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摘要集

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目　录

4D 打印形状记忆聚合物及其复合材料的研究进展

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摘要：形状记忆聚合物（SMP）是一类能够在外部环境刺激下主动改变形状的智能材料。基于智能材料的变形具有轻质、高强度和可变刚度的优点，在许多领域，如航空航天、生物医学、机器人和传感器中显示出巨大的应用潜力。本综述引导读者了解功能性 SMP 及其复合材料、4D 打印技术以及应用的最新进展。在本文中，我们回顾了使用分子结构设计、接枝功能团和添加功能性填料的功能性 SMP 材料的性能。氢键的形成、功能团的引入和网络结构的形成在提高 SMP 的性能方面起着非常重要的作用。简单的结构通过传统制造技术制造，其变形模式单一，这限制了智能结构的工程应用。增材制造技术具有高精度、高效率、高速和稳定产品的优点，近年来受到了越来越多的关注，特别是在小批量、个性和复杂形状方面。增材制造技术的出现不仅推动了智能材料和结构的发展，还为其在新领域的应用提供了新的机会。功能性 SMP 材料与 4D 打印技术的结合，可以实现复杂结构的快速加工及个性化设计，它为柔性电子、智能机器人和微创医学高科技产业带来了新的、更智能的发展方向。

关键词：形状记忆聚合物；复合材料；4D 打印技术；可变形结构；应用

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Research Progress of Shape Memory Polymers and Composites for 4D Printing

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Abstract : Shape memory polymers (SMP) are a kind of intelligent materials that can actively change their shape under external environmental stimuli. Based on the of smart materials, they have the advantages of light weight, high strength, and variable stiffness, and show great application potential in many fields, such as aerospace, biomedical, and sensors. This review guides the reader through the latest progress in functional SMP and their composites, 4D printing technology, and applications. In this paper, we the performance of functional SMP materials synthesized by using molecular structure design, grafting functional groups, and adding functional fillers. The formation of hydrogen bonding, the introduction of functional groups and the formation of network structure play a very important role in improving the performance of SMP. Simple structures are manufactured by traditional manufacturing technology, and their deformation mode is single, limits the engineering application of intelligent structures. Additive manufacturing technology has the advantages of high precision, high efficiency, high speed, and stable products, and has attracted more and more attention recent years, especially in small batches, personalized, and complex shapes. The emergence of additive manufacturing technology has not only promoted the development of intelligent materials and structures but has also provided new for their application in new fields. The combination of functional SMP materials with 4D printing technology can achieve rapid processing of complex structures and personalized design, bringing new and smarter development directions the high-tech industries of flexible electronics, intelligent robots, and minimally invasive medicine.

Key words : Shape memory polymer; Composite material; 4D printing technology; Deformable structure; Application

基于半互穿网络结构的 PEEK 导电功能化策略及其生物学性能研究

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摘要：聚醚醚酮（PEEK）具有优异的生物相容性以及与人体骨骼相近的弹性模量，是骨缺损治疗的理想植入材料。然而，其生物惰性仍是亟需解决的关键问题。本研究通过溶胀和原位聚合，将聚苯胺（PANI）导电高分子链引入 PEEK 的三维网络空间，形成 PANI/PEEK 半互穿网络（semi-IPN）导电层。所得导电 PEEK 材料具有优异的导电性（9.2×10^{-3} 至 5.2×10^{-2} S/cm）、与人体骨相匹配的力学性能以及良好的细胞增值活性。本研究为 PEEK 的导电功能化提供了一种简单且通用的策略，其导电性为目前已报道的 PANI/PEEK 复合材料中最高，并且此方法还可应用于其他生物相容性聚合物的导电功能化处理。

关键词：导电功能化；聚醚醚酮；半互穿网络；导电聚合物；原位聚合

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Electrically Conductive Functionalization Strategy of PEEK Based on Semi-Interpenetrating Network Structure and Its Biological Performance

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Abstract： Polyetheretherketone (PEEK) exhibits excellent biocompatibility and an elastic modulus similar to human bone, making it an ideal implant material for bone defect treatment. However, its bioinertness remains a critical issue to be resolved. In this study, polyaniline (PANI) conductive polymer chains were introduced into the three-dimensional network of PEEK through swelling and in situ polymerization, forming a PANI/PEEK semi-interpenetrating network (semi-IPN) conductive layer. The resulting conductive PEEK material demonstrates outstanding conductivity (9.2 × 10−3 to 5.2 × 10−2 S/cm), mechanical properties matching those of human bone, and excellent cell proliferation activity. This study provides a simple and versatile strategy for the conductive functionalization of PEEK, achieving the highest conductivity among reported PANI/PEEK composites. Furthermore, this method can be extended to the conductive functionalization of other biocompatible polymers.

