Study of Remanent Activated Sludge Used as Biosorbent (I) Effect of pH on Zeta Potential of Dissociative Bacteria and Its Application in the Adsorption of Activated Sludge

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Abstract: The thesis researched the effect of pH value on the adsorbability of activated sludge and on zeta potential of dissociative bacteria in it. We found that with the change of pH, the changing trend of the two was consistent. Considering the cell wall as functionary target, the author discussed the chemistry reaction between acid or alkali and peptidoglycan or teichoic-acid of the cell wall. From this, the author explained the changing trend of bacterial zeta potential, and expounded the relation between it and the adsorbability of activated sludge. [Life Science Journal. 2005;2(1):68 – 71] (ISSN: 1097 – 8135).

Keywords: biosorbent; activated sludge; zeta potential; dissociative bacteria

1 Theory

1.1 The surface zeta potential of bacteria in activated sludge

There are many sorts of microorganism, but most are bacteria[1]. The chemical components of bacterial cell wall and polymer on the surface of the cell decide that the surfaces of bacteria are electronegative. So bacteria are the main reason why activated sludge has adsorbability.

Activated sludge possesses adsorbability, which is related with the zeta potential of bacteria in it[2]. And the value of zeta potential is tied up with the value of charge on bacterial surface. The value of zeta potential is determined by dint of electrophoresis phenomenon of electriferous particulate with the function of electric field. From the Helmohohz-smolachowski formula[3], it has direct ratio with electrophoresis velocity of electriferous particulate. So it can be calculated by determining the value of the velocity.

In this article, we studied the effect of pH value on the zeta potential of bacteria in activated sludge. And our purpose, for one thing, it was to research how to change the charge value of bacteria and improve the adsorbability. For another, it was important for the research of microbe ecology to investigate the optimum pH condition for microbe to develop. The reason was that pH value directly affected the microbe's variety, quantity and life activity, mode of metabolization and also type of production metabolized, surface speciality and so on[4]. Moreover, the significance of the problem studied consists in providing theoretic groundwork and thinking direction for recycle investigation of remnant activated sludge.

1.2 Structure and chemistry component of bacterial cell wall

Bacteria have special structure of cell wall which other organisms have not. Substance constituting the framework of bacteria is peptidoglycan composed of peptide chain and amino sugar chain. And add other components such as amylose, muramic acid, protein, mucopolysaccharide, and then bacterial cell wall with different kinds of function has been made up[5].

2 Materials and Methods

2.1 Material

Reagent: NaOH (AR), HCL (AR), Active carbon (The No. 3 Chemistry Reagent Factory of Tianjin City); Fresh activated sludge; Reactive brilliant red X-3B (C. I. Reactive Red 2); Acid lake blue A (C. I. Acid Blue 7) (The No. 3 Reagent Factory of Shanghai).

Apparatus: TL – 5. 0 desk style centrifugal machine (Shanghai Centrifugal Machine Graduate School, Shanghai, China); 79 – 1 magnetic force heating blender (Jintan Medical Treatment Apparatus Factory, Jintan, China); BDL-B surface potential particle diameter apparatus (Shanghai Shangli Survey Apparatus Factory, Shanghai, China); pH-pXFL:G1 acidity meter (Fanlong Instrument Corporation, Shanghai, China); 721 spectral photometer (The No. 3 Analysis Apparatus Factory of Shanghai, Shanghai, China).

2.2 Method

(1) Pretreatment of sludge: Remove some water of the fresh activated sludge by centrifugal (2000 rpm, 3 min), and wash it four times with distilled water. Then get the abluent wet sludge (containing water 93%).

(2) Effect of pH value on zeta potential of dissociative bacteria in activated sludge: Get 20 g wet sludge every share, place in 100 cm^3 distilled water, and adjust the pH to needed value. Then separate it by centrifugal and measure pH value of the clear liquid above, and determine respectively the surface zeta potential of six kinds of dissociative bacteria, that is staphylococcus, micrococcus, diplococcus, spirillum, bacillus and capsul-micrococcus[6].

