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(57) Abstract:

The present invention relates to a nano gold–graphene oxide nanocomposite composition designed to synergistically combine the unique properties of gold nanoparticles and graphene oxide into a stable and multifunctional material system. The composite comprises uniformly distributed gold nanoparticles anchored onto a graphene oxide matrix through controlled interfacial interactions, resulting in enhanced optical, electrical, catalytic, mechanical, and biocompatible characteristics. The graphene oxide framework prevents nanoparticle aggregation while providing high surface area and functional groups, and the gold nanoparticles contribute superior catalytic activity, plasmonic behavior, and chemical stability. The proposed nanocomposite overcomes limitations of conventional nanomaterials such as poor dispersion, instability, and limited scalability. The invention is adaptable for diverse applications including biomedical diagnostics and therapy, biosensing, environmental remediation, energy storage, catalysis, and advanced electronic systems. The composition supports scalable synthesis, tunable properties, and long-term stability, enabling effective industrial and commercial utilization.

FORM 2

THE PATENTS ACT, 1970

(39 of 1970)

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The Patent Rules, 2003

COMPLETE SPECIFICATION

(See section 10 and rule 13)

TITLE OF THE INVENTION

“Nano Gold-Graphene Oxide Nano Composite Compositions”

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The following specification particularly describes the nature of the invention and the manner in which it is performed:

Field of Invention:

The present invention relates to the field of nanotechnology and advanced functional materials, particularly to nano-engineered composite compositions. More specifically, the invention pertains to nano gold–graphene oxide nanocomposite compositions that integrate the unique physicochemical properties of gold nanoparticles with the high surface area and functional groups of graphene oxide. The invention lies at the intersection of materials science, chemical engineering, and applied nanoscience. It addresses the synthesis, formulation, and stabilization of hybrid nanocomposites for enhanced electrical, optical, catalytic, and antimicrobial performance. The proposed system is relevant to applications in biomedical engineering, biosensing, drug delivery, energy storage, environmental remediation, and nanoelectronics. The invention also relates to scalable preparation methods ensuring uniform dispersion and controlled particle size. Furthermore, it contributes to multifunctional nanomaterials with improved mechanical strength, thermal stability, and biocompatibility. Overall, the invention advances the development of high-performance nanocomposite materials for industrial and scientific applications.

Background of the Invention:

The rapid advancement of nanotechnology has led to the exploration and development of novel nanomaterials with tailored properties that can overcome the limitations of conventional materials used in industrial, biomedical, and environmental applications. Among various nanomaterials, noble metal nanoparticles and carbon-based nanostructures have attracted significant attention due to their exceptional physicochemical characteristics. Gold nanoparticles, in particular, have been extensively studied for their remarkable optical properties, chemical stability, biocompatibility, and catalytic activity. Simultaneously, graphene oxide has emerged as a highly versatile two-dimensional nanomaterial derived from graphene, possessing a large specific surface area, abundant oxygen-containing functional groups, excellent mechanical strength, and tunable electrical properties. The convergence of these two material classes into a single nanocomposite system offers an opportunity to synergistically enhance their individual advantages while mitigating inherent drawbacks.

Traditional gold nanoparticle systems, although highly effective in applications such as sensing, catalysis, and biomedical diagnostics, often suffer from issues related to particle aggregation, limited surface interaction, and reduced stability under varying environmental conditions. Similarly, graphene oxide, while exhibiting excellent dispersibility in aqueous media and strong interfacial interactions, faces challenges such as restacking, reduced conductivity compared to pristine graphene, and limited functional specificity when used alone. These challenges necessitate the development of composite systems that can combine the strengths of both materials in a controlled and stable manner. Nano gold–graphene oxide nanocomposite compositions represent a promising solution to these limitations by enabling uniform distribution of gold nanoparticles on the graphene oxide matrix, thereby enhancing surface reactivity, charge transfer efficiency, and functional performance.

