A Study of Composting System of Municipal Solid Waste with Bio-surfactant

Beidou Xi [1], Yingjun Li [2], Zimin Wei[1,3], Yue Zhao[3], Hongliang Liu [1]

1. Chinese Research Academy of Environmental Science, Beijing 100012, China; Xibeidou@263.net
2. Beijing Vocational Agriculture, Beijing 100012, China
3. Northeast Agriculture University, Harbin, Heilongjiang 150030, China; Weizm691120@163.com

Abstract: Three sets of adding Bio- surfactant experiments were conducted to understand composting processes with bio-surfactant. Inoculating Strains Ⅲ(2), Pseudomonas aeruginosa (PA) and Bio-surfactant to MSW system by 0.4%、0.4%、0.008% for Run 1, Run 2, Run 3, respectively. The composting experiments showed that: The system of treatment 1 (0.4% Strains Ⅲ(2)), reduce surface tension between liquid and solid to 36 mN/ml at 24 hours. Compared with the control, the quantity of humic from 10.6% to 18.2% and accumulation H_2S of outlet gas was around half of the control. Thus, Inoculation composting technology with bio-surfactant is a promised method to enhance composting efficiency and improve composting quality. [The Journal of American Science, 2(1):66-70].

Keywords: municipal solid waste; composting; bio-surfactant; efficiency composting process

1. Introduction

Composting is a well-know system for rapid organic matter (OM) stabilization and humification (Adani, 1995; Desai J D, 1997), and Compost is organic fertilizer containing primary nutrients as well as trace minerals, humus and humic acids, in a proportion that almost exactly matches plant requirements, and in a slow release form that does not burn plants. At present, because of the poor compost technology in China, some problems, such as, low efficiency of MSW compost, unstable production qualities, and some strong smells, made a lot of compost factory be a state of stop production and half –stop production owing to the unmarketable of compost production, worse environment of compost plant, and expensive fee of MSW treatment (Nakano, 1992), therefore, how to increase the efficiency of compost, improve the environment and qualities of compost have become the technological keys. Bio-surfactant comes from the metabolic product of microorganisms; it can improve the microenvironment of compost, promote the dissolution of infectant and accelerate the process of compost reaction. In this paper, the further study on strengthen compost technology by Bio-surfactant has important theory and practice meaning on popularization of MSW compost in China.

2. Materials and Methods

2.1 Materials

Because of the complex and unsteadiness of MSW compositions, primary MSW compost would produce many uncertainty factors. In this paper, compost materials are made up of many substances according to a certainty proportion (Table 1), properties of compost materials were showed in Table 2.

Table 1. The composition of compost materials

Materials	Potato	cabbage	meat	rice	paper	soil	unit	note
Contents	40	20	10	10	5	5	/%	

Table 2. Properties of compost materials

Treatment	Organic Carbon %	Water %	Ash %	Organic matter %	Total Nitrogen %	Total Phosphorus %	Total Potassium %	C/N	pH
Compost	30~35	50~60	25~35	55~65	1.2~1.5	?	?	24~30	6.5~7
Materials	35	68	20	70	3.4	1.8	?	10.3	7.2

Culture medium compositions: peptone, NaCl, K_2HPO_4, agaragar, potato distill juice, glucose, wort, barm juice, distilled waster, *et al*.

Experiment instruments: surface tension instrument, TOC analysis instrument, culture box, compost reactor, O_2-H_2S detection instrument, CO_2 detection instrument (ANALYZER LX-70) (Zhang, 2003).

2.2 Experiment methods

20 kg compost materials (water content 55%-60%) put into compost reactor (Figure 1) designed with a total volume of 27 L, and 300 mm in length, 300 mm in width, and 300 mm height. Additional equipments: churn-dasher, pH probe, gas flow meter, temperature maintenance box, an O_2-H_2S monitoring instrument (Model MD-520E), and a CO_2 analyzer (Model LX-710).

The experimental design included 4 treatments (Table 3). The experimental strains included strainsIII (2) and pseudomonas aeruginosa (PA) which produce bio-surfactant strongly. The different strains were respectively inoculated in 500 mL corresponding culture medium, and cultured by shake for 40 h at 28℃. And the suspension was inoculated in composting. Inoculating concentrations of the suspension were shown in Table 3. The bio-surfactant of treatment 4 was purified from the culture solution of strainsIII (2).
During composting, a 30 g sub-samples was taken once a day. A 10 g was analyzed for moisture content and ash. A 10 g was extraction by $Na_2P_4O_7$ solution, and analyzed humus. A 10 g was added to distilled waster, and analyzed surface tension and pH.

