INVESTIGATIONS ON SURFACE MODIFICATION OF CARBON FIBER TO IMMOBILIZATION BEHAVIOR OF ACTIVATED SLUDGE AND ITS APPLICATION EFFECTS IN WATER-TREATMENT PROCESS

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Abstract

It is found that the activated sludge that contains abundant microorganism can be immobilized on the PAN-based carbon fiber (CF) rapidly after surface modified in the nitrate of 0.5mol/L by cyclic voltammetry (CV) where the potential must be over 2.3v in the carbon fibers anodic oxidation and the oxidation mechanism of carbon fibers is also discussed as well. The CF's hydrophilic ability is almost doubled through this anodic oxidation surface modification. However, it is show that the amount of the bio-film immobilized on CF increased no more after 20 hours activated sludge immobilization process, where the relationship between the dry weight of the bio-film on CF and the equilibrium moisture content rate is specified. As an application, the activated sludge immobilized on CF is used to wastewater treatment and the COD removal rate is up to 60% after 5 hours comparing with that of the traditional activated sludge treatment process.

Key words

Carbon fiber, surface modification, sludge immobilization, bio-film treatment, wastewater

1. Introduction

Bio-film wastewater treatment technology is an effective solid-liquid exchange process where the organic waste materials are decomposed on the interface between the wastewater and the bio-film immobilized on the carbon fibers in order to purify the wastewater. This technology occurred at the end of 19^{th} century and is one of the main bio-treatment process to wastewater now accompanying with the activated sludge one. Comparing with the activated sludge technology, bio-film wastewater treatment provides more higher treatment efficiency and stability, impact resistance load, smaller volume occupation, manageable advantages etc. These merits attract more interests of environmental experts and research scholars.

Since the activated sludge immobilized on the specific carriers' surface plays a key role in decomposing the organic waste in the wastewater, it becoms very important to select a proper microorganism carrier in the bio-film treatment process. During the development of bio-carriers, it experienced a stone, gravel, slag, coke and other solid materials stages to the current polyethylene, olystyrene, polyamide and other organic compound ones in the shape of ripple、tube、and honeycomb respectively. It is regarded as that the research on the bio-immobilization carrier concerns with the technique development of the bio-film wastewater treatment.

With a very well bacteria-philic ability during the activated sludge immobilization behavior, in the past decade, CF is utilized as the bio-immobilization carrier in the bio-film wastewater treatment process by some researchers and show an effective results in microorganism immobilization. However, the surface of CF must be modified before it is normally used as a bio-immobilization carrier in order to improve its surface hydrophilic nature. In the current research, a high strength carbon fiber, namely, PAN-based carbon fiber (T300), is introduced to be modified as a bacteria-philic carbon fiber (BPCF) and act as a bio-immobilization carrier materials, where the surface modification is carried out through electrochemical oxidation process. The focuses are mainly placed on the aspects of the modification parameters, such as the electrolyte concentration, the electrochemical oxidation parameters, and the resulting effects, such as equilibrium moisture content rate (EMR%) vary with the specific dry weight of bio-film immobilized on CF, the specific dry weight of bio-film changes with time passed, the COD removal rate with BPCF. As a new developing bio-film treatment process, BPCF seems more promising and effective comparing with those traditional activated sludge treatments in the current environmental water treatment solutions.

2. Experiment

2.1 Experimental equipment and materials

CHI660C electrochemical analyzer. PAN-based carbon fiber (T300) manufacture in Lanzhou. Activated sludge from Chengdu Sanwayao wastewater treatment plant. and domesticated in lab.

2.2 Experimental methods

2.2.1 Cyclic voltammetry(CV) and chronoamperometry(CA)

After sizing on CF surface are got rid off by dipping it into acetone liquid, cut it to 10cm long sections and electrochemistry oxidation in 0.5mol/L nitrate electrolyte. Studying the carbon fibers electrochemical oxidation process by cyclic voltammetry (CV). Potential-current curve is shown in Figure1.