Key words： Conductive functionalization， Polyetheretherketone, Semi-Interpenetrating network, Conductive polymer, In situ polymerization

含功能性基团 MOFs 在液相吸附的应用及复合智能基材的应用展望

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摘要：近年来，液相体系中杂质的吸附由于环境等问题的突出而受到越来越多地关注。由于在液相吸附中的吸附质无论是离子还是分子都具有自身的特点，所以针对不同类型吸附质的吸附就需要有针对性的吸附剂。而金属有机框架材料 MOFs 由于其良好的比表面积、丰富的反应位点而受到广泛地应用，进一步地，具有功能化基团的 MOFs 更能针对有各自特点的吸附质进行针对性定制吸附，即这种含功能性基团的 MOFs 往往能成为针对性的吸附剂，从而使得吸附能够实现高效率、低经济的双重化发展。本文从含有功能性基团的 MOFs 出发，综合概述了引入功能性基团的途径，以及不同类型的基团通过什么方式实现对吸附质的针对性吸附。最后，提出了含功能性基团的 MOFs 和吸附质的选择策略。该策略能够在面对一个特定的吸附质时，分析结构，选择具有合适的功能性基团 MOFs 进行吸附。同时，MOFs 本身的粉末状在应用中比较局限，复合合适的智能基材能够打破这种局限性，比如，经过脱木素处理后的轻木具有多孔的结构，其上具有丰富的官能团，能够为 MOFs 提供许多生长位点，并且由于木材本身的形状记忆效应，还能够压缩后在液相环境下形状回复。未来，这样的 MOFs/智能基材复合材料具有很大的发展潜力。

关键词：功能性基团；液相吸附；针对性；选择策略；MOFs/智能基材

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The application prospects of MOFs containing functional groups in liquid-phase adsorption and the application prospects of the composite of MOFs containing functional groups and smart substrates

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Abstract： In recent years, the adsorption of impurities in liquid-phase systems has received increasing attention due to prominent environmental and other issues. Since the adsorbents in liquid-phase adsorption, whether ions or molecules, all have their own characteristics, targeted adsorbents are required for the adsorption of different types of adsorbents. Metal-organic framework materials (MOFs) are widely used due to their good specific surface area and abundant reaction sites. Further, MOFs with functional groups can be more specifically customized for adsorbents with their own characteristics. That is, such MOFs containing functional groups can often become targeted adsorbents. This enables adsorption to achieve a dual development of high efficiency and low economy. This article starts from MOFs containing functional groups and comprehensively summarizes the approaches for introducing functional groups, as well as the ways in which different types of groups achieve targeted adsorption of adsorbates. Finally, the selection strategies of MOFs and adsorbents containing functional groups were proposed. This strategy is capable of analyzing the structure when facing a specific adsorbate and selecting MOFs with appropriate functional groups for adsorption。

Key words： functional gene，Liquid-phase adsorption，pertinence，selection strategy，MOFs/ smart substrate

低电阻和加载-卸载滞后优化的导电水凝胶复合材料

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摘要：本研究通过紫外光聚合构建聚丙烯酸/N,N'-双丙烯酰胱胺/溴化 1-丁基-3-乙烯基咪唑（PAA/NB/IL）双交联水凝胶，系统评价其力学，传感及生物相容性能。化学-物理双交联策略中，IL 的咪唑基团通过共价键与 PAA 网络结合增强导电性，NB 的二硫键与共价交联赋予力学稳定性。实验表明，PAA/NB/IL 100 在 120%与 150%应变下循环压缩滞后环面积分别为 0.019 MPa·mm/mm³和 0.028 MPa·mm/mm³，五次循环应力衰减率<3%。其电阻响应灵敏度达 20%（腕部弯曲 90°），细胞存活率>95%。该材料在动态形变恢复性、传感灵敏度与生物相容性间实现协同优化，为可穿戴柔性传感器提供新材料平台。

关键词：水凝胶；柔性传感器；生物相容性；力学性能；离子导电性；医疗电子；生物材料；可穿戴设备

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Conductive hydrogel composites optimized for low resistance and loading-unloading hysteresis

