Topic: Enhancement of the formation of multilayered anaerobic granules in UASB reactors

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ABSTRACT

The formation of multilayered anaerobic granules mainly consists of nucleation and maturation phases. This study was aimed to construct initial granule nuclei with high syntroph microbial activities and enhance the formation of mature granule by stimulating EPS production. Three UASB reactors were used as R1 (control reactor, no cationic polymer addition), R2 (dynafloc 8265 addition) and R3 (chitosan addition). Mixed VFA (acetate: propionate: butyrate = 2:1:1 based on gram COD) was used as main substrate during nucleation phase. The addition of cationic polymers were aimed for shortening nucleation time. After nucleation phase, early maturation phase was started by switching mixed VFA to glucose for stimulating EPS production without polymer addition.

The addition of chitosan significantly decreased the zeta potential value of microbial aggregates in R3 from -26.4 to -10.5 mV at day 0 and 58, respectively. This zeta potential value affected on fast nucleation time in R3 which was observed at day 58. Nuclei ratio and average diameter size of microbial aggregates of R3 at day 58 were approximately 55.1% and 115 μm, respectively. Granule ratio in each reactor was low at day 58 in which the highest of granule ratio was observed in R3 as 8.2%. During maturation phase, granule ratio in R3 significantly increase as 17.6, 30.8 and 34.2% at day 74, 88 and 118, respectively. Higher nuclei ratio in R3 at day 58 was good as starting point for granule formation during early maturation phase. EPS produced during early maturation phase trapped nuclei with other nuclei to form large aggregates or granule. The microbial adaptation to mixed VFA during nucleation phase successfully increased the activity ratio between methanogen (acetoclastic methanogens) to non-methanogens (glucose-degrading microorganism). However, glucose enhanced the activity of GDM resulting on decrease of activity ratio between methanogens and non-methanogens activities during early maturation phase. The balance between methanogens and non-methanogens was adversely affected, especially in R1 and R2.

The structure of the microbial aggregate in R3 at day 58 was stronger and more compact compared to those in R1 and R2, which were weak and loose. Filamentous microorganisms were dominant inside the microbial aggregate of R1. While, the dominant microorganism inside microbial aggregates of R2 and R3 were mixed microorganism (cocci-, rod- and filament- shaped microorganism). Self-aggregation of microorganism may occurred in R1 and the addition of cationic polymers in R2 and R3 trapped mixed microorganism to form nuclei. At day 118, the morphology of microbial aggregates in each reactor was improved due to the effect of EPS. Microbial aggregates of R3 were very similar with the structure of mature granule which showed smoother surfaces and more spherical shapes.

The microbial distribution in the microbial aggregate of each reactor at day 58 showed that *Archaea* was dominant over *Eubacteria* in that aggregates which indicated that the methanogen population was larger than that of the acetogens due to the adaptation to mixed VFA. However, it cannot be determined that the layer of microorganism was formed in this phase because mixed microorganism groups, *Archaea* and *Eubacteria*, were still randomly dispersed in microbial aggregates of each reactors. At the end of early maturation phase (day 118), microbial distributions in granule of R3 were better than that at day 58. Red *Archaea* clumps, presumptive methanogens, was mostly located at middle and inner part of aggregates. Those *Archaea* clumps were surrounded by green *Eubacteria*, presumptive acidogenic or acetogens microorganism. It can be concluded that green *Eubacteria* clumps around red *Archaea* clumps were acetogens microorganism because the distance between VFA degraders (acetogens microorganism) and methanogens was close each other. Those position allowed the possibility of syntroph relationships inside microbial aggregate of R3. These microbial distribution in microbial aggregate of R3 was probably the main cause for better ACM activity and reactor performances during early maturation phase.

Keywords: Anaerobic granule; multilayered; syntroph; nuclei; cationic polymers