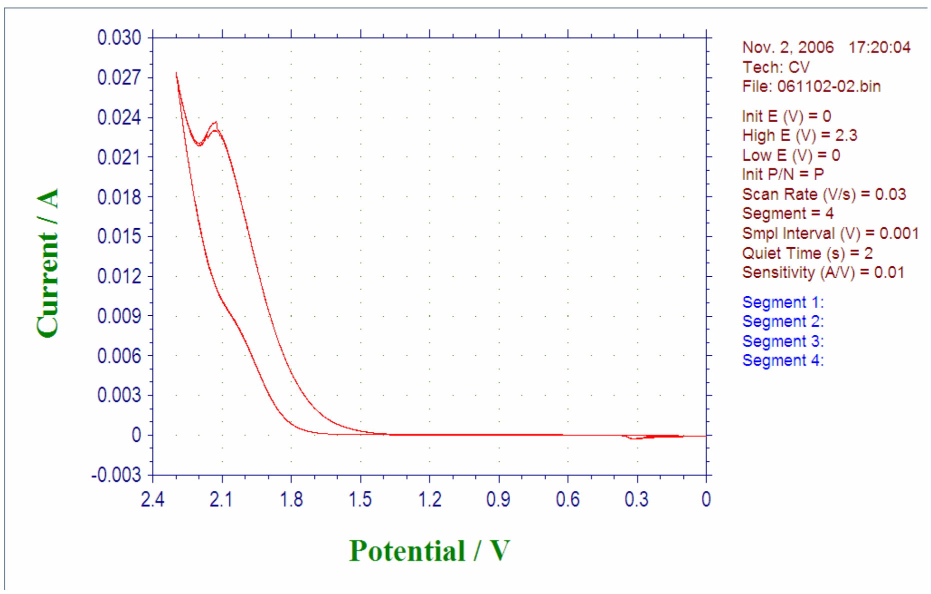

Figure 1. CV curve of CF electrochemistry oxidation in 0.5mol/L nitrate electrolyte

From Figure1 we can see that there is a oxidation peak nearby 2.13v in the first positive scanning process, and in the second positive scanning process the peak slightly move ahead. This phenomenon maybe indicated that the first oxidized is further oxidized in the second positive scanning process. From the Figure 1 we also observed that there is negative peak nearby 0.3v in the return scanning process. This phenomenon maybe one parts of the oxidation were restored when the potential scanning from positive to negative. The oxidation mechanism of carbon fibers is show in Figure 2.

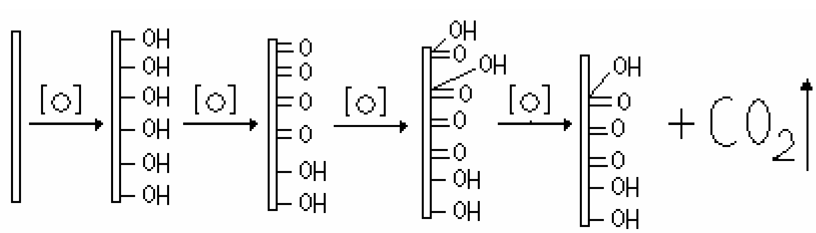

Figure 2. Oxidation mechanism of CF

By analyzing above, the potential must higher than 2.3v if we want to electrochemistry oxidation the carbon fibers in 0.5mol/L nitrate electrolyte. We controlled the potential on 3v in this paper and the time-current curve of chronoamperometry(CA) is shown in Figure3. From the picture we can conclude that the oxidation is mild reaction process and then tend to stably along with time increasing.

