Forum F Biological Materials

F01 (Invited)

The Composite and Hybridization Approach in Developing New Biomaterials

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In the early part of the last century, various materials were used as “biomaterials” for human body repair. The modern-day biomaterials development started in the middle of the last century when it was realized that borrowing engineering materials to use them in the medical field had insurmountable problems and that new materials must be developed specifically for medical applications. Most human body tissues, such as bone, are natural composite materials. In bone, two levels of composite structure are identified: first, the bone apatite reinforced collagen forming individual lamella at the nm to □ m scale and, second, osteon reinforced interstitial bone at the □ m to mm scale. With a biological template such as bone, the R & D in biomedical composites for hard tissue replacement by mimicking the bone apatite-collagen structure was started in the 1980s. Many researchers around the world have since adopted this composite approach and investigated a variety of bioactive bioceramic-polymer composites of various characteristics in order to meet clinical requirements. Through careful materials design, this biomimicking, composite approach has also been used in developing ceramic-matrix and metal-matrix composites for human tissue repair in major load-bearing parts of the body. The huge advantages of using biodegradable biomaterials for human tissue repair to eliminate second surgeries have led to the extensive exploration of biodegradable composites. These biomedical composites (biodegradable or non-biodegradable) can be used in areas such as orthopaedics and dentistry. Since more than two decades ago, great interest in tissue engineering has led to wide investigations into composite and/or hybridized tissue engineering scaffolds. These scaffolds, with careful design and manufacture, possess multiple functions and can significantly enhance tissue regeneration. Advanced composite or hybridized scaffolds are now used for regenerating tissues such as blood vessels, cartilage and peripheral nerve. On the other hand, in recently emerging areas such cancer nanotechnology, advanced theranostics, which are nanodevices for cancer detection and treatment, are mostly based on nanocomposite particles. These new theranostics have multiple capabilities and provide combined therapies for cancer treatment. This talk will give an overview of our efforts in the R & D of biomaterials using the composite and hybridization approach and discusses important factors affecting the performance of these materials.

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F02 (Invited)

Mesoporous Silica Nanoparticles / Magnetic Iron Nanoparticles Based Nanocarriers for Stimuli-Responsive Targeted Tumor Therapy

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Construction of stimuli-responsive controlled release system for targeted drug delivery to specific cells is essentially important for cancer therapy since most chemotherapeutics are severely toxic [1]. Surface-functionalized magnetic nanoparticles (MNPs) and end-capped mesoporous silica nanoparticles (MSNs) presented themselves as ideal stimuli-responsive carriers for controlled drug and/or gene delivery, owing to their good biocompatibility, tunable sizes and large surface areas. To trigger drug release via signals derived from cells and to confirm the biosaftey of MSNs-based system attracted much attention in the related field.

We present here three kinds of stimuli-responsive drug delivery systems (redox, pH and enzyme). For redox-responsive system, we fabricated nanoreservoirs based on collagen end-capped MSNs that demonstrated great potential for both cell-specific targeting and redox-responsive controlled release of drug. Lactobionic acid (LA) bearing galactose group was introduced to be targeting moiety [2]. We fabricated a redox responsive controlled release system employing disulfide bonds as couple linkers to immobilize β-cyclodextrin grafting polyethylenimine (PEI/β-CD) molecules onto MNPs for efficient intracellular hydrophobic anticancer drug delivery. We also constructed Cytochrome c end-capped MSNs as redox-responsive drug delivery vehicles for tumor-targeted triplex therapy in vitro and in vivo. AS1411 aptamer was further tailored onto MSNs for cells/tumors targeting. For pH-responsive system, we employed 4-carboxyphenylboronic acid (CBA) as reactive agents anchored onto the surfaces of mesoporous silica supports and lacotobionic acid grafted bovine serum albumin (LA-BSA) molecules as efficient end-caps of MSNs. We also fabricated pH-responsive dendrimer-like MSNs for imaging and targeted tumor therapy in vivo. As for enzyme responsive system, we constructed multifunctional MSNs for drug delivery in response to overexpressed matrix metalloproteinase (MMPs) in tumor microenvironment. The biological responses (intracellular distribution, endocytosis pathway, cell apoptosis, tissue toxicity etc.) of those systems were investigated in vitro and/or in vivo as well.

F03

The Development and Applications of Collagen-Based Biomedical Materials and Its Relevant Theory

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In this paper, the structure and properties of collagen, the rationale of collagen modification, the isoelectric point theory of collagen and its aggregation, and the multi-level collagen aggregates and its level division methods, etc, are clarified systematically. Meanwhile, the development progress of collagen-based biomedical materials both in China and abroad is summarized, and the research results of the collagen-based biomaterials our research group achieved are especially emphasized. Furthermore, the existing problems in the research and development of the collagen-based biomedical materials are pointed out, thereout, the development tendency of collagen-based biomaterials is proposed preliminarily. And on this base the future development thoughts of the collagen-based biomedical materials are further put forward prospectively.

