammad Shakeel Ahmad

Title of Thesis: Development and characterization of low temperature efficient dye sensitized solar cells

Status: Graduated with distinction in 2018.

Masters: Completed:

1. **Name of Student: Usman Ahmed**

Title of the Thesis: Development and characterization of pt free Carbon-based counter electrode for dye sensitized solar cell

Status : Graduated in 2019

Ph.D.: Ongoing

1. **Name of Student:** Mohammed Moinul Islam

Title of Thesis: Analysis and Performance Evaluation of nano enhanced Phase change materials integrated photvoltaic modules

Status: Candidature Defense completed

2. **Name of Student:** Amirul Syafiq

Title of Thesis: Synthesis and characterization of self-cleaning hydrophobic coating using organic resin

Status: Submitted Thesis **August 2019.**

3. Name of the Student: Mathew George

Title of Thesis: Development and Performance evaluation of *Concentrated* photovoltaic/Thermal (CPV/T) collector with nano-enhanced phase change materials.

Status Proposal defense defended in 2018

4. **Name of the Student:** Hatem Aljaerani

Title of Thesis: Thermal properties improvement of HITEC Molten Salts by Nanoparticles

Status: To appear for Proposal Defense **2019.**

5. **Name of the Student:** R. REJI KUMAR

Title of Thesis: Nano-enhance phase change materials for thermal energy storage appliations.

Status: Registered in OCtober **2019. (Early stage)**

6. **Name of the Student:** Imtiaz Ali

Title of Thesis: Nano-enhance phase change materials for PV appliactsion.

Status: Registered in OCtober **2019. (Early stage)**

Masters: Ongoing

1. **Name of Student:** Nur Atirah Wahida

Title of Thesis: Crack Analysis of Diferent Photovoltaic Modules Using Electroluminescene Technique

Status: Candidature Defense completed

COURCES TAUGHT

Master of Renewable Energy

1. Energy Conservation and Management
2. Energy for Sustainable Development
3. Research Methodology

Master of Technology (M.Tech.)

4. Solar Energy: Fundamentals, Devices and System
5. Policy and Regulatory Aspects of Renewable Energy Power Generation

EVALUATION ACTIVITIES

- Ph.D. Thesis reviewer of National Institute of Technology, Surathkal, Karnataka, India. (2019)
- Ph.D. Thesis reviewer of GLA University Mathura,India. (2019)
- Chairman and assessor for Candidature defence and proposal defence of Ph.D. and Master Thesis for 2017/2018 in University of Malaya.
- Chairman and assessor for Candidature defence and proposal defence of Ph.D. and Master Thesis for 2016/2017.
- Chairman for Candidature defence and proposal defence of Ph.D. and Master Thesis for 2015/2016.
- Evaluator of the quality of the research outputs and standing for South Africa's National Research Foundation (NRF).
- Ph.D. Thesis reviewer of Visvesvaraya Technological University, Karnataka, India.(2017).
- International panel member of Ph.D. thesis evaluator in NIT, Bhopal, India.

INVITED SPEAKER

- Keynote speaker in Recent advances in Non-Conventional energy resources using solar based technologies (RANET 2019) organised by IMS College of Engineering, Ghaziabad India during 26-27th July 2019.

- Guest Lecture at GLA university Mathura, India during 28-29th July 2019.
- Guest Lecture at Shri Mata Vaishno Devi University, India during 30-31st July 2019.
- Keynote speech at National Symposium on Energy, Environment and Sustainable Development organised by Central University of Jammu, India on 31st July 2019.
- Keynote Speaker in 5th International Conference on Electrical Energy Systems (ICEES 2019) organised by SSN College of Engineering, Chennai, India during 21-22nd February 2019.
- Invited speaker in International conference on Renewable Energy for Sustainable Environment: Challenges and Remedies" at Department of Energy Management, Shri Mata Vaishno Devi University, Jammu & Kashmir, India during 27-28th March 2017.
- Invited speaker at Southeast and South Asia and Taiwan Universities (SATU) Presidents forum 2016 during 11th Nov. to 13th Nov. 2016 by National Cheng Kung University (NCKU), Taiwan.
- Invited speaker at 2016 Taipei Tech and Southeast Asia Universities SATU Alliance Interaction Workshop organized by TaiPei Tech., Taiwan during 13th Oct. -14th Oct. 2016.

EDITORIAL BOARD MEMBER OF JOURNALS:

1. Journal of Daylighting (Scopus Index)
2. Archives of Agriculture and Environmental Science

INTERNATIONAL ADVISORY BOARD /TECHNICAL COMMITTEE MEMBER IN CONFERENCES

1. Workshop Chair & Technical Review member of International Scientific Forum (ISF) 2019 to be organized by UMPEDAC, University of Malaya, Malysia during 16-17th December 2019.
2. Technical committee member of the International conference on sustainable innovation in engineering and technology (SIET 2019). Organised by Asia Pacific University, Malaysia during 25-26th Sept. 2019.
3. Technical committee member of the 5th IET International conference on clean energy and technology (CEAT 2018) organized by UMPEDAC, University of Malaya, Malysia during 5-6th September 2018.
4. International Advisory committee member of the International Conference On ADVANCES IN MECHANICAL ENGINEERING AND NANOTECHNOLOGY (ICAMEN), March 08-09, 2019 organised by Manipal University, India and UMP, Malaysia.

