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New insights into membrane fouling based on characterization of cake sludge and bulk sludge: An especial attention to sludge aggregation

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HIGHLIGHTS

- Cake and bulk sludge aggregation in MBR was evaluated by extended DLVO theory.
- Cake sludge had higher DSI and more colloids, LB-EPS and negative charge.
- Cake sludge exhibited worse aggregation ability than bulk sludge.
- Worse sludge aggregates was more easily attached to membrane for cake formation.

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ABSTRACT

In order to obtain a better understanding of the relationship between sludge characteristics and the cake formation in membrane bioreactors (MBRs), the characteristics of cake sludge and bulk sludge were investigated and compared. Based on the extended Derjaguin–Landau–Verwey–Overbeek (extended DLVO) theory, the aggregation abilities of cake sludge and bulk sludge were also evaluated. It is observed that cake sludge showed worse aggregation ability than bulk sludge. Further analysis indicated that small flocs, colloids, loosely bound extracellular polymeric substances (LB-EPS), hydrophobicity and negative charge played important role in cake formation and sludge aggregation. Cake sludge with worse aggregation had higher distribution spread index (DSI), more colloids and LB-EPS, higher hydrophobicity and more negative charge. The results indicated that sludge aggregation might reflect membrane fouling potential of sludge.

1. Introduction

Membrane bioreactors (MBRs) offer many advantages over conventional activated sludge process, such as reduced footprint, superior effluent quality, higher biomass concentration and less sludge production (Meng et al., 2009; Zhang et al., 2011). However, membrane fouling results in severe flux decline or rapid transmembrane pressure (TMP) increase, high energy consumption, and frequent membrane cleaning or replacement, which directly leads to the increase in maintenance and operating costs (Wang et al., 2009).

Sludge cake formation on the membrane surface is viewed as the major cause of membrane fouling in MBRs (Khan et al., 2009; Lin et al., 2011; Meng et al., 2007). The sludge cake mainly originates from the biomass of bulk sludge. It is reasonable to think that bulk sludge play a major role in the formation of the cake layer on the membrane surface (Le-Clech et al., 2006). Some studies have revealed that the fouling behaviors of bulk sludge and cake sludge were significantly different (Buyukkamaci, 2004; Wang et al., 2007). Therefore, a detailed comparison of cake sludge and bulk sludge will be helpful to understand the formation and development of cake layer.

To date, several attempts have been made to characterize cake sludge and bulk sludge. Wang et al. indicated that the accumulation of biopolymer clusters within the pores of the sludge cake was mostly responsible for the unusually high filtration resistance of cake sludge (Wang et al., 2007). Lin et al. argued that small flocs, bound extracellular polymeric substances (EPS) and inorganic materials played important role in cake formation process (Lin et al., 2011). These studies mainly focused on the effect of certain components in sludge suspension on cake layer formation. Recently, some researchers have confirmed that the aggregation ability of bulk sludge played a key role in cake formation during membrane filtration process. Sludge aggregation depends on the EPS, sludge structure, surface charge, flocculation, settling properties, dewatering properties and adsorption ability (Sheng et al.,

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