Short Communication (NS-3)

SULFIDE OXIDATION IN FLUIDIZED BED BIOFILM REACTOR USING POLYMERIC MATERIAL AS SUPPORT PARTICLES

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ABSTRACT
Biological sulfide oxidation of synthetic wastewater in fluidized bed bioreactor is studied using heterogeneous population of micro-organisms obtained from tannery effluent treatment plant. The FBBR used in this study is fabricated with glass having total volume of 0.6l (length of 0.38m and diameter of 0.045m). A separate 2l bottle is used as aeration tank to avoid the turbulence in the fluidized bed bioreactor. Nylon particles are used as carrier material. The diameter and density of the particles is 2-3mm and 1104kg/m³, respectively. Experiments are conducted in the bioreactor at a fixed bed height using sulfide concentrations of 100mg/l, after the formation of biofilm on the surface of carrier material. The hydraulic retention time of the reactor is 0.9hr. Microscopy techniques are used to study the development and formation of biofilm. Biofilm thickness reached 43µm after fifteen days from start-up of the reactor. From the results it is observed that almost 90-92% sulfide removal is obtained at hydraulic retention time of 0.9hr. Sulfur is the main end product of bacterial sulfide oxidation.

Key Words: Hydraulic retention time, Oxidation, Sulfide, Tannery, FBBR (Fluidized Bed Bio-Reactor)

INTRODUCTION
Over the past several decades, increasing discharge and improper management of liquid and solid industrial wastes has become a great problem for environment. Sulfide emission is one of the major problems in industries like distillery, paper and pulp, viscous rayon, tanneries and petrochemical plants1-2. Sulfide is emitted into the environment as dissolved sulfides in wastewater and as H₂S in waste gases. Sulfide poses a serious disposal problem when discharged into a stream. It is highly toxic to human beings as well as aquatic animal life even in very low concentrations. It gives an irritating, rotten-egg smell above 1ppm and can cause headaches, nausea or affect central nervous system even at low level of exposure3. It causes death within 30minutes at concentrations of only 800–1000 mg/l, and instant death at still higher concentrations4. Sulfide in wastewater is also corrosive5. As the most reduced form of sulfur, sulfide has a high oxygen demand of 2molO₂/molS²⁻ resulting in depletion of oxygen6.

In order to remove sulfide from wastewater streams, a number of physicochemical methods are commonly used but high chemical and catalyst requirements along with their disposal makes them highly expensive. Microbiological methods have been developed as an alternative to chemicals methods. Several microorganisms have been studied for sulfide oxidation. Aerobic microorganisms or chemotrophes used for the oxidation of sulfide are the species of Thiobacillus, Pseudomonas, Beggiatoa and...
Thiothrix\textsuperscript{7-9}. Anaerobic microorganisms or phototrophs such as Chlorobium and Chromatium can be used for the sulfide oxidation\textsuperscript{10-12}.

Various researchers have studied the sulfide oxidation in different reactors like continuous stirred tank reactor and packed bed reactor. Liquid fluidized beds of solid particles with attached microbial growth are increasingly used in wastewater treatments. A Fluidized Bed Bio-Reactor (FBBR) has several advantages over other conventional reactors for the treatment of wastewater such as lower hydraulic retention time, high biomass concentration, no bed clogging and small area requirement\textsuperscript{13}. In this study, the sulfide oxidation in fluidized bed bioreactor with nylon particles as support materials is investigated.\textsuperscript{14}

**MATERIAL AND METHODS**

**Reactor**

A fluidized bed biofilm reactor is used for sulfide oxidation in the present study. The schematic representation of FBBR is presented in Fig. 1.

![Fig. 1: Schematic view of FBBR](image)

The FBBR used in this study was fabricated with glass having total volume of 0.6l (length of 0.38m and diameter of 0.045m). A separate 2l bottle is used as aeration tank to avoid the turbulence in the fluidized bed bioreactor. The reactor has three sampling ports uniformly located. These ports were used to extract liquid and bioparticle samples from the reactor. Nylon particles are used in this study as support particles. The diameter and density of the particles are 2-3mm and 1104kg/m\textsuperscript{3} respectively. Sulfide containing synthetic wastewater was prepared using sodium sulfide flakes obtained from Qualigens Fine Chemicals, India. The influent sulfide concentration of 100mg/l was maintained using tap water and fed from the bottom of the reactor with a peristaltic pump (Miclins PP20). The hydraulic retention time of the reactor was around 0.9hr and the temperature was maintained at 30°C±2°C. The air was continuously supplied to the aeration tank such that the dissolved oxygen was sufficient enough (greater than 3mg/l) for the growth of bacteria. The reactor pH depended on the operational conditions and this parameter was monitored but not controlled during the experiment. The samples were drawn at 24hrs interval and analyzed for pH, temperature, dissolved oxygen, sulfate and sulfide.