(3) Effect of pH on adsorbability of activated sludge: Separately place 2 g wet sludge in 50 cm^3, 100 mg/L reactive brilliant red solution and acid lake blue solution. And adjust the pH value using 0.5 mol/L HCl. When the system reaches adsorption equilibration, determine pH and absorbency of the solution at the most adsorption wavelength of the corresponding dyestuff with 721 spectral photometer. Then calculate the adsorption value of activated sludge and elimination rate of reactive brilliant red and acid lake blue at different pH.

(4) Compare of adsorbability of activated sludge and active carbon: Dry some active carbon (−200 mesh) at 105℃ for 4 hours in oven. Take 0.15 g dried active carbon every share, at pH = 6 and 3, separately place in 50 cm^3 reactive brilliant red solution (250 mg/L) and acid lake blue solution (300 mg/L). When it comes to adsorption equilibration, determine its absorbency. Simultaneously, at the same condition determine the adsorption of 1.5 g dried activated sludge at pH = 3. Calculate respectively the equilibrium concentration and adsorption value.

3 Results and Discussion

3.1 Effect of pH on zeta potential of dissociative bacteria in activated sludge

With alteration of pH, the changing circs of surface zeta potential of the six kinds of bacteria are shown in Figure 1.

We can see from Figure 1 that when pH reduces, zeta potential (minus means the surface of bacteria take negative charge) of the six kinds of bacteria are all decreasing. At low pH, the changing trend is similar to that of surface potential of activated sludge granule reported[3]. And the differences between them just prove that zoogloea is not entirely equal to dissociative bacteria in character.

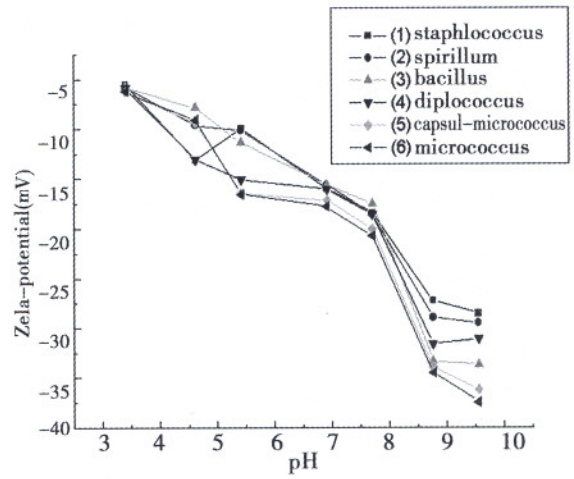


Figure 1. Effect of pH on zeta potential of dissociative bacteria in activated sludge

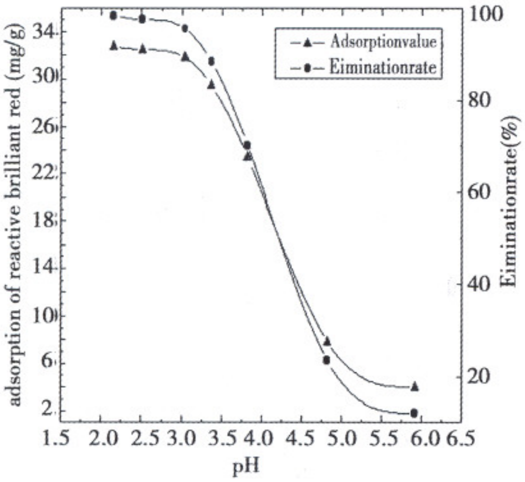
The changing trend of zeta potential of the dissociative bacteria in Figure 1 can be explained by the chemical reaction between H^+ and peptidoglycan. When add acid to the dissociative system of bacteria, on the one hand, amido and imido group in peptidoglycan are protonized and then take positive charge. On the other hand, ionization equilibration of carboxyl moves to the reverse direction and thus the amount of carboxyl negative ion is reduced. Therefore, while pH of the system is minshing, the negative charge of cellular surface is decreasing, and bacterial velocity of electrophoresis is also decreasing with the function of electric field. It results in reduction of bacterial surface zeta potential.