Keywords collagen, modification, aggregate, biomedical materials

F04

XAS Study of Low Dimensional Dilute Magnetic Semiconductors

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Electrically conducting polymers induce specific cellular responses at the molecular level. One of the crucial limitations of the use of conducting polymers in tissue engineering is their inability to degrade. The incorporation of conducting polymers into degradable polymers to obtain materials that are both electroactive and degradable is therefore highly anticipated [1]. In our work, we designed degradable conductive copolymers based on polylactide and aniline ologiomers and demonstrated their potential application for bone and skeletal muscle tissue engineering. In the first work, we synthesized six-armed star-shaped poly(l-lactide) (PLLA) by ring opening polymerization (ROP). The prepolymer dissolved in THF was chemically crosslinked by hexamethylenediisocyanate (HDI) to obtain shape memory polymer (SMP). The electroactive shape memory polymers (ESMP) were obtained by adding 5 wt % amino-capped aniline trimer (ACAT) and CSA (doping the ACAT) into the reactant mixture before reaction [2]. SMP and ESMP exhibited strong mechanical properties (modulus over GPa) and excellent shape memory effects: short recovery time (several seconds), high recovery ratio (over 94%), and high fixity ratio (almost 100%). Cyclic voltammetry (CV) test verified good electroactivity of ESMP. Furthermore, ESMP significantly enhanced the proliferation of C2C12 cells by AlamarBlue assay compared to SMP and linear PLLA (control). In addition, the ESMP greatly improved the osteogenic differentiation of C2C12 myoblast cells compared to PH10 and PLA in terms of ALP enzyme activity, immunofluorescence staining, and relative gene expression by quantitative real-time polymerase chain reaction (qRT-PCR). These intelligent SMPs and electroactive SMP with strong mechanical properties, tunable degradability, good electroactivity, biocompatibility, and enhanced osteogenic differentiation of C2C12 cells show great potential for bone tissue engineering. In the second part, we prepared novel electroactive hyperbranched polylactide (HPLA) materials by chemical chain extension and grafting to overcome the PLLA’s brittleness and lack of bioactivity [3]. In the first step, the hyperbranched HPLA with ductility was synthesized by chain extension reaction of four-armed PLA. The HPLA sample showed a tremendous increase in the elongation at break to 158.9%, which was much higher than linear PLLA with an elongation to failure no more than 10%. In the second step, various amounts of aniline tetramer (AT) were grafted on the end hydroxyl group of hyperbranched HPLA by esterification. The electroactive HPLA (HPLAAT) remain the ductility and was endowed electroactivity. CV test verified the electroactivity of HPLAAT samples. These HPLAAT polymers also showed improved thermal stability and demonstrated tunable enzymatic degradation behavior which was relevant to their natural degradation after transplantation in vivo. Importantly, the HPLAAT significantly improved the proliferation of C2C12 myoblasts in vitro compared to HPLA. Furthermore, these polymers greatly promoted myogenic differentiation of C2C12 cells as measured by quantitative analysis of myotube number, length, diameter, maturation index, and myogenic marker expression at both mRNA (MyoD and TNNT) and protein levels. Taken together, our study shows that these electroactive, ductile and degradable HPLAAT copolymers represent significantly improved biomaterials for muscle tissue engineering compared to HPLA.

F05

Enzymatic Preparation of Fibroin-Based Functional Materials with Polyphenol

Oxidase

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Silk fibroin can be widely used in textile industry, medical and clinical fields, owing to its good biocompatibility, mechanical and physiological properties. Enzymatic modification of silk fibroins allows processing under mild conditions, offering a safer and cleaner alternative. Polyphenol oxidases (tyrosinase, laccase) can catalyze the oxidation of the phenolic hydroxyl group in tyrosine residues of fibroin proteins. These reactive groups that generated from enzymatic oxidation might further couple with amines, amino acids, and other amino-containing compounds, which provides a potential bio-method for functionalization of fibroin materials. In our recent work, we demonstrated that enzymatic incubation with a mushroom tyrosinase evidently impacted the structure of silk fibroins, and led to a noticeable change in the properties of the fibroin materials. Enzymatic grafting of chitosan and lactoferrin onto silk fibroins for antibacterial functionalizationwere carried out with the tyrosinase, respectively. The modified fibroin samples exhibited encouraging resistance to S. aureus and E. coli. Meanwhile, the actions of tyrosinase on the (+)-catechin were investigated, and improved antioxidant activity and better durability were obtained for the fibroin membrane after enzymatic coupling of catechin.Elastin was also successfully bonded to fibroinsurfaces with tyrosinase, the mechanical property for the composite membrane of elastin/fibroin was improved, together with satisfactory biocompatibility.The tyrosinase-mediated modification could be regarded as a potential bio-method for preparation of the fibroin-based functional materials.

F06

Self-healing Nanostructured Colloidal Gels for Bone Tissue Regeneration

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The extraordinaryself-healing ability of many human organsis the most important source of inspirations for design of synthetic materials capable of autonomously reversing the damage development. In particular, by employing individually week but collectively strong bindings at the microscopic level, many bone tissues such as bones showed intrinsic self-healing ability and high mechanical strength.

Enlightened by micro-architecture of bone tissues, we innovatively develop a class of colloidal gels which allow for a “bottom-up” approach for the design of mechanically strong and self-healing scaffolds by employing organic and inorganic nanoparticles as building blocks. By introducing non-covalent electrostatic interactions, such colloidal networks typically showed a intriguing shear-thinning and self-healing behavior, which can be attributed to the fast and reversible re-establishment of the electrostatic interactions between anionic and cationic nanoparticles as well as re-arrangement of

jammed particles packing upon gel equilibration. The use of nanoparticles, which can also serve as delivery vehicles for therapeutic purposes, rendered the gels of capable of programmable release of multiple biomelucules by fine-tuning individual particle degradation. Further in vivo studies confirmed their decent biological properties of the injectable gels as well as capacity to accelerate bone regrowth even in load-bearing physiological condition.

Therefore, these novel colloidal gels that allow autonomic repair of structural and mechanical properties, and be capable of controllable release of therapeutic biomolecules to provoke the cascade of intrinsic healing process of human tissues could potentially open a promising avenue for the design of biomaterials for tissue regeneration.

F07

Effects of ICA on the Proliferation and Secretion of Chondrocytes in Bioscaffold Based on 3D Printing Technology

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Articular cartilage plays an important role in weight-bearing and movement. However, it is also more easily damaged in intra-articular fractures. As the cartilage has no vessel and nerve, so it is hardly to repair itself once damaged seriously. Tissue engineering is a potential way to cure the cartilage damage because it combines scaffold and cells. Gels are commonly used as the base material for 3D bio-printing, which had been proved that it can provide the environment of extracellular matrix. Icariin (ICA), a traditional Chinese medicine which has been demonstrated to be a promoting compound for extracellular matrix synthesis and gene expression of chondrocytes, is employed to investigate its potential ability in improving cell viability and promoting matrix secretion. The operating parameters for printing accurate composite bioscaffold were studied. The printing velocity and the pressure provided by an air pump were found to be the dominant factors with optimized parameters of 18mm/s and 0.35Mpa, respectively. The printed scaffold has an interconnected porous microstructure with open pores. The cell adhesion experiment, showed that cells were circular, spread out broadly, unfolded completely and connected with each other after 1 h, 3 h, 5 h and 7 h. The MTT test indicated that the OD value of 10 μg/ml was much bigger than those of other groups of 100 μg/ml, 1μg/ml and 0.1μg/ml ICA ($p < 0.05$) after 7 and 14 days. The content of Glycosaminoglycan (GAG) released are determined by Dimethylmethylene Blue (DMMB) dye-binding assay and the results reveal that ICA can promote the release of GAG with a best concentration of 10 μg/ml.

