CHEMICAL ENGINEERING TRANSACTIONS
VOL. 62, 2017
A publication of AIDIC
The Italian Association of Chemical Engineering
Online at www.aidic.it/cet
Guest Editors: Fei Song, Haibo Wang, Fang He
Copyright © 2017, AIDIC Servizi S.r.l.
ISBN 978-88-95608- 60-0; **ISSN** 2283-9216
DOI: 10.3303/CET1762004

Hydrolytic Acidification of Jujube Processing Wastewater + Contact Oxidation Treatment Test

Pengyuan Si, Junliang Liu*,Zhihui Song, Dezhong Li, Tiejian Zhang

Institute of Urban and Rural Construction, Hebei Agricultural University, Baoding 071001, China
hb-ljl@163.com

In this paper, it uses the technology of coagulation sedimentation – hydrolytic acidification – contact oxidation in treating the jujube processing wastewater, which makes membrane forming on the combined filler in reactor successfully by adopting domestic wastewater, and then dilutes jujube processing wastewater with domestic wastewater according to certain proportion to realize acclimatization of the biological membrane and complete starting of the reactor, and finally completes the biochemical treatment test of the jujube processing wastewater diluted by the feed water via backflow of the yielding water. The yielding water is stable during the test operation, and it has greater removal efficiency as to COD_{cr} and ammonia nitrogen.

Jujube is full of nutriments, has wide varieties, and possesses edible value, healthy-keeping value and medical value. Jujube processing has a long history in our country, there are numerous jujube processing enterprises, and the jujube is mainly processed to dried jujube, preserved fruit, jujube vinegar, jujube chips, jujube milk and jujube wine, etc. However, it has a greater difficulty to treat the wastewater generated in the jujube processing process, and the wastewater is one of the wastewaters with serious pollution in the food industry (Xu et al., 2014; Bi et al., 2010; Chen and Li, 2008; Wang et al., 2013). This test uses the technology of coagulation sedimentation – hydrolytic acidification – contact oxidation in treating the jujube processing wastewater, and achieves certain effects.

1. Feed Water Quality of the Test

The wastewater adopted in this test is the industrial wastewater of a jujube processing plant in Cangzhou city, with high contents of COD_{cr}, ammonia nitrogen and total phosphorus and lower pH. As jujube denucleation may generate jujube residues during the jujube processing process, the wastewater has high content of suspended solids. Moreover, plenty of white sugar and citric acid need to be used in jujube cooking and soaking processes, while white sugar makes rising of the COD_{cr} content in wastewater, and citric acid can reduce pH of the wastewater. As the wastewater has plenty of large-particle jujube residues, initial sedimentation is needed before coagulation sedimentation, and the test water is the supernatant liquor after the initial sedimentation, with the water quality as shown in Table 1.

Table 1: Test Water Quality

Water Quality Index	pH	Chroma city (Times)	Turbidity (NTU)	COD (mg/L)	BOD_5 (mg/L)	Ammonia Nitrogen (mg/L)	Total Phosphorus (mg/L)
	3.9	333	232	85600	20800	334	28

2. Coagulation Sedimentation

Coagulation is one of the better choices for pretreatment, and it is a commonly accepted water treatment method with earlier application (Chen, 2007). By screening the appropriate coagulant via tests and determining the optimal application conditions, we can reduce the subsequent treatment burden and save the operation cost. In this test, it gives judgment according to the change of turbidity and CODcr of the jujube processing wastewater, and researches on the influence of coagulant dosage, coagulant aid dosage, pH and

Please cite this article as: Pengyuan Si, Junliang Liu, Zhihui Song, Dezhong Li, Tiejian Zhang, 2017, Hydrolytic acidification of jujube processing wastewater + contact oxidation treatment test, Chemical Engineering Transactions, 62, 19-24 DOI:10.3303/CET1762004

coagulation time on the coagulation of jujube processing wastewater. It firstly determines scope of each influencing factor with single factor analysis method, and finally confirms the optimal coagulation conditions by conducting orthogonal test. According to this test, the optimal coagulant is polymeric aluminum, coagulant aid is polyacrylamide, and the optimal coagulation conditions are as follows: coagulant dosage 120mg/L, coagulant aid dosage 15mg/L, pH 7, and coagulation time 20min. The water quality after treatment is as shown in table 2.

