

Indian scientists developed a self-charging energy storage device powered by sunlight

प्रविष्टि तिथि: 30 JAN 2026 3:23PM by PIB Delhi

An innovative sunlight-powered supercapacitor called photo-capacitor developed by scientists can both capture and store solar energy in a single integrated device.

This could be a remarkable step towards clean and self-sustaining energy storage systems paving the way for efficient, low cost, and eco-friendly power solutions for portable, wearable, and off grid technologies.

Traditionally, solar energy systems rely on two separate units: solar panels for energy capture and batteries or supercapacitors for energy storage. While such hybrid systems are widely implemented from large-scale solar farms to portable electronics, they rely on additional power management electronics to regulate voltage and current mismatches between the energy harvester and the storage unit. This requirement increases system complexity, cost, energy losses, and device footprint, which becomes particularly detrimental for miniaturised and autonomous devices.

This new photo-rechargeable supercapacitor, developed by the Centre for Nano and Soft Matter Sciences (CeNS), Bengaluru, an autonomous institute under the Department of Science and Technology (DST), Government of India, seamlessly combined both processes converting sunlight into electrical energy and storing that energy for later, thus simplifying design and minimising energy loss during conversion and storage.

Under the guidance of Dr. Kavita Pandey, innovated with the help of binder-free use of nickel-cobalt oxide (NiCo_2O_4) nanowires, which have been uniformly grown on nickel foam using a simple in situ hydrothermal process.

These nanowires, only a few nanometres in diameter and several micrometres long, form a highly porous and conductive 3D network that efficiently absorbs sunlight and stores electrical charge. This unique architecture allowed the material to act simultaneously as a solar energy harvester and a supercapacitor electrode.

When tested, the NiCo_2O_4 electrode exhibited a remarkable 54% increase in capacitance under illumination, rising from 570 to 880 mF cm^{-2} at a current density of 15 mA cm^{-2} . This exceptional performance stems from the efficient generation and transfer of light-induced charge carriers within the nanowire network. Even after 10,000 charge-discharge cycles, the electrode retained 85% of its original capacity, demonstrating its long-term stability, an essential feature for practical applications.

To evaluate its real-world applicability, the researchers prepared an asymmetric photo-supercapacitor using activated carbon as the negative electrode and NiCo_2O_4 nanowires as the positive electrode. The device delivered a stable output voltage of 1.2 volts, maintained 88% of its capacitance retention even after 1,000 photo-charging cycles, and operated efficiently under varying sunlight conditions-from low indoor illumination to intense 2 sun intensity. This stability indicates that the nanowire structure can endure both mechanical and electrochemical stress over extended periods of use.

By integrating sunlight harvesting and energy storage in a single device, the team developed self-charging power systems that can function anywhere even in remote regions without access to an electrical grid.

Such technology can substantially reduce dependence on fossil fuels and conventional batteries, paving the way for a sustainable and green energy future. In addition to the experimental, theoretical study was carried out to understand why the NiCo_2O_4 nanowire system performs so efficiently.

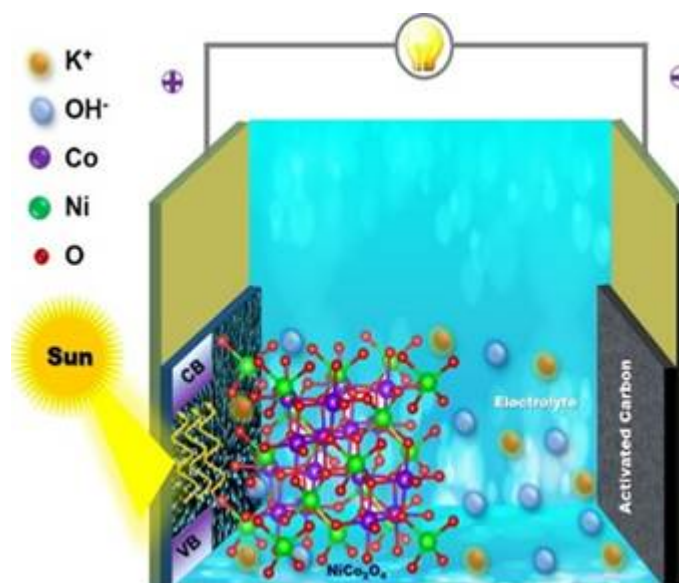


Fig. Schematic illustration of photo-rechargeable supercapacitor

This study revealed that nickel substitution in the cobalt oxide framework narrows the band gap to approximately 1.67 eV and induces half metallic behavior. This means the material behaves as a semiconductor for one type of electron spin while remaining metallic for the other: a rare dual property that enables faster charge transport and higher electrical conductivity. Such spin dependent conductivity is particularly valuable for photo-assisted charge storage applications.

Integrating sunlight capture and charge storage in a single architecture has been a long-standing goal in sustainable energy research.

This study also demonstrates the synergy between experimental and theoretical insights in materials research. While experiments confirmed enhanced capacitance and durability, theoretical simulations revealed the atomic-level mechanisms driving these improvements. Together, they provide a comprehensive understanding of how nanostructured materials can be optimized for light-responsive energy storage.

This work, published in Sustainable Energy & Fuels (Royal Society of Chemistry Journal), introduces a new class of smart, photo-rechargeable energy storage devices. Overall, this research represents a paradigm shift in renewable energy storage. With further development, such systems could play a pivotal role in achieving India's clean energy ambitions and inspiring similar innovations worldwide.

NKR/FK/AV

(रिलीज आईडी: 2220804) आगंतुक पटल : 458
इस विज्ञप्ति को इन भाषाओं में पढ़ें: Urdu , हिन्दी