In recent years, research efforts have focused on hybrid nanocomposites to achieve multifunctionality required for next-generation technologies. The integration of gold nanoparticles with graphene oxide not only improves electron mobility and optical responsiveness but also introduces active sites suitable for chemical binding, biological interactions, and catalytic reactions. Existing methods for synthesizing such nanocomposites often involve complex procedures, harsh chemical reagents, or lack reproducibility, which restrict large-scale production and practical deployment. Moreover, many reported systems do not adequately address long-term stability, uniform nanoparticle anchoring, or controlled particle size distribution, leading to inconsistent performance across applications.

The background of the proposed invention is further motivated by the increasing demand for advanced materials in biomedical applications such as targeted drug delivery, bioimaging, photothermal therapy, and biosensing. Gold nanoparticles are known for their non-toxicity and ease of surface functionalization, making them suitable for biological environments. Graphene oxide contributes additional benefits through its high loading capacity for biomolecules and drugs, as well as its ability to interact with cells and tissues. However, without a well-designed composite structure, these materials may exhibit reduced efficacy or undesirable interactions. Therefore, there is a strong need for a nano gold–graphene oxide composite composition that ensures biocompatibility, controlled interaction with biological systems, and enhanced therapeutic or diagnostic performance.

Environmental and energy-related applications also drive the development of such nanocomposites. Graphene oxide-based materials have shown promise in water purification, pollutant adsorption, and energy storage devices due to their high surface area and chemical tunability. The incorporation of gold nanoparticles can significantly enhance catalytic degradation of contaminants, improve electrochemical activity, and increase sensitivity in environmental monitoring systems. Despite these advantages, current materials often lack durability, regeneration capability, or sufficient catalytic efficiency, highlighting the necessity for improved composite formulations.

From an industrial perspective, scalability, cost-effectiveness, and reproducibility are critical factors that existing nanocomposite technologies often fail to meet. Many synthesis techniques reported in the literature are laboratory-scale and unsuitable for commercial production. Additionally, the lack of standardized compositions and processing conditions leads to variability in material properties. The background of the proposed invention recognizes these challenges and emphasizes the importance of developing a robust, controllable, and scalable nano gold–graphene oxide nanocomposite composition that can be adapted across multiple application domains.

Furthermore, regulatory and safety considerations play an increasingly important role in the adoption of nanomaterials, especially in healthcare and environmental sectors. Gold nanoparticles are generally regarded as safe, while graphene oxide's safety profile depends on its size, surface chemistry, and concentration. A well-designed composite system can reduce potential toxicity by stabilizing nanoparticles, preventing uncontrolled release, and enabling predictable interactions. Existing solutions do not sufficiently address these aspects, creating a gap that the proposed invention aims to fill.

In summary, the background of the proposed invention is rooted in the limitations of standalone gold nanoparticles and graphene oxide materials, the growing demand for multifunctional and high-performance nanocomposites, and the need for scalable, stable, and application-oriented material systems. The nano gold–graphene oxide nanocomposite composition represents an evolution in material design, offering synergistic enhancement of optical, electrical, catalytic, mechanical, and biological properties. This background establishes the necessity and relevance of the proposed invention in addressing current technological gaps and enabling advanced applications across biomedical, environmental, energy, and industrial fields.

Summary of the Proposed Invention:

