II－444 KINETIC CONTROL OF UASB PROCESS TREATING PHENOL WITH OPTIMUM RECIRCULATION

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1.Introduction Because of the inhibitory of phenolic compounds, the feasibility of biological process depends on the acclimation of biosystem[1], and the optimum control of biological process[2]. In order to achieve the goal mentioned above and understand the charateristics of anaerobic microbes, the mechanism of biodegradation and biokinetics should be understood in details[3]. The concept of kinetic control had been used to perform an UASB bioreactor associated with adjustable recirculation of effluent. During three years, a *54-L* UASB bioreactor loaded with *180-cm* height of the granular sludge had been operated sucessfully to treat *2,000 ppm* of phenol without inhibition . In this biokinetic study, a series of batch tests *Biochemical Methane Potential* (BMP), was conducted as a good skill to investigate the microbial characteristics of in-site anaerobic sludge, *i.e.* the critical methane production rate, R^*, the critical phenol inhibiting concentration, S^*, and the modified Haldane model with the kinetic parameters of R_{max}, K_s, and K_i. Several recirculating ratios from *3* to *6* were performed to search for the relationships of the in-tank concentration profile and these biokinetic parameters. By the point of view in bioactivity and mass transfer phenomenon, the upflow superficial velocity was controlled at *3 m/hr* with adjustable recirculating ratio of *5:1* . While the peocess performance incated the optimum condition for the UASB system. With dense biomass of *30 gVSS/L*, and extremely high degradation rate of *1.14 kgCOD/kgVSS-day* , the recirculated UASB process achieved almost complete removal of *3,000 ppm* phenol at a short hydraulic retention time of *6 hours*. The highest volumetric loading was accomplished up to *30* $kgCOD/m^3$*-day*. Application of the BMP batch tests was proved as a powerful skill to control a continuous-flow UASB process at the optimum performance through a long-term period.

2.Material and Methods In this study, RUASB as shown in Figure 1, was constructed by a plexiglass column with the height of *200 cm* and the inside diameter of *15 cm*. The top of the column was connected to an expanded column with the diameter of *30 cm* and the height of *80 cm*, that decreased the upflow velocity and a good settling of suspended solids. A concentrical plexiglass water jacket with the outside diameter of *18 cm* was installed to maintain a constant temperature at *35°C*. A RUASB bioreactor with the empty volume of *54 L* was operated with the adjustable recirculating ratio, such as *5:1*, and the corresponding superficial velocity at *3 m/hr*. Consenquently, the RUASB process could accomplish a very high loading up to *30* $kg\ COD/m^3$*-day* at the hydraulic retention time (HRT) of *6 hour*. Meanwhile, the procedure of BMP test was modified from Owen's[4]. Seeding sludge was transfered from RUASB bioreactor into the serum bottles under a strictly anaerobic system as the apparatus shown in figure 2. The composite solution with a volume of *30 mL* contained appropriate amount of anaerobic sludge, nutrient, and buffer. Another *30 mL* of substrat solution with various concentrations of phenol was added into each serum bottle. After stripping out the residual air in the head space with CO_2 and N_2 gas, the finished serum bottles were capped tightly and incubated in an orbital shaker at *35°C*. Incubation experiments with various phenolic concentrations were

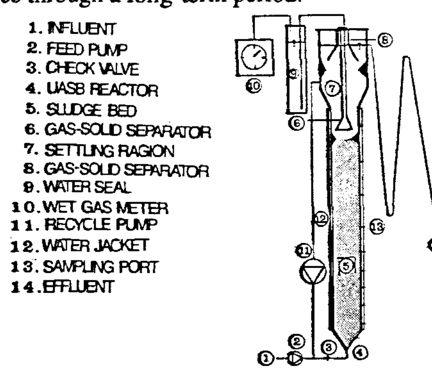

Figure 1. Schematic diagram of RUASB system.

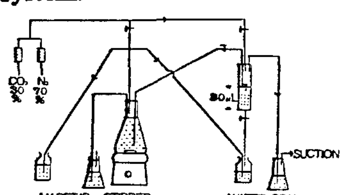

Figure 2. Schematic diagram of procedure for the anaerobic transfer of defined media into serum bottles.

carried out to evaluate the speccific gas production rate (*R*). The data of the specific gas production rate used to select an appropriate model in this study.

3.Results and Conclusions Figure 3 shows the concentration of COD, Phenol, VSS in the effluent, and the biogas production rate of the RUASB process. Within twelve months of operation, four of recirculating ratios, 6:1, 5:1, 4:1, 3:1 were conducted to evaluate the process performance. The results indicated high stability of the concentration of COD, phenol, and VSS present in effluents of each experimental contition, and the biogas production rate also recovered rapidly after two weeks of microbial adaptation. Application of kinetic control could enhance the efficiency of RUASB process. Three experiments of BMP test were carried with the anaerobic sludge which was taken from the bottem of RUASB treating phenol during the latter period of each recirculating of 5:1, 4:1, 3:1, were illustrated in Figure 4. It reveals clearly that the characteristics of anaerobic biosystem in our experiments is sorted to be a typical biokinetic model of substrate inhibition. Therefore, a modified Haldane eguation[5], $R=R_m/[1+(K_s/S)+(S/K_i)^n]$, was recognized as the appropriate biokinetic model for our experimental data. Meanwhile, the optimum performance was showed that the effluent recirculating ratio was controlled at *5:1* as showed in Figure 4. The optimum critical specific biogas production rate (R^*) was *580 mL Biogas/gVSS-daay* (equivalent to *1.14 kgCOD$_r$/kgVSS-day*) and cririical phenol inhibiting concentration (S^*) was *300 mgPhenol/L*. Furthermore, we applied these experimental data to control the applied phenol loading and phenol concentration into RUASB bioreactor. We could accomplish a very high loading up to *30 kgCOD/m^3-day* at hydaulic retention time (HRT) of 6 hours.

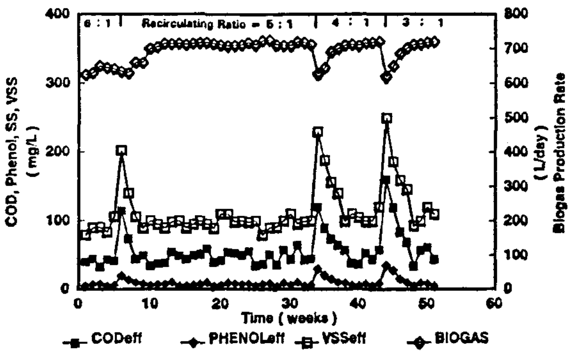

Figure 3. Operation and results of each recirculating ratios(6 : 1, 5 : 1, 4 : 1, 3 : 1).

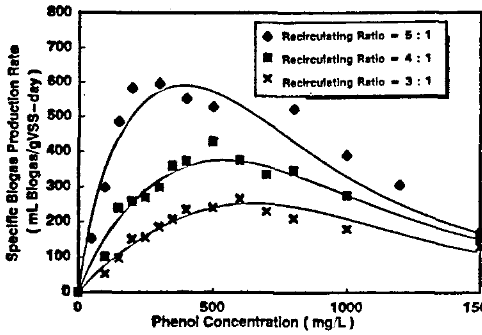

Figure 4. Nonlinear regression fit of modified Haldane equation to specific gas production rate from BMP test.

4.Acknowledgements The partial supports of this work by the National Science Council of the Republic of China and National Cheng Kung University, are gratefully acknowledged.

5.References

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