

Research development of compound bioflocculant

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Abstract. The research background and characteristics of compound bioflocculant (CBF) were introduced. The paper focused on research and application of CBF, including producing compound bioflocculant by Low-cost substrate and engineering application of CBF. Finally the research development of CBF in the future were discussed.

Introduction

Flocculants are useful agents in the aggregation of colloids, cells and suspended solids and are commonly used for drinking water production, waste water treatment, fermentation processes, and food production [1]. In general, flocculants are classified into three groups: inorganic flocculants, such as aluminum sulfate and polyaluminum chloride; organic synthetic flocculants, such as polyacrylamide derivatives and polyethylene imine; and naturally occurring flocculants, such as chitosan, sodium alginate, and microbial flocculants. Despite the effective flocculating performance and low cost of the synthetic chemical flocculants, their use has resulted in some health and environmental problems [2]. In contrast, bioflocculants, extracellular biopolymeric substances secreted by bacteria, fungi, algae and yeast are biodegradable and nontoxic flocculants [3, 4].

Microbial flocculants is a kind of metabolites produced by the microorganism, the main ingredients are glycoproteins, polysaccharides, protein and DNA et al. It is obtained by the fermentation of bacteria and fungi, extraction, purification in use of microbial technology, is a new type of water treatment agent [5-7]. Microbial flocculant is biodegradable, non-toxic and safe of high efficient for wastewater treatment. The study on the bioflocculant began in the 1950s, Japanese scholars first discovered microbial culture liquid with flocculation. In 1976, Nakamura et al studied microbes producing flocculation effect, and raised the research hotspot for microbial flocculant [8]. In 1986, Kurane et al [9] used *Rhodococcus erythropolis* S1 strain isolated from nature to produce flocculant NOC-1 with good flocculation effect. The research of microbial flocculant, has been mainly concentrated on producing strain screening and flocculant fermentation liquid for wastewater treatment in laboratory scale tests, there were many problems in the process of research, for example, high cost for producing bioflocculant, screening the strain was difficult, the flocculation process and mechanism is not clear, and so on. In recent years, in order to improve the effect of flocculation, reduce the producing bioflocculant cost, compound bioflocculant began to receive the much attention of researchers [10, 11].

Bioflocculants are mainly composed of macromolecular substances, such as polysaccharide and protein [12, 13]. The composition and properties of bioflocculants depend on type of bioflocculant-producing microorganisms (BPMs), composition of media and environmental conditions [14]. Although so many studies about bioflocculants have been done, low flocculating capability and high cost are still the major problems in limiting bioflocculants development for practical application [15]. Consequently, screening for microorganisms producing bioflocculants with high flocculating activities [2, 4], improving the flocculating performance of the bioflocculants [16], and seeking for low-cost substrates for producing bioflocculants have become recent hot topics in this field [17].

The concept of compound bioflocculant (CBF) was first put proposed by Professor Ma of Harbin Institute of Technology [16, 18]. The raw fermentation material of compound bioflocculant was agricultural waste straw. The high-efficiency combined production of bioflocculant utilized the composition flora of cellulose degrading bacteria and flocculant producing bacteria, through two stage fermentation, realized the coupling of cellulose scarification section and producing flocculating section. Therefore, compound bioflocculant on the basis of compound bacteria has advantages of bacterial activity, the flocculation effect, the cost of production, compared with single microorganism producing flocculant, becomes the hot spot in the current research.

Ma et al. [16, 18] put forward the conception of CBF, which was produced by mixed culture of bioflocculant-producing microorganisms and could exhibit excellent flocculating ability. The compound bioflocculant in the present research was produced by mixed culture of two bioflocculant-producing microorganisms, *Rhizobium radiobacter* F2 and *Bacillus sphaericus* F6. CBF possesses higher flocculating activity than bioflocculants by single culture of F2 and F6 [19]. So far, the domestic scholars mainly concentrated in the screening and optimization of compound bacteria culture [20], application of compound bioflocculant for treatment raw water and wastewater. The domestic and international research status of compound bioflocculant in recent years and its future research development were introduced in the paper.

