# THE STUDY OF THE SYNTHETIC WASTE WATER OF MONOSODIUM GLUTAMATE BEING TREATED WITH HCR PROCESS

LIU KANGHUAI AND LI JUNBO

*Depart. Of Resources and Environment, Guilin Institute of Technolgy, Guangxi, China, 541004*

*E-mail: lkh06@yahoo.com*

LI YUEZHONG, XI WEIMING AND A.VOGELPOHL

*Institute of Material transfer of TU-Clausthal, 38638, Hanover, Germany*

*E-mail: liyuezhong@yahoo.com*

The experimental result is that the monosodium glutamate waste-water, which contains high COD and $SO_4^{2-}$, can be treated by HCR process. The removal rate of COD is up than 80% when influent-COD-content is higher than 10000mg/L and $SO_4^{2-}$ content is higher than 14500mg/L. Both its volumetric loading and sludge loading are higher, and sewage production is a little lower in HCR process than in other aerobic process. It may be the best method for treating the monosodium glutamate waste-water in China. It should be noticed that foam might be the sub-production during its running.

## 1 Introduction

The monosodium glutamate waste-water is a kind of organic sewage which contains higher COD and $SO_4^{2-}$ (when sulfuric acid being used) and $NH_3$-N. Some environmentalists have done a lot of work about how to treat the monosodium glutamate waste-water for a long time. For example, Shen Yaoliang and Le Yanran (1990), Hen Xiaogang and Li Chun (1999) have done some experimental study on it by using the conventional anaerobic process and UASB process respectively, whose experimental results show that the effect of treatment are better when waste-water doesn't contain $SO_4^{2-}$ or only a little, at the same time the temperature has to be controlled very strictly (35°C) and HRT(hydraulic retention time) is more than 72h[1]. If the waste-water contains a lot of $SO_4^{2-}$ , COD-to-$SO_4^{2-}$ ratio (COD/ $SO_4^{2-}$) will be more than 6 and the $SO_4^{2-}$ ions concentration will be less than 2000mg/L[2]. As plenty of $SO_4^{2-}$ will inhibit the effect of the anaerobic biological process, Zuo Jiang'e and Hu Jicui have done some special study about it and consider that people should look for and develop a kind of new process to treat the waste-water containing the high $SO_4^{2-}$ ions concentration[3] . Shi ping and Zhang Feijuan also thought that if we want to treat the waste-water containing high concentration of $SO_4^{2-}$ in the anaerobic process, a special method to remove $SO_4^{2-}$ should be used, after their analyzing about $SO_4^{2-}$ ions influence to the methanogenic organism[4].

Because of the reasons mentioned above, so far, we haven't found a good method to treat the monosodium glutamate waste-water. During the past years, to some degree, the monosodium glutamate waste-water has polluted the natural water bodies or has made much more load of the city sewage treatment system in China. The monosodium glutamate is a good cooking condiment, Chinese people like it very much, so, with the level of gastronomy improved, the output of monosodium glutamate is always increasing in China. Today the government has worked out our national policy for environmental protection, the monosodium glutamate waste-water must be treated to the effluent standard. So, it is extremely urgent to look for a kind of reasonable method to treat the monosodium glutamate waste-water.

In experiment, we want to solve the following questions:

• Acquainting that whether the ability of degrading pollutant can meet the requirement of the sewage treatment when COD and $NH_3$-N (ammonia nitrogen) is very high.

• Acquainting high-concentration $SO_4^{2-}$ ions in waste-water will influence the running effect of the HCR process and whether it will be compatible with the conditions of our country. Whether it has the developing and extending possibility.

## 2 The experimental method and the base conditions

2.1 The outline of HCR testing system

The HCR (High performance Compact Reactor) process, whose advantages are high dissolved oxygen and fast velocity of biological metabolism, is a kind of high performance and aerobic biological treatment method, so it is fit to treat the sewage which contains a high-COD concentration and has a good biodegradability, but it isn't fit to be treated by the anaerobic process[5,6]. The HCR system, as shown in Fig.1, consists of a compact reactor, a two-phase jet, a settling tank and the compatible tube and pumps. In the course of running, the HCR process can remove the organic pollutant efficiently because the system can keep enough dissolved oxygen in the waste-water, which results in the velocity of biological metabolism is very fast and the biological quantity is large (SS>=10g/L).

The reactor volume of the HCR system is 15L and the settling tank volume is 29L in the experiment. And the circulation pump and the sludge returned pump are controlled by a adjusting frequency equipment and are also calculated in electromagnetic flow meter.

