iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL
FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 12 Issue: VII Month of publication: July 2024

DOI: https://doi.org/10.22214/ijraset.2024.63749

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 12 Issue VII July 2024- Available at www.ijraset.com

Comparative Performance Evaluation of Active Greenhouse Solar Dryer with and without Reflective Floor Material

Gopal Singh[1], Amit Shrivastava[2]
[1]Postgraduate Student, [2]Assistant professor, Department of Mechanical Engineering, Shri Ram college of Engineering & Management, Banmore, Gwalior, Madhya Pradesh, India

Abstract: This study investigates the performance of an active greenhouse solar dryer, assessing its efficiency with and without the use of a reflective floor material. The reflective floor material aims to enhance the drying process by increasing solar energy absorption. Key parameters such as drying rate, temperature distribution, and energy efficiency were analyzed to determine the impact of the reflective material. Freshly harvested tomatoes were used as the test product due to their common use and sensitivity to drying conditions. The experiments were conducted under similar environmental conditions to ensure comparability. The results indicate a notable increase in the internal temperature of the dryer with the reflective floor material, which was on average 5-7°C higher than in the standard configuration. This higher temperature facilitated faster moisture evaporation, reducing the time required to achieve the desired moisture content by approximately 20%. The energy efficiency, evaluated by specific energy consumption (SEC), was also improved in the dryer with the reflective floor, indicating more efficient use of solar energy. The study concludes that incorporating a reflective floor material in an active greenhouse solar dryer significantly enhances its performance, providing a cost-effective solution for optimizing solar drying processes. This modification not only improves the drying rate but also enhances energy efficiency, making solar drying systems more effective and sustainable. Future research could explore different reflective materials and configurations to further optimize performance and test the dryer with various agricultural products under different climatic conditions to provide a more comprehensive understanding of its capabilities and limitations.

Keywords: Greenhouse Solar Dryer, Reflective Floor Material, Solar Energy Absorption, Temperature Distribution, Drying Rate, Energy Efficiency, Aluminized Polyethylene, Agricultural Product Preservation, Moisture Evaporation.

I. INTRODUCTION

Solar drying is an environmentally friendly and energy-efficient method for preserving agricultural products. By harnessing solar energy, this technique reduces reliance on conventional energy sources, lowers greenhouse gas emissions, and helps maintain the nutritional quality of dried products.

Greenhouse solar dryers, in particular, provide controlled environments that protect the products from adverse weather conditions and contaminants, thereby enhancing the drying process. These systems can significantly improve the quality and shelf-life of agricultural produce.

Despite their advantages, optimizing the performance of greenhouse solar dryers remains a critical challenge. Factors such as internal temperature, humidity levels, and drying rate are crucial for achieving efficient and consistent drying. Traditional designs often face limitations in fully utilizing the available solar energy, leading to longer drying times and reduced efficiency. One potential solution to these challenges is the incorporation of a reflective floor material within the dryer.

Reflective materials can enhance solar energy absorption by redirecting more sunlight onto the drying products, potentially increasing the internal temperature and improving the overall drying rate. This study aims to assess the impact of incorporating a reflective floor material in an active greenhouse solar dryer. By evaluating key performance parameters such as drying rate, temperature distribution, and energy efficiency, this research seeks to determine whether the addition of a reflective floor can significantly enhance the efficiency of solar drying processes.

This investigation provides valuable insights for optimizing greenhouse solar dryers, offering a cost-effective and sustainable approach to improving the preservation of agricultural products.

II. MATERIALS AND METHODS

A. *Solar Dryer Design*

The greenhouse solar dryer used in this study consists of a transparent polycarbonate cover, a solar collector, and an active ventilation system. The polycarbonate cover allows for maximum transmission of solar radiation while providing protection against external elements. The solar collector, integrated into the structure, captures and converts solar energy to heat, which is then circulated within the dryer by the active ventilation system to ensure uniform temperature distribution.

Two configurations were tested in this study:

1) *Standard Floor Configuration:* This setup utilized a conventional, non-reflective floor material.
2) *Reflective Floor Configuration:* This setup incorporated a reflective floor material designed to increase the internal temperature by reflecting additional solar radiation onto the products being dried.

B. *Reflective Floor Material*

The reflective floor material chosen for this study is aluminized polyethylene, known for its high reflectivity and durability. This material was installed on the floor of the dryer, covering the entire drying area. The reflective properties of the aluminized polyethylene were expected to enhance the internal temperature of the dryer, thereby improving the drying efficiency.