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Abstract： In this study, we constructed poly(acrylic acid)/N,N'-bis(acryloylcystamine)/brominated 1-butyl-3-vinylimidazole (PAA/NB/IL) double-crosslinked hydrogels by UV photopolymerization, and systematically evaluated their mechanical, sensing, and biocompatibility properties. In the chemical-physical double cross-linking strategy, the imidazole moiety of IL is bound to the PAA network via covalent bonding to enhance electrical conductivity, and the disulfide bonding of NB with covalent cross-linking confers mechanical stability. Experiments showed that the cyclic compression hysteresis loop area of PAA/NB/IL 100 was 0.019 MPa • mm/mm^3 and 0.028 MPa • mm/mm^3 at 120% versus 150% strain, respectively, with a stress decay rate of <3% for five cycles. It has an electrical resistance response sensitivity of 20% (90° wrist flexion) and a cell survival rate of >95%. The material is synergistically optimized between dynamic deformation recovery, sensing sensitivity and biocompatibility, providing a new material platform for wearable flexible sensors.

Key words： Hydrogel; Flexible sensor; Biocompatibility; Mechanical property; Ionic conductivity; Medical electronics; Biomaterial; Wearable device

氨基化碳纳米管改性环氧胶黏剂的粘接性能和吸波性能优化设计

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摘要：功能化复合材料结构的设计与连接通常需要用到兼具力学性能和优异电性能的胶粘剂。本文以多壁碳纳米管（MWCNT）及表面氨基化多壁碳纳米管（MWCNT-NH_2）为改性填料，研究了二者含量及表面氨基化对环氧胶黏剂粘接性能与吸波性能的影响规律。结果表明：MWCNT 对胶黏剂性能具有显著调控作用，随其含量增加，粘接强度呈“先升高-再降低”的变化趋势，而吸波性能则随含量增加持续增强。表面氨基化改性通过提升 MWCNT-NH_2 与环氧基体的界面相容性，显著优化了胶黏剂的粘接性能，但其表面官能团的引入导致 MWCNT-NH_2 电子结构改变和导电网络破坏，致使 MWCNT-NH_2 改性胶黏剂的吸波性能较未氨基修饰的 MWCNT 体系大幅下降。

关键词：复合材料连接；碳纳米管；氨基；胶黏剂；粘接性能；吸波性能

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Optimized Design on Bonding and Microwave Absorption Properties of MWCNT-NH2 Reinforced Epoxy Adhesive

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Abstract：The design and preparation of functionalized composite structures often require adhesives with both mechanical properties and excellent electrical performance. In this study, multi-walled carbon nanotubes (MWCNT) and surface-aminated multi-walled carbon nanotubes (MWCNT-NH_2) were used as reinforcing fillers to investigate the effects of their contents and surface amination on the bonding and microwave absorption properties of epoxy adhesives. Results show that MWCNT significantly regulate the adhesive properties: with increasing content, the bonding strength exhibits a trend of first increasing and then decreasing, while the microwave absorption performance gradually enhances. Surface amination modification improves the interfacial compatibility between MWCNT-NH_2 and the epoxy matrix, thereby significantly optimizing the bonding performance. However, the introduction of surface functional groups alters the electronic structure of MWCNT-NH_2 and disrupts the conductive network, resulting in a substantial decline in the microwave absorption performance of the MWCNT-NH_2-modified adhesive compared to the unaminated MWCNT system.

Key words：Composite Joining；MWCNT；Amino；adhesive；bonding；Microwave Absorption

基于多通道传感器的变曲率结构变形反演系统

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摘要：碳纤维复合材料的大范围应用对变形监测技术提出了更高的需求，当前常用的非接触式/接触式变形监测技术难以同时满足全局变形监测和实时性需求。本文在KO理论的基础上，结合应变传感器的工作原理构建了连续弯曲变形反演理论框架，并通过空间圆弧插补方法，得到反应变形特征的可视化曲线。结合变形反演理论的应用需求，开发了多通道传感器，传感器集成了7个传感单元和一体式可插拔金手指接口。其中，单独的传感单元具有和商用应变片媲美的传感性能，采用多通道传感器测量不同几何尺寸的圆环，证明了传感结果的曲率半径误差小于2.5%。最后，采用变形反演系统对模拟机翼后缘和碳纤维支撑杆的变形状态进行了测试，反演结果与实际变形结果展现出高度的一致性。

关键词：变形反演方法；电阻式应变传感器；多通道传感器；变体机翼后缘；复合材料变形监测

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A multi-channel sensor-based system for inverting the deformation of variable curvature structures

