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Scientific Research

Construction and Application of Engineered Bacteria for Bioaugmentation Decolorization of Dyeing Wastewater: A Review

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Abstract

With the development of dyeing wastewater treatment biotechnology, the advantages of bioaugmentation bacteria gradually catch people's eyes. Therefore, its construction and application research has also attracted the attention of the majority of scholars. This article summaries the construction and application of bioaugmentation engineered bacteria used to treat dyeing wastewater in recent years, including the screening, domestication and application of single and mixed flora bacteria. In addition, the impact of the strengthening effect of all genes is also described in this paper. Finally, the optimization and promoted use of bioaugmentation bacteria are out looked.

Keywords

Bioaugmentation; Engineered Bacteria; Decolorization; Dyeing Wastewater

1. Introduction

With the rapid development of the economy, the displacement of the printing and dyeing industry has increased significantly. According to the incomplete statistics, annual emissions of printing and dyeing wastewater are about 20 million tons, generally accounted for from 60% to 80% of the integrated discharge, which ranks fifth in the country's industrial wastewater emissions (Wang et al., 2012). Therefore, the treatments of industrial wastewater are becoming more and more difficult. Dye used in printing and dyeing industry is mostly synthetic dye. And the join of some new additives, PVA size etc makes printing and dyeing wastewater has the features of large chromaticity, great ranges of COD changes, high alkalinity, poor biodegradability, big fluctuation of water temperature and quantity.

In recent years, the application of biological strengthening technology in dying wastewater treatment attracts the eyes of many scholars, which refers to adding microbes with specific functions into the original biological

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treatment system in order to improve its treatment effect (Han, 1999). The use of strengthening bacteria in dealing with other wastewater such as the wastewater containing pyridine and petrifaction also confirmed its powerful processing capability (Qiao et al., 2012; Ma et al., 2008), and the bacteria used in treating azo dye have got some achievements, and its biological decolorizing research also had certain progress (Saratale et al., 2011; Manjinder et al., 2005; Anjali et al., 2007; Song et al., 2003). The bioaugmentation engineered bacteria used in the decolorization of printing and dyeing wastewater are more and more widely. Dosing microorganisms with special degradation to the printing and dyeing wastewater treatment system can greatly increase the decolorization effect of wastewater.

2. Engineered Bacteria and Its Construction for Bioaugmentation

Engineered bacteria can be divided into special engineered bacteria and generalized engineered bacteria. Special engineered bacteria refer to separating certain target genes with various degrading properties, and then obtain various degradative effects within it through gene operations that can degrade a variety of new types of organics. However, generalized engineered bacteria is a mixed flora reasonably combined by the high efficiency degradation bacteria which were separated, screened and identified from natural environment, polluted environment and treatment systems, and it can degrade various organics efficiently (Ma et al., 2008), which leads to its widely application.

2.1. Genetic Engineered Bacteria

Constructing genetic engineered bacteria to deal with environmental issues is the front topics in environmental biotechnology, which combined modern biotechnology with environmental problems. Genetic engineered bacteria can be directed effectively to use contaminant-degrading gene in microbial cells to perform the function of purifying pollutants.

Jin et al. (2005) firstly constructed genetic engineered bacteria pGEX-AZR/E. coli JM-109 possessing the ability of degradation of azo dyes, the results indicated that genetic engineered bacteria possess high efficiency in various azo dyes treatments, especially the small molecular one. Through constructing metagenomic library with large insert fragments, Gou et al. (2012) proved that the activated sludge Fosmid library can be used to actively screening functional genes, and it also has the potential to develop new genes, and lay the foundation for building the genetic engineered bacteria.

Due to the low success rate, high cost, and long adaption time of genetic engineered bacteria expression, and certain problems of hereditary, purification function and biosafety, its applications are not widely. Besides, there are some difficulties in the promotion.

2.2. Generalized Engineered Bacteria

Generalized engineered bacteria for bioaugmetation refer to the high effect bacteria strains separated and domesticated from activated sludge that treating printing and dyeing wastewater, and they have special degradation function of printing and dyeing wastewater pollutants.

The bioaugmetation engineered bacteria reported so far are mostly separated from sludge and polluted environment and then domesticated into apply (Chen et al., 2003; Yue et al., 2003; Zou et al., 2012; Wang et al., 2009; Li et al., 2011). One mixed bacterial consortia SKB-II was isolated from a textile wastewater treatment plant by Bella et al. (2009). This consortium has good effect for decolorizing individual as well as mixture dyes. At 1.0 g/L starch supplementation, the decolorization rate reached 80-96% of a single dye (Congo red, Bordeaux red, etc.), and for mixture dyes the decolorization rate also reached 50-60% when present as a mixture at 10 mg/L. In order to adapt to the reactors, the researchers generally fixed constructed engineered bacteria on suspended solids or fixed carrier by immobilization technology. After isolating high efficient bacteria consortia from wastewater activated sludge, Ma et al. (2008) put them into the reactor. After treating, the effluent water quality is better than the first standard of Table 2 in Integrated Wastewater Discharge Standard (GB8978-1996).

3. Application of Bioaugmentation Engineered Bacteria

3.1. Application of Individual Bacteria Strain

In recent years, the application of bioaugmetation engineered bacteria dealing with wastewater became more and more widely. There are more and more scholars constructed them to treat printing and dyeing wastewater, and also obtained some achievements.

