Application of AnMBR Ion Exchange Technology in Water Treatment

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Abstract. Ion exchange technology is widely used. Ion exchange technology is often used in industrial separation and purification. Ion exchange technology has the advantages of deep purification, high efficiency and comprehensive recovery. With the continuous development of ion exchange technology, the application of ion exchange technology in water treatment is increasing. This article details the application of ion exchange technology in water treatment.

1. Introduction
Ion exchange technology actually refers to that when water passes through the ion exchange column, cations and anions in water are exchanged with H⁺ of positive resin ion and OH⁻ of negative resin ion in exchange column, so as to achieve the effect of desalination and sterilization[1-3]. Its working principle consists of electrodialysis and electrolysis. Electrodialysis is to arrange the negative ions and positive ions in the water around the electrolytic electrode in a staggered way. After being electrified, the electrode will generate a certain DC electric field in the water around it[4]. Under the action of DC electric field, plus the potential difference between them, the negative ions and positive ions will selectively migrate on both sides of the electrode, thus forming anionic domain and cationic domain for a short time in the water, anionic domain electricity is negative, cationic domain electricity is positive, so that the impurities in water can be separated and adsorbed, which achieves the purpose of desalination, sterilization and impurity removal; and electrolysis is to directly ionize the ions of a compound to produce two or several other new substances.

Up to now, ion exchange technology in water treatment is mainly applied to the treatment of industrial wastewater, which is to use the electro osmosis technology of ion exchange technology to treat industrial wastewater, ionize the compounds which contain copper, iron and sulfur in the water and then combine with other elements to synthesize particles, precipitates or metal substances adsorbed around the electrode. Although the industrial wastewater is inedible, it can be used as industrial water again. The key point is that the metals in the industrial wastewater can be recovered, and separate the metals and precious metals in the wastewater. In this way, not only the reuse of waste can be achieved, but also the environmental pollution caused by light industrial wastewater can be greatly reduced[5-6]. With the increasing pressure of environmental protection and the development of membrane materials and equipment industry, people pay more and more attention to the application of ion exchange membrane technology in metallurgy[7-9]. It is of great significance in optimizing metallurgical process and treating waste acid and wastewater from metallurgical industry. However, ion exchange technology...
needs to be powered on all the time, once the power supply is cut off, the water treatment process will be cut off. In this way, the cost will increase. Therefore, at present, it is used in industry and rarely used for civil[10].

2. Desalination
Desalination technology is mainly to desalinate seawater to produce fresh water, which is used to realize the utilization of water resources, the treatment methods of desalination include reverse osmosis and electrodialysis. The technology uses natural zeolite molecular sieve as basic material. Natural zeolite molecular sieve is a kind of white, non-toxic and odorless crystal powder, which can adsorb a variety of ions with the size of 0.3-2 nm. In the framework structure of molecular sieve, cations are located in a certain position in the pore or cavity, and can exchange with each other in aqueous solution. The specific method is to add natural zeolite molecular sieves as basic materials into AgNO3, exchange with Ag ions, and then the Ag ions exchanged on the anionic framework of natural zeolite were used to precipitate CI ions in the solution, at the same time, alkali metals and alkaline earth metals such as Na ions and Mg ions in the solution are back exchanged on the anionic framework of natural zeolite molecular sieve to complete the desalination of seawater or brackish water.

3. Salt production from seawater
At present, electrodialysis is the second application in concentrating seawater and making salt by evaporation crystallization. Due to the small area occupied by the process, not affected by the climate conditions, and the high purity of the product, great progress has been made in the economic and technical indicators in the past 30 years. In Japan, at the end of 1960s, the concentration of concentrated brine by electrodialysis was 170g / L, and the power consumption per ton of salt was 350kwh; so far, the concentration of brine can reach 200g / L, and the power consumption per ton of salt has dropped to 150kwh. It is said that the limit power consumption index is 120 kwh per ton of salt. At present, Japan uses electrodialysis to produce 1.5 million tons of salt annually, and other countries produce 400000 tons.

The resistance of the membrane is a large part of the membrane stack, so the ion exchange membrane is required to have low resistance and high selective permeability. There are two types of anion exchange membrane: one is the copolymer of 4-vinylpyridine and divinylbenzene, the other is the copolymer of chloromethyl styrene and divinylbenzene. The structure of cation exchange membrane is copolymerization of styrene sulfonate and divinylbenzene. Because multivalent ions such as Ca2+ and SO2- are easy to precipitate and scale in the concentration chamber, which hinders the continuous
process, and the migration of multivalent ions reduces the migration of Na⁺ and Cl⁻, the membrane is required to have better selective permeability for monovalent ions for electrodialysis seawater salt production. By adding electrolytes with different charges to the surface of dialysis chamber membrane, the problem of blocking multivalent ions was solved.