**Microbial culture and medium**

A heterogeneous population of microorganisms was obtained from the effluent treatment plant in a local tannery. An inoculum is obtained by cultivating the mixed culture of microorganisms in shake flasks. The composition of nutrient solution was Glucose -10g/l, yeast extract -0.34g/l, ammonium chloride -0.84g/l, potassium dihydrogen phosphate -0.134g/l, dipotassium hydrogen phosphate -0.234g/l and magnesium chloride -0.084g/l. All the chemicals used in this study are of analytical grade, obtained from S.D. Fine Chemicals, India.

**Analytical methods**

Analytical determinations are performed according to APHA standard methods\textsuperscript{15}. Sulfide concentration is measured by iodometric titration method and sulfate is analyzed at 420nm using a spectrophotometer (Lamotte, USA). The elemental sulfur is calculated by subtracting the produced amount of sulfate from influent sulfide concentration. Microscopy techniques are used to study the development and formation of the biofilm.
RESULTS AND DISCUSSION

Initially the reactor was inoculated with inoculum, equivalent to 4x10^7 CFU/ml to start growth of microorganisms on solid particles. The packed bed height before starting the reactor was 16cm. The reactor was fed with inoculum with growing medium followed by the recycling of the solution for 24hrs. 10% inoculum over the last 24hrs was added into new culture medium every day in order to keep sufficient nutrients for growth of microorganisms.

Biofilm formation

Biofilms are clusters of microbial cells that are attached to a surface. In a fluidized bed reactor, the process of the biofilm formation on solid support is initiated by the suspended cells present in the inoculum. At the beginning, biofilm formed when some microorganisms attached onto the nylon particles. As the biofilm grew and more metabolite accumulated on the particle surface, the whole particle became covered with the biofilm. Finally, mature biofilm formed on the surface of nylon particles. Fig. 2 shows the microscopic view of the bare nylon particles at 40x. Biofilm formation on nylon particles was started after three days from start-up of the reactor and continued to grow. Biofilm thickness grew very slow and stabilized at 43µm after fifteen days from start-up.

Fig. 3 shows the microscopic view of the biofilm formation after twelve days from the reactor startup. However the biofilm formed on the particles are not uniformly distributed on the particle surface.

Fig. 4 shows the increase in biofilm thickness with time. The growth of biofilm was slow initially, increased after 9 days and started stabilizing after 12 days.

Reactor operation

Fig. 5 shows the sulfide oxidation pattern in the fluidized bed reactor. The sulfide influent concentration was kept constant at 100mg/l in this experiment. The reactor was fed with 0.066g/m^3/hr sulfide loading rate at a feed rate of 0.66l/hr. The hydraulic retention time to the reactor was 0.9hr. The effluent sulfide concentration was around 20mg/l within 4-5 days of reactor operation. The reactor showed 90% sulfide oxidation on 9th day of the reactor operation.

The products from sulfide oxidation are sulfate and sulfur due to biological reaction. Sulfate formation in biological sulfide oxidation process depends upon the amount of oxygen supplied. The formation of sulfur is preferred over sulfate formation because sulfur can be removed very easily. Fig. 6 and Fig. 7 show the sulfate and sulfur formation during the reactor operation. Sulfate formation was in the range of 4-12mg/l. The sulfur formation increased gradually and 85% was obtained at sulfide loading rate of 0.066g/m^3/hr.

Fig. 2 : Microscopic view of bare nylon particle at 40x
Fig. 3 : Biofilm formation on nylon particle after twelve days from the reactor startup
CONCLUSION

Sulfide oxidation using mixed culture in fluidized bed reactor has been studied. Polymeric material (nylon) was used as support material for growth of biofilm. It was concluded from the experiments that fluidized bed reactor with nylon particles can be used for sulfide oxidation. Almost 90% sulfide can be oxidized at hydraulic retention time of 0.9hr. The sulfur production of 86% was obtained at sulfide loading rate of 0.066g/m²/hr.

REFERENCES


