Title: Highly Stable Perovskite Solar Cells Using Graphene and its Derivatives: A Review

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Abstract: Perovskite solar cells (PSCs) are a leading photovoltaic technology, with efficiencies now exceeding 28%. However, their commercialization is hindered by poor long-term stability against moisture, oxygen, heat, and UV radiation. A promising solution is presented by graphene and its functionalized derivatives, e.g., graphene oxide (GO), reduced graphene oxide (rGO), graphene quantum dots (GQDs), and so forth, due to their exceptional electrical, mechanical, and barrier properties. In this review, the application of these graphene-based nanomaterials (GBNs) to enhance PSC stability is systematically examined. The integration of GBNs into all key device components—including transparent electrodes, electron and hole transport layers (ETLs/HTLs), interfacial layers, and encapsulation coatings—is analyzed. Key findings show that GBNs significantly improve device performance and durability. For instance, rapid electron extraction is facilitated by GBN-modified ETLs, while robust moisture resistance is provided by graphene-based HTLs and encapsulants, enabling high PCE retention (>90%) under harsh conditions. Recent advancements are summarized in this paper, highlighting how functionalized graphene derivatives are critical enablers for the development of commercially viable, stable next-generation PSCs.

Key words: device stability functionalized graphene graphene perovskite solar cells photovoltaics

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