F08 (Invited)

R & D and Application of Biomedical Metal Materials in Advanced Manufacturing Implants

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Biomedical metal materials belong to the new multifunctional materials used as diagnoses, therapies and substitute for human tissues, organs and promoting their functions, the effect of which can not be substituted by drugs. Since the advanced implants used by advanced manufacturing technique such as Ti dental implants, artificial joints and vascular intervening stents etc. have been widely applied, the various problems emerged during the long-term cure had promoted researchers to improve traditional biomedical materials, and also to develop novel biomedical titanium alloys in the meantime. In order to satisfy the various clinical demands, biomedical Ti alloys must have the excellent biomechanical compatibility to ensure the long-term service of surgical implants. Aim at the high-level devices to develop the advanced manufacturing technology such as 3D printing, porous and micro-nano forming etc., and to study on the application and method innovation of these new technologies. Because of the special surrounding of human body, the implants have to possess the following properties other than the biocompatibility: (1) bio-functionality; (2) continuous stability; (3) biomechanical adaptability with human bone, in which they are closer relationship with biomechanical compatibility; (4) easy to machining, lower finished cost.

To improve or enhance the Ti alloys with excellent biomechanical compatibility has become an important research direction of surgical implants materials. The paper summarizes the international researches, developments and application of biomedical titanium alloys, aims at the increase in biomechanical compatibility and better workability, also introduces the exploration and improvement of alloy designing, working processing, microstructure and phase transformation, and finally outlines the directions for scientific research on the biomedical titanium alloys in the future.

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F09 (Invited)

Application of Supercritical Fluid Technologies in Drug Delivery System

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Supercritical CO_2 technologies have been shown to have greatpotential in pharmaceutical science; they are effective in producing drug and/or polymer particles for biomedical applicationsdue to the mild

critical conditions (Tc = 304.1 K, Pc = 7.38 MPa),non-toxicity, non-flammability, and low price of supercritical CO_2. We have employed the supercritical CO_2 technologies in the developments of drug delivery system as follows.

With the combination of organic nonsolvent, we have successfully used the solution-enhanced dispersion by supercritical CO_2 (SEDS) to produce the drug or polymer fine particles without contamination. And the drug-polymer composite particles with sustained-release functions were also studied.

We have designed a novel process of suspension-enhanced dispersion by supercritical CO_2 (SpEDS), which has been successfully used to produce the core-shell structured drug-polymer composite microspheres with a higher drug load, encapsulation efficiency and longer sustained-release effect.

An emulsion-combined precipitation of compressed CO_2 antisolvent (PCA) process has been developed to fabricateporous polymer microspheres, which meetthe requirements for pulmonary drug delivery. This process has potential for producing a promising inhalable carrier for pulmonary drug delivery, particularly for the protein drugs which are limited in oral administration.

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F10

Raman Imaging Helps Assess and Study the Biocompatibility of Biological Materials

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Raman spectroscopy and imaging are known to be valuable tools for the analysis of materials, from organic compounds to inorganic material. Raman Imaging technology provides a fast, non-destructive, in-vivo tool to help study the formation or deformation of the biological tissues or cells. Meanwhile, it can help assess and study the biological replacement materials, for example, the biocompatibility, the deformation, and the biological growth. The most recent application, Raman Imaging was applied to the characterization of a new carbon hydroxyapatite/β-glucan composite developed for bone tissue engineering. The composite is an artificial bone material with an appetite-forming ability for the bone repair process.

F11

Biological Evaluation of Three-dimensional Printed PLGA/ TCP Scaffold for Jaw Restoration

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To explore the probability of using low temperature rapid prototyping (LTRP) technique to fabricate the customized scaffold for jaw restoration and evaluate its biological properties.

LTRP technique was used to fabricate the PLGA/TCP scaffolds. Micro-CT and scanning electron microscope (SEM) were applied to characterize the surface morphology and porosity. Confocal laser scanning microscope (CLSM) was exploited to observe the features of the MC3T3-E1 cells adherent to the scaffold. Meanwhile, the proliferation capability of the cells at the 1st, 2nd, 3rd day after treated with the extracts of the scaffold was assessed by the cell counting kit-8 (CCK-8). Moreover, The PLGA/TCP scaffolds incorporated with recombinant human bone morphogenetic protein-2 (rhBMP-2) of high and low dose were implanted into the latissimus dorsi muscle of the rats, and 6 weeks later, the samples were harvested to estimate the volume and shape of the new bone.

The architecture of the 3D printed PLGA/TCP scaffold was fully controlled and uniformed with 100% connectivity rate. The porosity was 72.9±2.54% and the diameter of the pores was 353±22 μm. There were also micropores of different sizes in the struts, which increased the superficial area. The biological properties were excellent with lots of viable MC3T3-E1 cells adhering on the exterior and inner surface validated by F-actin staining and calcein AM vital staining, which corresponded to the CCK-8 test demonstrating that this material could accelerate the proliferation ability of the cells in the early stage ($P < 0.05$). For in vivo test, the histological examination and micro-CT showed an obvious ectopic new bone formation of the PLGA/TCP scaffold incorporated with rhBMP-2, but the scaffolds of high-dose group were with irregular shapes.

Customized PLGA/TCP scaffolds for jaw restoration can be manufactured by LTRP. The scaffold showed an excellent biocompatibility and ectopic osteoinductivity when incorporated with rhBMP-2. However, the shape of the tissue engineered construct with high-dose rhBMP-2 did not match the initial scaffold.