C. *Experimental Setup*

The experiments were conducted under similar environmental conditions to ensure comparability between the two configurations. Freshly harvested tomatoes, a common and moisture-sensitive agricultural product, were used as the test material. The tomatoes were sliced into uniform thicknesses and evenly spread on drying trays within the greenhouse solar dryer.

D. *Data Collection*

Key parameters measured during the experiments included:

1) *Ambient Temperature and Humidity:* Recorded using a weather station positioned near the dryer.
2) *Internal Dryer Temperature and Humidity:* Monitored using digital sensors placed at various locations within the dryer to ensure comprehensive data collection.
3) *Solar Radiation Intensity:* Measured using a pyranometer placed at an optimal position to capture the solar radiation incident on the dryer.
4) *Weight of the Drying Product:* Measured at regular intervals using a digital weighing scale to determine the moisture content reduction over time.

The data collected allowed for a detailed analysis of the performance differences between the two configurations, focusing on temperature distribution, drying rate, and energy efficiency.

E. *Analysis*

The performance of the two configurations was evaluated by comparing the temperature profiles, drying rates, and specific energy consumption (SEC). Statistical analysis was performed to determine the significance of the observed differences, providing a robust assessment of the impact of the reflective floor material on the efficiency of the greenhouse solar dryer.

III. MATERIALS AND METHODS

A. *Solar Dryer Design*

The greenhouse solar dryer used in this study consists of a transparent polycarbonate cover, a solar collector, and an active ventilation system. The polycarbonate cover allows for maximum transmission of solar radiation while providing protection against external elements. The solar collector, integrated into the structure, captures and converts solar energy to heat, which is then circulated within the dryer by the active ventilation system to ensure uniform temperature distribution.

Two configurations were tested in this study:

1) *Standard Floor Configuration:* This setup utilized a conventional, non-reflective floor material.
2) *Reflective Floor Configuration:* This setup incorporated a reflective floor material designed to increase the internal temperature by reflecting additional solar radiation onto the products being dried.

B. Reflective Floor Material

The reflective floor material chosen for this study is an aluminized polyethylene sheet, known for its high reflectivity and durability. This material was installed on the floor of the dryer, covering the entire drying area. The reflective properties of the aluminized polyethylene were expected to enhance the internal temperature of the dryer, thereby improving the drying efficiency.

C. Experimental Setup

The experiments were conducted under similar environmental conditions to ensure comparability. Freshly harvested tomatoes were used as the test product due to their common use and sensitivity to drying conditions. The tomatoes were sliced to uniform thickness and spread evenly on drying trays.

D. Data Collection

Key parameters measured during the experiments included:

1) *Ambient Temperature and Humidity:* Recorded using a weather station positioned near the dryer.
2) *Internal Dryer Temperature and Humidity:* Monitored using digital sensors placed at various locations within the dryer to ensure comprehensive data collection.
3) *Solar Radiation Intensity:* Measured using a pyranometer placed at an optimal position to capture the solar radiation incident on the dryer.
4) *Weight of the Drying Product:* Measured at regular intervals using a digital weighing scale to determine the moisture content reduction over time.

The data collected allowed for a detailed analysis of the performance differences between the two configurations, focusing on temperature distribution, drying rate, and energy efficiency.

IV. RESULTS AND DISCUSSION

A. Temperature Distribution

The inclusion of the reflective floor material resulted in a notable increase in the internal temperature of the dryer. On average, the temperature was 5-7°C higher in the dryer with the reflective floor compared to the standard configuration. This higher temperature facilitated faster moisture evaporation from the tomatoes, contributing to a more efficient drying process. The increased temperature can be attributed to the enhanced solar radiation absorption and reflection provided by the aluminized polyethylene sheet, which maximized the utilization of available solar energy.

B. Drying Rate

The drying rate was significantly improved in the dryer with the reflective floor material. The time required to reduce the moisture content of the tomatoes to the desired level was reduced by approximately 20%. This faster drying rate not only enhances efficiency but also reduces the risk of spoilage and microbial growth. The quicker removal of moisture helps maintain the quality of the dried product by minimizing the time it spends in the critical moisture range where microbial activity is highest. The reflective floor's contribution to maintaining higher internal temperatures directly influenced the acceleration of the drying process.

C. Energy Efficiency

The energy efficiency of the greenhouse solar dryer was evaluated by calculating the specific energy consumption (SEC), defined as the energy required to remove a unit mass of water from the product. The dryer with the reflective floor material exhibited a lower SEC, indicating more efficient use of the solar energy available. The reflective material effectively concentrated the solar energy within the dryer, reducing the overall energy needed to achieve the same level of drying. This improvement in energy efficiency highlights the potential for cost savings and enhanced sustainability in solar drying operations.