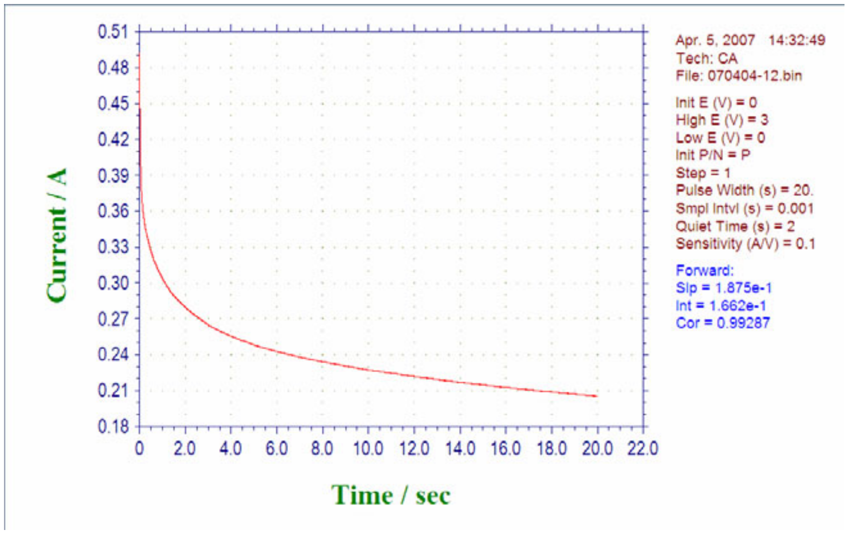

Figure3. CA curve of electrochemistry oxidation in 0.5mol/L nitrate electrolyte

2.2.2 Equilibrium moisture content rate(EMR%)

CF hydrophilic capability is determined by EMR%. Put the carbon fibers into a airtight container which full of saturated ammonium sulfate liquid on the bottom.(relative humidity is 85%). After 36 hours, take it out and weigh quickly, sign for W_1. Then put it into a 120°C oven to dry in 2 hours, get it out and put it into a dryer with silicone on the bottom. 5 minute later, take it out and weigh quickly, sign for W_0. The EMR% expression is shown below.

$$EMR\% = (W_1 - W_0)/W_0 \times 100\%$$

Where W_1 indicates the weight of dry carbon fibers and W_0 that of wet carbon fibers respectively.

From test, the original CF's EMR% is only 2.54%, but after 30s electrochemistry oxidation in 0.5mol/L nitrate electrolyte, The EMR% is rising to 5.25%. That is to say the EMR% increase 2.71 percentage point Compared to the original CF, and the CF's hydrophilic capability raise more than doubled.

2.2.3 Relationship between dry weight of bio-film and time

Table1. Relationship between dry weight of bio-film and time

Time h	4	6	8	10	12	22	24	26	30
DWBg /gCF	0.0785	0.103	0.118	0.123	0.204	0.331	0.752	0.750	0.755

(Note : DWBg/gCF sign dry weight of bio-film immobilized on per gram of carbon fibers)

From Table1, we can draw the curve of the relationship between dry weight of bio-film and time. It is shown in Figure4. The curve shown that the bio-film immobilized on the carbon fibers is basically stabilization after 20 hours.

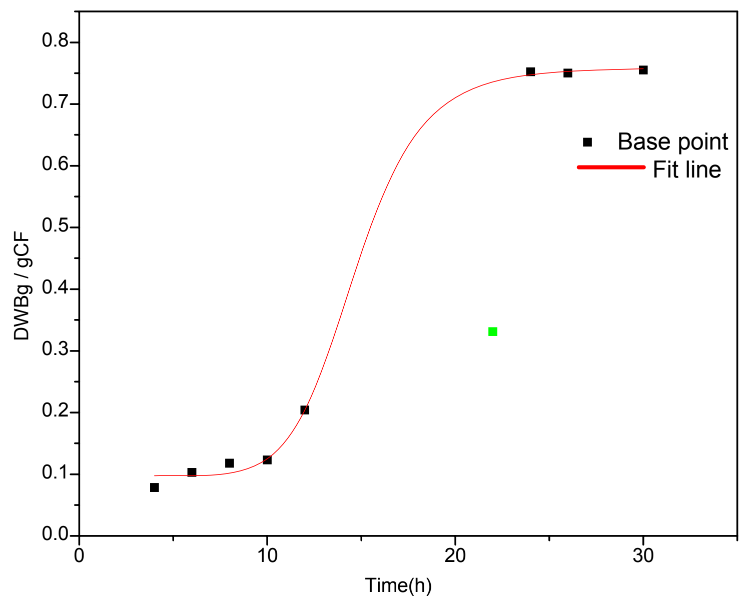

Figure4. Relationship between dry weight of bio-film and time

2.2.4 Relationship between dry weight of bio-film and EMR%

Table2. Relationship between dry weight of biofilm and EMR%

EMR%	3.12	3.86	4.43	4.74	5.25
DWBg/gCF	1.17	1.56	2.46	1.65	1.26

Figure5. is base on table2. From it we can see that DWBg/gCF is rising up with EMR% rising in the beginning. And then it is going down with EMR% rising. DWBg/gCF reaches its maximum when EMR% is near 4.3. It is obvious that DWBg/gCF is relationship with EMR%. In this point the bio-film immobilized on the carbon fibers is more than the others.

