学 位 論 文 概 要

平成 28 年 2 月 1日

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学位論文題目

Improvement of Membrane Bioreactor Operations for Color and Oil Removal from Wastewater

学位論文の要旨

Membrane bioreactor (MBR) process is the technology that has gained a considerable numbers of applications into wastewater treatment processes in recent days. It is a type of modification to conventional activated sludge process under which solid/liquid separation is undertaken through membrane filtration. One of the greater advantages of the MBR process is the operation at a high sludge retention time, which enables keeping in the reactors a variety of microorganism which can extend the removable compounds in biological wastewater treatment. In addition, high effluent water quality without the presence of suspended particles by the introduction of MBR is attractive for the reuse of industrial wastewater.

The characteristics of industrial wastewater are quite different depending on its source. Biomass process including molasses distillation and sulfuric acid hydrolysis often generates wastewater having acidic characteristics. Saline and high-temperature wastewater containing a variety of organic compounds is a difficult target for wastewater treatment. The produced water from oil and gas production activities, shipboard wastewater, and textile wastewater are the examples of this type of wastewater.

The aim of this study is to investigate the performances of membrane bioreactors (MBR) for wastewater treatment under high temperature operation and acidic operation to improve the removal of color and oil from industrial wastewater. The removal of color was focused because the remaining yellow or brown color in treated industrial wastewater usually originates from high molecular weight organic matters which are recalcitrant to biological degradation. Oil was also focused because oil in wastewater often disturbs the treatment of industrial wastewater by forming aggregates especially under low temperature conditions. High temperature operation is preferable to avoid the problems of oil in wastewater.

Few literatures can be found for the operation of MBR below pH 3. There are few studies showing the advantage of thermophilic MBR for the treatment of dilute wastewater.

In the first experiment, the advantage of acidic operation below pH of 3, which operation was out of the usually accepted condition for membrane bioreactors (MBRs), was examined targeting the treatment of sulfuric acid hydrolysis wastewater generated in the biomass processing without pH neutralization. Stable operation of both an acidic reactor and a neutral pH reactor was observed for 91 days, though higher trans-membrane pressure

was observed for the acidic reactor, which accumulated proteins and polysaccharides in the supernatant. COD removal for the acidic reactor was 48.5% and that for the neutral pH reactor was 63.6% when biologically pretreated molasses wastewater was fed to the reactors. Higher percentage removals of COD (89.0% for the neutral pH reactor and 84.0% for the acidic reactor) were observed, when molasses wastewater (COD 650 mg/L) was directly fed to the reactor because of higher concentration of biologically degradable organic matter in the feed solution. In spite of lower COD removal in the acidic reactor, higher removal of color was observed spectrophotometrically with the low pH operation. Higher color removal in the acidic reactor was due to the enhanced adsorption of colored substances in the acidic environment followed by gradual biological degradation judging from the increased tendency of the removal of color.

The second experiment was targeting for the treatment of saline and high temperature wastewater containing oil and organic matters of different biodegradability. A thermophilic condition (50℃) beyond the usual operating condition for MBR was examined to avoid the disturbance for the treatment by oil in wastewater. The performances obtained for 35 days were compared with those of a room-temperature reactor. The removal of COD was comparable for the two reactors. The half-life time of mineral oil (C_{15}-C_{22} alkanes) was around 2 hours for the thermophilic reactor, while that of room-temperature reactor was around 3 hours. However, the operation at the high temperature condition decreased the removal of melanoidin color from 58% to 44% compounds. The fouling of the membrane was more severe for the thermophilic reactor. The room-temperature reactor maintained a volume flux of 0.22 m/day, while keeping the volume flux at the same level was difficult for the thermophilic reactor. It was suggested that lower flux operation of the membrane and worse effluent quality have to be considered, if high-temperature operation is required.

These results on MBR operation with extreme conditions showed that the membrane fouling is the most serious problem, though low pH operation is preferable for the color removal and thermophilic operation is preferable to avoid the problems caused by oil in wastewater. Future research for the stable operation will be needed on the mitigation of the accumulation of proteins and polysaccharides in the supernatant of MBRs to realize the operation with the extreme conditions.