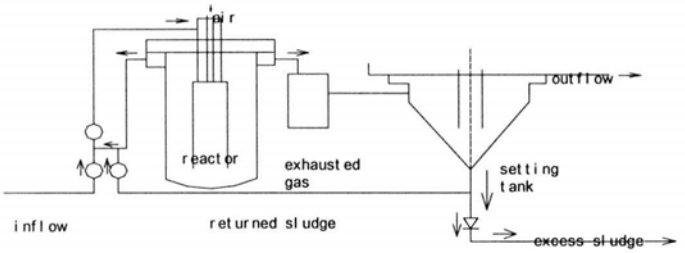


**Fig.1** The HCR Process Chart

2.2 Making up the monosodium glutamate waste-water

We have known that the COD concentration of the waste-water which is formed after having been fermented and segregated in the factory is about 25000mg/L, the mixed COD concentration is about 10000mg/L and the $SO_4^{2-}$ concentration is about 15000mg/L after mixed with other kind of waste-water. Therefore the synthetic monosodium glutamate waste-water is made up as follows: We use refined white sugar instead of organic carbon, and the weight ratio of white sugar-to-monosodium glutamate is 3:1. And we adjust the $SO_4^{2-}$content by using the sodium sulfate, the real $SO_4^{2-}$ content is near to the mixed waster water of the monosodium glutamate industry. In order to ensure the normal metabolism and prevent that too high content of $NH_3$-N will cause some bad influence, we have increased the content of phosphorus in the waste-water appropriately. At the same time we added a little heavy-metal elements and other compositions to keep the total balance of biological reaction system.

The major chemical matters, which we used in the experiment, include white sugar, urea, magnesium sulphate, iron (III) chloride, Primary potassium phosphate, and Secondary potassium phosphate, calcium chloride, monosodium glutamate etc.

2.3 The experimental operating conditions and testing method

In this experiment, the flow quantity of the circulation pump is about 1600-2130L/h. The concentration of the dissolved oxygen in the reactor is about 2.5-5mg/L,and its average value is about 3.9 mg/L. The changeable scope of PH is about 6.28-8.40; the sludge returned velocity is about 37.6-46.6 L/h.

All of the pollution elements were tested in accordance with the German standard. The TOC-content is measured by using the TOC-500 type analyzer, and the content of $SO_4^{2-}$, $NO_3^-$, and $Cl^-$ ions are tested by using 690-type ion chromatography analyzer. And the COD-content is measured by adopting a set of special equipment and the $NH_3$–N-content is tested by using the UV-2102 PC type UV-VI scanning spectrometer; and DO and PH value is measured by using a convenient equipment. MLSS and MLVSS are measured by using the gravimetry method.

## 3 The experimental results and discussion

Only after ten days, the tamed sludge had come up to the expected concentration. After running normally in the beginning, the volumetric loading of reactor was usual kept at 30kg COD/$m^3$.d; subsequently, we gradually increased the volumetric loading of the reactor. We spent two months on this experiment and the result shows that the effect of the waster-water treating is satisfactory. Now we can conclude as follows:

3.1 The compatibility of the HCR process for the monosodium glutamate waste-water

We derived from the active sludge of petroleum waste-water as feed sludge whose primary concentration was about 5g/L. After being tamed for one week, the sludge of the waste-water had a concentration being 8g/L; and ten days later, it had exceeded 10g/L, at the same time the removal rate of TOC and COD was higher up than 80% and at the same time, its upswing tendency was very obvious.

That the COD concentration came up to 10000mg/L and $NH_3$-N concentration came up to 1000mg/L was our primary experimental motive, so we adopted the way that the flow quantity and concentration increased in step, at the same time every fixed volumetric loading run for two or three days, if we couldn't find any abnormal phenomena we would increase the volumetric loading value. After the volumetric loading of the reactor had exceeded 60kg COD/$m^3$d, the reaction system run stably for more than one week, and the running results, as illustrated in Fig.2 and Fig.3, showed that the removal rate of COD exceeded 90% in all cases. When the volumetric loading had exceeded 80kgCOD/$m^3$.d the COD removal rate was still more than 90%, which illustrated that the HCR system has higher compatibility for the synthetic monosodium glutamate waste-water containing high-sulfate.

From the relationship of the inflow-COD and its removal efficiency (Fig.4) we know that the inflow-COD-total is in positive relationship with its removal efficiency in the system, which illustrates that its loading ability can be still increased very easily. In fact the running result of the practical system shows that the inflow-COD concentration has been up to 20000mg/L[7,10].

It is well known that the volumetric loading of the conventional aerobic process is only less than 10kgCOD/$m^3$.d, and the volumetric loading of the high performance

anaerobic process UASB can't be more than 20kgCOD/$m^3$.d either. The HCR process of high volumetric loading is good for treating organic waste-water of higher concentration and need less building-up area for the reactor. So it should be one of the best major high-loading and high-efficiency reactors. It proved that treating monosodium glutamate waste-water using the HCR system has wide and bright prospect.