5. International Advisory committee member of the “International conference on Renewable Energy and Energy Conservation (ICREEK 2018)” organized by Poornima University, Jaipur during May 11-12, 2018.
6. International Conference on Engineering, Science, and Industrial Applications (2017 ICESI) August 2-4, 2017 at Chulalongkorn University, Bangkok, Thailand.
7. Renewable Energy for Sustainable Environment: Challenges and Remedies" at Department of Energy Management, Shri Mata Vaishno Devi University, Jammu & Kashmir, India during 27-28th March 2017.
8. Advisory Committee member of “National Conference on Advances in Mechanical Engineering (NCAME-2016)” organized on 12th March.
9. Technical Committee member of IET conference on clean energy and technology (CEAT 2016) to be held at Kuala Lumpur, Malaysia.
10. Technical Committee member of National Conference on Bio-Energy 2013 organized by SSS-National Institute of Renewable Energy, Kapurthala, Punjab, India

OTHER DUTIES

- Chaired a Session Track in International conference on sustainable innovation in engineering and technology (SIET 2019). Organised by Asia Pacific University, Malaysia during 25-26th Sept. 2019.
- Chaired a Session Track 5th IET International conference on clean energy and technology (CEAT 2018) organized by UMPEDAC, University of Malaya, Malysia during 5-6th September 2018.
- Chief Invigilator for Semester II, 2015/2016 Examination session at University of Malaya, Malaysia.
- Chaired a Session Track 4th IET International conference on clean energy and technology (CEAT 2016) organized by UMPEDAC, University of Malaya, Malysia in 2016.
- Chaired a session track “ Power Systems” in 2014 IEEE conference on clean energy and technology (CEAT 2014) during 24-26 Nov. 2014 in Kuching, Malaysia.

FELLOWSHIP/AWARDS

- Best presenter award in International conference on sustainable innovation in engineering and technology (SIET 2019). Organised by Asia Pacific University, Malaysia during 25-26th Sept. 2019.
- Best paper award in International conference on sustainable innovation in engineering and technology (SIET 2019). Organised by Asia Pacific University, Malaysia during 25-26th Sept. 2019.

- Post Doctoral research Fellowship at, UMPEDAC, University of Malaya, Malaysia.
- Post Doctoral research Fellowship at Sardar Swaran Singh National Institute of Renewable Energy, Ministry of New and Renewable Energy, Govt. of India, Kapurthala, Punjab, India.
- Senior Research Fellowship (SRF) under National Renewable Energy Fellowship of Ministry of New and Renewable Energy, Govt. of India.
- Junior Research Fellowship (JRF) under National Renewable Energy Fellowship of Ministry of New and Renewable Energy, Govt. of India.
- Project Fellowship on project entitled "Design and Development of Batteries for Solar Photovoltaic Applications" at Solar Energy Centre, Ministry of New and Renewable Energy, Gwalpahari, Gurgaon, India.

TRAINING AND SHORT TERM COURSES

- Participated in one week TEQIP Sponsored Short Term Course on "Energy and Environment Management" organised by Department of Chemical Energy and Department of Industrial & Production Engineering at Dr. B. R. Ambedkar National Institute of Technology, Jalandhar (NIT, Jalandhar) during October 19-23, 2013.
- Attended 2nd South Asia Renewable Energy Conference 2007 on 25-26th Apr 2007.
- Attended five day training programme on "Photovoltaic System Design, Installation, Operation, Maintenance and Repair" during 20-24th Feb 2007 at Solar Energy Centre, Gwalpahari.
- Attended seminar on Lead – Acid Storage Battery system on 17th Jan 2007 at Solar Energy Centre, Gwalpahari.

REVIEWERSHIP OF JOURNALS

- Energy: An International Journal (Elsevier)
- Renewable and Sustainable Energy Reviews (Elsevier)
- Energy Conversion and Management (Elsevier)
- Solar Energy (Elsevier)
- Solar Energy Materials and Solar Cells (Elsevier)
- Applied Thermal Engineering (Elsevier)
- Journal of Cleaner Energy Production (Elsevier)
- Photonics and Nanostructures - Fundamentals and Applications (Elsevier)
- Measurement (Elsevier)
- Energy Efficiency (Springer)
- Clean Technologies and Environmental Policy(Springer)

- Heat and Mass Transfer (Springer)
- Ionics (Springer)
- International Nano Letters (Springer)
- Mitigation and Adaptation Strategies for Global Change (Springer)
- Journal of Thermal Analysis and Calorimetry (Springer)
- Waste and Biomass Valorization (Springer)
- Heat and Mass Transfer (Springer)
- ACS Applied Materials & Interface (ACS)
- Biofuels (Taylor and Francis)
- IET Renewable Power Generation (IET)
- Multidiscipline Modeling in Materials and Structures (Emrald Publishing Group)
- Pigment & Resin Technology (Emrald Publishing Group)
- Environmental Progress and Sustainable Energy (John Wiley & Sons)

PUBLICATIONS

Publication Citation Index

(Google Scholar https://scholar.google.com.my/citations?user=FbozkbcAAAAJ&hl=en**)**

Citation Indices	All	Since 2013
Citations	1376	1335
h-index	20	19
I10-index	25	25

(A): PATENTS

1. Rahim NA, Syafiq A, Vengadaesvaran B, **Pandey AK**. A Method of Producing Hydrophobic and Self-Cleaning Coating, Patent Application Number PI2018703705, Filed.
2. Rahim NA, Selvaraj J, Hossain MS, **Pandey AK.** A system for cleaning a Photovoltaic panel, Patent application No. PI2019002410, Filed.
3. Rahim NA, Selvaraj J, Hossain MS, **Pandey AK.** A Photovoltaic thermal panel, Patent application No. PI2019002411, Filed.
4. Tyagi SK, **Pandey AK**, Tyagi VV. Phase change material based direct flow solar water heating system for useful applications, Patent Application No 1367/DEL/2015.
5. Tyagi SK, **Pandey AK,** Pal K. Improved Biomass Cookstove having higher Thermal Efficiency, Patent Application No.1113/DEL/2014.

