FCCI

Research & Development Center

<u>Title</u>

<u>Developing Materials for Perovskite Solar Cells with Surprisingly High Performance</u>

TOPICS: Energy, Green Energy, Solar Cells, Solar Energy, Perovskite Solar Cells,

<u>Prepared By:</u>

Anam Shareef

(Research Assistant)

M.Phil. Physics

Research & Development Department

ADVISORY BOARD

Engr. Ahmad Hassan

Chairman FCCI (R & D)

Dr. Hafiz Muhammad Asif Javed

Supervisor

(University *of Agriculture, Faisalabad.*)

Dr. Muhammad Arif

Co-Supervisor

(N.F.C Institute of Engineering and Fertilizer Research)

Working Group

Anam Shareef

(University *of Agriculture, Faisalabad.*)

Atifa Irshad

(Co-worker)

(University *of Agriculture, Faisalabad.*)

Developing Materials for Perovskite Solar Cells with Surprisingly High Performance

TOPICS: Energy, Green Energy, Solar Cells, Solar Energy, Perovskite Solar Cells,

Abstract

Passivation using organohalide salts is thought to be an important method for reducing faults in modern perovskite solar cells (PSCs). Furthermore, this technique is hampered by the production of preferred two-dimensional (2D) perovskite sheets with reduced charge transportation, particularly during hot circumstances, which impedes solar efficiency and device scale-up. We investigated the power barriers of 2D perovskite synthesis from ortho position, meta-, and para-isomers of (phenylene) di (ethyl ammonium) iodine (PDEAI2) intended for customized defect functionalization to solve this constraint. Processing using the most sterically restricted ortho-isomer not only avoids the development of a two-dimensional perovskite coating on the surface, even at high temperatures but also optimizes the passivation impact on both superficial and profound faults. The PSCs that come after have a 23.9 % effectiveness and long reliability (over 1000 hours). The perovskite modules with a 26 cm2 energetic surface achieved a record performance of 21.4 %

1. Introduction

1.1. Perovskite solar cells (PSCs)

Another of the globe's quickest solar cell technologies is perovskite solar cells (PSCs). These components are made of low-cost elements and are the thinnest, lightest, and most flexible. However, there is one big drawback to this form of solar cell: the rapid deterioration of perovskite materials in ecological circumstances. Passivation is a basic but efficient approach to increasing the durability of perovskite solar cells. It is also one of the most successful approaches for removing perovskite material flaws and associated detrimental impacts. The passivated perovskite surfaces develop more resistance to environmental factors such as temperatures and moisture, as well as more stability, increasing the device's lifespan.

Perovskite offers many advantages in the solar cell/module realm:

- It has a broad energy bandgap, which means it can be tuned more easily and converts more sunlight into energy.
- Current lab performance is comparable to that of silicon crystals and other thin-film technologies, and tandem PSCs have a realistic chance of exceeding 33%.
- Using solutions preparation, perovskite manufacturing is greatly facilitated and does not require the specialized equipment and infrastructure required for semiconductor handling.
- It's made as a thin-film production, which means it uses 20 times fewer components.
- It does not necessitate the use of rare or limited-supply elements or minerals.
- Perovskite has high fault tolerance, resulting in high production productivity and ease of use in systems larger than 300 W (current thin films necessitate exceptional engineering, cost, and risk to increase manufacturing deposition area).
- PSC-based panels can be designed to look like standard rectangle solar panels or to be versatile, allowing for a variety of technologies and applications.
- Depending on the production technique used, perovskite solar modules have a modest ecological imprint.
- With today's photovoltaic module technologies, returns on investment are measured in months rather than years.

2. Stability

The constant villains are light-induced cell degradation and ecological reliability. PSC consistency was a major issue earlier on. However, just as there have been significant advances in cell effectiveness, there have also been tremendous advances in cell stabilization.

Figure. 1. Perovskite Mineral Crystal

The science of light-induced deterioration is now well established. The selection of elements for the electron transport sheets on each side of the photovoltaic cell was a key stumbling block. Several laboratories or other organizations have effectively replaced old components and overcome LID problems. Regarding the weatherization front, exposure to humidity, oxygen, and other ordinary atmospheric elements can generate fast module deterioration in supercapacitors, just as it can with conventional thin films and crystallized silicon solar cells. Considerations concerning ecological deterioration have been mostly addressed utilizing typical "packing" assembling approaches.

This reminds me of the earlier days of copper indium gallium selenide (CIGS) cell development when humidity intolerance was a typical stumbling block. However, CIGS-based devices are already widely used, with no significant difficulties with ecological durability. Both light-induced and atmospheric PSC degrading characteristics have surpassed 1,000 hours of accelerated product lifecycle evaluation (the PV industry benchmark for technological advances), with a few exceeding 10,000 hours. Other stabilizing issues, such as structural durability, application voltage warming, temperature impacts, and existing Volta Gate behaviors, are addressed in the assessment process with a variety of solutions.