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Abstract: The extensive application of carbon fiber composite materials has put forward higher demands on deformation monitoring technology. The current commonly used non-contact/contact deformation monitoring technologies are difficult to simultaneously meet the requirements of global deformation monitoring and real-time performance. Based on the KO theory, this paper combines the working principle of strain sensors to construct a continuous bending deformation inversion theoretical framework. Through the spatial circular arc interpolation method, a visualization curve reflecting the deformation characteristics is obtained. In combination with the application requirements of the deformation inversion theory, a multi-channel sensor is developed. The sensor integrates 7 sensing units and an integrated plug-in gold finger interface. Each individual sensing unit has sensing performance comparable to commercial strain gauges. The measurement of circular rings with different geometric dimensions using the multi-channel sensor proves that the curvature radius error of the sensing results is less than 2.5%. Finally, the deformation inversion system is used to test the deformation states of the simulated wing trailing edge structure and the carbon fiber studdle. The inversion results show a high degree of consistency with the actual deformation results.

Key words: deformation inversion method; resistive strain sensor; multi-channel sensor; morphing trailing edge; composite material deformation monitoring

高温变构条件下柔性智能发汗冷却结构微通道形貌与应变调控机制

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摘要：面向跨大空域、宽速域、智能飞行等新的技术需求，兼顾防热与变形需求的柔性热防护结构已成为新一代智能飞行器实现气动外形实时调控的核心技术之一。然而对于采用主动热防护技术的柔性结构，其内部复杂通道在实现冷却剂高效输运和对流换热增强的同时，也引入了显著的局部应力集中效应。此类显著降低结构的疲劳寿命，尤其在变体机翼等需经历大变形幅度与高频变形的部位尤为突出。本文以橡胶基柔性智能发汗冷却结构为研究对象，通过施加近真实飞行环境下的热-力载荷工况，系统分析了结构内部通道边缘特征对力学响应的影响，为此类柔性热防护结构的优化设计提供了理论依据。研究采用圆角优化策略，重点探讨不同通道直径与角度下应变分布的调控机制。优化结构边缘特征对提升橡胶基热防护结构工程应用价值具有重要意义:一方面可有效规避大尺寸制备过程中脱模损伤的产生，另一方面可增强结构抗疲劳性能，从而实现更耐久的柔性热防护系统。

关键词：柔性热防护系统；橡胶基复合材料；热-力耦合；应力集中效应；应力优化

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Microchannel morphology and strain control mechanisms in intelligent transpiration cooling structures under high-temperature—deformation conditions

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Abstract: With the emerging technological demands for cross domain (flight regimes and speed domain)adaptability and intelligent flight capabilities, deformable thermal protection structures that concurrently addressthermal protection and structural deformation requirements have become a core technology for enabling real-timeaerodynamic shape regulation in next-generation intelligent aerospace vehicles. However, for thermal protectionmeasures employing active thermal protection technologies, the intricate internal channel networks designed toenhance coolant transport efficiency and convective heat transfer often induce pronounced localized strainconcentration effects. These phenomena significantly reduce structural fatigue life, particularly in morphing wingcomponents subjected to large deformation amplitudes and high-frequency actuation cycles. This study investigatesrubber-based transpiration cooling, intelligent protection structures under near-realistic flight thermal-mechanicaloading conditions. A systematic analysis of the influence of interal channel edge features on mechanical responsesis conducted, providing theoretical foundations for the optimized design of such deformable thermal protectionsystems. The research proposes a rounding optimization strategy to explore the strain distribution regulationmechanisms under varying channel diameters and angles. Optimizing structural edge characteristics holds significantimplications for enhancing the engineering applicability of rubber-based thermal protection systems: it not onlmitigates demolding-induced damage during large-scale fabrication processes but also improves fatigue resistancethereby enabling more durable deformable thermal protection architectures.