(B):JOURNAL/SCOPUS/BOOKCHAPTERS/CONFERENCES

(Total Impact Factors of Journals = 222.348)

YEAR 2020

1. Syafiq A, Vengadaesvaran B, Ahmed U, Rahim NA, Pandey AK, Bushroa AR, Ramesh K, Ramesh S. Facile synthesize of transparent hydrophobic nano- CaCO3 based coatings for self-cleaning and anti-fogging. Materials Chemistry and Physics, 239 (2020) 121913. **(Impact Factor 2.781).**

YEAR 2019

ISI JOURNAL/SCOPUS PAPERS

1. Hossain MS, **Pandey AK**, Selvaraj J, Rahim NA, Rivai A, Tyagi V V. Thermal performance analysis of parallel serpentine flow based photovoltaic/thermal (PV/T) system under composite climate of Malaysia. Applied Thermal Engineering, 153 (5) (2019) 861-871. **(Impact Factor 4.026).**
2. Hossain MS, **Pandey AK,** Jeyraj A/L Selvaraj, Rahim N A, Islam MM, Tyagi VV. Two side serpentine flow based photovoltaic-thermal-phase change materials (PVT-PCM) system: Energy, exergy and economic analysis. Renewable Energy, 136 (2019) 1320-1336. **(Impact Factor 5.439).**
3. Chapra K, Tyagi VV, Pathak AK, **Pandey AK,** Sari A. Experimental performance evaluation of a novel designed phase change material integrated manifold heat pipe evacuated tube solar collector system. Energy Conversion and Management 198(2019) 111896. **(Impact Factor 7.181).**
4. Chapra K, Tyagi VV, Pathak AK, **Pandey AK, Anand S,** Sari A. Thermal performance of phase change material integrated heat pipe evacuated tube solar collector system: An Experimental Assessment. Energy Conversion and Management (2019) . **(Impact Factor 7.181). (Accepted)**
5. Khaleda ZF, Vengadaesvaran B, Syafiq A, Rahim NA, **Pandey AK**, Kasi R, Subramaniam R. Synthesis of nano-TiO2 coating systems for solar cell. Pigment & Resin Technology (2019) (Accepted) **(Impact Factor 0.724).**
6. George M, **Pandey AK,** Rahim NA, Tyagi VV, Shahabuddin S, Saidur R. Concentrated Photovoltaic Thermal Systems: A Component-by-Component View on the Developments in the Design, Heat Transfer Medium and Applications. Energy Conversion and Management 186(2019) 15-41. **(Impact Factor 7.181).**
7. Syafiq A., **Pandey A.K.,** Rahim N.A., Vengadaesvaran B., Shahabuddin S. Self-cleaning and weather resistance of nano-SnO2/modified silicone oil coating for

photovoltaic (PV) glass applications. Journal of Materials Science: Materials in Electronics 30(13) (2019), 12584-12596. **(Impact Factor 2.195).**

8. Chapra K, Tyagi VV, **Pandey AK.** Thermodynamic and techno-economic analysis of heat pipe ETC water heating system for Indian composite climate. Journal of Thermal Analysis and Calorimetry (2019). (https://doi.org/10.1007/s10973-019-08487-z). **(Impact Factor 2.471).**
9. Singh G, Singh PJ, Tyagi V V, Barnwal P, **Pandey A K**. Exergy and thermo-economic analysis of ghee production plant in dairy industry. Energy 167 (2019): 602-618. **(Impact Factor 5.537).**
10. Syafiq A, Vengadaesvaran B, Rahim NA, **Pandey AK**, Bushroa AR, Ramesh K, Ramesh S. Transparent Self-Cleaning Coating of Modified Polydimethylsiloxane (PDMS) For Real Outdoor Application. Progress in Organic Coatings 131(2019) 232-239. **(Impact Factor 3.420).**
11. Singh G, Singh PJ., Tyagi VV, **Pandey AK**. Thermal and exergoeconomic analysis of a dairy food processing plant. Journal of Thermal Analysis and Calorimentry, 136 (3) 2019 1365–1382. **(Impact Factor 2.471).**
12. Shahabuddin S, Arshid N, Shahid MM, Khanam R, Saidur R, **Pandey AK**, Ramesh S. Polyaniline-SrTiO3 nanocube based binary nanocomposite as highly stable electrode material for supercapacitors. Ceramics International. 45 (9) (2019) 11428-11437. **(Impact Factor 3.450).**
13. Singh G, Singh PJ, Tyagi VV, **Pandey AK**. Exergy and thermoeconomic analysis of cream pasteurisation plant. Journal of Thermal Analysis and Calorimetry 137 (4) (2019) 1381–1400. **(Impact Factor 2.471).**
14. Singh G, Singh PJ, Tyagi VV, Barnwal P, **Pandey AK**. Energy, exergy and exergoeconomic analysis of high temperature short time milk pasteurization plant. International Joirnal of Exergy. 30 (1)(2019) 26-61. **(Impact Factor 1.13).**
15. Panchal H, Patel DK, Sathyamurthy R, Kumar M, **Pandey A K**. Annual Performance analysis of Single basin passive solar still coupled with evacuated tubes : Comprehensive study in climate conditions of Mahesana, Gujarat. International Journal of Ambient Energy, 40 (3), (2019) 229-242. **.(SCOPUS)**
16. Vengadaesvaran B, Syafiq A, Pandey AK, Rahim NA. Transparent Self-Cleaning Coating Consisting Hydrophobically Modified-Polymer. Journal of Advanced Research in Materials Science 52, Issue 1 (2019) 1-8. **.(SCOPUS)**
17. **Pandey AK,** George M, Rahim NA, Shahabuddin S, Samykano M, Saidur R. Investigation on the suitability of Polyaniline(PANI) based composite Phase Change Material for Low Concentration Photovoltaic Thermal Application. International

