

Short communication

# Effect of fatty oil dispersion on oil-containing wastewater treatment

Toru Matsui<sup>a,\*</sup>, Akira Miura<sup>b</sup>, Toshio Iiyama<sup>b</sup>, Naoya Shinzato<sup>a</sup>,  
Hitoshi Matsuda<sup>b</sup>, Keizo Furuhashi<sup>b</sup>

<sup>a</sup> Center of Molecular Biosciences, University of Ryukyus, 1 Sembaru, Nishihara-cho, Okinawa 903-0213, Japan

<sup>b</sup> Bio-Research Centre, Japan Energy Co., 3-17-35 Niizo-minami, Saitama 335-0027, Japan

Received 13 July 2004; received in revised form 22 October 2004; accepted 27 October 2004

Available online 15 December 2004

## Abstract

The performance of an immobilized continuous fluidized reactor for salad oil-containing model wastewater was examined at a high loading rate using polyurethane as a support, to be applied in fat- and oil-containing wastewater treatment, generated by daily activities in restaurant kitchens. At an organic loading rate higher than 0.6 kg/m<sup>3</sup>/day, there was a significant amount of white solid (WS), identified as a mixture of calcium di-stearate and di-palmitate, suggesting that saturated fatty acid degradation was limited at such a high loading rate, possibly due to its solubility in the wastewater. Increased oil dispersion by the addition of a surfactant ranging from 10 to 100 μm particle size could result in less than 30 mg/l oil concentration after the treatment at 5 kg/m<sup>3</sup>/day.

© 2004 Elsevier B.V. All rights reserved.

**Keywords:** Fats; Oils; Immobilized reactor; Particle size; Dispersion; Saturated fatty acid; Waste

## 1. Introduction

Fats and oils are typically contained in wastewater generated from kitchens, e.g. in restaurants, and they tend to clump together and clog drain lines and grease traps. Fats and oils are essentially triglycerides consisting of straight-chain fatty acids attached, as esters, to glycerols. Biological triglyceride degradation is generally recognized as the hydrolysis of ester bonds by lipase followed by the degradation of the released fatty acids via beta-oxidation. Additional specificities (positional, fatty acid residues, or stereochemical) of microbial lipases and specificities in fatty acid degradation should be considered since fatty acid residues in the triglycerides of fats and oils are saturated or unsaturated, and may contain an odd or even number of carbon atoms. Nevertheless, few reports have focused on the substrate specificities in fat- and oil-containing wastewater treatment. Bioaugmentation technology [1–3] is also necessary after estimating the critical steps in fat and oil degradation.

In this report, we examined an immobilized fluidized reactor for salad oil-containing wastewater treatment at a high loading rate and found that long-chain saturated fatty acid degradation is critical but ester hydrolysis is not. Based on this finding, the oil particle size in the reactor was optimized to enhance saturated fatty acid degradation.

## 2. Materials and methods

### 2.1. Bioreactor

A schematic diagram of the continuous bioreactor (working volume 5 l) with artificial oil-containing wastewater is shown in Fig. 1. Commercially available porous polyurethane cubes were used for immobilization support. The activated sludge was obtained from the grease trap in our company restaurant.

### 2.2. Reactor operation

Polyurethane foam (No. QPB13, 1 cm × 1 cm × 1 cm, Bridgestone Kaseihin Co., Tokyo, Japan) was used for

\* Corresponding author. Tel.: +81 98 895 8973; fax: +81 98 895 8944.  
E-mail address: tmatsui@comb.u-ryukyu.ac.jp (T. Matsui).

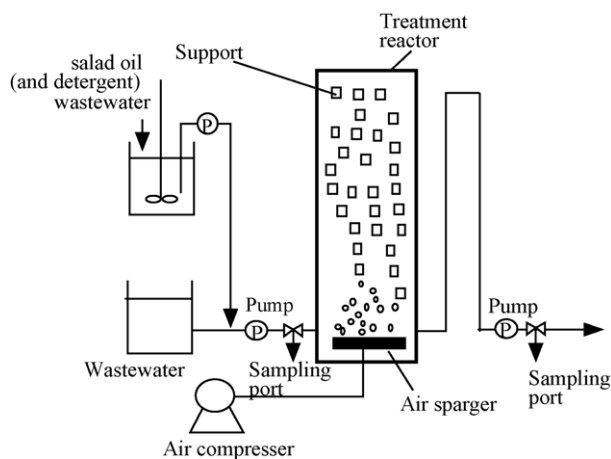


Fig. 1. Schematic system of oil-containing wastewater treatment with immobilized activated sludge.

