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Optimization of operating parameters using response surface methodology for adsorption of crystal violet by activated carbon prepared from mango kernel

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Key Words: Adsorption, ANOVA, crystal violet dye, mango kernel, response surface methodology, student's t-test

ABSTRACT

An adsorbent prepared from mango seed was used to study its sorption potential on removing Crystal Violet dye from aqueous solution. The influences of operating parameters like pH, temperature, initial concentration and adsorbent dosage on dye adsorption were studied. A maximum dye removal of 95% was achieved with an initial concentration of 10 mg L⁻¹. The percentage removal was mathematically described as a function of experimental parameters and was modeled through response surface methodology. The results show that the responses of color removal in adsorption of dyes were significantly affected by the synergistic effect of linear term of time and dosage and the quadratic term of temperature and time. A 2⁴ full factorial design of experiments was adopted and statistical analysis was performed in the form of the analysis of variance and Student's t-test, which gave good interpretation in terms of interaction of experimental parameters. The interaction of the parameters temperature, pH, dye concentration and adsorbent dosage on Crystal Violet removal is also highly significant with confidential level > 99%.

INTRODUCTION

For the past many decades, textile and dyeing industries have discharged vast amounts of synthetic colourant into the environment. Approximately 100 t dye varieties are commercially available in the world dye market and most of them are synthetic and highly soluble one [1,2]. It was reported that about 10 kt of these dyes are annually produced for dyeing activities and approximately 1 kt was released into the aquatic environment with or without proper treatment [3-5]. Such discharged dye wastewater would contribute more to the chemical oxygen demand of water bodies. These dyes are highly carcinogenic, mutagenic, teratogenic in nature even in small amount, hence its elimination or removal from the aquatic environment becomes mandatory.

Several physicochemical processes are generally adopted to treat dye wastewater. This includes adsorp-

tion [6], coagulation and flocculation [7], membrane filtration [8], electrochemical process [9], irradiation and ozonation [10]. However, all these processes except adsorption are not economically viable and could not be used by the treatment plants. Being a conventional process adsorption is practiced by most of wastewater treatment plants due to its easy handling, low cost and better efficiency. However it also has a limitation due to the cost of the activated carbon, which is employed as adsorbent. Hence to overcome such limitation more focus was given by the researchers in synthesizing or preparing a low cost adsorbent or biosorbent. Several investigations have been reported using industrial or agricultural wastes as adsorbents and the data have shown that those wastes exhibit good adsorption capacity [11-17]. For instance agricultural wastes like straw, coconut shell, cashew nut shell and citrus fruit peel were utilized as raw materials in preparing the activated carbon. In the present

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Photodegradation of methyl tert-butyl ether vapor by using photocatalyst immobilized nonwoven fiber textiles

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Key Words: MTBE, TiO₂, ZnO, metal-doping, nonwoven fiber textile, photocatalysis

ABSTRACT

This study demonstrated a bench-scale photoreactor for degradation of gaseous methyl tertiary butyl ether (MTBE) using the photocatalyst immobilized nonwoven fiber textiles. Commercial TiO₂, ZnO and sol-gel prepared metal-doped TiO₂ were individually immobilized onto the nonwoven fiber textiles for testing, and three levels of photocatalyst loadings were immobilized by hot pressing for comparison of MTBE removal efficiencies. The photocatalytic experiments were conducted under the irradiation of a fluorescent lamp. The use of commercial TiO₂ (ST-01) provided the remarkable performance of 75 to 100% MTBE degradation, while the ZnO immobilized nonwoven fiber textiles only performed 17 to 29% MTBE degradation. The use of W-doped, Fe-doped and Ag-doped TiO₂ provided the performance of 61, 47 and 37% MTBE photodegradation, respectively. The photocatalytic performance of commercial ST-01 TiO₂ superior to ZnO and metal-doped TiO₂ is possibly ascribed to its small particle size and large surface area that may result in more active sites on surface. According to intermediate identification by gas chromatography/mass spectrometry, MTBE photodegradation can proceed in the route of pathway A to form tert-butyl formate, tert-butyl alcohol and acetone or pathway B to form methyl acetate. The detected CO₂ concentrations showed an increasing trend during all photocatalytic experiments and it implicated that MTBE vapor could be successfully mineralized through fluorescence-irradiated photocatalysis. Experimental results supported the future application of photocatalyst immobilized nonwoven fiber textiles on lowering the MTBE level in ambient air.