conference on sustainable innovation in engineering and technology (SIET 2019). Organised by Asia Pacific University, Malaysia during 25-26th Sept. 2019. To be published in Scopus-Indexed Journal: – International Journal of Mechanical and Production Engineering Research and Development (IJMPERD) (ISSN: 2249 6890) (Accepted). **.(SCOPUS)**

18. Pandey A K, George M, Rahim NA, Shahabuddin S, Tyagi VV.. A Glance into the various Parameters affecting Thermal Conductivity in Phase Change Materials. The 6th International Conference on Advanced Engineering and Technology (6th ICAET) will be held in Incheon, South Korea during December 13-15, 2019. The 6th ICAET conference proceedings will be published in SCOPUS cited Key Engineering Materials by Trans Tech Publication Publishing. **.(SCOPUS)**
19. Tyagi VV, Pathak AK, Anand S, Kothari R, **Pandey AK**, Saidur R. Thermal performance study of the Single slope evacuated tube integrated desalination system. International conference on sustainable innovation in engineering and technology (SIET 2019). Organised by Asia Pacific University, Malaysia during 25-26th Sept. 2019. To be published in Scopus-Indexed Journal: – International Journal of Mechanical and Production Engineering Research and Development (IJMPERD) (ISSN: 2249 6890) (Accepted). **.(SCOPUS)**
20. Shouquat MS, Rahim NA, Selvaraj J, **Pandey AK**. Experimental Investigation on Energy Performance of hybrid PV/T-PCM system. *2019* Fifth International Conference on Electrical Energy Systems (ICEES)*, Chennai, India, 2019, pp. 1 5.* **.(SCOPUS)**
21. George M, **Pandey A K**, Rahim NA, Shahabuddin S, Tyagi VV. Investigation of Al2O3 based phase change material composite for solar thermal system application. International Scientific Forum (ISF) 2019, to be published in SCOPUS Cited IET. **.(SCOPUS)**
22. Nagar S, Shukla MK, Sharma K, Pandey AK. Evaluation of mechanical properties of graphene epoxy composites using continuum based micromechanical models. International Scientific Forum (ISF) 2019, to be published in SCOPUS Cited IET. **.(SCOPUS)**
23. Chopra K, Pathak P K, Tyagi VV, Pandey AK. Recent Advancements in Design of Flat Plate Solar Collectors. International Scientific Forum (ISF) 2019, to be published in SCOPUS Cited IET. **.(SCOPUS)**
24. Dheeraj Kumar Nagilla, V. V. Tyagi, Kumaran Kadirgama, K. Chopra, **A. K. Pandey**, Richa Kothari. *Application of Phase Change Materials in Solar Water Heating Systems*

for Thermal Energy Storage. International Scientific Forum (ISF) 2019, to be published in SCOPUS Cited IET **.(SCOPUS)**

25. Deepak Pathania, Sarita Kumari, S. Sood, **A K Pandey**. Analysis of photocatalytic properties of tragacanth gum -cl-p(lactic acid-co-itaconic acid)/zno-ag nanocomposite. International Scientific Forum (ISF) 2019, to be published in SCOPUS Cited IET **.(SCOPUS).**

BOOK CHAPTERS

26. **Pandey A K,** Ahmad M S, Rahim, N A Tyagi VV. (2019). Natural Sensitizers and Their Applications in Dye-Sensitized Solar Cell. In *Environmental Biotechnology: For Sustainable Future* (pp. 375-401). Springer, Singapore.
27. Pathak AK, Chopra K, Singh HM, Tyagi VV, Kothari R, Anand S, **Pandey AK**. (2019). Role of Solar Energy Applications for Environmental Sustainability. In *Environmental Biotechnology: For Sustainable Future* (pp. 341-374). Springer, Singapore.

BOOKS

28. **Title:** Dye-Sensitized Solar Cells: Emerging Trends and Advanced Applications
    Authors: Dr. Adarsh Kumar Pandey, Dr. Syed Shahabuddin, Mr. Muhammad Shakeel Ahmad.
    Publisher: Elsevier
    Status: Proposal Accepted, 2019 (Book writing in process)
29. **Title:** Advances in Hybrid Conducting Polymer Technology
    Authors: Dr. Syed Shahabuddin, **Dr. Adarsh Kumar Pandey,** Prof. Mohammad Khalid, Dr. Priyanka Jagadish
    Publisher: Springer Nature
    Status: Proposal Accepted, 2019 (Book writing in process)

