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Strengthening artificial muscle of oil-water composite network by nanotechnology

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Abstract. Artificial muscle, as a new technology, has a broad application prospect and market in the future, which is more effectively applied to the medical repair of human muscle damage, enhance the strength performance of human muscle, and enrich the function of artificial robots. Nanotechnology is also a high-precision technology that can be added to artificial muscles to make expansion and contraction more reliable. Currently, nanotechnology is constantly innovating in artificial muscles. There have been examples of using artificial muscles to add touch systems for real-time interaction and temperature changes, as well as combining sacrificial coordination keys with mechanical training processes to allow artificial muscles to bear more than their own multiple weights. Carbon catheters using nanotechnology have been shown to contract by as much as 20%. However, while focusing on enhancing the performance of artificial muscles, the bionic ability of the material itself has been neglected, and the elasticity and stretch of the muscle is a major difficulty. Therefore, there are still some shortcomings and areas that can be improved in this field. In this paper, we discuss how to use carbon conduit nanotechnology to strengthen artificial muscles, which provides effective reference materials for human beings to better understand the application of artificial muscle nanotechnology.

Keywords: Nanotechnology, artificial muscle, 3D printing technology, oil-water composite network, mechanical exoskeleton

1. Introduction

In recent years, with the continuous progress of science and technology, many breakthrough innovations have been made in all aspects of human life. Among them, artificial muscle technology is a research field that has attracted much attention. As an application of bionics, artificial muscle has broad potential and application prospect. This paper will analyze the development status and future trend of artificial muscle technology. First of all, let's understand the principle of artificial muscle technology. Artificial muscle is a kind of flexible material that can contract and stretch, which is realized by imitating and copying the structure and movement principle of muscle fibers. Can produce contraction or extension movement, thus simulating muscle movement. At present, artificial muscle technology has made a series of important breakthroughs. First of all, its application in the field of robotics has been widely explored. Artificial muscles can be used to drive the robot to make it more flexible and adapt to various environments. For example, some researchers have successfully applied artificial muscles to the design and manufacture of bionic arms, which makes the robot arm closer to the flexibility and accuracy of

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human arms. In addition, artificial muscle technology can also bring innovation to the medical industry. For example, artificial muscle can be used to solve the problem of muscle atrophy or injury. Patients with muscle diseases or loss of muscle function can restore their motor function by implanting or connecting artificial muscles. The development potential of this technology is not only to improve people's quality of life, but also to profoundly change the way of rehabilitation treatment. In the future, there are still many development spaces and challenges for artificial muscle technology.

First of all, we should improve the performance and maneuverability of artificial muscles. At present, there are still some problems in durability and stability of artificial muscle materials, which need further optimization and improvement. Secondly, it is necessary to reduce costs and promote commercial applications. At present, the research and development of artificial muscle technology is still in the laboratory stage. To realize its commercial application, more capital and human resources need to be invested. In addition, the application of artificial muscle technology also needs to face some ethical and legal considerations. The implantation and use of artificial muscle involves human intervention, and safety and morality must be guaranteed in this process. Therefore, relevant laws, regulations and moral standards need to be formulated and improved accordingly to ensure the reasonable and responsible application of artificial muscle technology. To sum up, artificial muscle technology, as a research field with great potential, has made important breakthroughs in the field of robotics and medical care. However, it still faces a series of challenges and problems, which need further research and improvement. With the continuous progress of technology and the increasing social demand, it is believed that artificial muscle technology will have a broader application prospect and bring more convenience and improvement to human life.