INTRODUCTION

Due to the air pollution problem regarding lead particles caused by the use of alkyl lead additives, methyl tertiary butyl ether (MTBE, C₅H₁₂O) was introduced to replace alkyl lead additives in the late 1970s. MTBE did maintain the adequate octane rating, prevent engine knocking, improve gasoline combustion and reduce auto emission of volatile organic compounds and suspended lead particles. Typically, reformulated gasoline blends with 10 to 15% MTBE before sale in order to reduce carbon monoxide and hydrocarbon emissions from vehicle exhaust. It has been noticed that the continual use of MTBE has imposed significant adverse impacts on groundwater supply [1]. Besides, the presence of MTBE in the troposphere was about 10 mg m⁻³ that is expected to rise with increasing use [2,3]. MTBE has been classified as a possible human carcinogen [4], and thus the risk regarding the

exposure of MTBE vapor in ambient air around the gasoline stations is a focal environmental issue.

Numerous treatment processes have been proposed for removing MTBE from water include aerobic biodegradation [5], air stripping [6], adsorption [6,7] and advanced oxidation. However, these conventional remedy schemes have generally indicated either low efficiency or high costs for MTBE removal [6]. Advanced oxidation technologies can employ the generation of hydroxyl radicals to degrade or even mineralize MTBE with a high reaction rate such as ozone/hydrogen peroxide [8], Fenton's reagent [9], UV/peroxide [10], potassium permanganate [11], persulfate [12], gamma radiolysis [13], electrochemical oxidation [14-17] and photocatalysis [18].

The studies of applying photocatalysis to degrade MTBE in the gas phase are rather few. Titanium dioxide (TiO₂) is a widely-used photocatalyst due to its photo-stability, non-toxicity, low cost and water insol-

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Levels and composition of volatile organic compounds from the electric oven during roasting pork activities

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Key Words: Oven, indoor air, VOCs, aromatics, cooking

ABSTRACT

The present study investigated levels and composition of volatile organic compounds (VOCs) from the electric oven pork roasting commonly associated with indoor air quality issues of human activities. A series of experiments were conducted to evaluate three heating temperatures of 170, 200, and 230 °C to identify the characteristics of the VOCs emitted. Fumes were collected in SKC sampling bags and later analyzed by gas chromatography mass spectrometry. There were fifteen VOCs identified as follows: *n*-undecane, 3-methylheptane, 1-butene, propylene, *n*-pentane, *m*-diethylbenzene, styrene, isopentane, *o*-ethyltoluene, *n*-dodecane, *n*-butane, 1-pentene, *n*-heptane, 1-hexene and *n*-hexane. The results indicate that total VOC mean concentrations show clear trend of increasing with heating temperature. Also, detailed distribution of alkanes, alkenes and aromatics in the oven emission data is discussed.

INTRODUCTION

In recent years considerable concern has arisen over the investigation of quantitative levels of volatile organic compounds (VOCs) in cooking events [1-6]. Moreover, concern about human exposure to VOC pollutants has historically been focused on ambient air and occupational/industrial environments, which are regulated by the government administrations (such as, EPA or Occupational Safety and Health Administration in the United States). Therefore, the emission of VOCs from cooking behaviour/activity on both air qualities and health issues is of critical importance [7-11]. Heated cooking oils can produce considerable amounts of acrolein, thus cooking is likely an important source of indoor acrolein [6]. A series of cooking experiments

were conducted by Seaman [6] to determine the emission rates of acrolein and other volatile carbonyls for different types of cooking oils (canola, soybean, corn and olive oils) and deep-frying different food items. The oil cooking resulted in high concentrations of acrolein (26.4-64.5 $\mu\text{g m}^{-3}$) which exceed all the chronic regulatory exposure limits and many of the acute exposure limits. Their report indicates that indoor acrolein concentrations can persist for considerable time after cooking in poorly-ventilated homes.