The proposed invention provides a nano gold–graphene oxide nanocomposite composition engineered to achieve synergistic enhancement of the intrinsic properties of gold nanoparticles and graphene oxide within a single, stable, and multifunctional material system. The invention focuses on the controlled integration of nano-sized gold particles onto a graphene oxide matrix to ensure uniform dispersion, strong interfacial bonding, and long-term physicochemical stability. By combining the excellent optical, catalytic, and biocompatible characteristics of gold nanoparticles with the high surface area, mechanical robustness, and functional group richness of graphene oxide, the proposed composition delivers superior electrical conductivity, enhanced surface reactivity, and improved functional performance compared to conventional standalone or poorly integrated nanomaterials. The invention is designed to overcome common limitations such as nanoparticle aggregation, graphene oxide restacking, inconsistent particle size distribution, and reduced durability under operational conditions. The developed nanocomposite composition is adaptable for diverse applications including biosensing, biomedical diagnostics and therapy, catalysis, environmental remediation, energy storage, and advanced electronic systems. Additionally, the proposed invention emphasizes scalable synthesis, reproducibility, and tunable material properties, enabling effective translation from laboratory-scale development to industrial and commercial utilization while maintaining safety, reliability, and performance consistency.

Brief Description of the Proposed Invention:

The proposed invention relates to a nano gold–graphene oxide nanocomposite composition that is carefully engineered to integrate gold nanoparticles with a graphene oxide matrix in a highly stable, uniform, and functionally enhanced manner. The invention focuses on the development of a composite material in which nanoscale gold particles are anchored, distributed, and retained on the surface and within the layered structure of graphene oxide through controlled physicochemical interactions. The composite composition is designed to exploit the synergistic effects arising from the combination of gold nanoparticles, known for their exceptional optical, catalytic, and biocompatible properties, and graphene oxide, recognized for its high surface area, rich functional groups, mechanical strength, and tunable electrical behavior. By integrating these two components at the nanoscale, the invention provides a material system that exhibits superior performance characteristics compared to individual components used independently.

In the proposed invention, graphene oxide acts as a multifunctional support platform that prevents aggregation of gold nanoparticles while simultaneously enhancing their active surface exposure. The oxygen-containing functional groups present on graphene oxide, such as hydroxyl, epoxy, and carboxyl groups, facilitate strong interfacial bonding with gold nanoparticles, ensuring uniform dispersion and long-term structural stability. This interaction significantly improves electron transfer efficiency, surface reactivity, and durability of the composite under varying environmental and operational conditions. The gold nanoparticles contribute localized surface plasmon resonance effects, enhanced catalytic activity, and excellent chemical inertness, which collectively elevate the functional utility of the nanocomposite composition.

The invention further emphasizes controlled synthesis parameters that allow precise regulation of gold nanoparticle size, shape, and loading density on the graphene oxide framework. Such control enables fine-tuning of optical, electrical, thermal, and catalytic properties according to specific application requirements. The nanocomposite composition is designed to maintain structural integrity and performance consistency even under prolonged usage, mechanical stress, or exposure to chemical and biological environments. This stability addresses major limitations observed in conventional nanocomposite materials, such as particle detachment, agglomeration, and performance degradation over time.

The proposed nanocomposite composition is versatile and adaptable for a wide range of applications. In biomedical and healthcare-related fields, the composite can be utilized for biosensing, bioimaging, drug delivery, photothermal therapy, and diagnostic platforms due to its high biocompatibility, functional surface chemistry, and enhanced signal responsiveness. The presence of gold nanoparticles enables sensitive detection and targeted interactions, while graphene oxide provides high loading capacity and efficient transport pathways. In environmental applications, the composite composition demonstrates improved adsorption, catalytic degradation, and sensing capabilities for pollutants, toxins, and chemical contaminants, thereby supporting water purification, air monitoring, and environmental remediation technologies.

In energy and electronics domains, the nano gold–graphene oxide nanocomposite composition offers enhanced electrical conductivity, charge storage capacity, and electrochemical stability, making it suitable for applications such as supercapacitors, batteries, conductive coatings, and nanoelectronic devices. The composite structure facilitates efficient charge transport while maintaining mechanical flexibility and thermal stability. The invention also supports catalytic and electrocatalytic applications, where the high surface area and active sites of the composite improve reaction kinetics and efficiency in chemical processing and energy conversion systems.