Table 2: Water Quality after Treatment

Item	COD_{cr} (mg/L)	Turbidity (NTU)	Ammonia Nitrogen (mg/L)	Total Phosphorus (mg/L)
Water quality after treatment	46224	28	108	8
Removal rate	46%	88%	68%	71%

3. Inoculation and Membrane Forming

Hydrolytic acidification and contact oxidation reactors of this test all adopt D150mm combined filler beams with spacing 100mm, and the combined filler possesses the characteristics of good heat dispersion, good water distribution and gas distribution performances, easy membrane forming and bubble cutting (Xiao and Xu,2006; Wang et al., 2011; Kuang et al., 2017; Zhu et al., 2011). The inoculated sludge of this test takes from the sludge thickener of the Lugang sewage treatment plant in Baoding city which mainly processes the domestic wastewater of Baoding city, and the sludge possesses stronger activity. During inoculation and membrane forming of the hydrolytic acidification and contact oxidation reactors, the domestic wastewater in the urban sewage pipeline is taken as the raw water, which could provide the microorganism in activated sludge with nutrient substance, possesses 400mg/L CODcr, 60mg/Lammonia nitrogen, 8mg/Ltotal phosphorus and the microelements necessary for the microorganism growth, and can satisfy the demand of the microorganism growth in activated sludge (Zhang et al., 2013; Chen, 2007; Zhou and Peng, 2015). At the beginning of inoculation and acclimatization, we shall firstly pour the inoculated sludge into the reactor, with the inoculated sludge accounting for 1/4 of the effective volume of the reactor, and then fill it up with domestic wastewater, and contact it with the oxidation reactor for the 24h stuffy aeration, and water quality of the supernatant liquor in the reactor tested after 24h is as shown in Table 3. It can be seen from the test results that the nutrient substances in wastewater are consumed greatly, the urban domestic wastewater can provide membrane forming of microorganism with suitable environmental conditions, and the membrane forming test can be conducted. After 24h stuffy aeration, water shall flow into the reactor, the designed hydraulic retention time of hydrolytic acidification reactor is 12h, and that of contact oxidation reactor is 8h. Hydrolytic acidification reactor shall show the blackening trend since from the second day after continuous water inflow after membrane forming, and the reaction color is fully black in the third day, the dissolved oxygen is about 0.8mg/L as tested at that time, and it is basically in anaerobic state. Membrane forming of the hydrolytic acidification reactor is about 20 days, and the biological membrane on filler is black and thinner; dissolved oxygen in contact oxidation reactor maintains at 3.5mg/L, the water in reactor is relatively turbid in the first day of continuous water inflow, the clear yielding water can be obtained in the second day, while the biological membrane on filler is not formed at that time, for removal effect of the inoculated sludge remained in reactor on the organic matters. Along with progress of the membrane forming, the biological membrane on filler is mature gradually; membrane forming time is about ten days. Moreover, the biological membrane on filler is in yellowish-brown and relatively thick and solid.

Table 3: Water Quality after Stuffy Aeration

Item	COD_{cr} (mg/L)	Ammonia Nitrogen (mg/L)	Total Phosphorus (mg/L)
Hydrolytic acidification	291	46.3	5.2
Contact oxidation	58	5.1	6.5

Yielding water qualities of hydrolytic acidification reactor and contact oxidation reactor during membrane forming are as shown in Figure 1 and 2.

