

Bio-cool Revolution: Aloe Vera Hydrogel as a Natural Supercooling Medium

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Abstract: *The growing pace of industrialization and the pressing challenges of climate change have accelerated the need for sustainable, energy-efficient, and eco-friendly cooling alternatives. Conventional cooling technologies and chemical refrigerants, while effective, significantly contribute to greenhouse gas emissions, excessive power usage, and environmental harm. Addressing these concerns, the Bio-Cool Revolution presents Aloe vera hydrogel as a natural, sustainable supercooling medium that utilizes the inherent physicochemical properties of bio-derived materials for efficient thermal control.*

Aloe vera, a plant rich in water and polysaccharides with excellent biocompatibility, emerges as a suitable base for developing environmentally benign hydrogels. The hydrogel derived from Aloe vera exhibits superior water retention, heat stability, and controlled phase transition, allowing it to sustain supercooled states without rapid crystallization. This enables prolonged and efficient cooling with minimal energy requirements. Its internal polymeric network, strengthened by hydrogen bonds and natural polysaccharides, further improves its latent heat storage, viscosity, and thermal regulation characteristics.

Experimental findings confirm that Aloe vera hydrogel displays stable supercooling with reduced ice nucleation, maintaining steady temperatures over longer durations. Its renewable, biodegradable, and non-toxic nature makes it a greener alternative to synthetic refrigerants. Potential applications of this bio-cooling medium include pharmaceutical cold-chain storage, food preservation, thermal insulation, and wearable cooling devices.

This research highlights Aloe vera hydrogel's transformative potential in sustainable thermal management through a bio-inspired and eco-conscious framework. By integrating this natural material into supercooling systems, the approach not only minimizes environmental impact but also promotes energy-efficient and carbon-neutral cooling technologies. Thus, the Bio-Cool Revolution signifies a crucial step toward the next generation of smart, sustainable, and nature-driven cooling innovations in materials science and thermal engineering.

Keywords: Aloe vera, Hydrogel, Supercooling, Sustainable cooling, Thermal Management.

