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Advancements in Energy Storage: Exploring the Impact of Graphene Composites

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Commentary

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Abstract

Advancements in energy storage technology have made significant progress with the use of graphene composites. Graphene, a two-dimensional carbon material, is known for its excellent electrical conductivity, exceptional mechanical strength, and unique thermal properties, making it a key material for improving the performance of batteries and supercapacitors. Researchers are working to harness these properties to develop more efficient energy storage solutions. These efforts are particularly important in response to the growing global demand for sustainable energy systems, including renewable energy sources and electric vehicles.

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Energy storage technologies have been driven by the increasing global demand for energy and the urgent need for sustainable solutions [1, 2]. A promising material in this area is graphene, which has high electrical conductivity, a large surface area, and a high level of mechanical strength. Supercapacitors and batteries are next-generation energy storage technologies based on the properties of graphene [3]. Structures of graphene combined with nitrogen-containing molecules produce electrodes with optimum electrode properties. Modifying the electrodes improves the charge storage capacity and ensures their stability throughout the process, addressing a crucial challenge in energy storage [4]. Furthermore, conductive polymers and transition metal oxides have been synthesized to form advanced nanocomposites [5, 6]. It has been demonstrated that graphene composites can produce energy at levels comparable to those produced by conventional batteries while maintaining many of the characteristics of supercapacitors. Several structural parameters can be adjusted to improve ion transport and charge storage in these materials [7].

The unique properties of graphene make it possible to create electrodes with high capacity and fast energy release. The combination of graphene with other materials, such as transition metal dichalcogenides (for example, MoS_2), has been shown to enhance the electrochemical performance of energy storage [8]. The composites are expected to overcome the limitations associated with traditional energy storage technologies while improving their stability and cycling capabilities [7]. A graphene material enriched with nitrogen improves the conductivity and electrochemical performance of battery electrodes, enabling faster charging and discharging [9]. This is particularly important in light of the increasing demand for high-performance batteries in electric vehicles and renewable energy fields. The scalability of graphene production methods has made it possible to use these materials for commercial power storage devices. Graphene's flexibility makes it a suitable material for hybrid energy storage systems.

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Combining graphene and polymer produces composite materials with enhanced dielectric properties that can be used for energy storage in incorporated batteries [10]. By advancing energy storage technology, it will be possible to maximize energy density and reduce the size of energy storage devices.

Moreover, graphene-based energy storage technologies will likely reach commercialization if their manufacturing process is scalable. Researchers have recently concentrated on cost-effective and eco-friendly graphene synthesis techniques. For graphene to be adopted widely in the commercial sector, it must be incorporated into existing energy storage systems [11].

Despite significant progress in graphene-based energy storage solutions, their implementation remains challenging. There is also a need to consider scalability and cost-effectiveness in graphene synthesis [12]. Additionally, a longer-term analysis of graphene composites under various operating conditions is needed. By optimizing the synthesis strategy, new composite materials may improve the performance of energy storage devices in the future. Graphene composites significantly improve energy storage devices. Due to their specific properties and engineering know-how, graphene is a key player in the future of energy storage. Their capabilities will make graphene a crucial part of meeting the energy needs of the 21st century.

Authors' contribution

Mohammad Hassan Shahavi: Conceptualization, Writing—Original Draft Preparation, Writing—Review and Editing**, Nadir Ayrilmis:** Interpretation, Writing—Original Draft Preparation, Writing—Review and Editing.

Declaration of Competing Interest

The authors declare that there are no competing interests.

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Data Availability

No data was used for the research described in the paper.

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