Anaerobic Treatment of N, N-Dimethylformamide (DMF)-Containing Industrial Wastewater

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論文内容要約

With the rapid development of modern industrialization and economic globalization, the massi-- quantity of industrial wastewater discharged from a variety of chemical industries is becoming a worldwi formidable environmental issue which causes negative effects on ecosystem and also seriously endange human health. The degradation-resistant organic wastes contained in the chemical wastewater own lo BOD and are persistent to biodegradation. Conventional treatment processes are considered not suitable the treatment of high strength chemical organic wastewater. Anaerobic digestion, as an efficient, eco-frienc economic and energy-saving biological process, is extensively applied in the anaerobic treatment of a varie of wastewater streams and organic wastes. In this study, the author selected a common organic compound N-dimethylformamide which has been widely applied and implemented in the industries like texti manufactory of synthetic leather and fiber, polymer dissolution, pesticides and pharmaceuticals as organic polar solvents. While DMF has excellent versatility, the excessive discharge of DMF-containing industrial wastewater is becoming a critical environmental issue. DMF is known for its hepatotoxicity and carcinogenicity, and its thermal stability and weak degradability make this compound obstinate and recalcitrant in nature. Few studies have focused on the anaerobic digestion of DMF because of its weak degradability. However, a great number of studies focused on the aerobic degradation of DMF. In this dissertation, by acknowledging the previous studies on aerobic degradation of DMF, the author initially cultivated DMF-degrading activated sludge and then mixed it with normal anaerobic digested sludge to establish a co-cultured sludge. With the cooperation of hydrolysis and methanogenesis, this new consortium could effectively degrade DMF into methane under the anaerobic condition. The author then applied this consortium in both lab-scale UASB and SAnMBR to investigate the feasibility and stability of this consortium. Results indicated that this co-cultured consortium could only temporarily remain activated for a few weeks. The DMF-hydrolyzing bacteria kept decaying all the time because they could not grow under the anaerobic condition. By investigating the characterization and kinetics of the microbial community structure.

The author found these DMF-hydrolyzing bacteria are in fact denitrifying bacteria, they are facultatively anaerobic and could grow aerobically and anaerobically. However, because the system in this study is a methanogenic system without any nitrate dosage, these denitrifying bacteria were unable to grow. As a result, the author also proposed some suggestions and improvements as future perspectives to enhance the hydrolysis of this co-system and maintain a stable anaerobic treatment of DMF-containing wastewater.

Due to the lack of DMF-hydrolyzing bacteria, DMF has been shown to be difficult to degrade under the anaerobic condition. However, DMF can be effectively degraded under the aerobic condition with continuous aeration. That is also why few studies have reported the methanogenic degradation of DMF. Only with the cooperation of both DMF-hydrolyzing bacteria and methylotrophic/hydrogenotrophic methanogens can DMF be degraded under the anaerobic condition.

Although the co-cultured consortium consisting DMF-degrading activated sludge and normal anaerobic digested sludge indeed demonstrated the excellent ability in the methanogenic degradation of DMF. This artificially established microbial consortium only remains its activity temporarily for a few weeks, because those DMF-hydrolyzing bacteria originating from activated sludge could not grow under the anaerobic condition. Therefore, they kept decaying all the time and the DMF hydrolysis gradually weakened. With new inoculation of fresh activated sludge into the UASB and AnMBR, both the removal efficiency of DMF and the methane production rate recovered immediately. However, the high efficiency and biogas production only remained for a while, and continued to drop to a low level. Frequently inoculating activated sludge into the UASB and AnMBR is not an optional solution.

For archaeal community, it has been proved that the methanogenic degradation relies on both the methylotrophic and hydrogenotrophic methanogenesis. From samples of batch experiment, samples of UASB and AnMBR, a number of bacteria were selected as the candidates which have potential to hydrolyze DMF into DMA and formic acid. However, these bacteria were all enriched in aerobic activated sludge and gradually decayed after inoculated into the UASB or AnMBR under the anaerobic condition. The reason for the decay is that there bacteria are all aligned as denitrifying bacteria. Although they are facultative anaerobes, they need nitrate as the electron acceptor under the anaerobic condition. In our study, both UASB and AnMBR are methanogenic conditions where no nitrate has been dosed, and neither the substrate contains nitrate. These facultative anaerobes could not grow under the anaerobic condition. They could only utilized the C-1 substrates such as MMA and formic acid, however, these C-1 substrates would be further consumed by methanogens, resulting in a “niche overlap”. These facultative DMF-hydrolyzing bacteria were gradually outcompeted by methanogens under the condition without nitrate.

As these DMF-hydrolyzing bacteria are probably unable to feed on DMF as the sole substrate, the introduction of other organic matter is likely to enhance the degradability of this co-system. The co-digestion strategy could be either the combination of DMF and other chemicals, or the combination of DMF with other common organic matter or biomass. Some previous studies succeeded in the co-digestion of DMF and antibiotics and obtained a stable operation, however, the mechanisms and functional microorganisms would be changed in the co-system. If we use co-digestion strategy in future study, the entire mechanism of DMF degradation and community structures of both archaea and bacteria would be all changed.

Because these DMF-hydrolyzing bacteria are denitrifying bacteria, the addition of nitrate (or nitrite) as an elector acceptor was considerable to improve the growth rate of these DMF-hydrolyzing bacteria by establishing a nitrate-reducing mineralization process under the anaerobic condition. However, a competition was also likely to extend to the organic carbon source between denitrification and methanogenesis, which would lower the methane production and suppress the process of methanogenesis. As such, the nitrate dosage should be strictly controlled.