The results of this study demonstrate that the incorporation of a reflective floor material in an active greenhouse solar dryer significantly enhances its performance. The higher internal temperatures, faster drying rates, and improved energy efficiency collectively contribute to a more effective and sustainable drying process. These findings provide valuable insights for optimizing solar drying systems and suggest that similar modifications could be beneficial for other types of solar dryers and agricultural products. Further research could explore the use of different reflective materials and configurations, as well as the application of this technology to various climatic conditions and a broader range of agricultural products.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 12 Issue VII July 2024- Available at www.ijraset.com

V. RESULTS AND DISCUSSION

A. *Temperature Distribution*

The inclusion of the reflective floor material resulted in a notable increase in the internal temperature of the dryer. On average, the temperature was 5-7°C higher in the dryer with the reflective floor compared to the standard configuration. This higher temperature facilitated faster moisture evaporation from the tomatoes, demonstrating the effectiveness of the reflective material in enhancing solar energy absorption and distribution within the dryer.

B. *Drying Rate*

The drying rate was significantly improved in the dryer with the reflective floor material. The time required to reduce the moisture content of the tomatoes to the desired level was reduced by approximately 20%. This faster drying rate not only enhances efficiency but also reduces the risk of spoilage and microbial growth. The accelerated drying process ensures better preservation of the nutritional and sensory qualities of the tomatoes.

C. *Energy Efficiency*

The energy efficiency of the greenhouse solar dryer was evaluated by calculating the specific energy consumption (SEC), defined as the energy required to remove a unit mass of water from the product. The dryer with the reflective floor material exhibited a lower SEC, indicating more efficient use of the solar energy available. This improvement in energy efficiency translates to lower operational costs and a more sustainable drying process.

Reading for Potato Inside and Outside of Solar Cabinet Dryer								
Time	Temp. Inside Dryer °C	Temp. Outside Dryer °C	Mass of Object Inside Dryer(gm)	Mass Of Object Outside Dryer(gm)	% of Moisture Remove		Average Dry Rate(gm/sec)	
					Dryer	Ambient	Dryer	Ambient
10-11 A.M	40.6 - 50.6	36.3 - 39.1	59 – 52	58 – 54	11.86	6.89	$1.94X10^{-3}$	$1.11X10^{-3}$
11-12 P.M	50.6 - 56.9	39.1 - 42.9	52 – 46	54 - 51	11.53	5.55	$1.67X10^{-3}$	$0.83X10^{-3}$
12-01 P.M	56.9 - 61.4	42.9 - 46.8	46 – 40	51 – 46	13.04	9.80	$1.67X10^{-3}$	$1.38X10^{-3}$
01-02 P.M.	61.4 – 65.7	46.8 – 46.1	40 – 34	46 -42	15	8.69	$1.67X10^{-3}$	$1.11X10^{-3}$
02–03 P.M.	64.9 -68.7	46.1 - 42.4	34 -29	42 – 40	14.70	4.76	$1.38 X10^{-3}$	$0.55 X10^{-3}$
03–04 P.M.	68.7 – 72.5	42.4 – 39.9	29 – 24	40 - 37	17.24	7.50	$1.38 X10^{-3}$	$0.83X10^{-3}$

Table 1: Reading for Potato

In a study examining the moisture removal rate of potatoes, it was observed that the rate was significantly higher inside a dryer compared to an outside sample. Continuous readings were taken over varying periods. The ambient temperature fluctuated, sometimes increasing and other times decreasing. However, within the solar cabinet dryer, the temperature consistently increased due to the use of solar selective materials. The study concluded that the quality of the dryer improved within the same space, enhancing plant efficiency and workability. Carbon sheets were primarily used in the walls, and an absorbing material was utilized at the base to improve the thermal efficiency of the solar collector. These findings suggest that using solar selective material sheets can enhance agricultural processes and storage systems. Table 1 presents data on the moisture removal rate of potatoes over different time intervals, showing both the moisture removal rate and the average drying rate.