4. Removal of natural organic matter from water
Natural organic matter (NOM) exists in groundwater and surface water. Humus is the main component of NOM, most of which are refractory anionic macromolecules with various molecular weights. NOM concentration in drinking water is usually 2-10 ppm. It is of great environmental significance to eliminate and control the natural organic matter (NOM) in drinking water. The ion exchange process for NOM removal is an efficient technology and is recommended to be used at the beginning of the treatment process. This method can significantly reduce the concentration of NOM and prevent the formation of disinfection by-products (DBP), such as trihalomethanes (THM). A comparative study on the removal of humus adsorbed on activated carbon, anion exchange resin, carbonaceous resin and metal oxide shows that the ion exchange process is the most effective. Ion exchange is very effective for eliminating charged NOM. Non charged NOM species that are not normally removed by ion exchange may account for 10% - 40%. Because the polar components of NOM can lead to a large number of disinfection by-products, ion exchange can be regarded as a very useful method to prevent the formation of DBP. In industrial scale, the removal of NOM from surface water is a key parameter, which will seriously affect the quality of drinking water. If NOM is successfully removed in the first step of surface water treatment, the efficiency of subsequent treatment process and the quality of drinking water will be improved.

5. Removal of copper from wastewater by ion exchange technology
Macroporous sulfonic acid cation exchange resin was used to process copper ion in industrial wastewater, and it was detected. The resin was adsorbed again and again under various conditions, and then the adsorption capacity of the adsorbed resin was detected. According to the experimental results, strong acid resin and pk208 resin had the strongest adsorption capacity, and they had better resource reusability, so they had good interaction. The exchange capacity is relatively stable. In addition, its exchange capacity is not small, Cu²⁺ adsorption is also strong, and the treated water quality will not violate the national copper wastewater treatment standards. The principle of exchange is: compared with other resins, macroporous resins have certain differences, whether in the state of drying or wetting, or in the state of concentration or water swelling, they will occupy larger pores than other resins and disperse in the resin. Therefore, the surface area of macroporous resin will be larger, so in the process of exchange between resin and copper ion, copper ion will present a rapid dispersion state, and then the exchange process will be quickly ended, which also improves its work efficiency to a certain extent.

6. Removal of chromium from wastewater by ion exchange technology
The strong basic anion exchange resin is used to treat the wastewater containing chromium. According
to the experiment, the corresponding treatment is made according to the comparison between the simulated wastewater containing chromium and the actual wastewater containing chromium. Some conditions of wastewater pH value and exchange time are used to separate the chromium ions to be treated in the wastewater. If the initial concentration of chromium ions in the wastewater is higher than 0 Mg / L, after treatment, the wastewater discharge does not violate the national standard. When the regeneration activity of ion exchange resin is implemented, only 8% sodium hydroxide solution and 50 °C temperature are needed, and the resin regeneration rate is more than 0.95, which also achieves the reuse of resin. In the treatment of chromium containing wastewater, ion exchange method can also be used. In fact, anion exchange resin is used to treat chromium in wastewater, while cation exchange resin is used to separate chromium. Ion exchange process has the following advantages in the treatment of chromium containing wastewater: good adaptability, good adhesion, large saturation capacity, the concentration of chromium in the treated wastewater does not violate the national standard, in addition, the wastewater can be reused, and the chromic acid can also be recycled. This treatment method has broad prospects.

![Figure 3. Process flow chart of chromium containing wastewater treatment by ion exchange](image)

7. Treatment of cyanide wastewater by ion exchange technology
Cyanide containing wastewater mainly comes from mineral processing, nonferrous metal smelting, metal processing, coking, electroplating, electronics, chemical industry, tanning, instrument and other industrial production. Cyanide is a highly toxic substance. Its toxicity to human body is mainly due to its combination with high iron cytochrome oxidase, which produces cyanide high iron cytochrome oxidase and loses the function of oxygen transfer, causing tissue asphyxia. Cyanide in water can be divided into simple cyanide and complex cyanide. The toxicity of complex cyanide is much less, but the zinc cyanide and cadmium cyanide complexes are almost completely dissociated in very dilute solution, which is highly toxic to fish under normal pH of natural water. The toxicity of dilute solution containing copper cyanide and silver cyanide complex anions to fish is mainly caused by the toxicity of undissociated ions. Iron cyanide complex ion is very stable and has no obvious toxicity, but in dilute solution, it is easy to produce toxic HCN by rapid photolysis under direct sunlight. Cyanide belongs to the second kind of pollutants. As cyanide is a highly toxic substance, any discharge of cyanide will pollute the water source and farmland, threaten the life safety of human, livestock and fish, and seriously damage the ecological balance.
Figure 4. Principle of cyanide wastewater treatment by ion exchange