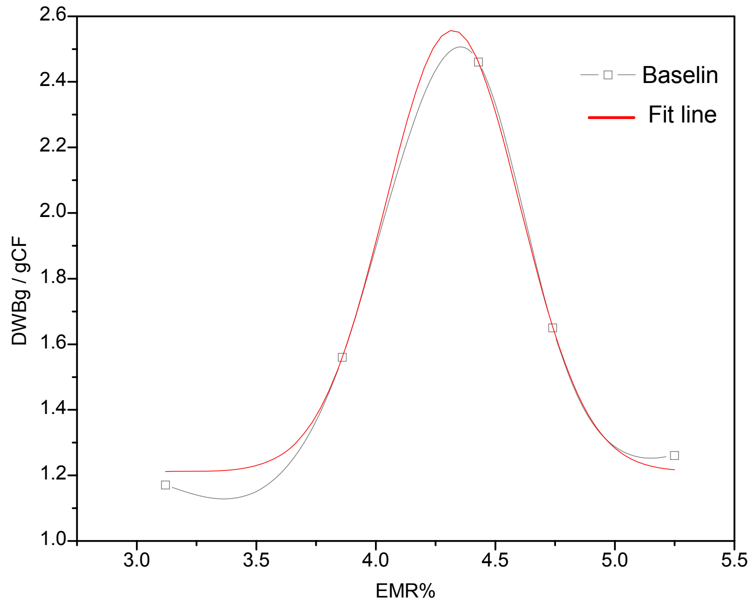

Figure5. Relationship between dry weight of bio-film and EMR%

2.2.5 COD wipe off rate

Put the carbon fibers into the lab activated sludge pool in 24 hours for immobilized the bio-film. And then take it out for the media of bio-film wastewater treatment.

Micro-polluted water is wait for treatment (COD=86.4mg/L). After 5 hours later in bio-film wastewater treatment technology which use carbon fibers as microorganism carrier. Its COD decline to 34.56mg/L. that is to say COD wipe off rate reach to 60.0%.

At the same conditions, using the lab activated sludge as media for the traditional activated sludge treatments to purify the wastewater. It's COD wipe off rate is only 11.11% after 5 hours later.

It is obvious that bio-film wastewater treatment using carbon fibers as the microorganism carrier has more efficiency than traditional activated sludge technology.

3. Conclusion

1) Carbon fibers surface oxidation in nitrate electrolyte can significantly increase the hydrophilic capability, and the potential must control above 2.3v in the oxidation process.
2) Bio-film immobilized on the carbon fibers tends to a relatively stable after 20 hours.
3) Carbon fibers bio-film immobilization amount achieves the maximum when EMR% value is of 4.3 rather than at the maximum EMR% value.
4) The result show that the COD wipe off rate is over 60.0% after 5 hours when the modified CF is utilized as the bio-film carriers. This treatment is more efficiency than traditional activated sludge one where the COD wipe off rate is only 11.11%.

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References

Fan Fu-zhou, Kang Yong, Kong Qi. 2005. Research progress of biofilm carrier for waste water treatment. Chemical Industry and Engineering Progress
12(24):1331-1335.

He Zhen-kun,Liu Jie,Wang Shao-tang. 2003. The formation mechanism of carbon fibers biofilm Ⅱ .Effects of carbon fibers surface characteristic on the activity and multiplication of microorganism. New Carbon Materials
18(1):43~47.

Liu Jie,He Zhen-kun,Wang Shao-tang. 2001.The formation mechanism of carbon fibers biofilm Ⅰ .Effects of carbon fibers surface characteristic on the immobilization of microorganism. New Carbon Materials
17(3):20-24

Liu,Y.1995.Adhesio kinetics of nitrifying bacteria on various thermoplastic supports. Colloids and Surfaces B:Biointerfaces
5:213-219

Morper, M. R. 1996. Vpgrading of activated sludge system fornitrogen removal by application of the LIN POR_CN process. Wat.Res
30(1):242-245

Shen Yaoliang. 1995. Fixup microorganism technology and appliance in waste water treatment. Pollution Prevention Technology
8(1):12-14.

Zhao, Q. L. and Wang, B. I. 1996. Evaluation on a pilot-scale attached-growth ponds system treating dimestic wastewater. Wat,Res
30(1):242-24.5