F12

Degradable Photothermal Conversion Materials Based on Two-Dimensional Black Phosphorus

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Nanomaterials with strong near-infrared absorption and high photothermal conversion ability have shown great application potential in many areas including cancer treatment. However, the current photothermal conversion

nanomaterials generally have poor biodegradability and would stay in the body for a long period of time accentuating the risk of deleterious effects, which limit their clinic applications. Recently, we have developed a kind of biodegradable photothermal conversion nanomaterial based on black phosphorus, a newly developed two-dimensional semiconductor. It has been found that black phosphorus has high photothermal conversion ability, and can degrade into nontoxic phosphate and phosphonate in aqueous media. However, their photothermal applications still suffer from rapid degradation of their optical properties during circulation in the body. Based on these facts, we first explore the synthesis strategy to control the thickness and lateral size of black phosphorus, and improve their near-infrared photothermal conversion performances. Secondly, we study the biodegradation behavior and photothermal cancer therapy based on black phosphorus. Surface coordination and polymer encapsulation are suggested to control the degradation rate of black phosphorus in physiological mediums. By using the black phosphorus after such treatments, It has been achieved not only the stable optical performance and tumor accumulation for highly efficient photothermal cancer therapy, but also ensuring that the materials can be discharged harmlessly from the body after completion of the therapeutic functions. The successful development of such biodegradable photothermal conversion nanomaterials would promote its clinic photothermal applications.

F13

Silk-based Flexible Solid State Supercapacitor PreparedbyScreen-Printingfor Wearable Applications

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Flexible supercapacitors have attracted much attention owing to their great potentials in wearable electronics. However, flexible solid state supercapacitor with silk fabric as the supporting substrate has not been realized. In this work, a simple and low-cost method is introduced to fabricate flexible solid-state supercapacitors on silk fabric via screen printing technology for the first time. With conidium-derived carbon/MnO2 as active materials the silk-based symmetric supercapacitors were prepared by screen-printing, exhibiting a volume capacitance of 1.495F/cm3 at a scan rate of 10mV/s and an energy density of ~1.7 μWh/cm2 at a power density of 0.434mW/cm2. Due to its excellent flexibility and good performance, the screen-printed supercapacitor could be used as an energy supply unit in a wearable system.

F14

Microstructure-Related Mechanical Properties of Nacre in Pinctada Shell

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Biological materials with various outstanding properties have been studied for a long time by investigators. As a

kind of natural biological material, sea shells exhibiting the complexity and unique architectures have drawn much attention in recent years. In the present work, Pinctada shell was selected as the target material, and its microstructures and mechanical properties were characterized by SEM, XRD and three-point bending tests. SEM examinations show that this shell exhibits a nacre (brick-and-mortar) structure, which is stacked by mineral-plates along the thickness direction. The XRD patterns reveal that the phase composition is merely composed of aragonite CaCO3 for the whole shell. The bending strength of the shell has a relationship with the positions on the shell both along longitudinal and transverse directions (namely, parallel to or perpendicular to the growth line of the shell). At the same position, there is no difference in the strength along these two directions, while the strengths exhibits different values at different positions since the thickness of aragonite plates changes depending on the position. Specifically, the thinner the aragonite plates, the higher the bending strength is. It is expected that these studies can further reveal the fracture mechanisms in the nacre structure, and provide a experimental basis for developing high-performance biomimetic materials.

KEYWORDS *Pinctada* shell; Nacre; Aragonite; Plate thickness; Microstructures, Three-bending strength

F15 (Invited)

Nano-functionalized Silk for Smart Wearable Devices

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With rapid advances of miniaturization and wireless technologies, electronics has been associated with traditional textiles to develop smart wearable devices for daily health monitoring and fitness tracking1-2. It is of great demand to fabricate flexible materials that possess both wearability and practical functions for wearable devices.

Silk from Bombyx mori cocoons, a natural protein fiber consisting of 18 amino acids, is considered as an ideal support for wearable electronics because of its softness, high hygroscopicity and superior skin affinity3, which fulfill the basic requirements of wearable devices on comfort and flexibility. However, practical applications of silk as building components of wearable devices are still rare due to its lack of specific functions such as sensing and conductivity.

In this talk I will first introduce properties and applications of silk, a natural protein fiber with great flexibility, environmental friendliness and excellent mechanical strength. Our research works on surface modification of silk with nanomaterials for antibacterial applications will then be presented. Thirdly, fabrication of a silk fiber sensor for physiological measurements will be discussed. Finally, I will show our recent achievements on the preparation of conductive silk textiles and their application in thermal sensing4-8.

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Program of the Municipal Higher Educational Institution of Chongqing

F16 (Invited)

Self-Defensive Metallic ion Coordination Polymer/Titania Nanotube System with Bacteria-Triggered Antimicrobial Agent Release

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The current work reports novel hybrid coatings with highly efficient, bioresponsive, controlled-release antibacterial activity constructed by buildingcoordination polymer ontitania nanotubes (TNTs). These hybrid coatings exhibit a self-defensive behavior triggered by acidification of the immediate environment by pathogenic bacteria, such as the gram-negative bacterium *Escherichia coli*(*E.coli*) and gram-positive bacterium*Staphylococcus aureus*(*S. au*). The antibacterial agents such as antibiotics and nanosilver can be loaded in TNTs that are sealed by coordination polymer through the connection of metallic ions such as Zn^{2+}or Ag^{+} as intermediate coordination bonds being sensitive to H^{+}. Release profiles confirm that the amount of antimicrobial agents released from all coatings keeps a very low level at pH 7.4 even for as long as over 20 days. However, the covered coordination polymer can be uncpaped to release antibacterial agents from TNTs due to the breakage of the coordinate bond triggered by lowing pH. The release rate increases as the pH value decreases. Consequently, these coatings exhibit an increased antibacterial efficiency as the acidification becomes serious in the biological environment. In addition, thishybridsurface system favors the proliferation and ontogenesis of MC3T3 osteoblasts at earlierstage (3 days) and middle stage (13 days), respectively. Hence, these smart coatings demonstrate a great potential for the development of hard tissue implants with excellent self-antibacterial performance and good biocompatibility

F17

The Research Progress of Biodegradable Zn-Based Alloys Used for Medical Application

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Biodegradable medical device which can be completely degraded and disappear after the healing of human body tissues would avoid a second surgical procedure to remove the temporary parts for fixation. Zn ion is a vital nutrient and anti-inflammatory factor for life. Zn ion can be absorbed and have no poisonous side effects during degradation of the Zn-based alloys. And zinc is widely acknowledged as an essential element for biological function. What's more, zinc has an appropriate degradation rate, slower than magnesium faster than iron.