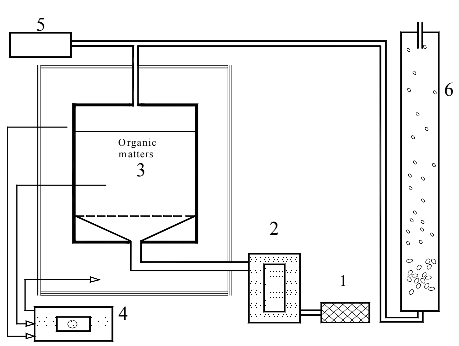

Table 3. Quantity of Bio- surfactant accession in compost materials

Trentments	Additive	Dose, % w/w
Control (CK)	--	--
1	Strainsβ（2）	0.4
2	Pseudomonas Aeruginosa (PA)	0.4
3	Bio-surfactant	0.008

1.3 Analyses methods

1.3.1 Analyses items and methods

(1) Surface tension measurement

To 10 g fresh MSW sample and 90 mL of distilled water was added, And the solution was shaken (100 rpm, 27℃) for 1h, the suspension was then centrifuged (4×10^3 r · min^{-1}) for 30 min and the supernatant was filtered through a 0.45-um membrane filter, then measured by surface tension instrument (Xi, 2003).

(2) Air feed quantity and gas concentration in outlet tested by O_2-H_2S detection instrument and CO_2 detection instrument, respectively.

2.3.2 Calculated methods

Oxygen consumption rate can be defined as the consumption oxygen quantity of per unit time in dry compost materials degradation. Oxygen consumption rate and accumulated oxygen consumption profile can

$$\sum R = A_0 a \int_0^t \frac{q(z_i - z_e)}{V_M} dt$$

be calculated by the gas difference of inlet to outlet (Haug, 1993).

Where, R is the oxygen consumption rate (mol · (h · kg)$^{-1}$); q is the airflow (m^3 · h^{-1}); z_e is O_2 concentration of outlet gas (mol · kg^{-1}); z_i is O2 concentration of inlet gas (mol · kg^{-1}); V_M is the volume of per mol gas (mol · mol^{-1}); M_d is the weight of dry matter (kg); a is the oxygen quantity of per unit organic matter degradation (1.27g · kg); A_o is the molecular weight of oxygen (0.032 kg · mol).

2. Results

2.1 Surface tension profile during composting

The surface tension profile was showed at fig. 2, during composting, the surface tension of CK declined to the minimal value (46.5mN·m^{-1}) at 72 h, and could maintain under 50 mN·m^{-1} only for 60 h; but that of adding strain III (treatment 1), pseudomonas aeruginosa (treatment 2) and bio-surfactant (treatment 3) declined to the minimal value (36.0 mN·m^{-1}, 36.5 mN·m^{-1}, 39.8 mN·m^{-1}) and maintain under 50 mN·m^{-1} for 108 h, 96h and 96h, respectively. The results showed, to a certainty range, the surface tension related to the adding strains which could produce the surfactant, or directly adding bio-surfactant. In this study, the decline range of surface tension at treatment 1 and 2 were lower than that of CK and treatment 3 during composting. And ordered as follow: treatment 1, treatment 2 > treatment 3 > CK. the results suggested, the inoculating strains which selected from composting, could regulate metabolism according to surroundings, and produce relevant surfactant to reduce the surface tension between liquid and solid, then make the substance easily to be extracted from inherent of solid waste. Compared to adding strains, the ability of adapting composting system by directly adding bio-surfactant was limited. Therefore, to declined the surface tension between liquid and solid during composting, inoculating microbes which could produce surfactant, is a effective way.

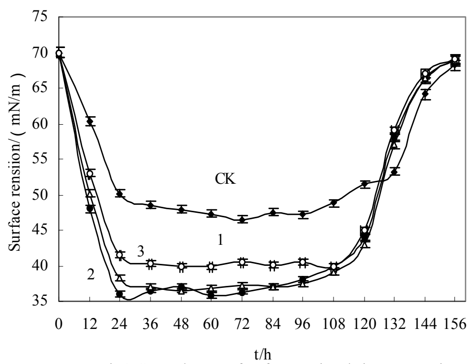

Fig.2 Curve changes of surface tension during composting

2.2 Oxygen consumption rate and accumulation oxygen consumption

The Figure 3 and Figure 4 showed, Oxygen consumption rates and accumulation oxygen consumption of treatment 1, 2 and 3 all increased at a different degree compared to CK. For CK, treatment 1, treatment 2, and treatment 3, the maximal oxygen consumption rates were 0.10 mol·(h·kg)$^{-1}$ at 96 h, 0.163 mol·(h·kg)$^{-1}$ at 48 h, 0.15 mol·(h·kg)$^{-1}$ at 72 h, 0.125 mol·(h·kg)$^{-1}$ at 72 h, and the accumulation oxygen consumption were 300.5 g·kg^{-1}, 460.1 g·kg^{-1}, 442.8 g·kg^{-1}, 380.17 g·kg^{-1} with 240 h operation, respectively. The results showed that inoculating microbes on composting could increase the oxygen consumption rate rapidly, and the maximal oxygen consumption rate was 1.6 times of CK.