YEAR 2018

ISI JOURNAL/SCOPUS PAPERS

30. **Pandey A K,** Hossain M S, Tyagi VV, Rahim N A, Selvaraj J, Sari A. Novel Approaches and Recent Developments on Potential Applications of Phase Change Materials in Solar Energy. Renewable and Sustainable Energy Reviews 82P1 (2018) 281-323. **(Impact Factor 10.556).**
31. Chopra K., Tyagi V.V., **Pandey A K**, Sari A. Global advancement on experimental and thermal analysis of evacuated tube collector with and without heat pipe systems and possible applications. Applied Energy 228 (2018) 351-389. **(Impact Factor 8.426).**

32. Ahmad M S, **Pandey A K,** Rahim N A, Shahabuddin S, Tyagi S K. Chemical sintering of TiO2 based photoanode for efficient dye sensitized solar cells using Zn nanoparticles. Ceramics International 44 (2018) 18444-18449. **(Impact Factor 3.450).**
33. Syafiq A, **Pandey A K**, Vengadaesvaran B, Rahim N A, Shahabuddin S. Organic-Inorganic composite nano coatings with superhydrophobicity and thermal stability. Pigment & Resin Technology (2018) (https://doi.org/10.1108/PRT-04-2018-0038). **(Impact Factor 0.724).**
34. Syafiq A, **Pandey A K,** Vengadaesvaran B, Rahim N A. Study on self-cleaning performance and hydrophobicity of TiO2/Silane coatings, Pigment & Resin Technology (2018) (https://doi.org/10.1108/PRT-02-2018-0010). **(Impact Factor 0.724).**
35. Ahmed U, Alizadeh M, Rahim NA, Shahabuddin S, Ahmad MS, **Pandey AK**. A comprehensive review on counter electrodes for dye-sensitized solar cells: A special focus on Pt-TCO free counter electrodes. Solar Energy 174 (2018) 1097–1125. **(Impact Factor 4.674).**
36. Syafiq A, Balakrishnan V, **Pandey AK**, Rahim NA. Superhydrophilic Smart Coating For Self Cleaning Application On Glass Substrate. Journal of Nanomaterials, 2018 (https://doi.org/10.1155/2018/6412601 **(Impact Factor 2.233).**
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PERSONAL PROFILE

Name	: Dr. Adarsh Kumar Pandey
Father's Name	: Mr. Suresh Chandra Pandey
Mother's Name	: Mrs. Urmila Pandey
Date of Birth	: 05 April 1983
Passport No.	: J3834624
Sex	: Male
Nationality	: Indian
Linguistic Proficiency	: Hindi, English
Marital Status	: Married
Permanent Address	: Vill.- Purebichchhoor, Post- Bichchhoor
	Dist.- Pratapgarh, State- Uttar Pradesh, India, Pin-230302

DECLERATION

I hereby declare that the above mentioned information is correct to the best of my knowledge.

Place: Selangor, Malaysia Adarsh Kumar Pandey

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Two side serpentine flow based photovoltaic-thermal-phase change materials (PVT-PCM) system: Energy, exergy and economic analysis

M.S. Hossain [a, **], A.K. Pandey [b, *], Jeyraj Selvaraj [a], Nasrudin Abd Rahim [a, c], M.M. Islam [a], V.V. Tyagi [d]

[a] UM Power Energy Dedicated Advanced Centre, Wisma R&D, Level 4, Jalan Pantai Murni, University of Malaya, Kuala Lumpur 59990, Malaysia
[b] Research Centre for Nano-Materials and Energy Technology (RCNMET), School of Science and Technology, Sunway University, No. 5, Jalan Universiti, Bandar Sunway, Petaling Jaya, 47500 Selangor Darul Ehsan, Malaysia
[c] Renewable Energy Research Group, King Abdulaziz University, Jeddah 21589, Saudi Arabia
[d] School of Energy Management, Shri Mata Vaishno Devi University, Katra 182320, India

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ABSTRACT

Amalgamation of thermal collector at the back of PV overcomes with low energy conversion efficiency issue upto some extent and improves overall efficiency of the systems. Use of phase change materials (PCM) in PV/T collectors as an intermediate thermal storage media offers a promising solution to this problem by storing large amount of heat. The aim of this research work was to design and develop a photovoltaic/thermal-phase change materials (PV/T-PCM) system and evaluate its energy, exergy and economic performance. Lauric acid as PCM contained in leak-proof aluminum foil packets are placed around the flow channel allowing extended period of thermal storage. The PV/T-PCM system has been studied at different volume flow rates viz. 0.5–4 L per minutes (LPM) to get the optimized performance of the system. Maximum thermal efficiency of PV/T-PCM collector was found to be 87.72% at 2 LPM. Maximum electrical efficiency of PV and PV/T-PCM systems has been found to be 9.88% and 11.08% (4LPM) respectively. The maximum exergy efficiency of PV and PV/T-PCM system has been found 7.09% and 12.19% (0.5 LPM) respectively. An economic analysis of the proposed system has also been carried out with a view to examine the feasibility of its commercialization.

1. Introduction

Two or more energy conversion devices or fuels can be can be combined to get the enhanced efficiency which is typically known as hybrid power systems [1,2]. Increase in photovoltaic (PV) module temperature deceases the electrical efficiency therefore, cooling of PV module may increase the electrical efficiency. Cooling of PV can be done either using air or water as a cooling fluid which is commonly known as photovoltaic/thermal (PV/T) collector which produces electrical and thermal energy simultaneously [3]. The higher overall energy performance is important for the success of PV/T system however, one of the advantage of the PV/T system is production of electrical and thermal energy by the same system which reduce the demands on physical space and equipment cost as compared to the separate PV and solar thermal systems which are placed side-by-side [4,5]. So far, many studies has been conducted by different authors around the World on PV/T to improve the overall efficiency. A comparative study was performed on between hybrid PV/T with active solar heating and cooling systems and passive convectional system, overall thermal and electrical efficiency was found to be enhanced by nearly 25% in the proposed model [6]. Hybrid PV/T collector was also studied using simulation model and it was found that electrical and thermal energies varied between −2.64% to +1.73% and −4.90% to +7.37% with experimental data. This can be considered as a reliable tool both for short-term and long-term yield analysis [7].