Recent years, zinc based alloys as a new biodegradable metal material aroused the interest of some researchers. This report comprehensively reviews the research progress of biodegradable Zn-based alloys used for medical application, including improving the properties of alloys, the research of used as orthopedic device and stents. In addition, the problem and development trends of Zn-based alloys are summarized.

F18

Molecular Design of Bioprobes and Their Biological Applications

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Highlighted for their high signal-to-noise ratio, high spatial and temporal resolution, and noninvasive nature, targets-sensitive fluorescent probes in combination with digital fluorescence imaging technology is regarded as a promoting pivotal method for monitoring biological species or their metabolizing process in living cells. As a result, the development of novel easy-accessible probes with favorable photophysical characteristics, such as large Stokes shift, emission in visible to NIR region, and photostable, and usable in aqueous media for biological applications are vigorously pursued. In the past few years, we developed a series of probes with ClO-, Cu2+, homocysteine, NADH selectivities. The abilities of these probes as fluorescence tracers to detect the target species in live cells were investigated in details by confocal microscope.

F19

Thoughts and Practice of Design, Fabrication and Application for Traditional Chinese Medicines' Functional Separation of Material Substance

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1. The Chemical Composition of Traditional Chinese Medicines' substance

Chinese medicine and its compound is essentially a special, macrocosm drug group , which was made of a different chemical composition of the Chemical mother nucleus. Chinese medicine effective components such as alkaloids, flavonoids, glycosides, etc., which molecular weight is less than 1000 mostly. They constitute the material basis of the Chinese medicines. On the other hand, non-medicinal ingredients such as starch, proteins, pectin, tannin 's molecular weight islarge than 50,000. It is believed that they are the main cause of the current Chinese medicine's disadvantagessuch as large taking dose, poor stability andpoor quality control system. therefore, it requires the "refine "unit operations to remove the non-medicinal ingredients.

2. The situation of technique and materials used in Chinese medicine effective substance separation

Currently, the "separation" method for purifying Chinese medicine including alcohol precipitation, membrane separation, flocculation method and macroporous resin adsorption, with the purpose of removing non-efficacy of polymer material. The main mechanism of alcohol precipitation method is usingthe solubility difference of large and small molecules to remove the polymeric substance. Membrane separation method is using the different rejection rate of different molecular species to remove polymeric substance; Flocculation method is adding clarifying agent adsorption to remove coarse particles in the solution; Macroporous resin is to separate different substance by ifference between the different molecular sieve and van der Waals forces,. The method described above can achieve different degrees of refining effect, but there are lots of disadvantages such as loss of efficacy ingredient, low degree of purification and so on.

3. The design and preparation ideasfunctional materials used for traditional Chinese medicine effective substance separation.

This article is focusing the ideas of design and preparationseparate functional materials for Chinese medicine effective substances seperation, including the following two parts:

The discovery and exploratory research technique about "Resin composition" to refine Huanglianjiedutang, based on knowledge Discovery.

The scientific hypothesis, basic research methods and research framework based on the relation between "Membrane function - TCM solution structure - membrane structure"

F20

A Study on The Microstructures, Tensile Properties and FEM of a New Metastable Titanium Alloy Tube

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The microstructures characteristics of a new high strength metastable beta type titanium alloy Ti-Mo-V-Cr-Al system cold rolled seamless tube and the room temperature mechanical properties evolution under different heat treatment condition were studied. The results show that, the microstructures and mechanical properties are sensitive to heat treatment process. The main factors effecting the mechanical properties are the size and volume fraction of secondary alpha phase. The ultimate strength of the alloy is about 1226MPa, the yield strength is about 1150MPa and the elongation value is about 8% at 800 ℃/1h+530 ℃/8h. The ultimate strength of the alloy is about 1213MPa, the yield strength is about 1109MPa and the elongation value is about 8.5% at Y+560 ℃/4h. The mechanical properties show a better matching of strength and plasticity. The room temperature tensile fracture is made up of fibrous zone and shear lip zone with an obvious boundary at 800 ℃/1h+530 ℃/8h and Y+560 ℃/4h. The center of the fracture exists a lot of equiaxial dimple and presents ductile fracture. The fracture mode is microporous concentration.

F21 (Invited)

The Insight into the Development of Titanium Dental Implant

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Dental implantation surgery has been clinically conducted widely in the domestic stomatology hospitals. However, the dental implants are almost all imported from the developed countries, such as Swissland, Us and Germany. We allied with the domestic medical device company and dentists 8 years ago and developed a new kind of dental implant of titanium. After 8 years of combined efforts, the implant product received the Register Certificate from the SFDA in December of 2014 and has formally sold in the domestic market since last year.

In this paper, we reviewed the difficulties we overcame during the years of research and development of the implant. The focus is on the surface modification of the implant root and the connect junction between the implant root and the crown base. The SLA(Sandblast + Acid etch) surface with craters of various dimension is necessary for the implant root to achieve firm fixation of the titanium root inside the alveolar bone. In addition, the stable and strong connection between the implant root and the crown base is the decisive fact for the success of implant product. The taped connect junction is vital for this purpose.

