Enhancing short-chain fatty acids (SCFAs) production via acidogenic fermentation of sewage sludge: effect of sludge characteristics and PDS pre-oxidation

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Abstract
This study firstly employed low dose of peroxydisulfate (PDS) addition coupling with initial pH 10 (PDS&pH10) pretreatment to promote SCFAs production via acidogenic fermentation of iron containing sewage sludge (Fe-sludge). Experimental results showed that the maximal SCFAs yields and acetate proportions of reactors with PDS pre-oxidation were promoted by 1.27 and 1.56 times respectively. Moreover, SCFAs yields of thickened sludge (TS) fermentation were remarkably larger than those of waste activated sludge (WAS) fermentation. The concentration of soluble chemical oxygen demand (SCOD), protein (PN) and polysaccharide (PS) were all increased significantly in these reactors with PDS pre-oxidation, and especially the degree of flocs disintegration was significantly enhanced. Moreover, correlation analysis demonstrated that the SCFAs yields showed highly significant correlation (P<0.01) with SCOD, total PN, PN-soluble-EPS (SEPS) and significant correlation (P<0.05) with PS-SEPS and PS-tightly-EPS. Mechanism explorations exhibited that PDS pre-oxidation promoted solubilization of complex substrate and exhibited synergetic effect on effectively hydrolysis promotion by combining with initial pH10 pretreatment. Followingly, acidogenic fermentation was stimulated by the regulated pH and Oxidation-Reduction Potential (ORP) under PDS&pH10 pretreatment. Firmicutes was proved playing key role in improving SCFAs production and especially favoring for acetate promotion by converting additional SCFAs to acetate. Additionally, the metabolic pathway abundance revealed that PDS addition largely promoted the superpathway of sulfur oxidation and iron cycle metabolic activities which contributed to promote the solubilization and enhanced SCFAs production. Finally, the PDS&pH10 pretreatment was roughly estimated to be an economic solution for the Fe-sludge treatment.

Highlights:
1. Low dose of PDS pre-oxidation contributed to boost acetate production.
2. The substrate characteristics of sewage sludge had a large effect on SCFAs production.
3. Firmicutes played key role in SCFAs enhancement and favored for acetate promotion;
4. The availability of endogenous Fe²⁺ in Fe-sludge was stimulated by PDS addition.

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