There are several technologies, which can advantageously be applied to harness and harvest more thermal energy from the PV/T collector, such as, nanomaterials, phase change materials (PCM), etc. Out of which, the methods of latent heat energy storage is by using PCMs wherein the material can store energy at a particular temperature by changing its phase. Enormous amount of work on

* Corresponding author.
** Corresponding author.
E-mail addresses: shouquat64@gmail.com (M.S. Hossain), adarsh.889@gmail.com (A.K. Pandey).

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Research Paper

Thermal performance analysis of parallel serpentine flow based photovoltaic/thermal (PV/T) system under composite climate of Malaysia

M.S. Hossain[a,*], A.K. Pandey[b,*], Jeyraj Selvaraj[a], Nasrudin Abd Rahim[a], A. Rivai[a], V.V. Tyagi[c]

[a] UM Power Energy Dedicated Advanced Centre, Wisma R&D, Level 4, Jalan Pantai Murni, University of Malaya, Kuala Lumpur 59990, Malaysia
[b] Research Centre for Nano-Materials and Energy Technology (RCNMET), School of Science and Technology, Sunway University, No. 5, Jalan Universiti, Bandar Sunway, Petaling Jaya 47500, Selangor Darul Ehsan, Malaysia
[c] School of Energy Management, Shri Mata Vaishno Devi University, Katra 182320, India

HIGHLIGHTS

- Comparative experimental study on PV and PV/T systems.
- Two-sided serpentine-flow thermal absorber to cover more heat transfer surface.
- PV/T performance assessment based on both energy and exergy analysis.
- Thermal efficiencies of PV/T system were 74.62%.
- A 5.76% enhancement in electrical efficiency of PV/T as compared to PV.

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Keywords:
Energy efficiency
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ABSTRACT

Photovoltaic (PV) technology suffers from the major drawback of poor energy conversion efficiency that is further worsened by overheating of the module. Hybrid photovoltaic thermal (PV/T) collectors have brought about a notable change in this technology by enabling the extraction of both electricity and heat from the same module, thereby improving the overall efficiency. However, there are some technical challenges with these devices that obstacles their wide-scale application. The major shortcoming of conventional water based PV/T collector is that their operation is limited only in the daytime. To overcome these challenges, novel parallel serpentine pipe flow based PV/T has been designed, developed and studied. The experiments were performed at different volume flow rates viz. 0.5–4 L per minutes (LPM) to optimize the designed and developed PV/T. Maximum thermal efficiency of PV/T system was found to be as 76.58% at 2 LPM. Electrical efficiency of PV and PV/T-only was found to be 9.89% and 10.46% respectively. The maximum exergy efficiency of PV and PV/T system has been found 7.16% and 12.98% (0.5LPM) respectively.

1. Introduction

Hybrid power systems are combinations of two or more energy conversion devices (e.g. electricity generators or storage devices), or two or more fuels for the same device when fully integrated. Their system efficiencies are typically higher than that of the individual technologies used separately, and higher reliability can be achieved with the current energy storage technologies [1,2]. Hybrid photovoltaic thermal (PV/T) systems can extract heat from PV modules, heating air or water for reducing the operating temperature of the PV modules.

Electrical efficiency of the PV system decreases rapidly as the module temperature increases. On the other hand, an external electrical energy is required to circulate the working fluid through the system of the solar thermal collector. Therefore, a higher electrical efficiency of a PV module might be achieved by removing the heat through the circulation of cooling water [3,4]. In order to eliminate an external electrical energy loss the PV module has to be cooled and should be logically combined with the solar air/water heater collector which is called the solar photovoltaic thermal (PV/T) collector system giving the added advantage of being able to produce the thermal and electrical energies simultaneously [5]. The hybrid PV/T with active solar heating and cooling systems has been compared to a passive convectional system, where the proposed system enhanced overall thermal and electrical efficiency, that is nearly 25% higher [6]. A simulation model of a

* Corresponding authors.
E-mail addresses: shouquat64@gmail.com (M.S. Hossain), adarsh.889@gmail.com (A.K. Pandey).

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Experimental performance evaluation of a novel designed phase change material integrated manifold heat pipe evacuated tube solar collector system

K. Chopra[a,b], V.V. Tyagi[a,*], Atin K. Pathak[a], A.K. Pandey[c], Ahmet Sari[d,e]

[a] School of Energy Management, Shri Mata Vaishno Devi University, Katra 182320, Jammu & Kashmir, India
[b] School of Mechanical Engineering, Shri Mata Vaishno Devi University, Katra 182320, Jammu & Kashmir, India
[c] Research Centre for Nano-Materials and Energy Technology (RCNMET), School of Science and Technology, Sunway University, No. 5, Jalan Universiti, Bandar Sunway, Petaling Jaya 47500, Selangor Darul Ehsan, Malaysia
[d] Department of Metallurgical and Material Engineering, Karadeniz Technical University, 61080 Trabzon, Turkey
[e] Center of Research Excellence in Renewable Energy (CORERE), Research Institute, King Fahd University of Petroleum & Minerals (KFUPM), 31261, Saudi Arabia