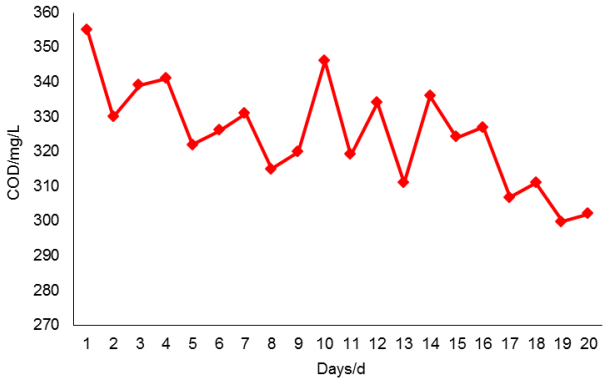

Figure 1: CODcr Change Curve of Hydrolytic Acidification Reactor

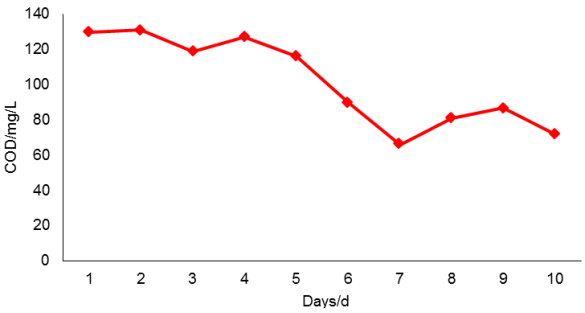

Figure 2: *CODcr Change Curve of Contact Oxidation Reactor*

4. Acclimatization Stage

Function of hydrolytic acidification is to degrade the macromolecular organic matters difficult to degrade and existed in wastewater to the micro molecular matters by utilizing hydrolysis of the hydrolytic acidification bacteria, and it can promote biodegradability of the wastewater, create conditions for the effective CODcr removal in the subsequent aerobic treatment process, and reduce CODcr content of the feed water in the contact oxidation process to some extent simultaneously (Wang et al., 2014; Guo, 2002; Li et al., 2014; Wang et al., 2015). It can be seen from water quality of the jujube processing wastewater that BOD/COD of the feed water is 0.24, so it belongs to the wastewater difficult for biodegradation, for there are proteins and cellulose contained in jujube residues, thus pretreatment of hydrolytic acidification bacteria is needed. Hydrolytic acidification reactor is organic glass column reactor with diameter 100mm and effective volume 0.025m^3, thus we can observe growing state of the biological membrane in reactor clearly. After successful membrane forming of hydrolytic acidification reactor and contact oxidation reactor, microorganism acclimatization shall begin, with acclimatization method as follows: the jujube processing wastewater after initial sedimentation and coagulation sedimentation is diluted by domestic wastewater and then flows in hydrolytic acidification reactor and contact oxidation reactor successively, we can increase proportion of the jujube processing wastewater gradually along with adaptation of the microorganism on biological membrane to the feed water to realize microorganism acclimatization, and the acclimatization shall be completed when jujube processing wastewater fully enters into the reactor, growing state of the biological membrane in reactor is favorable, and the yielding water is stable. The tests are conducted by taking proportions of domestic wastewater and jujube processing wastewater as 74:1, 73.5:1.5, 72.5:2.5 and 70:5 respectively, the proportions are changed at the 6th day, 11th day and 16th day respectively, and yielding water quality states of the reactors are as shown in Figure 3 and 4.