F22

Fabrication, microstructure and properties of HA/Mg-Zn-Ca bio-composites

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A biodegradable magnesium matrix and HA or beta-tricalcium phosphate (β-TCP) particles reinforced composite Mg–Zn–Ca/1beta-TCP (wt.%) and Mg–Zn–Ca/1HA (wt.%) were fabricated for biomedical applications by the novel route of combined high shear solidification (HSS) and equal channel angular extrusion (ECAE). The as-cast composite obtained by HSS showed a fine and equiaxed grain structure with globally uniformly distributed particles in aggregates of 2–25 μm in size. The hot deformation behavior of nano-sized hydroxylapatite(HA) reinforced Mg-3Zn-0.2 Ca composites were performed by means of Gleeble-1500D thermal simulation machine in the temperatures rang 523-673K and strain rates 0.001～1s-1 , and the microstructure evolution after hot deformation were also investigated. The optimum process conditions of composite might be concluded as 573–623 K/0.001–0.1 s-1. The addition of HA or TCP in magnesium alloy can improve the mechanical and corrosion resistance to some extent. The corrosion behaviour of composites in SBF were investigated by means of scanning electrochemical microscopy (SECM) and cell biocompatibility in SBF were also investigated.

F23

Preparation of Intelligent Supramolecular Hydrogels and Its application as 3D culture scaffold of ovarian cancer cell

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Destination: to prepare intelligent suparmolecular hydrogel by mimicking the key features of extracellular matrices (ECM) and culture ovarian cancer cells in 3D mold, then investigate the influence of microenvironments on behavior of cells.

Method: Through using the inclusion complexes interact between trans-azobenzene (or adamantane) groups and cyclodextrin cavities, some novel supramolecular hydrogels based on poly(methyl vinyl ether-alt-maleic acid) (P(MVE-alt-MA)) were formed from azobenzene (or adamantane) grafted P(MVE-alt-MA) (P(MVE-alt-MA)-g-Azo (or Ad)) (guest polymer) and β-cyclodextrin grafted P(MVE-alt-MA) (P(MVE-alt-MA)-g-β-CD) (host polymer) respectively. These hydrogels were used as matrix to culture ovarian cancer cells.

Results: These supramolecular hydrogels are intelligent or stimuli-responsive. The hydrogel (P(MVE-alt-MA)-g-Azo/P(MVE-alt-MA)-g-β-CD) are sensitive to both light and heating, and the hydrogel (P(MVE-alt-MA)-g-Ad/P(MVE-alt-MA)-g-β-CD) is self-healing, as shown by rheological properties. Using these intelligent hydrogels as cell culture scaffold to culture ovarian cancer cells, it was found these hydrogel are cytocompatible.

Conclusion: These smart hydrogels provided a good platform to study the behavior of ovarian cancer cells, namely, allow us to further deeply investigate the influence of microenvironments on behavior of cells.

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Keyword: P(MVE-alt-MA) hydrogel, 3D culture, ovarian cancer, ovarian cancer stem cell

F24

In Vitro Study On Corrosion Behaviors of Novel Zn-ZnO Composites

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Currently, the widely investigated Mg, Fe and their alloys are facing the corrosion rate problems, either too fast or too slow. Zn has standard electrode potentials between Mg and Fe, implying a more apposite degradation rate[1].Moreover, Zn is an essential element of human body as well[2]. In the present study, Zn composited with different contents of ZnOwas studied to see if we can tune its degradation rate.

Keywords: Zn-ZnO composites,*In vitro*, Corrosion behaviors, Biodegradable metal

F25 (Invited)

Preparation and Characterizations of Eucomma Ulmoides Gum/Polypropylene or Polyolefin Elastomer Thermoplastic Vulcanizate

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Using Eucommia ulmoides gum (EUG)/Polypropylene (PP) and EUG/polyolefin elastomer (POE) blend, we

prepared new type thermoplastic vulcanizates (TPV) successfully and characterized it in the various properties such as the tensile strength, toughness strength, crystallization and so on. The results showed that EUG has some good features to make a new structural TPV.

Keywords: Eucommia ulmoides gum(EUG); polyolefin elastomer(POE); thermoplastic vulcanizates (TPV); preparation; characterization

F26

Intrinsically ^{89}Zr-Labeled Gd_2O_2S: Eu Nanoprobes for in vivo PET And Γ-Ray-Induced Radioluminescence Imaging

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Objective: Cerenkov luminescence imaging (CLI) is a non-invasive imaging technique showing immense promise for clinical translation. However, weak signal intensity and poor tissue penetration depth are two shortcomings that limit its clinical applications. γ-ray-induced optical luminescence imaging, combining the merits of CLI with optical imaging, has the capacity to overcome the current limitations of CLI. In this study, Gd2O2S:Eu nanoparticles, radiolabeled with 89Zr, were optimized for in vivo sentinel lymph node (SLN) mapping using PET and γ-rayinduced optical luminescence imaging.

Methods: Uniform, cubic and mono-dispersed Gd2O2S:Eu nanoparticles (diameter ~20nm) were synthesized using a thermal decomposition method. These highly biocompatible and water-soluble nanoparticles were prepared using a single polythylene glycol (PEG) modification. The nanoparticles were comprehensively characterized, before undergoing chelator-free radiolabeling with 89Zr, for in vivo SLN mapping in BALB/c mice. Extensive in vitro, in vivo, and ex vivo experiments were performed to evaluate the pharmacokinetics, stability, and toxicity of these nanoparticles.

Results: Highly biocompatible and water-soluble 89Zr - Gd2O2S:Eu nanoparticles were successfully synthesized, using chelator-free technology, for in vitro and in vivo lymph node mapping. The nanoparticles were successfully excited by γ-rays emitted from 89Zr in vitro after hydrophilic modification. Upon subcutaneous injection of 89Zr - Gd2O2S @PEG nanoparticles (40μ L, ~2.26 MBq) into the left foot pad of normal BALB/c mice, serial PET scans were performed. Accumulation of 89Zr - Gd2O2S @PEG in the popliteal lymph node was found to be 8.6±4.1, 13.4±3.3 and 4.4±1.7 percentage of injected dose per gram of tissue (%ID/g) at 0.5, 2, and 6 h post-injection, respectively (n=3). Moreover, the accumulation of 89Zr - Gd2O2S @PEG in lymph nodes was clearly detected by γ-ray excited optical luminescence imaging at 0.5 and 2 h postinjection regardless of open filter (detecting both Cerenkov signal of 89Zr and γ-ray-induced luminescence signal) or 620 nm filter (detecting only γ-ray-induced luminescence signal, but NOT Cerenkov signal of 89Zr). Quantitative analysis further illustrates that the intensity of luminescence from the89Zr - Gd2O2S @PEG in 620 nm filter was 10-fold lower than that in open filter, but the potential application in vivo is

prominent compared with CLI. Ex vivo studies corroborated our findings in vivo, providing additional evidence that 89Zr - Gd2O2S @PEG nanoparticles may be successfully employed for SLN mapping with γ-ray-induced optical luminescence. Conclusion: This study successfully employed 89Zr -labeled europium-doped Gd2O2S nanoparticles for SLN mapping with PET and γ-ray-induced optical luminescence imaging, improving upon the current limitations of CLI in vivo and providing a new path for the development of dual-modality PET/optical imaging technologies.