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ABSTRACT

In this study, the thermal performance of a novel solar collector integrated with stearic acid as phase change material has been investigated. In this design, the solar radiation was collected by heat pipe equipped evacuated tubes and then stored in manifold integrated with phase change material. The stored thermal energy of phase change material then transferred to water flowing through bundle of finned copper pipes placed inside the manifold. In present study, the design, the operating principle and the experimental investigation of the developed system have been presented. The developed system was investigated with different mass flow rates and also discussed the influence of varying mass flow rate on the thermal performance of system. The experimental investigation of designed and developed system has been carried out for two modes i.e. mid-day charging mode and full-day charging mode. It has been observed that for considered mass flow rates, thermal efficiency of the system was varied in the range of approximately 52–62% for full-day charging mode while for mid-day charging mode, it was varied between 55 and 72%. The maximum value of thermal efficiency was approximately 72.52% at mass flow rate of 24 LPH for mid-day charging mode. The efficiency of phase change material for both modes was varied in the range of approximately 61–64%. The annual cost and annual fuel cost of the developed system are much lower than conventional system. Also, the initial capital cost for the developed system can be recovered after 6 years of operation. However, there is no recovery of initial investment for electricity based water heating system.

The proposed system overcomes two problems associated with conventional heat pipe evacuated tube solar collector: elimination of heat pipe overheating problem and low thermal conductivity of phase change materials. By this novel design of manifold, the influence of thermal stratification on the thermal performance of solar collectors can be completely eradicated.

1. Introduction

The global demand for hot water is increasing with very high rate due to the tremendous growth of population and economic development. The energy required to accomplished the demand for hot water is about 14% and 18% of total energy consumption in the residential sector of European Union and USA respectively [1]. As per report submitted by Indian Ministry of New and Renewable, India hot water demand in the residential sector was approximately 129 million/day in 2017 and it will be doubled by 2022 [2]. This huge demand for hot water is accomplished by electricity and fossil fuels.

The solar collectors for water heating applications are the most attractive solution to reduce the use of conventional energy resources [3]. The flat plate solar collector (FPSC) and evacuated tube solar collector (ETSC) are two types of collectors which are most commonly used for water heating applications in the residential sector [4]. The FPSCs are the most widespread solar collectors for water heating applications due to its simple design, high reliability, and little maintenance. However, due to low efficiency and the high initial cost of FPSCs, ETSCs have dominated the solar market. Currently, approximately 80% of installed solar collectors are now of ETSC type [5]. Moreover, ETSCs can heat the water up to 90 °C relatively at cheaper cost [6]. According to the recent

* Corresponding author.
E-mail address: vtyagi16@gmail.com (V.V. Tyagi).

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Improved electron density through hetero-junction binary sensitized TiO_2/ CdTe / D719 system as photoanode for dye sensitized solar cell

A.K. Pandey [a,*], Muhammad Shakeel Ahmad [b], Mahdi Alizadeh [b,c], Nasrudin Abd Rahim [b,d]

[a] Research Centre for Nano-Materials and Energy Technology (RCNMET), School of Science and Technology, Sunway University, Bandar Sunway, 47500 Malaysia
[b] UM Power Energy Dedicated Advanced Center (UMPEDAC), University of Malaya, 59990 Kuala Lumpur, Malaysia
[c] Laser-Plasma Research Institute, Shahid Beheshti University G.C., Evin, Tehran 19839, Iran
[d] Renewable Energy Research Group, King Abdulaziz University, Jeddah 21589, Saudi Arabia

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ABSTRACT

The combined effect of dual sensitization and hetero-junction symmetry has been investigated on the performance of TiO_2 based dye sensitized solar cell. CdTe nanoparticles have been introduced in TiO_2 matrix to function as sensitizer as well as act as hetero-junction between D719 dye and TiO_2 nanoarchitecture. Four concentrations of CdTe i.e. 0.5 wt%, 2 wt%, 5 wt% and 8 wt% have been investigated. Morphological and compositional studies have been conducted using scanning electron microscope (SEM) and X-ray diffraction (XRD) respectively. Light absorption characteristics have been investigated by employing Uv–vis spectroscopy and the overall performance has been studied using solar simulator and electrochemical impedance spectroscopy (EIS). Performance has been found to be increased with the addition of CdTe due to high electron density and reduction in recombination reactions. An increase of 41.73% in incident photo conversion efficiency (IPCE) and 75.57% in short circuit current density (J_{sc}) have been recorded for the specimens containing 5 wt% CdTe compared to bare TiO_2 based DSSCs. Further addition of CdTe leads to reduction in overall performance of DSSCs.

1. Introduction

Our today's social, technological and industrial development is heavily based on fossil fuels such as coal and petroleum which are already on the brink of extinction [1]. Other problems associated with fossil fuels are our inappropriate technology of using them for production of electrical, mechanical and heat energy which cause emission of high magnitudes of green house gases and other air pollution [2]. Harmful emissions of these gases are not only damaging our eco-system but also put the very human life on earth at risk [3]. Recently this issue has stimulated scientific communities to improve the technology of using fossil fuels in an efficient way to reduce emissions and to develop new greener and sustained ways to meet the energy demand of developing global village [4]. In this regard, solar energy is by far the most debated and trusted source of renewable energy and immense efforts to harvest solar energy have been made to directly convert sun light into usable form of energy such as electricity, heating and cooling systems [5].