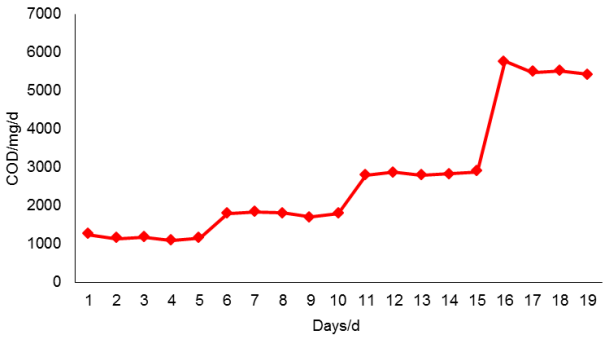

Figure 3: CODcr Change Curve of Hydrolytic Acidification Reactor

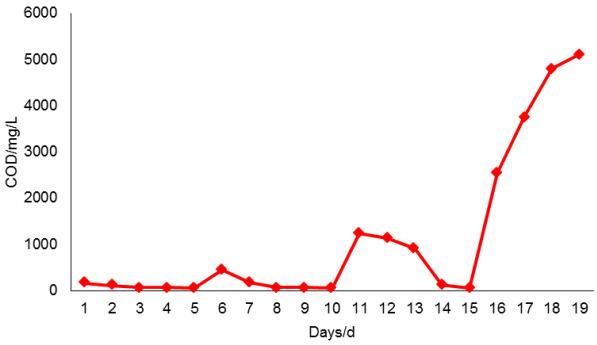

Figure 4: *CODcr Change Curve of Contact Oxidation Reactor*

It can be seen from the CODcr change curve of reactor that: when CODcr of the feed water increases, that of the yielding water of hydrolytic acidification reactor shall increase correspondingly. According to the test analysis, CODcr removal rate of the hydrolytic acidification reactor does not remain stable along with increment of the CODcr in feed water when the hydraulic retention time is fixed, while the total CODcr removal amount shows unchanged roughly, for the microorganism on the combined filler of hydrolytic acidification reactor has long generation time and is lesser in quantity, anaerobe metabolism is slow, and only a fraction of organic matters can be used in compound of the cells of microorganism after being decomposed. When CODcr of the feed water increases, hydrolytic acidification reactor shall show too low pH value, reduction of pH value shall be more obvious when CODcr of feed water is greater, and the lowest pH value is about 3, for numerous accumulations of the volatile organic acids caused by hydrolytic acidification of the anaerobic bacteria to the organic matters. However, the fermentation bacteria cannot decompose the organic acid timely when pH is relatively low, and too low pH also has inhibiting effect on the hydrolytic acidification bacteria. In this test, it adjusts too acidic phenomenon of the hydrolytic acidification reactor by adding sodium hydroxide in the feed water, and pH value of the feed water is adjusted to 7.5~8.0, and pH value in the hydrolytic acidification reactor is maintained at 6.5 around. Contact oxidation reactor still has better CODcr removal effect when CODcr of the feed water increases and CODcr of the yielding water shows sharply increment during the process, for insufficient oxygen dissolution and too low pH value of the yielding water of hydrolytic acidification reactor, which also affects growth and metabolism of the aerobe in the contact oxidation reactor. Thus, we can take measures timely to increase aeration rate and ensure dissolved oxygen value during operation of the reactor, prevent pH value of the reactor from being too low by adding sodium hydroxide in reactor, and ensure removal efficiency of the reactor thereof. However, when CODcr increases to the level above 5,000, it shall be hard to adjust the dissolved oxygen by increasing the aeration rate, the dissolved oxygen in reactor shall always be in the relatively low level, and the reactor shall be not able to remove CODcr effectively, thus the biological membrane on the combined filler in contact oxidation reactor shall begin to go bad and lose activity gradually, the reactor shall not exert the function of removing organic matters finally, and operation of the reactor shall be failure. According to the test, adding proportion of the jujube processing wastewater and domestic wastewater of the feed water shall be controlled below 5:70.

5. Second Starting of the Feed Water Dilution

The reason for failure of the reactor operation is that aerobic biological membrane is unsuitable for the operation in the condition with high-density organic matters, and too high density of the organic matters of feed water is easy to cause too high extracellular osmotic pressure of aerobe, which may result in inactivation of the microorganism (Zhou et al., 2014; Zhang et al., 2014). Moreover, when the dissolved oxygen in reactor reaches the limit, it shall be not able to provide the aerobe with sufficient dissolved oxygen continuously, and microorganism shall not give normal respiration. According to analysis, it is appropriate to determine CODcr value of the contact oxidation reactor as 2,500mg/L.

Membrane forming and starting of the reactor shall be conducted again after failure of the reactor operation, we can dilute the feed water by backflow of the yielding water after success of the second membrane forming to prevent density of the organic matters of the feed water from being too high, the backflow ratio shall be 2.5:72.5, namely that we shall mix 2.5 volumes of jujube processing wastewater after coagulation sedimentation with 72.5 volumes of yielding water. During the test, yielding water is stable, CODcr of the yielding water is below 100mg/L, ammonium removal rate is relatively high, ammonia nitrogen of the yielding water is not greater than 5mg/L, and the total phosphorus is about 5mg/L. Deficiencies of this test are as follows: plenty of yielding water is used in diluting the feed water, which results in too little yielding water, and the water treatment capacity is insufficient; yielding water quality index is still higher, while it has reached the yielding water standard for sewer, and it needs to give further treatment to the yielding water to reach the reuse water standard.

6. Conclusions

(1) The coagulation sedimentation – hydrolytic acidification – contact oxidation technology can be used in processing the jujube processing wastewater, and the yielding water effect is better. However, as CODcr density of the jujube processing wastewater is great, it shall be needed to dilute the feed water, and the yielding water volume shall be smaller. As permitted by conditions, we can give treatment by mixing the domestic wastewater with the jujube processing wastewater.

(2) According to this test, the optimal coagulant for coagulation sedimentation of the jujube processing wastewater is polymeric aluminum, coagulant aid is polyacrylamide, and the optimal coagulation conditions can be determined by conducting orthogonal test as follows: coagulant dosage 120mg/L, coagulant aid dosage 15mg/L, pH 7, and coagulation time 20min.

(3) Membrane forming of reactor can be completed with the domestic wastewater in urban sewer, the water quality condition is appropriate, and the membrane forming speed is quick; the urban wastewater and jujube processing wastewater can be used in acclimatization of the biological membrane of reactor by mixing, and the test can reach the better effect.

(4) Contact oxidation reactor cannot operate in the condition with high-density CODcr, for the high-density organic matters may cause insufficient oxygen dissolution in reactor, growth retardation of biological membrane, and finally failure of the reactor operation.

(5) As jujube processing wastewater belongs to high-density organic wastewater, and anaerobic reactor is suitable for the operation in the condition of higher-density organic matters, it is suggested to process the jujube processing wastewater with anaerobic reactor.

Reference

Bi J.F., Yu J.J., Bai S.S., Wang P., Ding Y.Y., 2010, Research Status of Jujube Processing Technology at Home and Abroad, Academic Periodical of Farm Products Processing, (2), 30-31, DOI: 10.3969/jissn.1671-9646(X).2010.02.016.