2. To analyze the problems in the research of artificial muscle

"In former China, 26 million people suffered from burns and scalds every year, 30% of them were children, and 96,000 children died of burns and scalds every year in the world" said by an expert in scar treatment [1]. Skin burns can't be repaired by themselves unless they are very slightly injured. In addition, the demand for skin transplantation is increasing due to large-scale skin damage caused by other reasons. So artificial skin transplantation has become a hot topic with the development of science and technology. At present, there are many ways to repair human skin by transplanting skin through genetic engineering. The research on artificial muscle is to a great extent to prepare artificial muscle through the hydrogel, silica gel, nylon thread, etc., so as to achieve the purpose of simulation. Hydrogel is one of the very good artificial muscle materials. Hydrogel keeps its initial stress (> 95%) after 500 tension cycles (strain 200%). Hydrogel is more than 70% water, so it is very compatible with human skin tissue. The electronic skin made of hydrogel can sense objects within 20 cm, respond within 0.1 seconds, and repair itself more than 5,000 times. This recovery process can be completed in about 0.25 seconds [2]. However, it is rarely found in synthetic polymer gel that has fiber structure and related mechanical hardening reaction to stress or strain. So the paper needs to find a strong mechanical power. As for the "central axis" used to assist the contraction of artificial muscles, nylon thread is often selected for rotational energy storage, which is a relatively novel preparation material because of its low price and moderate tension. In the preparation process, the crystals in the nylon component are melted, and the elastic effect of shrinking and pulling can be achieved after knot formation. The contraction force of normal human muscles is about 20%, while that of unprocessed artificial muscles only reaches 2%, and it will reach about 50% after nylon thread is stored [2]. On the current basis, the contraction force is higher than that of the bionic human body effect, but it is still not enough. It only reduces the high cost of nanotechnology and becomes lighter, but its shortcomings are also obvious. There is still a long way to go from the multi-faceted research of nanotechnology artificial muscle, which does not provide more help and enhance the sports effect of artificial muscle. Compared with nanotechnology, the stretchable contraction strength of artificial muscle is still insufficient. To sum up, we still need to find more tough materials to test, and everything goes back to the original point-nanotechnology. Nanotechnology belongs to high-precision density materials, and one micron is equal to 1000 nanometers. Nanotechnology is in the transition zone between the micro-world and the macro-world. In this range, research and free control of technology are carried out to find out more possibilities. The size of nanomaterials is closely related to their physical and chemical properties. When the size reaches the nanometer level, the relative volume of its surface area will be larger, which will significantly change the chemical activity, thermal stability, mechanical properties and photoelectric properties of the material. Compared with the artificial muscle made of nylon thread, the tensile test of nano-technology artificial muscle shows that the fiber toughness reaches 121.2 MJ m-3, which is comparable to natural silk. Its actuating performance is also excellent, in which the energy storage efficiency can reach 75.5%, the actuating strain can reach 80% and the actuating stress can reach 5.5 MPa. The Young's modulus of the fiber has changed greatly by four orders of magnitude during the actuation process, and the high-speed actuation with a strain rate of 150% per second can be realized under the condition of bearing 700 times the self-weight [3,4]. At present, nanotechnology has been promoted as the "darling" of the new era in many fields of materials, which are mostly used in nano-medicine, solar cells, biological imaging and other fields. In this environment, a number of journals have demonstrated the practicability of nano-hydrogel as an artificial muscle, which has opened a new research door.

3. Possibility of nanotechnology to meet the expected standards

Nano-materials are highly surface active, have a large amount of surface energy and unsaturated chemical bonds that allow them to adsorb any species, thus increasing the reactivity of metal catalysts and improving the thermodynamic properties of the materials. Nanotechnology is a very precise and meticulous cutting-edge technology. At present, a team has combined nanotechnology with hydrogel, and the colloid and surface chemistry produced are carbon nanotubes, such as fullerenes, various nanoparticles and nanorods, which provide valuable materials for nanotechnology artificial muscles [3-5]. This paper will demonstrate the feasibility of using nano-materials to make artificial muscle experiments from three aspects. First of all, nanoparticles can improve the elasticity and extensibility of hydrogel materials: a study has been conducted to prepare a material without elastic hysteresis in a polyacrylamide hydrogel with low cross-linking density and 96% water content using hyperbranched silica nanoparticles (HBSPs) as the main bonding site. When the strain ratio is 7, only 1.3% elastic hysteresis is observed. The fracture strain ratio of this material is 11.5. These hydrogels combined with nanoparticles have tensile strength and elasticity that other materials can't match. Secondly, nanotechnology can help skin repair quickly. Researchers at Indiana University School of Medicine have developed a technology that may be used to treat traumatic muscle loss. Previously, this technology has been proven to be able to transform skin tissue into blood vessels and nerve cells. Nanotransfection is a technique based on electroporation, which can deliver or transfect genes and drugs at the nanometer level. It is minimally invasive and can reprogram tissue functions by delivering specific genes in a short time with harmless electric sparks. Help skin repair, and hydrogel can effectively contact cells and tissues, because their water content reaches 70%, which promotes the effective release of drugs [5]. The mixed system containing hydrogels and nanofibers can realize the controlled release of factors promoting neovascularization and anti-inflammatory response. Thirdly, artificial muscle materials based on carbon nanotube yarns were first proposed by Prof. Baumann's team, and several breakthroughs have been made in this field. The research results were published in top international journals. In 2012, Science: a new type of carbon nanotube yarn artificial muscle, its strength can reach 85 times that of human muscle; Science in 2014: Cheap fishing line and sewing thread are twisted into artificial muscle fibers, which are 100 times stronger than human muscles; Science in 2017: carbon nanotube yarns that can generate electricity only need to be stretched or twisted; Science in 2019: Sheath drives artificial muscles; A new flexible refrigeration strategy-"twisted heat refrigeration"; 2021Science : Monopolar stroke, electro-osmotic pump carbon nanotube yarn artificial muscle. Generally speaking, nanotechnology is constantly progressing and exploring, and has made great progress in different aspects, which confirms that nanotechnology is in the leading and key position of artificial muscle[6-9]. However, the current research is in progress, and there are still difficulties and bottlenecks to be broken through, such as uncontrollable changes in temperature and ph, too thick artificial muscles or too expensive prices to achieve large-scale and mass production, and unable to help more disabled people and people in need to obtain artificial muscles that can repair their skin. In a word, the processing of artificial muscle by nanotechnology has been greatly improved, and the public view is also positive, which is enough to reach the expected standard and exceed a certain level, but there is still room for improvement, and further research and innovation are needed to determine the market of this technology by predicting its future development.