The traditional treatment methods of cyanide containing wastewater mainly include chlorine oxidation, acidification recovery, sulfur dioxide air method and lean liquid total circulation method. Most of the above methods have some disadvantages, such as high treatment cost, no obvious treatment effect, complex equipment, serious secondary pollution and so on. In order to explore an advanced, economical and reasonable treatment way, Gong Chunlong and others investigated the performance of three kinds of resins (lis-106c, lsd-263, lsd-363) in the treatment of cyanide containing wastewater through experiments. The results showed that lsd-263 anion exchange resin had better effect in the treatment of low mass concentration cyanide containing wastewater. After treatment, the total cyanide concentration in the wastewater can be reduced to 1.04 mg/L.

Due to the limitation of saturated adsorption capacity of ion exchange resin, at present, the saturated adsorption capacity of many types of ion exchange resin is small. When ion exchange resin is used to treat high concentration wastewater, it will be saturated quickly. In practical application, it requires a large amount of ion exchange resin and high frequency regeneration, so the resin is not suitable for treating high concentration cyanide wastewater. With the development of chemical industry and the development of resin with high saturated adsorption capacity, the range of cyanide mass concentration in cyanide containing wastewater treated by ion exchange resin method will be expanded, and the cyanide containing wastewater with high mass concentration can also be treated by ion exchange resin method.

8. Treatment of phenol containing wastewater by ion exchange technology
Phenol is a kind of toxic substance which is harmful to people, animals and plants. It is also a kind of valuable and widely used organic reagent. With the development of coal processing industry, petroleum industry and chemical industry, many factories discharge a large number of phenol containing wastewater with different concentrations and compositions in the production process, which causes serious pollution to the environment. It must be treated first and then discharged. This is not only the requirement of environmental protection, but also the purpose of recycling valuable raw materials. The treatment methods of phenolic wastewater include biofilter, activated sludge, chemical oxidation, elimination, liquid membrane separation, ion exchange and so on. Chen Jianlin et al. Carried out detailed adsorption, desorption and scale-up experiments on high concentration phenol containing wastewater from a dye chemical plant with macroporous adsorption resin. The results showed that H-103 resin had good adsorption and desorption performance in this experimental system. The adsorption capacity of phenol was 600 mg/g, and the phenol recovery rate was 96%. Both 5% NaOH solution and industrial ethyl alcohol have good elution and regeneration effect, and the resin can be reused for many times without obvious change in adsorption performance. The eluate can be directly reused in production, which can achieve the unity of environmental benefits and economic benefits.

Zhang Lizhen and others used weak base ion exchange resin to treat phenol containing wastewater. Weak base ion exchange resin was used to treat phenol containing wastewater. The equipment was simple, the operation was convenient, the resin could be reused after regeneration, the cost was low, and the treatment effect was good. It was an ideal treatment method. He studied the adsorption capacity of macroporous resin, mv-14, sl-14, 70 at different pH values and concentrations. The results show that the macroporous resin has the highest adsorption capacity and the most complete and concentrated
desorption of phenol. This is because the macroporous resin itself is a styrene skeleton, similar to the structure of phenol, has good affinity, and the adsorption of phenol is the best. Therefore, among the four resins, macroporous resin is the most suitable for the treatment of phenolic wastewater.

9. Removal of mercury from wastewater by ion exchange technology

Huang Dezhi used the combined process of coagulation sedimentation ultrafiltration ion exchange to treat the mercury containing wastewater in a chemical plant. Through the sample identification of the wastewater discharged from the workshop, the results showed that the mercury containing wastewater treated by the combined process was in line with the discharge standard. The process mainly uses "ultrafiltration" and two-stage resin. The main principles are as follows: first, to screen out the suspended mercury in industrial wastewater through one-stage UF; second, to treat the dissolved Hg$^{2+}$ in wastewater by two-stage resin. When the resin reaches the saturated state, it will be eluted. At this time, the eluted high concentration mercury containing solution will diffuse to the sedimentation tank for precipitation. This combined process to treat mercury in wastewater is in line with the national discharge standard, and the operation process is relatively simple, and the cost is not high.

![Figure 5. Process flow of mercury containing wastewater treatment](image)

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