Medical & healthcare, Antibacterial / Antiviral, Noble metal catalysts, Electroless plating

Technology for immobilizing noble metal nanoparticles on various substrates

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Abstract

This technology enables the strong immobilization of metal nanoparticles on the surfaces of various substrates, such as ceramics, polymers, and fibers. The process is simple: the substrate is immersed in an aqueous solution containing metal ions, followed by irradiation with ionizing radiation. Since the method uses gamma rays or electron beams, which are commonly employed for the sterilization of medical devices, the treated materials do not become radioactive. The technology can be customized by selecting different combinations of metals and substrates depending on the intended application.

Background & Results

By combining gold and iron oxide, composite nanoparticles can be produced for use as novel magnetic beads in nanobiotechnology, some of which have already been commercialized. This technology also enables the facile synthesis of bimetallic noble metal nanoparticles with excellent catalytic performance, which are expected to be applied to energy-related fields such as fuel cell catalysts. In addition, silver nanoparticles can be firmly immobilized on fiber surfaces, imparting strong antibacterial and antiviral properties, with some products already on the market. Furthermore, by immobilizing palladium nanoparticles on polymer surfaces, we have developed an electroless plating process that eliminates the need for conventional etching steps, thereby reducing environmental impact. In this way, our technology allows flexible combinations of metals and substrates tailored to specific needs, with potential applications across a wide range of fields including healthcare, energy, and industry.

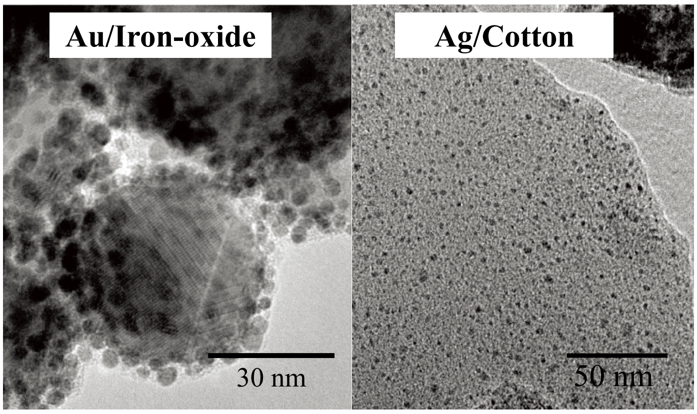
Significance of the research and Future perspectives

In this study, we have developed a core technology that utilizes radiation-induced chemical reactions for the synthesis of practical materials applicable to a variety of fields. Specifically, a substrate material (e.g., nanoparticles, fibers, or polymers) is immersed in an aqueous solution containing noble metal ions and irradiated with ionizing radiation. The radiolysis of water generates reactive species, which instantaneously reduce the metal ions to form nanoparticles that are simultaneously and strongly immobilized on the substrate surface. This process integrates “synthesis” and “immobilization,” which conventionally required multiple steps, into a single, streamlined step that achieves both process simplification and high bonding strength.

Traditional studies in radiation chemistry have primarily focused on elucidating reaction mechanisms and fundamental processes under irradiation, with limited application to the development of practical materials. Our research is unique in that it advances radiation chemistry from a purely academic domain to a practical technology for material fabrication.

As the radiation source, we use gamma rays and high-energy electron beams, which are widely applied in the sterilization of medical devices and food irradiation. These radiation sources are safe, as they do not make the treated materials radioactive. Gamma rays offer excellent penetration capability, enabling uniform irradiation even in reaction systems of several liters, making them suitable for large-scale processing. In contrast, electron beams have a high dose rate, allowing nanoparticle synthesis to be completed within seconds, ideal for rapid processing. Numerous commercial irradiation facilities are already in operation worldwide, and with proper process design, scaling up to industrial production is feasible. Moreover, irradiation costs are relatively low, meaning that neither throughput nor cost is likely to be a bottleneck for industrial applications.

Because this technology allows flexible design of metal–substrate combinations, it is expected to serve as a versatile platform for creating new materials across diverse fields, including healthcare, industry, and environmental applications.



TEM images of synthesized nanoparticle materials

Patent Japanese Patent No.4879492, No.4854097, No.7143998, No.7685750

Treatise

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