F27

Influence of Biocompatible Ag, Fe, Y Ions on the Behavior Of Mg–1Ca Alloy Treated With MEVVA

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Magnesium alloys with unique biodegradable trait raise great interests among researchers. However, overquick degradation rate has become the biggest problem limiting the further application of biodegradable magnesium alloys1. Plasma ion implantation has been considered good and convinient surface modification technique since it would introduce no abrupt interface and layer delamination, as well as independent of thermodynamic limitations2. However the influence of plasma ion implantation on biodegradable magnesium alloys seems controversial, for both enhanced corrosion resistance and accelerated corrosion rate were reported3-7. Herein we evaluated 3 kinds of ion implantation's influence on biodegradable magnesium alloys. Two kinds of corrosion mechanisms were proposed.

Keywords: Mg-Ca alloy; Plasma ion implantation; corrosion; biocompatibility

F28

Rapid and Green Fabrication of Micro- and Nano-Structural Titanium Dioxide Coatings on Titanium and Its Alloy

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Induction heat treatment (IHT) is inherently an efficient, clean, economical and easy- operated rapid thermal oxide

technology, which is well applied to surface modification of titanium and its alloys in medical field in the research. This method produces titanium dioxide coatings with a micro- and nanocrystalline structure on the surface of commercially pure titanium (TA2) and its alloy (Ti6Al4V) used in medicine. The special morphological characteristics, phase composition and structure, physico-chemical properties of the coatings formed by IHT are studied. Otherwise, different surface pretreatments, shot blasting and acid pickling, are used before IHT to study its effect on the oxide process and the properties of oxide coating. Consistency changes of morphological characteristics, properties and bioactivity of the thermal oxide layer obtained by IHT under tensile stress are also important results. The aim of this work is to determine the characteristics of bioactive micro- and nanocrystalline coatings, as well as to develop recommendations on producing these coatings using a new efficient method of induction thermal oxidation (ITO).

F29

Investigations of In Vitro Bioactivity of Sea Shells with Different Microstructures

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Biological minerals (e.g., shells, coral, etc.) not only exhibit outstanding mechanical properties with good toughness and strength, but also have a good biological activity due to the existence of organic matter of few percent. In the present work, three kinds of shells with different microstructures were selected as the target materials, i.e., Saxidomus purpuratus shell exhibiting a hierarchical structure with complex crossed-lamellar structure and porous fibrous/blocky structure, Scallop shell possessing a single crossed-lamellar structure, and Pinctada shell consisting of nacre (brick-and-mortar) structure. The growth of bone-like apatite on the surface of different layers in shells by a pre-treatment and an in vitro bioactivity assessment was investigated. Firstly, the specimens of different layers in these three shells were pre-processed by soaking them in phosphate buffer solution (0.2 mol/L Na2HPO4 and 5 g/L H3PO4 mixture), and an ion-exchange process was actually undergone. The results identified by XRD analysis show that the typical diffraction peaks of HAp appear in the XRD patterns of all soaked layers. It was confirmed by SEM and EDS examinations that, in Saxidomus purpuratus shell, the calcium phosphate compound deposition rate is slower and the deposition amount on the surface is relatively less in the complex crossed-lamellar layer than those in the porous block layer, and that the amount of calcium phosphate compound deposited on surface of Scallop shell are somewhat greater than that of Pinctada shell. Subsequently, the pre-processed slices were individually soaked in simulated body fluid (SBF) for a few weeks to explore the bioactivity. XRD and SEM analysis demonstrate that the different layers tend to exhibit a comparable bioactivity with the extension of soaking time. Finally, the effects of the different structures on the capacity of transformation into HAp and biodegradability in SBF solution were elaborated by detecting the changes of Ca and P concentrations. The obtained experimental results might provide some new ideas for developing hard tissue replacement materials with some desired performances such as low cost, superior bioactivity and suitable strength.

F30

Electron Transfer of Shewanella Putrefaciens Anode in Microbial Fuel Cells

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Surface chemistry of nanostructured materials plays a crucial role in interfacial electron transfer between bacteria and the electrodes, thus being of great significance for the performance of microbial fuel cells (MFCs). To address this issue, two electro-conductive organics (i.e.ionic liquid & phosphomolybdic acid) with different chemical properties were used to modify carbon nanotubes for improving interfacial electron transfer of Shewanella putrefaciens anode. The composite materials not only improve the adhesion of S. putrefaciens cells but also promote both of the flavin-mediated and the direct electron transfer between the S. putrefaciens cells and the anode. It is interesting that the composite materials are more favorable for the mediated electron transfer than for the direct electron transfer. CNT- ionic liquid/carbon cloth anode delivers 3-fold higher power density than that of CNT anode and shows great long-term stability in the batch-mode S. putrefaciens MFCs. The two composite materials could be a promising anode material for high performance MFCs. In summary, a suitable surface chemical modification can greatly boost the interfacial electron transfer from bacteria to electrodes through improving the hydrophilicity, electroactive area, electrochemical diversity of nanomaterials as well as promoting the anodic biofilm growth.