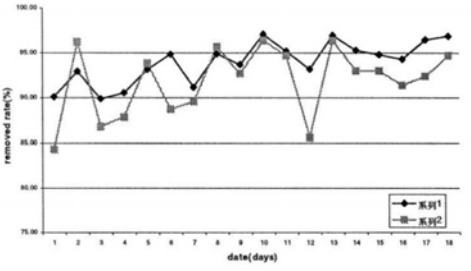


Fig.2 The changed trend of TOC & COD removal rate

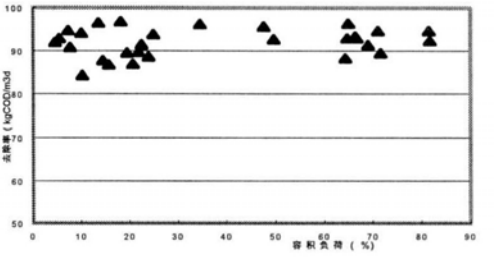

Fig.3 The relationship between capacity loading and COD removed rate

3.2 The possible influence of $SO_4^{2-}$

After fixed the concentrations of inflow-COD and $NH_3$-N, we increased the $SO_4^{2-}$ inflow concentration gradually. Our had done special experiment for $SO_4^{2}$ for two weeks. The experimental results showed that the running effect of HCR was not influenced by the high $SO_4^{2-}$ concentration when the $SO_4^{2-}$ concentration was increased up to 14500mg/L, and the volumetric loading of reactor was kept at about 35kgCOD/$m^3$.d and the sludge concentration was about 10-15g/L and the sludge loading exceeded 2kg COD/$m^3$.d. During the experiment, although the $SO_4^{2-}$ concentration of inflow increased up to 12000mg/L, the TOC removal rate was still near to 90% and the COD removal rate mostly exceeded 80% too.

Qin Linyuan (1989) thought only when the $SO_4^{2-}$ concentration was less than 6000mg/L, would the aerobic process not influence the treating efficiency[9] . This experiment illustrated that not only proper $SO_4^{2-}$ ions do not influence the treating effect of the HCR process, but also it can improve the ability of the removal COD (Table 1). The author thinks that enough dissolved oxygen will ensure the biological metabolism in the HCR process and maybe $SO_4^{2-}$ can help the biological oxidizing reaction and this is why the HCR process be superior to another processes.

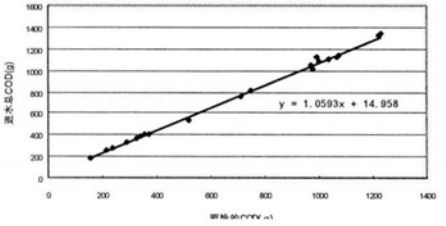


Fig.4 The relationship between Input COD and removed COD

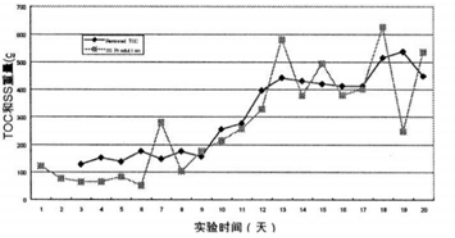


Fig.5 The changed trend of removed TOC & SS production

Table. 1 The relationship between $SO_4^{2-}$ concentration and the removal rate of pollution

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Concentration of $SO_4^{2-}$ (mg/L) | 2416 | 3543 | 4670 | 5796 | 7486 | 10303 | 13684 | 14585 |
| The TOC removal rate (%) | 93.06 | 90.06 | 88.94 | 88.64 | 81.44 | 90.12 | 89.20 | _ |
| The COD removal rate (%) | 66.99 | 77.20 | 80.84 | 84.48 | 86.77 | 85.59 | 86.75 | 80.99 |

3.3 The characteristic of the sludge production

In the experiment, we determined sludge-discharge-capacity according to the sludge concentration and adopted hand-operated method to discharge the excess sludge discontinuously, two or three times each day. We usually made the sludge concentration exceed 14g/L and the highest sludge concentration for 21.09g/L in the reactor. The sludge yield was determined by the removal rate of TOC, that is to say , when the removal rate of TOC is low, sludge yield is low; when the removal rate of TOC is high, the sludge yield is also high. Some single points has some undulation possibly due to the hand-operated discharge sludge, but the total changing tendency is of positive relationship(Fig.5).

