Comparing the effect of bioflocculant with synthetic polymers on enhancing granulation in UASB reactors for low-strength wastewater treatment

Jing-Song Wang, Yong-You Hu*, Chun-De Wu

School of Environmental Science and Engineering, South China University of Technology, Guangzhou 510640, P. R. China

Abstract

This study was aimed at introducing a novel bioflocculant to enhance anaerobic granulation in a UASB reactor for low-strength synthetic wastewater and comparing the effect with synthetic polymers. A laboratory-scale study was undertaken to achieve this goal. Four identical UASB reactors were operated in parallel in the treatment of low-strength synthetic wastewater over 136d at 35 ± 1 ℃. One unit (labelled R1) was injected weekly with bioflocculant, a 2nd unit (labelled R2) was operated with the addition of acrylamide-chitosan graft copolymer, a 3rd unit (labelled R3) was operated with the addition of cationic polyacrylamide, and a 4th (labelled R4) served as a control without any polymer addition. The results showed that R1 was the most efficient, while R3 performed better than the other two reactors. The rates of granulation in R1, R2 and R3 were enhanced by 50% vs. 87% vs. 75% when compared with R4. Though bioflocculant addition was not the most effective way of developing large-size granules, it was demonstrated to be the least inhibitory in enhancing micro-organism multiplication and improving microbial metabolic activity. The volatile suspended solids to suspended solids ratio and the sludge methanogenic activity of the granular samples from R1 were higher than those of the other three reactors. When compared with the control reactor, polymer-added reactors performed better at the most organic loading rate as polymer addition resulted in a considerably higher degree of retention of biomass and lower solids washout from UASB reactors. Granulation was achieved in all four of the reactors, but the granules from polymer-enhanced reactors appeared earlier and were larger than those from the control reactor were.

Keywords: anaerobic granulation, bioflocculant, polymers, UASB

Abbreviations

ACGC	acrylamide-chitosan graft copolymer
AM	acrylic amide
COD	chemical oxygen demand
ECPs	extracellular polymers
HRT	hydraulic retention time
OLR	organic loading rate
PAM	polyacrylamide
SMA	specific methanogenic activity
SRT	sludge retention time
SS	suspended solids concentration
SVI	sludge volume index
VFA	volatile fatty acid
VSS	volatile suspended solids concentration
UASB	upflow anaerobic sludge blanket

Introduction

In developing countries, a number of low-strength industrial wastewaters are frequently found. Moreover, many low-strength municipal wastewaters containing easily biodegradable matter are discharged without full treatment. In addition, in most urban areas the cost and availability of land are now a big problem. In an attempt to decrease water pollution in developing countries, a treatment system should be promoted to fulfil the following requirements: Simple design, easy construction, low energy demand and high treatment efficiency. The anaerobic technology offers great potential in this regard. As a popular anaerobic technology, the UASB reactor has been widely used to treat many types of wastewater because it exhibits positive features such as high organic loadings, low energy demand, short hydraulic retention time, long sludge retention time and little sludge production. More than 900 UASB units are currently operating all over the world (Alves et al., 2000). Usually, they are used to treat medium- and high-strength wastewaters (Lettinga et al., 1993; Fang et al., 1995). They are seldom applied to treat low-strength wastewater with COD concentration lower than 1 500 to 2 000 mg/ℓ because the development of granules in UASB reactors is very difficult when treating such wastewaters (Brito et al., 1997). To extend the application of the UASB reactor for low-strength wastewater treatment, research aimed at this kind of wastewater is necessary and significant, though few reports are found in the literature.

It is crucial to retain a high biomass concentration in a UASB reactor. In general, retention of biomass can be achieved by the principle of autoflocculation (i.e. self-immobilization of bacterial cells) leading to the formation of granules with good settling properties, and the formation of these granules is a key factor in the successful operation of a UASB reactor (Liu et al., 2002). As the anaerobic bacteria are slow-growing micro-organisms, a common problem in UASB operation is the long start-up period and the development of biogranules.

To overcome the limitations of long start-up periods and anaerobic granulation of UASB reactors, strategies for expediting granule formation are highly desirable (Liu et al., 2003;

* To whom all correspondence should be addressed.
☎ +86-20-87114706; fax: +86-20-87111378;
e-mail: ppyyhu@scut.edu.cn
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