immobilized support in the reactor (30 vol.%). Artificial wastewater (0.2% yeast extract (Difco, MD, USA), 0.2% Bacto-peptone (Difco, MD, USA), 0.04 ml Tween 80 (Tokyo Kasei Co., Tokyo, Japan), and 1000 ml of tap water, Biological oxygen demand  $376 \pm 21$  mg/l) was introduced into the reactor with commercial salad oil (Nisshin Oil Co., Tokyo, Japan). All the operations were performed at  $30^\circ\text{C}$  at an air flow rate of 0.5 vvm. Batch operation was performed before continuous operation to ensure that the activated sludge was immobilized on the support with fill-and-draw of the wastewater for about 7 days. After starting the continuous operation, the oil-loading rate was increased to the desired level by introducing salad oil-containing wastewater stirred at 300 rpm into the inlet. In order to control the oil particle size, a surfactant was added at 10 g/l with 3000 rpm mixing. The oil-loading rate ( $R$ ) was defined as follows:

$$R = \frac{C_{FO} (\text{kg}/\text{m}^3) \times F (\text{m}^3/\text{day})}{V (\text{m}^3)}$$

where  $R$  is the oil-loading rate,  $C_{FO}$  the oil concentration in the reactor,  $F$  the wastewater flow rate and  $V$  is the reactor volume. In this study,  $R$  was increased by increasing the  $C_{FO}$  with the residence time ( $V/F$ ) of 4 h.

### 2.3. Sampling and analyses

The oil concentration in the effluent was estimated as the *n*-hexane-extract amount prepared according to the Japan Industrial Standard method (No. K010224). The oil-particle diameter distribution in the reactor was analyzed by Mastersizer X (Malvern Instrument Ltd., Worcestershire, UK), according to the manufacturer's instructions. Soluble BOD was estimated according to the Japan Industrial Standard method (JIS.K0102.21) using biosensor type a-1 (Central Kagaku Co., Tokyo, Japan).

### 2.4. White substance (WS) analysis

Infrared spectrum (IR), elemental composition and gas-chromatography/mass spectrum (GC/MS) were performed by the Japan Energy Analytical Center Co. (Saitama, Japan).

### 2.5. Chemicals

A commercial surfactant, Family (Kao Co. Ltd., Tokyo, Japan) was used to enhance the oil dispersion, and contains alkyl ether sulfate as the main component. All other materials were of the highest purity commercially available and were used without further purification.

## 3. Results and discussion

Fig. 2 shows the continuous treatment results of salad oil-containing wastewater using the fluidized reactor (Fig. 1) without a surfactant addition. At an oil-loading rate higher than  $0.6 \text{ kg}/\text{m}^3/\text{day}$ , the outlet oil concentration was gradually increased, and a white solid substance (WS) appeared in the final stage, reaching an outlet oil concentration higher than 100 mg/l. The WS was observed even when the support material was changed to polyester or polypropylene (data not shown). The WS was water insoluble but was soluble in diethyl ether at acidic pH, suggesting that it is an acidic substance. GC/MS analysis of the diazomethane methyl ester of the diethyl ether extract revealed that the extract consisted of stearic acid and palmitic acid but no unsaturated fatty acids such as oleic acid were detected. WS element analysis revealed that (%) C: 68.0, H: 12.7, O: 12.0, Ca: 6.6 (with minor elements of S, N, Mg and Na), giving a composition of  $\text{C}_{30.2}\text{H}_{67}\text{O}_4\text{Ca}_{0.9}$ . The IR profile of WS showed the typical spectrum for carboxylic acid salt at  $1580$  and  $1360 \text{ cm}^{-1}$  (Fig. 3c). In addition, it was identical to that of authentic calcium stearate. Based on the above data, it was concluded that the WS component is a mixture of calcium stearate and calcium palmitate. The fatty acid composition of the salad oil before treatment was determined as palmitate (16:0):7.8%, oleate (18:1):54.7, linolate (18:2):30.2, linoleate (18:3):7.2.

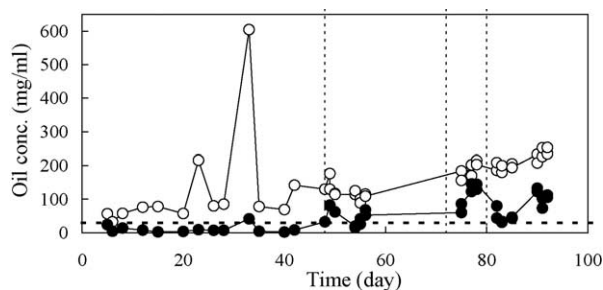


Fig. 2. Time course of continuous treatment of salad oil-containing wastewater using an immobilized reactor without surfactant addition. Open symbols: inlet oil concentrations. Closed symbols: outlet oil concentrations.

Download English Version:

<https://daneshyari.com/en/article/9674407>

Download Persian Version:

<https://daneshyari.com/article/9674407>

[Daneshyari.com](https://daneshyari.com)