Key words: Deformable thermal protection system; Rubber-based composites; Thermo-Mechanical coupling; Stress concentration effect;　Stress optimization

氧化石墨烯/邻甲基苯胺-苯胺共聚物纳米复合材料的制备及磁阻性能研究

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摘　要：采用自组装法合成了氧化石墨烯/邻甲基苯胺-苯胺共聚物纳米复合材料，利用对苯二胺对氧化石墨烯进行改性，调控了氧化石墨烯界面，促进了邻甲基苯胺-苯胺共聚物在氧化石墨烯表面的聚合。傅里叶红外光谱（FTIR）、热失重分析（TGA）、X 射线光电子能谱（XPS）和 X 射线衍射（XRD）表征结果说明邻甲基苯胺-苯胺共聚物在氧化石墨烯表面成功实现共聚。磁阻效应测试结果发现，引入邻甲基苯胺-苯胺共聚物后，该纳米复合材料的磁阻效应从 1.35%降到 0.83%，这归因于共聚物分子的 N 原子上推电子取代基甲基的存在，增加了 N 原子上的电荷密度，降低了磁阻效应。该工作表明可以通过改变 N 原子上的基团的电负性来调控纳米复合材料的磁阻效应，为有机磁阻效应的调控提供了新的研究方向。

关键词：氧化石墨烯；邻甲基苯胺-苯胺共聚物；纳米复合材料；磁阻；电负性

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Preparation and magnetoresistance property of Graphene oxide/o-toluidine aniline copolymer nanocomposites

Abstract: Graphene oxide/o-toluidine-aniline copolymer nanocomposites were synthesized by self-assembly method. The graphene oxide was modified by p-phenylenediamine first to promote the polymerization of o-toluidine aniline copolymer on its surface. The characterization results of Fourier transform infrared spectroscopy (FTIR), thermogravimetric analysis (TGA), X-ray photoelectron spectroscopy (XPS), and X-ray diffraction (XRD) indicated the successful preparation of o-toluidine-aniline copolymer on the surface of graphene oxide. The magnetoresistance test showed that after introducing the o-toluidine-aniline copolymer, the magnetoresistance effect of this nanocomposite was decreased from 1.3521 to 0.8349%. This was attributed to the presence of the electron withdrawing substituent methyl on the N atom of the copolymer molecule, which increased the charge density on the N atom and reduced the magnetoresistance effect. This work demonstrates that the magnetoresistance effect of nanocomposites can be regulated by changing the electronegativity of functional groups on the N atoms, providing a new research direction for the regulation of organic magnetoresistance effect.

Keywords: Graphene oxide; o-toluidine aniline copolymer; nanocomposites; magnetoresistance; electronegativity

Water-Tuned Dynamic Hydrogen-Bond Networks and Modulus Mismatch Synergy for Interfacial Toughening in Bilayer Hydrogels

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Abstract: Hydrogels suffer from low modulus-induced crack propagation, restricting their applications due to insufficient fracture toughness. Bilayer systems can enhance fracture toughness via modulus mismatch, but its synergistic toughening mechanism with interfacial adhesion remains unclear. Herein, a bilayer hydrogel system was designed by integrating metal-complexed CNF-PAAM/PAA layers to create "soft-hard" modulus mismatch and a 0.1 mm CNF-PAAM/PAA interlayer for enhanced interfacial adhesion. The CNF-mediated dynamic hydrogen bonding networks in the interlayer address energy dissipation deficiency under dynamic loading. Experiments showed that with 0.63% CNF content and 68.63% water content, the interfacial adhesion energy reached 307 J/m², reducing the energy release rate by 29.7% compared to the non-interlayer system. The elastic mismatch mechanism synergized with a 0.1 mm interlayer reduced stress concentration at the crack tip, increasing the critical elongation to 10. Based on Dundurs' theory, an energy release rate expression considering water content was derived, revealing the quantitative synergistic toughening mechanism of "adhesion interface-modulus mismatch".

Keywords: Bilayer hydrogel; Crack propagation; Interfacial adhesion; Fracture toughness; Energy release rate

High-Strength Thermally Responsive Shape-Memory Epoxy Composites

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ABSTRACT: In this study, a high-strength thermally responsive shape-memory epoxy composite (HTSMEP) was prepared via physical blending to develop intelligent materials with both high strength and thermo-responsive shape-memory properties. Fourier transform infrared spectroscopy (FT-IR) and differential scanning calorimetry (DSC) results confirmed that polycaprolactone (PCL) was uniformly dispersed in the epoxy matrix at an amorphous state without significant chemical reactions, forming a stable two-phase system. Shape-memory performance tests showed that the lowest programming temperature (LPT) of these composites was decreased from 110 to 70°C with increasing PCL content from 5 to 20 wt%, and the shape fixity (Rf) remained above 98.9%, indicating an excellent shape retention capability. Mechanical property tests revealed that the tensile strength of HTSMEP with 5 wt% content of PCL reached 81.5 MPa (1.1 MPa higher than that of pure epoxy), while the breaking elongation of HTSMEP with 20 wt% PCL was increased to 14.2%, with 71% higher than that of pure epoxy. These composites exhibit a potential application in electronic devices, intelligent structures, and other fields.