Chen H.H., Li X.R., 2008, The Investigation on Candied Fruits of Red Jujube, Food Science And Technology, (9), 37-41, DOI: 10.13684/j.cnki.spkj.2008.09.024.

Chen M.X., 2007, Experimental Study on Treatment of Printing and Dyeing wastewater by Coagulant of PAC and PAM, Science & Technology Information, 205, DOI:10.16661/j.cnki.1672-3791.2007.27.021

Chen Y., 2007, Research on the Application of Anaerobic Process in Sanitary Wastewater Treatment, College of Resources and Environment Science Chongqing University

Guo Y.L., 2002, Startup and Testrun of Anaerobic Reactor in A1/A2/01/O2 System For Coke Plant Wastewater Treatment, Taiyuan University of Technology.

Kuang H.Y., Guo Q.W., Chen S.L., Huang D.W., Bai J.Q., Gu X.Y., 2017, Performance of Bypass Purification Technology of Biological Contact Oxidation Process for Urban Lake Landscape Water Treatment, Water Purification Technology, 36(6), 58-64, DOI: 10.15890/j.cnki.jsjs.2017.06.010.

Li M.L., Jiang J.G., Zhang H.W., 2014, Effect of Ketchen Waste Hydrolysis Products on Domestic Wastewater Denitrification, China Environmental Science, 34(4), 917-923.

Wang X., Liu J., Ge H.B., Yuan M.Y., Zhang J.J., 2013, Case of Wastewater Engineering of Jujube Processing Industry, Environmental Science and Technology, 26(1), 52-55.

Wang G.W., Jiang J.Y., Zhou Y.X., Zhang S., Wang Y.J., Wang X.S., 2011, Study The Effect on Treatment of Acrylic Fibers Wastewater By Combined Filler Membrane A/O Process, Technology Of Water Treatment, 37(07),116-119, DOI: 10.16796/j.cnki.1000-3770.2011.07.031.

Wang X.H., Huang Y., Wang H., 2014, Comparative Study Between Attached Reactor and UASB Reactor for Hydrolysis and Acidification of Dyeing Wastewater, Chinese Journal of Environmental Engineering, 8(4), 1521-1525.

Wang X., Chu L.B., Ding P.Y., Zhang N., Yang C.P., Liu H.Y., Wang J.L., 2015, Biodegradation Characteristics of Petrochemical Wastewater by Micro-aerobic Hydrolysis Acidification, Huanjing Kexue Xuebao, 35(1), 161-167, DOI: 10.13671/j.hjkxxb.2014.0807.

Xu H.B., Shi G.M, Liu C.W., Li Z.Q., 2014, Design and Operation of Jujube Processing Wastewater Treatment Project, China Water & Wastewater, 30(14), 97-99

Xiao W.S., Xu W.G., 2006, Scale-Producing Test For Treating Domestic Wastewater By Membrane Bioreactor, Technology Of Water Treatment, 32(11), 71-73, DOI: 10.16796/j.cnki.1000-3770.2006.11.020.

Zhu L.F., Zhang Z.Y., Zhang Y.P., Liu L.L., Zhang R.T., 2011, Experimental Research on the Treatment of the Life Sewage in the Bio-Contact Oxidation Technology of Combined Fillers, Yellow River, 33(07), 76-78, DOI: 10.3969/j.issn.1000-1379.2011.07.030

Zhang W.Q., Wu S.B., Lang Q.Q., Dong R.J., 2013, Trace Elements on Influence of Anaerobic Fermentation in Biogas Projects, Transactions of the Chinese Society of Agricultural Engineering, 29(10), 1-11, DOI: 10.3969/j.issn.1002-6819.2013.10.001.

Zhou L., Peng B., 2015, Effect of Trace Elements for Improving the Aerobic Biological Treatment of Industrial Wastewater, Journal of Tsinghua University, 55(6), 653-659, DOI: 10.16511/j.cnki.qhdxxb.2015.06.009.

Zhou T., Xu X.R., Xu H., Li L.L., Liang H.Z., Li Y., Li S., 2014, Research of Bacterial Biofilm Growth Based on Osmotic Pressure Theory, Journal of Jinggangshan University(Natural Science), 35(5), 33-37

Zhang N., Tian X.W., Wang R.H., Chu J., Zhang S.L., 2014, Influence of Osmotic Stress on Fermentative Production of L-lactic Acid by Lactobacillus Paracasei, Science and Technology of Food Industry, 10, 98-104, DOI: 10.13386/j.issn1002-0306.2014.10.013.