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Application of Nanotechnology in Water Treatment and Wastewater Recovery

Linan Ye
Civil & Environmental Engineering, University of Illinois at Urbana-Champaign, Urbana, IL 61807, USA.

Abstract: "Ensuring clean drinking water" is a major challenge facing mankind in this century.The world's population base is large, the total population is growing, the water pollution is becoming more and more serious, and it is more and more difficult to remove. At the same time, due to climate change, many places have appeared the phenomenon of "shortage of fresh water resources", so the recycling and reuse of sewage to turn it into drinking water has become an urgent problem in contemporary society.However, the existing sewage treatment technology can not achieve the expected water purification effect. The emergence of nanotechnology provides an opportunity to develop a new generation of sewage treatment technology, indicating the direction of research and development of a new generation of water purifier.
Keywords: Nanotechnology; Water Treatment; Wastewater Recovery

Introduction

Water is the source of life. The "red line" of water resources is closely related to whether human homes can reproduce and thrive, and plays an important role in the sustainable progress and construction of human society.At the beginning of the 20th century, water treatment systems and wastewater treatment technologies have made great progress in ensuring the health of public drinking water and agricultural development. However, from the perspective of water supply worldwide, there are still many problems and serious challenges.This paper mainly discusses the specific application of nanotechnology in water purification system.

1. Current situation of freshwater resources environment and water treatment system in the world

Worldwide, 884 million people lack sufficient drinking water to maintain a normal life every year, and 1.8 million children die from diarrhea. According to the survey, the root cause is the shortage of freshwater resources caused by water pollution.Therefore, for most of the "developing countries", the environmental damage caused by development is a "common occurrence". Often in these places, water pollution is very serious, and there is an urgent need to provide a basic and efficient water treatment system.At the same time, in developed countries, the water treatment system has also encountered many challenges. On the one hand, the current water treatment system has been unable to meet people's requirements for the quality of drinking water;On the other hand, there are many sources of industrial pollution, and the production and living needs cannot change the process of man-made pollution. Neither the "centralized" water treatment system nor the "distributed" water treatment system can meet people's requirements for higher water quality.In the past, water treatment facilities not only consumed energy, but also caused loss of water, resulting in secondary pollution of water resources. Due to the continuous increase of the world population, resulting in the shortage of global water resources, so recycling and reuse of sewage has become a necessary measure in water-deficient areas.However, the current sewage treatment system cannot meet this demand. No matter what form of sewage treatment system, it cannot achieve the goal of "sustainable fresh water supply".Therefore, there is an urgent need for a new technology to provide efficient, versatile, convenient and economic water treatment process. Nanotechnology is a new and high technology, which can provide "more than the expected effect of traditional water treatment process"[1]. The research results show that the performance of water treatment process based on single nanotechnology is much better than that of common water treatment process.

2. Application Content of Nanotechnology

Nanotechnology can not only improve and upgrade the existing water treatment process, but also develop into a new water treatment process. In the field of water treatment, the "high specific surface area" of nanomaterials can be used to achieve water adsorption, photocatalysis, antibacterial and other functions, and the unique optical characteristics such as "superparamagnetism of particles" can be used to improve the quality of water treatment.

2.1 Use of adsorbent

Compared with conventional adsorbent, nano adsorbent has many advantages. For example, its unique high specific surface area, the interaction distance between particles, adjustable pore size, surface chemical characteristics, etc. "high specific surface area" means high adsorption capacity, which can show advantages in short-term and long-term dynamic adsorption.In addition, because its specific surface area and size at nanometer scale depend on the surface structure of particles, it can generate highly active adsorption sites, thus obtaining higher specific surface area and higher adsorption capacity.Due to its unique pore size and structural controllability, its adsorption performance in water has been greatly improved. Therefore, the project plans to apply it to a variety of water treatment technologies such as suspension reactor, filter membrane and loaded porous particles. Carbon nanotubes (CNTs) are a new type of highly efficient biodegradable materials. The binding sites on the surface of CNTs can interact with organic substances, such as the hydrophilicity and hydrophobicity of CNTs, pi-pi interaction, hydrogen bond, covalent bond, electrostatic interaction, etc., which can realize the efficient degradation of organic substances; However, the pH value of the pore of carbon nanotubes can be regulated, which limits its application in sewage purification. The high cost of carbon nanotubes also restricts its application in sewage treatment. In the direction of scientific research and development, it is proposed to apply it to the actual water body, and use its special paramagnetic characteristics to achieve efficient enrichment of various pollutants in the water body; With its excellent adsorption performance, it can be used as an adsorption material to carry out selective adsorption[2]. Recently, a new type of core-shell magnetic nano-materials has been chemically modified by combining core-shell two phases to form an active site capable of rapid, selective adsorption and rapid degradation, which shows good application performance in sewage purification.