4. Future opportunities for nanotechnology-based artificial muscle processing

Although nanotechnology artificial muscle is in the state of research, it has achieved the expected goal and opened up more innovative fields. Some experiments in a new direction can be used to predict the future development and direction of nano-technology artificial muscle. The medical field has always been the most important research direction, which is related to the eternal topic of human destiny and life. Nano-technology artificial muscle is also of great significance in this respect. Nano-hydrogel electronic skin promotes the development of the bionic medical field, and chameleon changes its skin color by controlling periodic guanine nanocrystal arrays. Nano-cellulose hydrogel for electronic skin was constructed by HPC, PACA and CNT: cellulose nanocrystals were assembled, and bright-colored composite hydrogel was obtained by ultraviolet polymerization. Gels with different colors can be prepared by adjusting the HPC concentration. For example, when the HPC concentration is from 50wt% to 70wt%, the color of the gel changes from red to purple, due to the decrease of P [10]. The change in pressure and temperature can be felt through the color change of hydrogel. This can protect the damaged skin from secondary injury, and this kind of experiment has been simulated and practiced on human hands. The color of the stimulated part changes obviously; In addition, the recorded electrical signals show that the resistance of the material also changes accurately, which can also help people who have no nerves and lack pain response to know that the damaged part of artificial muscle is serious, so as to treat it as needed, which opens up a new direction in the future medical field. In addition, there can be new development of red blood cells and nanotechnology between artificial exoskeleton skin, which not only exists on the surface of artificial muscle but also has internal fluidity and transmissibility. The title of the paper is Modular Assembly of red blood cell superstructures from metal-organic Framework nano-based Building Blocks [11]. The nano-system based on biological/artificial hybridization of biological substances and synthetic nanoparticles is the holy grail of materials science at present. The enrichment behavior of nanoparticles in organs can be regulated, and the elimination half-life in vivo is as long as 66.3 hours, far exceeding that of ordinary nanoparticle carriers. Red blood cells show resistance to osmotic pressure, detergents, toxic nanoparticles and hemolytic pressure caused by freezing environment to some extent. At the same time, due to the modular design idea, it is convenient to load various functional nano-primitives, thus realizing multi-functional integration. In particular, loading fluorescent molecules, molecular probes, magnetic nanoparticles and other functional elements onto armored red blood cells can facilitate the introduction of various functions, such as blood testing, drug delivery, magnetic response, multi-spectral imaging and so on. The design strategy of multifunctional armored red blood cells not only promotes the construction and design of biological/artificial hybrid nano-systems but also shows broad application prospects in biomedical engineering. Nano-technology artificial muscle is well known by more people, and the competition in the industry is also increasing. More and more attention is paid to the analysis and research of the artificial muscle market, and a lot of investment has been obtained, which has carried out a relatively benign economic cycle. And listed more future research direction experiments show that nano-technology artificial muscle can be realized in more development directions in the future. Although there may be new shortcomings in the future, it cannot be denied that it is the best artificial technology in artificial skin at present, which can be used in many fields such as expansibility, intelligence, human-computer interaction, biomaterials and so on. The application prospect of nanotechnology is also very broad, such as solar energy, information technology and biomedicine. The focus of artificial muscle is in the field of biomedicine, but it will never be the end, but a brand-new beginning. In the future, nanotechnology will play an important role in the accurate treatment of cancer, the new energy revolution and industrial manufacturing. It is expected that more experimental studies in the future will not only let people know about nano-technology artificial muscle and apply it in more possible places, but also develop green, reduce the cost of industrialization, and enable more people in need to use nano-technology artificial muscle.

5. Conclusion

In general, artificial muscle technology, as a research field with great potential, has made important breakthroughs and constructive achievements in the fields of robotics, medical care and other major aspects. In this paper, the benefits, various advantages and research directions of nanotechnology for artificial muscle are discussed. However, it still faces a series of challenges and problems that need further research and improvement, such as the high price and the improvement of performance mentioned in this paper. This paper aims to objectively evaluate the various possibilities of applying nanotechnology to artificial muscle and hope the future prospect of artificial muscle. With the continuous progress of technology and increasing social demand, artificial muscle technology will have a broader application prospect and bring more convenience and improvement to human life.

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