Keywords: epoxy composites, polycaprolactone, thermally responsive shape-memory, high-strength

新一代可显影液态金属弹性载药微球的开发及其在可视化 TACE 治疗中的应用

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摘　要：经动脉化疗栓塞（TACE）是治疗肝癌、肾癌、盆腔癌等疾病的一种很有前途的策略。然而，传统的栓塞剂通常不具备显影效果，且栓塞能力有限，导致 TACE 术中难以实时监测，术后肿瘤坏死率低、易复发。因此，本课题从肝癌 TACE 临床治疗实践出发，针对“如何实现载药微球肝癌 TACE 过程的可视化，以提高肝癌 TACE 治疗效果”这一科学问题，开发了一种新型 X 射线可显影弹性液态金属栓塞微球（X-MEN）。由于特殊的“水球”结构，X-MEN 具有良好的导管通过性和粘弹性。扫描电镜观察显示，X-MEN 可以更紧密地相互配合，从而有效地栓塞肿瘤血液供应动脉。X-MEN 对肿瘤供血动脉的栓塞效果优于临床常用的微球栓塞。；另外，该微球具有良好的 X 射线显影性，可以在 TACE 术中实时监控微球输注，从而实现栓塞过程的精准操控，避免异位栓塞；这种可视化技术有助于提高治疗的精确度，减少对正常肝组织的损害。。因此，X-MEN 被证明是一种非常有前途的长效栓塞剂，用于可视化 TACE 治疗。

关键词：液态金属，经动脉化疗栓塞，可视化栓塞，微球，药物递送

A novel visualizable liquid metal elastic drug-loaded microspheres and their application in visualizing TACE therapy

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Abstract: Transarterial chemoembolization (TACE) is a promising strategy for the treatment of liver cancer, kidney cancer, pelvic cancer and other diseases. However, traditional embolizing agents usually do not have a imaging effect and have limited embolizing ability, resulting in difficult real-time monitoring during TACE surgery, low postoperative tumor necrosis rate and easy recurrence. Therefore, starting from the clinical treatment practice of TACE in liver cancer, this project, aiming at the scientific question of "how to visualize the TACE process of liver cancer with drug-loaded microspheres to improve the therapeutic effect of TACE in liver cancer", has developed a new type of X-ray visualizable elastic liquid metal embolized microsphere (X-MEN). Due to the special "water ball" structure, X-MEN has good catheter permeability and viscoelasticity. Scanning electron microscopy observations showed that X-MEN could cooperate more closely with each other, thereby effectively embolizing the blood supply arteries of tumors. The embolization effect of X-MEN on the arteries supplying tumors is superior to that of the commonly used microsphere embolization in clinical practice. ; In addition, this microsphere has good X-ray imaging properties and can monitor the infusion of microspheres in real time during TACE surgery, thereby achieving precise control of the embolization process and avoiding ectopic embolization. This visualization technology helps to improve the accuracy of treatment and reduce damage to normal liver tissue. Therefore, X-MEN has been proven to be a very promising long-acting embolizing agent for visualizing TACE treatment.

Keywords: Liquid metal, TACE, Visible Embolization, Microsphere, Drug delivery

形状记忆智能空间展开结构设计及其验证

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摘　要：形状记忆聚合物作为一种典型的智能材料，在特定的外界激励下（如热、电、光、磁等）能够从预先设定的临时形状回复到初始形状，在航天航空、生物医学等领域具有应用前景。本文综述了形状记忆聚合物复合材料的空间展开结构设计方法，详细介绍了可展开铰链、桁架、豆荚杆、智能锁紧释放机构等空间展开结构的设计、相关力学性能和展开功能验证。

关键词：形状记忆聚合物，复合材料，空间展开结构，铰链，锁紧释放机构

Design and verification of shape memory smart space deployable structure

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Abstract: Shape memory polymer, as a typical smart material, can recover from a pre-set temporary shape to its initial shape under specific external stimuli (such as heat, electricity, light, magnetism, etc.), and has application prospects in aerospace, biomedical, and other fields. This work summarizes the design method of space deployable structure based on shape memory polymer composite materials. It provides a detailed review of the design, mechanical properties, and deployable functions of space deployable structures, such as deployable hinges, trusses, bean pod rods, smart locking and releasing mechanisms.

Keywords: shape memory polymer，composite material，space deployable structure，hinge，locking and releasing mechanism