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Temperature-Controlled Reduction of rGO–Polymer thin films and its effect on electrical conductivity and optical properties.

Reduced graphene oxide (rGO)–polymer thin films have emerged as adaptable components in flexible electronics, sensors, and optical devices. This article reviews how temperature-controlled reduction approaches –including thermal annealing, chemical reduction, and green reductants influence the structure and properties of graphene oxide (GO) embedded in polymer thin films. Emphasis is sited on how temperature affects reduction efficiency, oxygen removal, restoration of sp^2-carbon domains, and the resultant electrical conductivity and optical properties. We focus on thin-film composite systems with representative polymer hosts: poly(vinyl alcohol) (PVA), PEDOT:PSS, epoxy, thermoplastic polyurethane (TPU), and polyimide (PI). Key findings across multiple studies are compared to reveal consistent trends: higher reduction temperatures yield more extensive oxygen elimination and sp^2 network recovery, intensely boosting film conductivity while altering optical transitions. However, polymer thermal stability often limits the maximum temperature, necessitating careful selection of reduction methods. Structural–property relationships are analyzed –for example, how incremental oxygen removal sequentially restores graphitic domains and tunes the film's bandgap and transparency. The review also highlights practical implications for device applications, such as transparent electrodes and temperature sensors, and summarizes strategies - including low-temperature "green"reductions to achieve high conductivity without degrading polymer matrices. In conclusion, a clear understanding of temperature-dependent reduction in rGO–polymer films is essential for tailoring electrical/optical performance in next-generation flexible devices, and we outline future outlooks for optimizing these systems.

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