A key aspect of the proposed invention lies in its scalability and reproducibility. The composition and preparation methodology are designed to be compatible with large-scale manufacturing processes without compromising material quality or performance uniformity. This feature enables seamless transition from laboratory development to industrial production, addressing a critical gap in existing nanomaterial technologies. Additionally, the invention considers safety, environmental compatibility, and regulatory aspects by ensuring stable nanoparticle immobilization, reduced toxicity risks, and predictable material behavior.

the proposed invention further elaborates on the functional adaptability of the nano gold–graphene oxide nanocomposite composition by emphasizing its customizable surface chemistry and interaction mechanisms. The composite material is designed to allow post-synthesis functionalization using a wide range of chemical, biological, or polymeric agents, thereby enabling application-specific tuning without altering the core structural integrity. This adaptability allows the nanocomposite to be modified for selective binding, targeted delivery, or enhanced sensing performance depending on the intended operational environment. The graphene oxide matrix provides multiple anchoring points for functional molecules, while the gold nanoparticles serve as active centers for signal amplification, catalysis, or energy transfer.

The invention also considers the importance of dispersion stability in different solvents and media. The nano gold–graphene oxide nanocomposite composition exhibits improved dispersibility in aqueous and selected organic solvents due to the hydrophilic nature of graphene oxide and the stabilized attachment of gold nanoparticles. This property ensures consistent performance in liquid-phase applications such as biomedical formulations, inks for printed electronics, and catalytic suspensions. The enhanced dispersion stability minimizes sedimentation and phase separation, which are common drawbacks in existing nanocomposite systems.

Thermal and mechanical robustness are additional advantages of the proposed invention. The graphene oxide framework contributes structural reinforcement, while the gold nanoparticles maintain functional activity under elevated temperatures and mechanical stress. This combination allows the nanocomposite to be used in demanding environments such as industrial processing, high-temperature sensing, and mechanically flexible electronic devices. The composite composition is designed to retain its performance characteristics even after repeated thermal cycles or mechanical deformation.

The invention further supports integration into composite matrices, coatings, and thin films. The nano gold–graphene oxide nanocomposite can be incorporated into polymers, ceramics, or hybrid materials to impart enhanced conductivity, antimicrobial properties, or catalytic functionality. This integration capability broadens the scope of the invention to include smart coatings, functional textiles, packaging materials, and structural components with embedded sensing or protective features. The uniform dispersion of the nanocomposite within host matrices ensures consistent property enhancement throughout the material.

Another important aspect of the proposed invention is its role in advanced sensing and diagnostic platforms. The synergistic interaction between gold nanoparticles and graphene oxide significantly enhances signal transduction mechanisms, including optical, electrochemical, and surface-enhanced Raman scattering responses. This enhancement enables highly sensitive and selective detection of chemical and biological analytes at low concentrations. The nanocomposite composition supports rapid response times, high signal-to-noise ratios, and repeatable sensing performance, making it suitable for real-time monitoring applications.

The invention also addresses long-term storage and shelf-life considerations. The stabilized nanocomposite composition is designed to resist oxidation, aggregation, and chemical degradation during storage. This stability ensures that the material retains its functional properties over extended periods, reducing waste and improving reliability for commercial deployment. The controlled immobilization of gold nanoparticles on graphene oxide further minimizes the risk of nanoparticle migration or leaching.

From a sustainability perspective, the proposed invention supports environmentally responsible material design by enabling efficient material utilization and reduced resource consumption. The high functional efficiency of the nanocomposite allows lower material loading to achieve desired performance, thereby reducing overall material usage. Additionally, the potential for recyclability and regeneration of the nanocomposite in catalytic and environmental applications contributes to sustainable operational practices.

The invention also facilitates compatibility with emerging fabrication techniques such as inkjet printing, spray coating, and layer-by-layer assembly. This compatibility enables precise patterning and scalable fabrication of devices and components incorporating the nano gold–graphene oxide nanocomposite composition. Such fabrication flexibility is critical for the development of next-generation electronic, optoelectronic, and biomedical devices.