Fullana et al. [1] investigated emissions of low molecular weight aldehydes (LMWAs) from deep-frying of extra virgin olive oil, olive oil, and canola oil (control) at 180 and 240 °C, for 15 and 7 h, respectively. They collected the oil fumes in Tedlar bags and analyzed the samples by gas chromatography mass

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The preliminary study of iron and manganese removal from groundwater by NaOCl oxidation and MF filtration

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Key Words: MF, iron, manganese, groundwater, oxidation

ABSTRACT

The aim of this research is to investigate the removal conditions of iron and manganese ions from groundwater by aeration, chlorine oxidation and microfiltration (MF). The removal effects of iron and manganese under the conditions of oxidant doses, pH and reaction times were investigated in the Jar-test. Moreover, pilot-scale experiments were executed in Chang-Hua water treatment plant. The raw water containing iron and manganese ions were firstly oxidized by NaOCl and followed by MF filtration. The oxidized metal ions particles in membrane permeate were investigated by particle counter. For the Jar-test, the result indicates that pH higher than 7 and NaOCl dosage more than 3 mg L⁻¹ are necessary to reach more than 90% Mn²⁺ removal efficiency. For the pilot test, the Mn concentration of permeate was gradually decreased from 0.1 to 0.01 mg L⁻¹ after 2 wk operation. The accumulated sludge that is Fe-Mn oxide on membrane contributes an important role for Mn removal. Thus, this study confirmed that MF process can be applied properly for improving water quality to comply more stringent water quality standards.

INTRODUCTION

Groundwater is an important resource to act as a natural storage that can buffer against shortages of surface water. Taiwan contains rich groundwater resources where 30% of domestic water is supplied via groundwater. However, due to the stratum composition, the groundwater often contains iron and manganese ions. While the concentrations in excess, the water becomes red-brown, and endues the scaling problems in pipeline system. Thus, the water quality standards in Taiwan have specified their limitations, where Fe is less than 0.3 mg L⁻¹ and Mn is less than 0.05 mg L⁻¹.

In the traditional process, Fe and Mn in groundwater are initially oxidized using aeration and/or

chemical oxidant such as chlorine, hypochlorite, chlorine dioxide, ozone or potassium permanganate following the remove by filtration. The selection of various oxidants depends on which kinds of pollutants in water, as well as their effects on the water quality. Capital cost is also an important consideration. After the oxidation process, the Fe and Mn oxides are then removed through the sand filter. Moreover, previous studies have indicated that the presence of Mn oxide particles accelerates the formation of Fe-Mn oxide, contributing to the removal of Fe and Mn from groundwater [1]. Granular activated carbon is often used to enhance the adsorption of Mn²⁺ in filtration process [2-5]. However, the drawback is frequent regeneration or new carbon replacement.

In recent years, membrane process has been ap-

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Application of EPANET for the determination of chlorine dose and prediction of THMs in a water distribution system

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Key Words: Chlorine residual, chlorine decay, EPANET, water distribution, modelling

