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# Enhanced dewaterability of sewage sludge in the presence of Fe(II)-activated persulfate oxidation

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ABSTRACT

The potential benefits of Fe(II)-activated persulfate oxidation on sludge dewatering and its mechanisms were investigated in this study. Capillary suction time (CST) was used to evaluate sludge dewaterability. Both extracellular polymeric substances (EPS) and viscosity were determined in an attempt to explain the observed changes in sludge dewaterability. The optimal conditions to give preferable dewaterability characteristics were found to be persulfate ($S_2O_8^{2-}$) 1.2 mmol/gVSS, Fe(II) 1.5 mmol/gVSS, and pH 3.0–8.5, which demonstrated a very high CST reduction efficiency (88.8% reduction within 1 min). It was further observed that both soluble EPS and viscosity played relatively negative roles in sludge dewatering, whereas no correlation was established between sludge dewaterability and bound EPS. Three-dimensional excitation–emission matrix (EEM) fluorescence spectra also revealed that soluble EPS of sludge were degraded and sludge flocs were ruptured by persulfate oxidation, which caused the release of water in the intracellular pace and subsequent improvement of its dewaterability.



## 1. Introduction

Waste activated sludge is continuously produced from wastewater treatment plants. Dewatering is of paramount importance in the subsequent sludge processing as it reduces sludge volume and, consequently, the cost of transporting and disposal (Feng et al., 2009). However, sludge dewatering is still a universal issue, presumably attributed to the strong hydrophilicity of sludge flocs surface. Together with more stringent disposal regulations, this has caused an urgent demand for more efficient sludge dewatering methods.

Various methods have been investigated as potential pretreatment technologies to enhance sludge dewaterability, such as the addition of calcined aluminum salts (Zhen et al., 2011), alkaline pretreatment (Li et al., 2009), ultrasonication (Feng et al., 2009), electrolysis (Yuan et al., 2011a, 2011b), and microwave irradiation (Yu et al., 2009). Although these methods may have high dewatering potentials, their application has been limited by factors including sludge volume increase and high energy requirement for operation, as well as complexity of implementation.

For decades, advanced oxidation processes (AOPs) utilizing free radicals as a primary oxidant, have been given growing attention to for sludge dewatering, in view of short treatment time and high dewatering efficiency. Fenton and Fenton-like processes, as one group of AOPs, are frequently used for dewatering of different waste activated sludges (Lu et al., 2003; Neyens and Baeyens, 2003; Tony et al., 2008). The Fenton reagent ($H_2O_2/Fe^{2+}$) have to be used at low pH values (pH < 4.0) (Badawy and Ali, 2006) to avoid hydrolysis and precipitation of $Fe^{3+}$, which is one of the demerits of Fenton process for sludge dewatering. Persulfate is a strong and non-selective oxidant with a high redox potential of 2.01 V. It can be effectively activated by initiators, including heat, UV light, or transition metals ($Me^{n+}$) to generate sulfate free radicals ($SO_4^{-\bullet}$) which has a even higher redox potential estimated to be 2.60 V, similar to that of the hydroxyl radical (2.70 V). Some of reactions during the activation of $S_2O_8^{2-}$ may be expressed as follows (Yan et al., 2011; Oh et al., 2009, 2010):

$$S_2O_8^{2-} + 2e^- \rightarrow 2SO_4^{2-} \quad E^\circ = 2.01\ V \tag{1}$$

$$S_2O_8^{2-} + \text{heat/UV} \rightarrow 2SO^-\bullet \tag{2}$$

$$S_2O_8^{2-} + Me^{n+} \rightarrow Me^{(n+1+)+} + SO_4^-\bullet + SO_4^{2-} \tag{3}$$

$$SO_4^-\bullet + e^- \rightarrow SO_4^{2-} \quad E^\circ = 2.60\ V \tag{4}$$

The sulfate radicals have higher reduction potential at neutral pH and are more selective for oxidation at acidic pH as compared to hydroxyl radical. Moreover, it is relatively more stable in water, and thus may be more effective for the degradation of recalcitrant organic compounds (Romero et al., 2010). With the advantages of

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