In essence, this continued description underscores that the proposed nano gold–graphene oxide nanocomposite composition is not limited to a single function or application but serves as a versatile material platform. Its design philosophy emphasizes synergy, stability, scalability, and adaptability, ensuring relevance across multiple technological domains. The invention provides a comprehensive solution to existing challenges in nanocomposite material development by delivering a robust, multifunctional, and application-ready material system capable of meeting present and future technological demands.

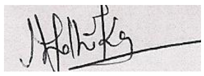
We Claim:

1. A nano gold–graphene oxide nanocomposite composition comprising graphene oxide sheets and gold nanoparticles uniformly anchored onto the surface of the graphene oxide, wherein the composite exhibits enhanced optical, electrical, catalytic, and mechanical properties due to synergistic interaction between the components.
2. The nanocomposite composition as claimed in claim 1, wherein the gold nanoparticles have a controlled nanoscale size distribution and are chemically bonded or physically immobilized onto oxygen-containing functional groups of the graphene oxide matrix to prevent aggregation.
3. The nanocomposite composition as claimed in claim 1, wherein the graphene oxide provides a high surface area support that enhances dispersion stability and electron transfer efficiency of the gold nanoparticles under varying environmental and operational conditions.
4. The nanocomposite composition as claimed in claim 2, wherein the loading density and spatial distribution of gold nanoparticles on graphene oxide are tunable to achieve application-specific optical, electrical, or catalytic performance.
5. The nanocomposite composition as claimed in claim 1, wherein the composite demonstrates improved biocompatibility and surface functionalization capability, making it suitable for biomedical applications including biosensing, drug delivery, and diagnostic platforms.

6. The nanocomposite composition as claimed in claim 3, wherein the composite exhibits enhanced electrochemical activity and charge transport properties suitable for energy storage, sensing, and nanoelectronic applications.
7. The nanocomposite composition as claimed in claim 1, wherein the composite material shows improved thermal stability, mechanical robustness, and resistance to chemical degradation compared to standalone gold nanoparticles or graphene oxide.

8. The nanocomposite composition as claimed in claim 2, wherein the composite is capable of being dispersed uniformly in aqueous and selected organic media, enabling use in coatings, inks, thin films, and composite matrices.
9. The nanocomposite composition as claimed in claim 1, wherein the composite exhibits enhanced catalytic and adsorption efficiency for environmental remediation applications including pollutant detection, degradation, and water purification.
10. The nanocomposite composition as claimed in claim 1, wherein the composition is scalable, reproducible, and suitable for large-scale manufacturing while maintaining consistent physicochemical and functional properties.

Dated this 06th day of January 2026

Signature: 

Applicant(s)

Dr. Muthadi Radhika Reddy et. al.

ABSTRACT

<u>Nano Gold-Graphene Oxide Nano Composite Compositions</u>

The present invention relates to a nano gold–graphene oxide nanocomposite composition designed to synergistically combine the unique properties of gold nanoparticles and graphene oxide into a stable and multifunctional material system. The composite comprises uniformly distributed gold nanoparticles anchored onto a graphene oxide matrix through controlled interfacial interactions, resulting in enhanced optical, electrical, catalytic, mechanical, and biocompatible characteristics. The graphene oxide framework prevents nanoparticle aggregation while providing high surface area and functional groups, and the gold nanoparticles contribute superior catalytic activity, plasmonic behavior, and chemical stability. The proposed nanocomposite overcomes limitations of conventional nanomaterials such as poor dispersion, instability, and limited scalability. The invention is adaptable for diverse applications including biomedical diagnostics and therapy, biosensing, environmental remediation, energy storage, catalysis, and advanced electronic systems. The composition supports scalable synthesis, tunable properties, and long-term stability, enabling effective industrial and commercial utilization.

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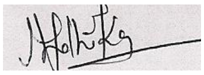
Signature: 

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