The characteristics of the compound bioflocculant

The compound bacteria theory as the foundation, the compound bioflocculant was produced mainly by mixed culture of more than two kinds of bacteria. Various strains promotes proliferation each other through synergistic action, and gave full play to their respective advantages, formed an effective complementary, so that the compound bioflocculant had maximum flocculating ability.

The compound bioflocculant was produced by two step fermentation, fermentation technology has the composite characteristics. Screening and construction of flocculant producing bacteria realized producing stable and high efficient bioflocculant; screening bacteria cellulose degradation bacteria and construction of bacteria flora realized the efficient and quick saccharification period. Two step fermentation by organic combination had efficient and simple process for producing the compound bioflocculant.

The main ingredients were including extracellular secretions of the producing flocculant strains, cellulose degrading bacteria bodies, flocculation bacteria bodies, cellulose residue etc.

Producing compound bioflocculant by Low-cost substrate

Compound bioflocculant has not been industrialized production and application of the large scale, one of the reasons is that the production cost is too high. So looking for cheap substrate and the development of low cost substrate is very necessary. The medium of cheap carbon source and nitrogen source for bioflocculant production can effectively solve the problem of high-cost culture medium, which offer potential opportunities for commercial production of CBF. Some scholars used dairy wastewater and sauce wastewater or other food wastewater as cheap culture medium to culture bioflocculant producing bacteria [21, 22]. It provided ideas of cheap substrate for producing compound bioflocculant. Chinese scholars in recent years has done a lot of researches in cheap substrate for the production of compound bioflocculant. Ma et al [16, 18] used cheap cellulose as a substrate of compound bioflocculant by two stage fermentation process for preparing CBF. Then Ma et al done a lot of researches in utilizing rice straw as substrate for preparation of compound bioflocculant [23]. Other Chinese scholars [24-27] used the distillery wastewater, brewery wastewater, food processing wastewater, sauce wastewater, monosodium glutamate wastewater to produce compound bioflocculant, then they achieved satisfying results, the studies laid the foundation for the industrial production of compound bioflocculant.

Application of compound bioflocculant in water treatment

Treatment of drinking water

The compound bioflocculant achieved good results in surface water treatment. Such as: Ma ET al's [28] study showed that when CBF dosage was about 14ml/L, the pH value was 7.5, the addition of CaCl₂ was 1.5ml/L. The optimal flocculation effect was obtained in the treatment of Songhua River water. The temperature has little influence on the flocculation efficiency.

Treatment of domestic sewage

Domestic sewage with the characteristics of high organic content, complex composition of the water quality, but compound bioflocculant in treatment domestic sewage showed good treatment properties. When CBF was used for treatment of domestic sewage, all kinds of pollutant removal rate was above 60% [29]; compound bioflocculant XZ has the high removal efficiency for SS and Chroma of domestic sewage, XZ also could improve the related indexes of activated sludge [10].

Treatment of industrial wastewater

Zhang Yuling et al's [30] research showed that when CBF treated starch wastewater, flocculation rate reached 80.0-90.3%. By the compound bioflocculant XJBF-1 for treatment of starch wastewater, printing and dyeing wastewater and landfill leachate, COD removal rate reached 88%, 66% and 58% respectively, and the treatment effect of starch wastewater and dyeing wastewater is better than that of the action polyacrylamide [31].

Conclusions

The compound bioflocculant research at home and abroad had been developed for more than 10 years, a lot of achievements were obtained. But large-scale applications of CBF met a certain difficulty. Therefore, a single chemical or bioflocculant are not suited to development needs of the current water pollution control engineering technology, the urgent needs of the market should be efficient, environmental friendly composite flocculants products. Research and development of new key technology of composite biological flocculants industry, provided new flocculants products and technology support for the safety of drinking water supply, water pollution control and water deep purification treatment. It would be an important direction for future development of bioflocculant.

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