There are two whitepapers on light-induced and environmental stability treatments. Salience partners TNO, imec, and the Eindhoven University of Technology recently published a report showing that encapsulated perovskite solar modules made with normal manufacturing procedures passed typical photovoltaic sector stabilization testing such as sunlight soaking, damp-heat, and thermal cycling.

3. KTU synthesized materials were used in solar mini modules

Utilizing the passivation process, KTU scientists collaborated with scientists from research institutes in China, Italy, Lithuania, Switzerland, and Luxembourg to considerably increase the reliability of perovskite solar cells. Through passivation, the perovskite surfaces become chemically inert, removing perovskite flaws that develop throughout manufacturing. The resulting perovskite solar cells have a 24.9% performance and lengthy functional reliability (over 1000 h). Dr. Kasparas Rakstys, leader of the experimental team at the KTU Department of Chemical Technology, KTU is the source of this image. "A two-dimensional (2D) surface of perovskite is being produced atop the usual three-dimensional (3D) perovskite light absorbers, making it harder for transport to travel, particularly at rising temperatures," says the researcher. When the solar cells grow heated, it is vital to avoid this, "explains KTU head scientist Dr. Kasparas Raktys, the founder of the idea." A multinational team of academics conducted a study to determine the minimum energy necessary to produce two-dimensional perovskite materials to overcome this issue. Various analogs of phenyl ethyl ammonium iodide produced by KTU were used to passivate the surfaces of the 3D perovskite layer.

The chance of two-dimensional perovskite production is determined by various isomers, which have identical chemical compositions but distinct configurations of atoms in space. The substances were evaluated in perovskite solar mini-modules with an energetic region approximately 300 times greater than usual laboratory-scale perovskite solar cells by scientists from the Lausanne Federal Institute of Technology (EPFL) in Switzerland. The solar power conversion performance of such mini modules was 24.4%, which was a new high. The surface of the performance mini-solar modules' perovskite sheet was covered using compounds created by KTU researchers.

The KTU investigator explains that the research showed that mitigating the harmful impacts of passivation on solar cells was highly successful. Due to the steric barrier that prevents two-dimensional perovskite production, an isomer with the passivation organizations nearest to each other has been identified to have the highest effective passivation. Surprisingly, the steric barrier is also employed to avoid or speed down unwanted responses in other fields of chemistry.

The invention appeared in one of the most prestigious journals

Nature Communications, one of the globe's most prestigious research publications, presented the findings. At present, KTU scientists are collaborating with partners from other nations to develop novel perovskite formulations and operational hole-transporting substances. World collaboration in research is essential, says Dr. Raktys, "since it is challenging to cover all fields such as chemistry, physics, and substances research operating in such an interdisciplinary area." Dr. Raktys received his Ph.D. at EPFL, Switzerland, after graduating with an MSc in Practical Chemistry from KTU, and afterward worked as a postdoctoral research scientist at UQ, Australia. He is currently employed at KTU. "I wanted to actualize my intellectual concepts in Lithuania following spending over 6 years at famous overseas experimental institutes, and so contribute to the efficient expansion and rising popularity of research in Lithuania." Performing in your nation, I feel, may give you more significance, motivation, and self-realization. The MJJ Organization’s funding contribution had a crucial role in this choice. According to Dr. Raktys, KTU research creates, evaluates, and hopes to use novel substances to make highly effective and reliable solar cells. "This is an exciting topic since perovskite solar cells are one of the fastest technologies, and their effective commercialization might help with global warming solutions," adds Dr. Raktys. This isn't the first time KTU researchers have established a global record in the field of solar technology. In collaboration with physicists from Berlin's Helmholtz-Zentrum (HZB), KTU scientists have enhanced the effectiveness of tandem silicon-perovskite solar cells, which currently stand at 29.8%, in collaboration with physicists from Helmholtz-Zentrum (HZB). This sort of solar component is a global document. [1] [2]

References

1. Liu, C., et al., Tuning structural isomers of phenylenediammonium to afford efficient and stable perovskite solar cells and modules. Nature communications, 2021. 12(1): p. 1-9.
2. Li, X., et al., On-device lead sequestration for perovskite solar cells. Nature, 2020. 578(7796): p. 555-558.

2. https://www.solarpowerworldonline.com/2020/02/perovskite-solar-cells-hero-villain-or-just-plain-fantasy/.

3. https://scitechdaily.com/breakthrough-self-assembly-innovation-enables-cheaper-solar-energy-production/.

4. https://scitechdaily.com/new-materials-synthesized-for-extremely-high-efficiency-perovskite-solar-cells/.s

5. https://www.nature.com/articles/s41467-021-26754-2.

6. https://www.nature.com/articles/s41586-020-2001-x.