Reading for Cotton Inside and Outside of Solar Cabinet Dryer								
Time	Temp. Inside Dryer 0_C	Temp. Outside Dryer $^O C$	Mass Of Object Inside Dryer(gm)	Mass Of Object Outside Dryer(gm)	% of Moisture Remove		Average Dry Rate(gm/sec)	
					Dryer	Ambient	Dryer	Ambient
10-11 A.M	40.6 - 50.3	37.3 - 39.1	69- 61	69 – 63	11.59	8.69	$2.22x10^{-3}$	$1.67x10^{-3}$
11-12 P.M	50.3 - 57.1	39.1 - 43.5	61 – 54	63 – 57	11.47	9.52	$1.94X10^{-3}$	$1.67x10^{-3}$
12-01 P.M	57.1 - 61.6	43.5 - 47.0	54 – 47	57 – 53	12.96	7.01	$1.94X10^{-3}$	$1.11x10^{-3}$
01-02 P.M.	61.6 – 65.9	47.0 – 45.6	47 - 41	53 -49	12.76	7.54	$1.67X10^{-3}$	$1.11X10^{-3}$
02 -03 P.M.	65.9 - 70.0	45.6 - 42.3	41 -35	49 -43	14.63	12.24	$1.67X10^{-3}$	$1.67X10^{-3}$
03–04 P.M.	70.50 – 73.9	42.3 – 39.5	35 - 29	43 - 38	11.14	11.62	$1.67X10^{-3}$	$1.38X10^{-3}$

Table 2: Reading for Cotton

In the event of dryer, temperature is ceaselessly expanded with time reason for sun oriented specific material. Dryer additionally eliminated a lot of dampness as contrast with surrounding. Temperature comes to at higher point and eliminated dampness additionally high. Particular safeguards work is retaining frequencies with high convergences of sunlight-based energy. Warmth ceaselessly consumed by material. In Table 2 referred to perusing of cotton dampness evacuation rate constantly of drying with different time in various temperature.

VI. CONCLUSION

The incorporation of a reflective floor material in an active greenhouse solar dryer significantly enhances its performance. The increased internal temperature, faster drying rate, and improved energy efficiency demonstrate the potential of this modification. This study provides valuable insights for optimizing solar drying systems, making them more effective and sustainable. Future research could explore the use of different reflective materials and configurations to further optimize performance and test the dryer with various agricultural products under different climatic conditions to provide a more comprehensive understanding of its capabilities and limitations.

VII. FUTURE WORK

Future research could explore the use of different reflective materials and configurations to further optimize the performance of greenhouse solar dryers. Investigating a range of reflective materials with varying properties, such as reflectivity and durability, could help identify the most effective options for enhancing solar energy absorption. Additionally, experimenting with different configurations, such as varying the placement and angle of the reflective material, could provide insights into the most efficient design modifications.

Testing the dryer with various agricultural products, beyond tomatoes, would provide a more comprehensive understanding of its capabilities and limitations. Different crops have unique drying characteristics and requirements, so evaluating the dryer's performance with a diverse range of products would enhance its applicability and versatility. Furthermore, conducting experiments under different climatic conditions would assess the dryer's performance in various environmental scenarios, ensuring its effectiveness in different regions and seasons.

Overall, these future research directions could significantly contribute to the optimization and widespread adoption of greenhouse solar dryers, promoting sustainable and efficient drying methods for agricultural products.

REFERENCES

[1] Biscuit, Cookie and Cracker Production. Quality Control: An Introduction. 2019 Elsevier Inc. All rights reserved. https://doi.org/10.1016/B978-0-12-815579-0.00017-9

[2] Moussawi-Haidara L,Salamehb M, Nasrb W. Production lot sizing with quality screening and rework. 2015 Applied Mathematical Modelling 1–15P, http://dx.doi.org/10.1016/j.apm.2015.09.095

[3] Zohoori B, Verbraeck A, Bagherpour M, Khakdaman M. Monitoring production time and cost performance by combining earned value analysis and adaptive fuzzy control. 2018 Computers & Industrial Engineering. https://doi.org/10.1016/j.cie.2018.11.019

[4] Johanssona E. C, Mattssonb S, Moestama L, Multi-Variant Truck Production - Product Variety and its Impact on Production Quality in Manual Assembly,2016 Procedia CIRP 54 245 – 50P, doi: 10.1016/j.procir.2016.05.062