Silicon based solar cells were the first ever devices used to directly convert sun light into electricity [6]. To date, the development of solar devices is a mature subject and we are now in the era of third generation of thin film solar devices which have proved its advantages of light-weight, flexibility, cost effective and environment friendly manufacturing [7]. Dye sensitized solar cell (DSSC) technology which gained its roots from thin film solar devices is now-a-days the technology of choice for its easy and flexible fabrication, transparency, light-weight and the ability to integrate with the architecture of buildings [8]. In its simplest explanation, the device consists of semi-conductor thin film coated on conducting substrate, dye sensitizer, electrolyte and catalyst coated on another conducting layer [9]. Dye sensitizer absorbs energy from incident light and oxidized placing electron to the conduction band of semi-conductor material (TiO_2). TiO_2 transfer electron to the external circuit through conducting substrate. Electrolyte gives its electron to the oxidized dye and accept electron from the external circuit with the help of catalyst (Pt) and gets reduced. This cycle keeps on repeating until the light source is available [10].

The reported efficiency of DSSCs reached up to 11.9%–13% while commercially reported efficiency of module is approximately 10.7% [11,12]. The theoretical efficiency of DSSC is calculated to be 32% [13]. The dye loading, recombination reactions and light absorption are the main parameters which heavily influence the efficiency of DSSC. Two

* Corresponding author.
E-mail address: adarsh.889@gmail.com (A.K. Pandey).

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Chemical sintering of TiO_2 based photoanode for efficient dye sensitized solar cells using Zn nanoparticles

Muhammad Shakeel Ahmad[a], A.K. Pandey[b,*], Nasrudin Abd Rahim[a], Syed Shahabuddin[b], S.K. Tyagi[c]

[a] UM Power Energy Dedicated Advanced Center (UMPEDAC), University of Malaya, 59990 Kuala Lumpur, Malaysia
[b] Research Centre for Nano-Materials and Energy Technology (RCNMET), School of Science and Technology, Sunway University, No. 5, Jalan Universiti, Bandar Sunway, Petaling Jaya, 47500 Selangor Darul Ehsan, Malaysia
[c] Centre for Energy Studies, Indian Institute of Technology Delhi, Hauz Khas, New Delhi 110016, India

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ABSTRACT

Recombination reactions due to poor inter-particle contact at lower temperatures (< 450 °C) is a bottle neck for cost effective flexible dye sensitized solar cells (DSSCs). In this study, TiO_2sintering to Coble initial stage at low temperatures has been achieved with low melting point zinc (Zn) metal nanoparticles. Zn nanoparticles showed improved inter-particle contact by formation of necks due to high surface diffusion at relatively lower temperatures (200 °C). Addition of Zn nanoparticles showed comparable, rather improved efficiency at 200 °C compared to reference TiO_2photoanode fabricated at 450 °C due to neck formation and surface plasmonic resonance (SPR) effect. Morphological studies revealed high contact formation between TiO_2 and Zn nanoparticles. Electrochemical impedance and Uv–vis spectroscopy showed improvements in charge transfer and light absorption activity respectively. Structural studies showed no any detectable change in phase due to high surface diffusion and capillary forces produced by Zn nanoparticles at the TiO_2/Zn interface.

1. Introduction

The technology of dye sensitized solar cells (DSSCs) for low cost conversion of sun light into electricity is probably one of the few technologies which came to its maturity and commercialization in a very short span of time since its first introduction in 1991 by Gratzel [1–3]. The basic architecture of solar device is a sandwich structure consists of semi-conductor thick/thin film (TiO_2), dye sensitizer (organic, inorganic compounds), electrolyte (iodide/tri-iodide) and catalyst (Pt or C) sandwiched between fluorine doped tin oxide (FTO) coated glasses. In principle, incident sun-light ejects electrons from dye sensitizer. This ejected electron has been successively picked up by TiO_2 network to transfer it to external load through transparent conducting oxide substrate (TCS). The excited dye sensitizer pick electron from iodide/triiodide electrolyte which in-turn reduce to original state by getting electron from external circuit with the help of catalyst. This regeneration process continues until the light source is present [4].

The concept of making these cells flexible is the priority to date due to its remarkable market potential in portable electronic devices, easy fabrication and transportation [5]. In flexible technology, two types of substrates i.e. metallic and conducting plastic sheets have been used. Plastic substrates further provide cost effective and light weight solution. Because of the low degradation temperatures of flexible plastic substrates (120–150 °C in case of ITO-PEN substrate) being used in the fabrication of photoanode for flexible DSSCs, their incident photon conversion efficiency (IPCE) is limited to 2–3% [6]. The basic cause of low efficiency is high recombination reactions due to poor inter-particle connections between nanoparticle surfaces which hinder the transfer of electrons from the semiconductor network. This hindrance facilitates electrons to be picked up by either dye sensitizer and/or electrolyte and thus reduce the efficiency of the solar device [7].

Various attempts have been made to improve the electron transfer which can be classified into two broad approaches i.e. (1) doping with more conductive elements such as CNTs &grapheme [8,9] and (2) overcoming thermodynamic sintering parameters by using various techniques such as mechanical cold pressing, chemical sintering and transfer of annealed photoanode [7,10,11]. Other strategies include hydrothermal synthesis and electro-phoretically deposited compact films [12]. It can be equally emphasized that most of the said techniques are not commercially viable with the exception of mechanical cold pressing (cold pressing is not a sintering technique rather it is a consolidation technique) and doping with other suitable cations and

* Corresponding author.
E-mail address: adarshp@sunway.edu.my (A.K. Pandey).

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