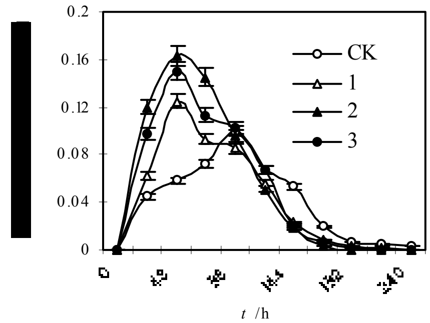

Figure 3. Curve changes of oxygen conxumption rate

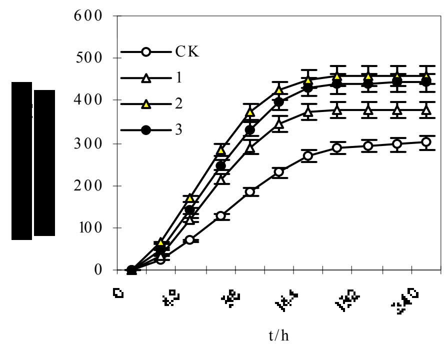

Figure 4. Curve changes of oxygen consumption accumulation rate

2.3 CO_2 and H_2S evolution of outlets gas

CO_2 and H_2S evolution of outlets gas could further study the compost proceed. During composting, the CO_2 and H_2S concentration was measured (Table 4). CO_2 concentration of treatment 1 and 2 reached up to 11.9%, 9.13% at 48 h, respectively, and was 2-3 times of CK (4.62%). During composting, H2S concentration in CK was highest among all treatments, whose maximal emission was 16.00 mL·m^{-3}, while the concentration in treatment 1, 2 and 3 was 3.5 mL·m^{-3}, 5.4 mL·m^{-3}, 8.8 mL·m^{-3}, respectively. The results indicted adding bio-surfactant could incline the surface tension between liquid and solid, increase the translation of organic matter, improve the surroundings of composting, and then restrain the emission of malodor gases. The orders were as followed: StrainsIII(2)> PA> Bio-surfactant, the reason for this was the inoculated microbes selected from composting system, could adapt the composting matrix environmental quickly, and produce bio-surfactants incessantly during composting process. The activity of directly adding bio-surfactant weakened owing to the limited ability to adapting composting environmental.

Table 4. Density changes of CO_2、H_2S by composting equipment export

Times (h)	Outlet CO_2 (%)				Inlet H_2S ($mL\cdot m^{-3}$)			
	Control	1	2	3	Control	1	2	3
24	2.267	7.11	5.58	4.19	3.5	0.54	1.9	1.9
48	4.62	11.89	9.13	8.48	5.6	1.14	5.4	6.3
72	6.89	10.72	7.57	6.85	16	3.5	4.8	8.8
96	7.61	7.43	5.09	5.92	13	2.1	3.6	8.4
120	5.63	3.02	3.70	3.21	10	1.8	3.1	3.9
144	3.63	2.00	0.99	1.14	5.8	0.8	1.3	0.5
168	2.87	0.43	0.405	0.31	2.0	0.09	1.01	0.2
192	1.25	0.1	0.12	0.19	0.9	0.06	0.08	0
216	0.54	0	0.08	0.14	0.2	0.0	0	0

Table 5. Compare of compost quality

Treatments	Humus(C,%)	TN(%)	TP(P_2O_5,%)	TK(K_2O,%)	Date rate of ova(%)	Colibacillus value
Control	10.6	0.7	0.50	0.6	95	10^{-1}~10^{-2}
1	18.2	2.1	0.75	0.9	100	10^{-1}
2	15.8	1.4	0.55	0.8	95	10^{-1}
3	12.2	0.73	0.54	0.9	95	10^{-1}~10^{-2}

2.4 compost quality

The product qualities including humus, TN, TP, TK, death rate of ova and colibacillus are investigated and listed in Table 5.

Table 5 showed the humic concentration of inoculating microbes treatment 1 and 2 increased compared with that of control. The total nutrition (N, P and K) were 3.75%, 2.75%, and were 2.08, 1.53 times of that in control (1.80%), respectively. Therefore, inoculating microbes which excrete bio-surfactant on composting not only can enhance composting rate, but also can improve the composting quality greatly.

3. Conclusions

In conclusion, we observed that inoculating Strains Ⅲ(2), Pseudomonas aeruginosa which could produce bio-surfactant, can not only accelerate the composting reaction rate but also improve the quality of compost. The paper analyzed the changes of concentration of outlet gases, surface tension, and compost quality in different treatments during static state composting, the result indicated, the effect on composting efficiency of different treatments were as followed, strains III(2) > pseudomonas aeruginosa > bio-surfactant > control.

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Correspondence to:

Beidou Xi, Zimin Wei
Chinese Research Academy of Environmental Sciences
Beijing 100012, China
Telephone: 01186-010-84913946
Cellular phone: 01186-13031038107, 01186-13141009271
E-mail: Xibeidou@263.net, Weizm691120@163.com

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