We calculated the increasing and reducing sludge in the HCR reactor in step in order to calculate the circumstances of sludge yield correctly and worked out the average output of sludge for 0.373kg SS/kg COD. Compared to the sludge-yield rate (0.55)[8] in the convention active sludge method, the sludge-yield rate of the HCR process reduced by 32.2%.

There was much more volatile matters, the ratio of MLVSS/MLSS changed from 0.86 to 0.93 and its average value was 0.904. The efficiency which unit-sludge output degraded the organic pollutant was calculated and obtained the average value of sludge loading for 3.02kgCOD/kg SS.d. This proves that the sludge loading of the HCR process is also higher than the conventional aerobic process.

## 4 The acquaintances and conclusions

The monosodium glutamate waste-water containing high $SO_4^{2-}$ can be treated effectively by the HCR process directly. Under the circumstances of not removing the $SO_4^{2-}$ ions, the HCR process not only can degrade COD stably but also have the lower excess sludge. The HCR process is a kind of high performance and high loading aerobic new technology indeed.

The industrial monosodium glutamate waste-water has good biodegradability [1,2], but this kind of industrial sewage is difficult to be treated by other biological methods because of its high $SO_4^{2-}$ ions. Adopting the HCR process can not only remove pre-treatment process of removing $SO_4^{2-}$, but also can reduce the build-up area for the reactor, which will saved a considerable money, so we estimate its comprehensive cost is lower than the conventional anaerobic and aerobic processes. Especially for those enterprises that have not enough field for rebuilding and can't develop the environmental engineering construction widely. The HCR process is one of the most useful methods for choice primarily.

In order to obtain some reliable design parameters, the next experimental study aim will be that how to make the volumetric loading, HRT and all kinds of circulating data reaching the optimal association under the conditions that effluent has met the

requirement of the discharge standard. The best running conditions and designed parameters will be determined at the lowest energy consumption.

The Nitrogen element of the waste-water mostly comes from urea and the monosodium glutamate so the content of free-N is very little and its chief way of existence is organonetrogen. The result of the experiment also shows the nitrating reaction don't proceed in larger scale in the system. The reason of this is probably that the COD concentration is too high and hasn't enough dissolved oxygen to make the nitration action going on. Considering the real monosodium glutamate waste-water contains higher $NH_3$-N, the question of removing the $NH_3$-N must be studied in further experimental study.

The experiment shows that HCR process also produces plenty of foam like other aerobic processes. In general, its producing conditions includes two reasons: Firstly, suddenly raising the sludge loading, such as too much discharge sludge flow, will cause the production of foam. Secondly, the sludge ageing or the bad activity will cause so. The foam often rise from unexpected circumstances, and these accidents can be avoid at all if the operation is proper and the management is right.

## 5 Acknowledgements

In the course of the experiment, the Institute of Material Transfer of the Technical University of Clausthal gave us energetic support and the person of the laboratory gave us specific guide, thanks for all.

## References

1. Shen Yaoliang Le Yanran the Controled Study of Stable Running of the Monosodium Glutamate with Anaerobic Treatment , Environmental Scicence, 1990.11(5) ,31-33
2. He Xiaogang .Li Chan the Anaerobic Biological Treatment of the Monosodium Glutamate –Amikacin Sulfate mixed Waster-water , the Environment Engineering Protection of Chemical Engineering ,1999,49,168-177
3. Zuo Jiane ,Hu Jicui the Anaerobic Biological Treatment of The Organic Waster-water Containing $SO_4^{2-}$, Environment Science ,1991,12(3),67-71
4. Shi Ping ,Zhang Feijuan the Study of Treating the Organic Waster-water Containing $SO_4^{2-}$with the Anaerobic Method the Technology of Prophylaxis and Treatment for Pollution ,1999,12(3),134-138
5. E.A.Naundorf , D.Subramnian , N.rabiger and A.Vogelpohl Biological Treatment of waster water in the compact reactor ,Chemical Engineering Process , 1985,19,229-233
6. M.K.N.Yenkie , S.U.Geissen and A.Vogelpohl , Biokinetics of wastewater treatment in the high performance compact reactor, The Chemical Engineering Journal,1992,49.B1-B12
7. H.Wildhagen , F.Schneider , A.Vogepohl , S.Geissen , Pilot test of biological treatment of brewery effluent using the HCR system at Gilde Brewery in Hanover , Brauwelt international , 111(1992)294-298
8. Gao Tingyao the Water Polluted and Controlled Engineering , The High-education Publishing House,1998, Beijing
9. Qin Linyuan the Biological Treatment of the Waster-water , The Tongji University Publishing House, 1989, Shanghai
10. Liu Kanghuai ,Li Yuezhong ,Li weiming HCR—the High Efficiency Aerobic Biological Treatment Technology , Water & Waste-water Engineering, 2000,26(4),25-28