MEMBRANE FOULING MECHANISMS IN MEMBRANE-COUPLED ANAEROBIC BIOREACTOR

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Recently, the advanced membrane separation technology has even been applied to the post treatment to biological process of wastewater treatment, since the efficiency of biological treatment significantly depends on maintaining a high biomass concentration in the bioreactor. Particularly, anaerobic microbes in the biological system have slower growth rates than aerobic microbes and thus it takes a long hydaulic retention time(HRT) to prevent biomass washout in the completely mixed anaerobic digester. The anaerobic sludge also has poor settleability owing to its diffusible and somewhat filamentous nature. Moreover, the residual gasification and consequent sludge rise in the clarifier compartment become a considerable problem, which proves that complete separation of biological solids is difficult. Thus, using a membrane-coupled anaerobic bioreactor(MCAB) incorporating UF or MF as the separation step after the well-mixed anaerobic bioreactor, the biological solids in the reactor can be completely retained and the relatively clear effluent can be produced. However, the major hurdle in the extensive use of membranes is membrane fouling, which limits the membrane performance. Membrane fouling could be attributed to the adsorption of organic species, the precipitation of less soluble inorganic species, and the adhesion of microbial cells on the membrane surface, which are in close association with the solute and/or membrane chemistry of the system. However, a comprehensive study of membrane fouling itself was insufficient in the MCAB system. Therefore, it is imperative to explore the fouling mechanisms for the MCAB system where membrane fouling is complicated by chemical and biochemical reactions as well as interactions between various solids and the membrane surface.

Membrane fouling mechanisms in a MCAB system have been examined and are presented in this article, where a longtime continuous experiment was performed at various operating conditions. Although the MCAB system revealed excellent COD removals, the viable suspended biomass was kept at a negligible level in the bioreactor. This is because the microbial cells move from the bioreactor to the membrane surface due to the high shear stress from the recycling pump. This conversion from a suspended growth to an attached one gave rise to severe membrane fouling. To remove the attached biomass, physical cleaning such as depressurization and flow stopping was attempted, resulting in a transient elevation in the permeation flux. Both cleaning efficiencies, however, were gradually reduced with operating time. This could be attributed not only to the compaction of attached biomass but also to the precipitation of less soluble inorganic species at the membrane surface. The inorganic precipitate was especially responsibe for hardening the cake layer at the membrane surface. The strong binding and solidification at the membrane surface led to pronounced external fouling. Based on a conceptual resistance-in-series model, the external fouling resistance gave a relatively large value of 30 times the internal fouling resistance. The inorganic fouling substance was analyzed using XPS and IR and was identified as $MgNH_4PO_4$(struvite). The struvite precipitation mechanism could be estimated somewhat quantitatively using the conditional solubility product and the products of the actual concentrations.