3.2 Effect of pH on adsorbability of activated sludge

Alteration of pH value makes change of the adsorbability of activated sludge. Figure 2 shows adsorption value of reactive brilliant red and acid lake blue by activated sludge at different pH value, and the change of elimination rate of the two dyestuffs in the experimental condition.

It can be seen from Figure 2 that the adsorption value is increased when pH value minishes. And the elimination rate takes on the same changing trend. Take reactive brilliant red for example, when pH reduces to about 4.7, the adsorption of activated sludge increases promptly. And when pH reduces to about 3.0, the adsorption goes on to increase but the change is not obvious. At pH = 3.0, the adsorption adds to 29.47 mg/g, and the elimination rate adds to above 95%. The changing status of acid lake blue is similar. Therefore pH=3 is an appropriate critical point of adsorption.

Comparing Figure 2 and Figure 3, we can know that with the change of pH, the changing trend of adsorption of activated sludge is in accord with that of dissociative bacterial surface zeta potential. Reactive brilliant red and acid lake blue are negative ion dyestuff. In water solution, electronegative sulfonic group ($-SO_3^-$) they ionized links with electropositive amido ($-NH_3^+$) in peptidoglycan by ionic bond[7]. When pH decrease, the zeta potential decrease, that is the negative charge of bacterial surface reduces. And it is advantageous for it to contact closely with the molecule of dyestuff, and for adsorption to happen. So the adsorption value is increased.



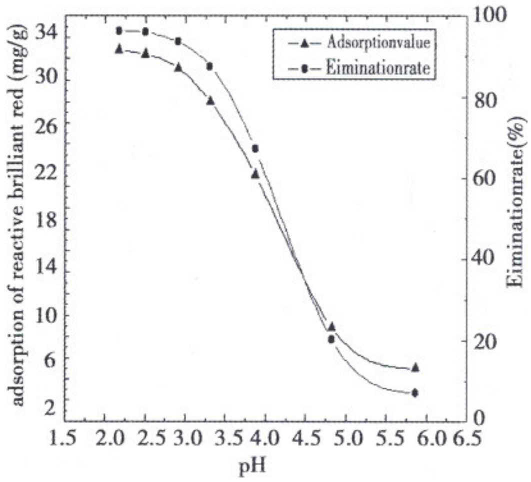


Figure 2. Effects of pH on adsorption of activated sludge on reactive brilliant red and acid lake blue

Table 1. Compare of adsorbability of activated sludge and active carbon

Dyestuffs and Their Concentrations	Active carbon PH=6 Balance Concentration mg/l	Active carbon PH=3 Balance Concentration mg/l	Active carbon PH=3 Balance Concentration mg/l	Activated sludge PH=3 Balance Concentration mg/l	Activated sludge PH=3 Balance Concentration mg/l
Reactive Brilliant Red (250 mg/l)	31.4	11.5	79.5	11.6	91.7
Acid Lake Blue (300 mg/l)	79.1	31.8	89.4	17.5	108.7

3.3 Compare of adsorbability of activated sludge and active carbon

As show in Table 1, the adsorption of active carbon is better at rather low pH condition. However, the adsorption of activated sludge is much higher than that of active carbon when pH = 3. This suggests that the adsorption of acidic activated sludge on dyestuffs is more rapid in pace, better in capability and effect.

4 Conclusion

To sum up from above, the change of pH condition makes surface zeta potential of bacteria change, and so does the adsorbability of activated sludge. Thereby, we can let activated sludge have better adsorbability by adjusting the pH.

Remanent activated sludge is the object for disposing in City Sewage Disposal Factory. If it can be used as sorbent after simple treatment, then not only the cost is very cheap but the effect is rather good. And this nicely accords with the research and development direction of sorbent for dyestuffs—sorbent with high effect and low cost.

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