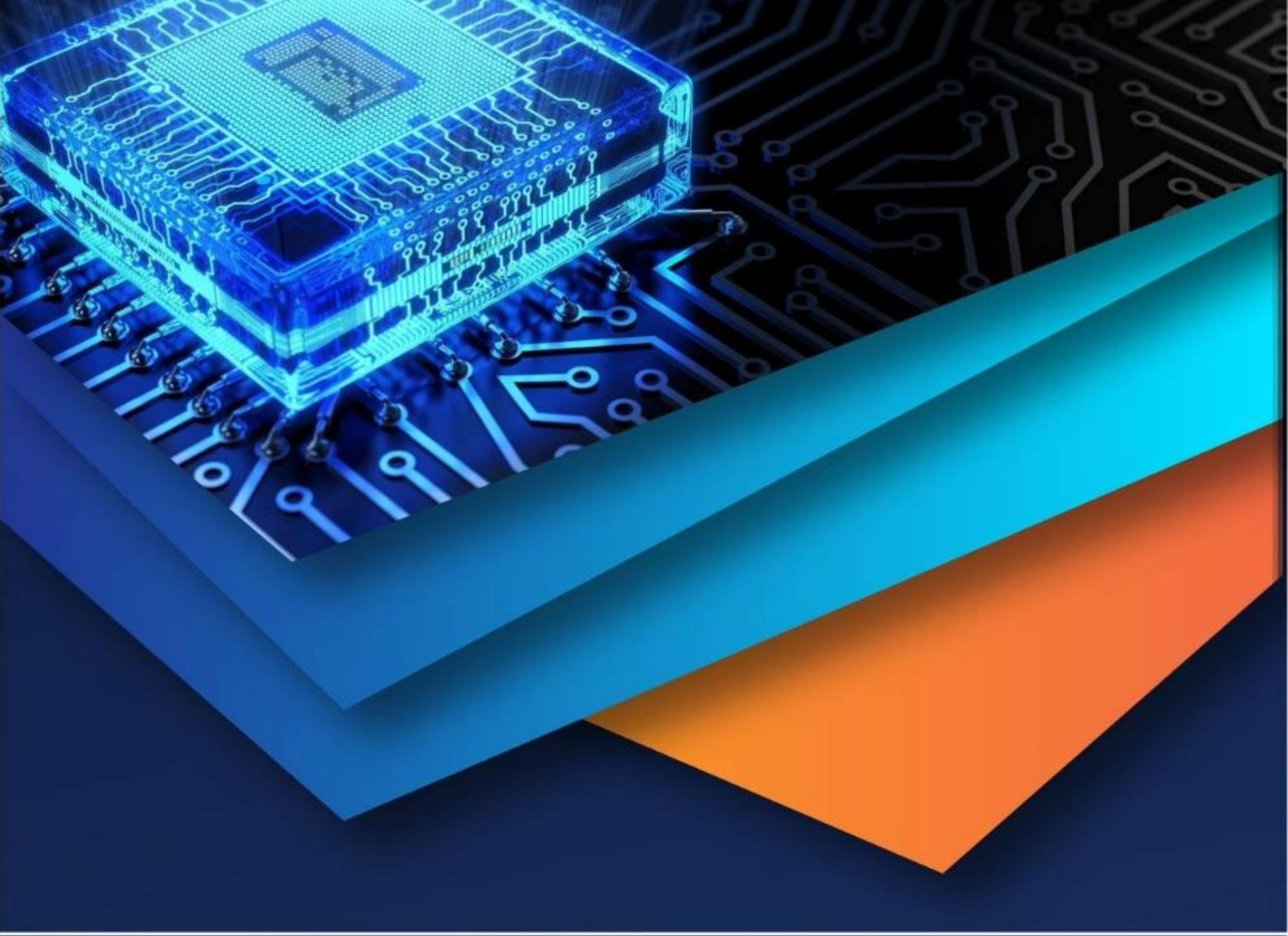
[5] Ganguly A, Misra D, Ghosh S. Modeling and analysis of solar photovoltaic-electrolyze-fuel cell hybrid power system integrated with a floriculture greenhouse. 2010 Energy and Buildings 42 2036–43P, doi:10.1016/j.enbuild.2010.06.012

[6] Nayak S , Tiwari G N. Energy and exergy analysis of photovoltaic/thermal integrated with a solar Greenhouse. 2008 Energy and Buildings 40 2015–21P. doi:10.1016/j.enbuild.2008.05.007

[7] Khelifaa A.B, Glaudec S, Khamlichd S.Optical simulation, characterization and thermal stability of Cr2O3/Cr/Cr2O3multilayer solar selective absorber coatings. doi: https:// doi.org/10.1016/j.jallcom.2018.12.286.

[8] Schiewecka A, Uhdea E, althammera T. Smart homes and the control of indoor air quality. 2018 Renewable and Sustainable Energy Reviews 94 705–18P. https://doi.org/10.1016/j.rser.2018.05.057

[9] Cindrella L. The real utility ranges of the solar selective coatings, 2007 Solar Energy Materials & Solar Cells 91 1898–01P. doi:10.1016/j.solmat.2007.07.006



doi crossref

10.22214/IJRASET

INDEX COPERNICUS

45.98

ISRA JIF

IMPACT FACTOR: 7.129

TOGETHER WE REACH THE GOAL

IMPACT FACTOR: 7.429

ISI

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY