

Bridging IoT Innovation and Green Chemistry: Pathways to Safer and More Sustainable Industrial Systems

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The engineering challenges of the 21st century demand solutions that are not only innovative but also environmentally responsible. Two fields-Internet of Things (IoT) technologies and green and sustainable chemistry- are now converging to transform how industries operate, how societies respond to crises, and how we safeguard public health and the environment.

The application of IoT in fire safety and disaster response illustrates this promise. My work on an IoT-enabled firefighting robot demonstrated how robotics can be deployed to protect human life in high-risk environments. However, the broader significance lies in coupling such devices with sustainable fire suppression agents and eco-friendly materials, thereby reducing the environmental impact of emergency interventions. This dual approach underscores a new paradigm: engineering solutions must protect lives while minimizing harm to ecosystems.

Meanwhile, advances in green chemistry are redefining industrial practice. Breakthroughs in low-carbon cement formulations, biodegradation of hazardous chemicals, and antibacterial nanomaterials show how sustainable chemistry can deliver cleaner, safer, and more efficient processes. Yet, their greatest potential emerges when they are integrated with IoT-driven systems capable of real-time monitoring, predictive control, and adaptive performance.

The future of industrial engineering rests in this fusion of smart systems and sustainable science. Imagine cement plants where IoT sensors monitor emissions from green formulations, laboratories where robotic platforms accelerate biodegradation processes, or public facilities where nanomaterials with antibacterial properties are embedded in infrastructure and monitored continuously for effectiveness. These are not speculative visions- they are emerging realities, shaped by research and industrial application.

This cross-disciplinary integration is not merely technical; it is societal. It advances the United Nations Sustainable Development Goals, reduces industrial carbon footprints, and equips nations to build resilient, health-conscious, and environmentally sustainable infrastructure. As scientists and engineers, our responsibility is clear: to design technologies that are smarter, safer, and more sustainable, ensuring that innovation serves both humanity and the planet.