F31

Screen-printing of Bi_2S_3 Nanowires on Silk Fabrics for the Construction of Flexible Optical Switch

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Wearable electronics has been one of the hottest research topics in recent years and fabric is regarded as a very promising substrate for the wearable units because of its excellent wearability. So far, there is no report on the construction of a fabric-based optical switch. In the present work we fabricate a silk fabric-based optical switch via screen-printing of silver interdigital electrode and Bi2S3 nanowires network layer. Bi2S3 NWs with the length of tens of microns and the diameter of 80-400 nm were prepared using a hydrothermal approach. The device fabrication process was monitored with the scanning electron microscopy. The as-prepared optical switch could efficiently convert light signals to electric signals and display outstanding photoconductivity and ideal photocurrent response. The performance of the devices has no significant reduction after 150 cycles of distortion and bending. It is demonstrated that the switch

could be used to trigger a LED light and a small fan, indicating its great potentials in wearable applications.

F32

Efficiently Preparing Silk Fibroin Nanofibers by Ultrasonication

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Ultrasonication was used to prepare silk fibroin nanofibers directly from dumming silk fiber in aquous solution. The existing problems, the key influencing factors and different pretreated methods in ultrasonic preparation of SFN were analyzed detailly. The SFF pretreated with mixed solutions of sodium carbonate and sodium phosphate could fully split to hundreds of ribbon-like SFN under optimum ultrasonic condition. The thichness of generated SFN was about 80nm and the length was up to hundreds of micrometers. The statistical results of 100 micron range indicated that the width of 97% SFN was within 300 nm. The structural analyses indicated that these prepared SFN were a new silk fibroin nanomaterial which had more finer dimension and -OH groups than SFF. The prepared SFN will be a promising material for various biomedical applications for its unique structure characteristics and its simple, environmentally friendly and low-cost preparation process.

F33

Feasibility Study of the Natural Derived Chitosan Dialdehyde for Chemical Modification of Collagen

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The aim of the study is to evaluate the chemical crosslinking effects of the natural derived chitosan dialdehyde (OCS) on collagen. Fourier transform infrared (FTIR) spectroscopy, differential scanning calorimetry (DSC) and circular dichroism (CD) measurements suggest that introducing OCS might not destroy the natural triple helix conformation of collagen but enhance the thermal-stability of collagen. Meanwhile, a denser fibrous network of cross-linked collagen is observed by atomic force microscopy. Further, scanning electron microscopy (SEM) and aggregation kinetics analysis confirm that the fibrillation process of collagen advances successfully and OCS could lengthen the completion time of collagen fibrillogenesis but raise the reconstitution rate of collagen fibrils or microfibrils. Besides, the cytocompatibility analysis implies that when the dosage of OCS is less than 15%, introducing OCS into collagen might be favorable for the cell’s adhesion, growth and proliferation. Taken as a whole, the present study demonstrates that OCS might be an ideal crosslinker for the chemical fixation of collagen.

F34

Versatile and Low-cost Microfluidic Complement Fixation Combining with Luminol Chemiluminescence for rapid and sensitive Diseases Biomarker Detection

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The complement fixation test (CFT) is a serological test that can be used to detect the presence of either specific antibody or antigen to diagnose infections, particularly with microbes that are not easily detected by culture methods. In the study, a polydimethylsiloxane (PDMS) /glass slide hybrid microfluidic device was firstly developed to manipulate solution compartment and communication within the microchannel to set up sampler and indicator system of CFT. Solution-based and phase agar-based on-chip CFT assays have been successfully demonstrated for biomarker carcinoembryonic antigen (CEA) and recombinant avian influenza A (H7N9) virus protein detection. Miniaturized assay format significantly reduced the assay time and sample consumption. Secondly inspired by the forensic scientists to examine blood at the scene of crime, the luminol chemiluminescence (CL) reaction was applied in CFT for ultrasensitive detection of proteins. Physiological complement-mediated cell lysis and haemoglobin leaking can trigger catalysis of luminol to emit light. The combination of CFT and luminol CL system was demonstrated for the detection of rH7N9 with 2.5 h short assay time. The range of linear detection was 0.25 fg/mL–25 ng/mL with limit of detection(LOD) was 0.14 fg/mL. The on-chip CFT and CFT- luminol CL assay did not include time-consuming washing or blocking steps, or expensive chemical conjugates, highlighting its advantages over heterogeneous immunoassays such as ELISA or fluorescent immunoassay. Most attractively, the testing results can be imaged and analyzed by smart phone, strengthening its point-of-care application potential. It is anticipated that on-chip CFT would be a supplement or back-up tool for on-chip immunoassay/ ELISA for disease diagnosis, food supervision etc.

F35

New Sensitive Colorimetric Immunoassay Based on Magnetic Nanoparticles Labeled and Signal Amplification Strategy

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Conventional enzyme-linked immunosorbent assay (ELISA) catalyzed substrate to produce a colored product utilizing enzymatic reaction specifically, and then qualitative or quantitative analyze by colorimetry; although enzymatic cascade reaction can effective amplify the detection signal, but the enzyme as a protein has its own drawbacks, such as expensive, fragile that difficult to preserve, the results can not be stored for too long. The method utilize iron oxide magnetic nanoparticles instead of the traditional enzyme as a marker. Metal ion chelator (Bathophenanthrolinedisulfonic Acid Disodium Salt) dissolved magnetic nanoparticles and complex with ferrous ion to produced orange complex in the presence of ascorbic acid as a reducing agent. Finally detect the analyte by visual observation qualitative or UV-visible spectrophotometer quantitive to achieve colorimetric immunoassay. In the method, magnetic nanoparticles as a donor of iron, can release large amounts of ferrous ions after dissolved. It need not subsequent biochemical reactions to amplify the signal, the signal strength is directly related to the concentration of analyte, and test results can be stored for longer time. Under optimal conditions, limit of detection (LOD) at 3.6pg mL-1 was achieved in lab buffer with carcinoembryonic antigen (CEA) as model analyte, demonstrating its great potential for early cancer diagnosis. Moreover, the developed colorimetric assay method can be easily adapted to the detection of other biomolecules (nucleic acid, saccharides, micromolecule and so on) by simple changing the recognition pairs.

Keywords: Magnetic nanoparticle (MNP); Colorimetric immunoassay; Cancer diagnosis