IIT Indore Develops Color-Changing Supercapacitor: A Game-Changer for Energy Storage and Heat Control

Researchers at the Indian Institute of Technology (IIT) Indore have developed a path-breaking technology that could change the future of energy storage. The team, led by **Professor Rajesh Kumar** from Materials and Device (MAD) Lab of the Physics Department, has created a revolutionary color-modulating supercapacitor that not only stores energy but also shows its charging status through visible color changes, while blocking infrared heat.

This electrochromic supercapacitor visually indicates its charge level — red when fully charged, green when half charged, and blue when fully discharged. This simple, real-time color feedback removes the need for separate monitoring circuits and allows users to know the device's energy status instantly. The color change is made possible through the electrochromic properties of a specially designed vanadium oxide complex that changes its optical characteristics during charging and discharging.

What makes this technology unique is its dual functionality. In addition to storing energy, the device actively blocks infrared heat by adjusting its heat-blocking ability with small electric currents. The prototype has shown excellent performance, achieving optical modulation of up to 70% at red color and 50% at blue color. The research team has used a specially tuned oxide-hydroxide complex of porous vanadium oxide that maximizes electroactive sites and ensures high efficiency.

The device is solid-state and flexible, meaning it can be bent or twisted without affecting its performance. The researchers have successfully demonstrated the technology using a large 25 cm^2 prototype, proving that it can be scaled up for real-world applications. **Prof. Rajesh Kumar** highlighted that this technology will be of immense use for industry working for the electronification of gadgets and vehicles. With small design changes, the same platform can also be used to create electrochromic batteries.

This innovation has immense potential for industries such as automotive, where electrochromic applications are growing rapidly. The global automotive supercapacitors market, valued at USD 1.3 billion approx. in 2023, is expected to rise to USD 7.5 billion approx. by 2032, showing a 22% annual growth rate. The technology can also help in smart buildings by filtering heat and reducing cooling costs while remaining transparent. In electric vehicles, it can improve energy efficiency through better thermal management and energy storage.

An important aspect of this achievement is the significant contribution of women scientists to the project highlights the importance of gender diversity in advancing scientific innovation. More than half of the research team comprises women, including **Bhumika Sahu, Dr. Tanushree Ghosh, Nikita and Dr. Suchita Kandpal**, along with lead researcher **Dr. Love Bansal and Deb Kumar Rath**. One of the lead Researchers Dr. Love Bansal is a Translational Research Fellow (TRF) under the pioneering Translational

Research Fellowship scheme of IIT Indore which provides financial support during the research.

Director of IIT Indore, **Professor Suhas Joshi**, praised the achievement, saying, *"This breakthrough is a proud moment for IIT Indore. It reflects our commitment to developing technologies that not only meet India's energy needs but also contribute to global sustainability goals. The TRF scheme has played a key role in nurturing such innovations by providing dedicated support to young researchers working to bridge the gap between laboratory research and industrial application."*

Prof. Rajesh Kumar said, *"Our technology combines energy storage, heat control, and visual feedback in one compact device, offering users a smarter, more efficient way to manage energy. It has the potential to transform multiple sectors, from consumer electronics to electric vehicles."*

This innovation from IIT Indore is poised to become a game-changer for green energy solutions. As it moves towards commercialization, it promises to make energy storage more efficient, intuitive, and sustainable, supporting the global transition to renewable energy.