A processing metal composite azo dyes Shiva's strain J18 143 was screened by Tie et al. (2010). The concentration of wastewater after treating could reach 0.12 g/L. Other scholars also isolated high efficient decolorization activity bacteria (Zhang et al., 2010). Although single bacteria possess good decolorization capacity, its applications in treating real wastewater are hard to be achieved. On one hand, the enzyme production and color removal of single bacteria can hardly adapt to the complex components of wastewater, on the other hand, the problems of the contamination of other bacteria cannot be solved (Yang et al., 2007; Brown et al., 1993). In order to overcome the limitations of single bacteria, the majority of scholars began to focus on the application of mixed consortium.

3.2. Application of Mixed Bacteria Consortium

Mixed bacteria consortium refer to a micro-ecological system in which two or more microorganisms reach the advantage of its largest group of the combined effects through common culture, interaction and mutual influence. The organic matter in dyeing wastewater may be degradated more thoroughly and completely due to the co-metabolism between a variety of bacteria. So the decoloration rate and the degradation effects of mixed bacteria consortium are all better than single bacteria. There have been many scholars engaging in screening and domesticating mixed bacteria consortium so far (Safia et al., 2007; Saratale et al., 2009). Taruna et al. (2008) screened a bacteria consortium TJ-1 which possesses the degradation capacity of acid orange 7 and a lot of azo dyes wastewater. The decolorization rate of TJ-1 is higher than single bacteria which prove that there are interactions among the bacteria. After treating AO7 solution 16 h at the concentration of 200 mg/L, the decolorization rate had reached 90% which showed perfect effects.

In addition to bacteria, many fungi also possess the capacity of treating dyeing wastewater, and many scholars also combined them together to explore the treatment effect (Kurade et al., 2012; Lade et al., 2012). Many scholars not only limited to do the laboratory research of mixed bacteria consortium, but also combined it with the reactor in order to achieve the application and promotion of mixed bacteria consortium in engineering.

3.3. Applications of Engineered Bacteria Combined Reactor

In recent years many bacteria consortia screened are applied to the reactor, and handled a large number of the dyeing wastewater combined with the role of the reactor resulted in achieving a good effect (Xu et al., 2010; Xu et al., 2010). Imen et al. (2012) used a sequencing batch reactor (SBR) inoculated with an acclimated novel microbial consortia 'Bx' to enhance a reactive dye Blue Bezaktiv S-GLD 150 dye. The experiment results indicated that under aerobic conditions the decolorization rate and removal rate of COD arrived 88-97% and 95-97% respectively at volumetric dye loading rates under 15 g dye/m3.d.

Bioengineering bacteria greatly enhanced the effect of wastewater treatment, as well as a successful biotechnology case applied in wastewater. After understanding the processing capacity of bio-engineered bacteria, how to optimize its performance is also one of the issues explored by the researchers.

3.4. Bioaugmetation Effects of the Xenobiotics

The bioaugmetation effects of the engineered bacteria have been tested by many experiments. On the base of screening and domesticating engineered bacteria, through optimizing the nutrient supply of the existing treatment system and adding the matrix (substrate) analogs, many scholars improved the vitality of the engineered bacteria or stimulate microbial growth, which lead to further strengthening treatment of the dyeing wastewater.

The group of Zhou jiti researched the role of anthraquinone intermediates on the decolorization strengthening of the dyeing wastewater (Jiao et al., 2009; Su et al., 2008; Wang et al., 2011; Guo et al., 2006; Fang et al., 2007). They examined the catalytic strengthening effects of quinone reduction bacteria in decolorizing azo dyes by six anthraquinone dye intermediates, and proved the augmentation effect of xenobiotics on engineered bacteria, and confirmed that the addition of the engineered bacteria did not damage the structure and characteristics of the original system. As a result, they optimized the engineering bacteria to improve its handling capacity (Guo et al., 2006; Xing et al., 2007).

4. Prospects

Bioaugmentation engineered bacteria occupies an irreplaceable position in the printing and dyeing wastewater treatment because of its various advantages, including powerful treatment capability, good decolorization effect, and little impact on the community structure of the original processing system and so on. Addition be added directly to the processing system, bio-engineered bacteria can also firstly be combined together when construction, and then put into use. Through the interaction between the bacteria consortium, the decolorization effect and degradation rate of the system are improved.

Adding biological engineered bacteria to reactors achieved the binding of engineered bacteria and treatment process, and optimized the treatment process. Traditional treatment technology itself has a processing capacity and load carrying ability, and screened engineered bacteria possessing good decolorizing ability significantly enhanced the processing capacity of the entire system. At the same time, the practical application of engineered bacteria has been extended, and the study of all aspects of its performances owned more practical significance. During the treatment process of bioaugmentation engineered bacteria, the addition of some xenobiotics optimized the performances of engineered bacteria, as well as improved its dyeing wastewater treatment ability and decolorization effects.

The decolorization of bioaugmentation engineered bacteria has been studied, and many efficient bacteria consortia have been screened and domesticated so far. But Further strengthening the engineered bacteria, further putting engineered bacteria into large-scale use, achieving its value are the direction we should strive as well as the goal of our struggle.

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