2.2 Sensing and detection technology

With the continuous emergence of new pollution sources, water quality detection will also face many new challenges, such as the low density and diversity of pollutants, which often interfere with the detection results in water quality detection.At present, the development of an efficient and economical detection method has become a hot spot in the field of water quality detection. Diagnostic disinfection, biofilm control, and rapid detection of microorganisms have become key research directions, and core technologies rely on "sensors" to provide timely response and targeted treatment. Organically combine nanomaterials with specific recognition reagents, improve the sensitivity and speed of detection through the electrochemical, optical and magnetic properties of nanomaterials, and realize multi-channel targeted detection through the electrochemical and optical properties of nanoparticles; With nanoparticles and carbon nanotubes as carriers, the detection rate is accelerated through enrichment and purification; Quantum dots, dye-doped nanoparticles, noble metal nanoparticles, magnetic nanoparticles, etc. have been widely used for detection. For dye-doped silicon and polymer nanoparticles, their absorption spectra and fluorescence emission spectra vary with the particle size and chemical composition, and have high fluorescence intensity; Precious metal nanoparticles, through surface refraction or aggregation changes, generate optical response with the help of the elements of the resonance surface, and can detect pathogens quickly, highly sensitive and selectively; At the same time, carbon nanotubes coated on conventional electrodes can increase the detection sensitivity, shorten the distance of electron transmission, and improve the detection efficiency. Through the coating of carbon nanoparticles, the detection efficiency of water quality can be increased and the detection cost can be reduced[3].

2.3 Sterilization and degradation

Conventional disinfectants, such as chlorine and ozone, will cause secondary pollution to the water body, thus threatening the safety of people's drinking water. Therefore, technological innovation must be carried out to develop non-toxic or side-effect-free disinfectants. Nanomaterials such as nano-silver, nano-zinc oxide, nano-titanium dioxide, nano-cerium oxide, carbon nanotubes and fullerene have strong antibacterial properties, which is because they either release highly toxic metal ions and combine with the cell membrane to play a bactericidal effect; Or produce living oxygen and conduct chemical reaction with microorganisms to inhibit the reproduction of microorganisms, and only a few toxic by-products are produced in this process. Due to its low toxicity and strong antibacterial activity, nano-silver is often used as a water treatment material for POU; The antibacterial property of nano-silver mainly comes from the release of $Ag+$, which can combine with protein sulfhydryl and phosphorus in DNA, and then play an inhibitory role on bacteria.

3. Application examples of nanotechnology in water purification

According to the investigation report on the concentration of antibiotics in the regional water environment, the antibiotic content in surface fresh water resources in the Pearl River Delta, the Yangtze River Delta, the Jianghan Plain and other regions is 110-800g/L. Although the drug concentration is relatively low, if humans take such antibiotic fresh water resources for a long time, it will enhance the antibiotic resistance of the whole body, even affect the endocrine regulation of the human body, resulting in a series of health problems. Therefore, paying attention to the purification and treatment of pharmaceutical wastewater is an important content to protect the life and health of the people. Although there are many mature pharmaceutical wastewater treatment methods at this stage, the effect is very weak. Using "nano materials" to carry out the adsorption and purification of pharmaceutical wastewater can greatly improve the efficiency of water purification. The research shows that when the ambient temperature is 25 ℃, the removal effect of the composite nano material "molybdenum disulfide" on the organic matter "ciprofloxacin" reaches 25 grams per hundred grams. After multiple cycles of adsorption and purification, the test calculation shows that molybdenum disulfide still has 65% biological adsorption activity. On this basis, the experimental object was chemically modified, and the modified pefloxacin and ciprofloxacin were used for a comparative test. The results showed that the adsorption effect of organic compounds modified by iron and manganese was significantly improved, showing a higher maximum adsorption energy, but its cyclic adsorption effect was decreased compared with the previous experiment. This experimental data shows that depending on the high specific surface area and stable chemical properties of nanomaterials, the adsorption and separation capacity can be improved under the premise of controlling the reaction cost, which is of great benefit to the treatment of pharmaceutical wastewater[4].

4. The importance of nanotechnology

Nanotechnology has brought a new opportunity for the development of the new generation of water treatment technology. It can make minor changes to the existing equipment, so as to expand the water treatment capacity and improve the water treatment efficiency. At the same time, nanotechnology can also be used to recycle sewage. Nanotechnology based on water purification system can improve tap water, reduce secondary pollutants and turn it into drinkable water. Similarly, in developing countries, nanotechnology can also make water purification systems easier to operate, maintain and update. At the same time, it can also use smaller electric and chemical means to meet certain specific water treatment needs. However, due to the high cost and unstable performance of nanomaterials, there are still some limitations in the industrialization of water treatment. I believe that with the deepening of scientific research and the continuous exploration of unknown fields, nanotechnology will play an irreplaceable role in the future.

Conclusion

To sum up, nano-materials are widely researched and developed due to their advantages of high cost performance, easy repair and recycling, and high purification efficiency. Water resources are important resources for human survival and development. In the future, improving the environmental protection of nanomaterials will become an important direction of scientific and technological research and development. Turning achievements into reality and serving human life will create healthier and higher quality development.

References

[1] Liu SF. Application and prospect of micro and nano materials in water treatment [J]. Light Industry Science and Technology, 2021, (09): 86-87.

[2] Huo ZG. Research on the application of micro-nano materials in water treatment [J]. Chemical Fiber and Textile Technology, 2021, (07): 31-32.

[3] Gong QH, Chen ZH. Application of nanoparticles in domestic water treatment [J]. Guangdong Chemical Industry, 2020, (16): 272-273.

[4] Li XJ, Ma Y. New progress in the application of nanomaterials and technologies in water treatment [J]. Chemical Design Communication, 2016, (05): 73-74+82.