ABSTRACT

The purpose of this study is to predict the level of chlorine residual and trihalomethanes (THMs) in a drinking water distribution system and to help operators to determine chlorine dose in a drinking water treatment plant (WTP) using EPANET 2.0. Water quality modelling was conducted by chlorine bulk decay and THM formation from bottle tests. Chlorine decay tests for the finished water of the WTP were performed on a monthly basis for one year. As the result, a simple equation for the target chlorine concentration in the finished water was derived by a multiple regression method in relation to initial chlorine concentrations, temperatures, total organic carbon and chlorine decay coefficients. The chlorine concentration after it leaves a WTP, before entering its distribution networks, is critical in maintaining chlorine residual levels throughout the system. It is apparent that the chlorine concentration of the finished water be maintained to be flexible to keep it at over 0.1 mg L^{-1} throughout the system because chlorine consumption is different according to the season, flow and pipe networks. These chlorine values of the finished water are the target chlorine concentrations for determining the chlorine dosage to the filtered water in a WTP. As the results of this study using a multiple regression model for chlorine decay and EPANET, the target chlorine concentrations of the finished water were set to 0.5 mg L^{-1} in spring and fall, 0.55 mg L^{-1} in summer and 0.45 mg L^{-1} in winter. These values are slightly lower than the existing target values.

INTRODUCTION

Water treatment has contributed to the prevention of waterborne disease and to safeguard human health in drinking water. Chlorine disinfection is one of the key factors in drinking water treatment processes. However chlorine disinfection may cause unpleasant tastes and odours due to the chlorine residual, corrosion of pipes, the formation of disinfection by-products such as trihalomethanes (THMs), among others. Therefore, management of the chlorine residual from finished water in a water treatment plant (WTP) to consumers' taps is critical to balance customer satisfaction and protection from pathogens. Understanding the factors contributing to the loss of chlorine and the formation of disinfection by-products is a requisite to maintain chlorine residual levels in distribution systems.

Chlorine residual levels with a range of 0.1 to 0.4

mg L^{-1} set by Seoul city as the government guideline in distribution systems are to meet the minimum level of chlorine residual levels throughout the entire water distribution systems and to alleviate customer complaints related to the odour of the disinfectant.

Flow in distribution system affects water quality in general and chlorine residual in particular. The concept of water quality modelling in distribution system networks was based on steady-state formulations in the early 1980s, and then dynamic water quality models were developed in the mid-1980s. There are now many modelling software packages available for hydraulic and water quality network analyses: EPANET, AQUIS, H2ONET, InfoWorks WS, MikeNet, Pipe2000, WaterGEM/WaterCAD and so on [1].

EPANET was developed in 1993 with the functions of modelling chlorine decay and THM formation [2]. Hydraulic modelling should be first developed for predicting chlorine residual levels within a water

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Decentralised wastewater management — New concepts and innovative technological feasibility for developing countries

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Key Words: Black water treatment, blending, grey water, water short habitations, socio-techno, economic, septic tank, upflow filter

ABSTRACT

On-site disposal methods (mostly septic tanks or pit latrines) are in use for addressing wastewater management in most of the developing countries particularly in rural, small towns and periphery areas of larger cities. The effluent from septic tank disposed without adequate treatment is violating the discharge standards thus contaminating the ground and surface water resources. Water supply in most of the small and periphery areas of large cities in developing countries is low. Generally, the water supply rate in small and periphery areas of large cities is ranging from 70 to 125 L per person per day which equates to a raw sewage BOD (biochemical oxygen demand) of 560 to 800 mg L⁻¹ (considering 80% water supply) for which conventional underground sewerage system is not feasible and there is no conventional technologies to reduce the BOD to the permissible standards. Therefore, there is a need to evolve an alternate sanitation system that would be sustainable from socio-techno-economic and environmental perspectives.

This paper documents the performance of a unique decentralized sanitation system installed in a Tsunami rehabilitation colony under such scenario. The authors present results from experiments on the treatment of black water from toilet by septic tank with upflow filter and subsequent treatment of blended wastewater by waste stabilization pond systems. The data show that the septic tank with upflow filter that treat black water, has the average COD (chemical oxygen demand) removal efficiency of 61%, BOD of 69% and that of suspended solids (SS) 85%. The data also show that the comprehensive system has the COD removal efficiency of 95%, BOD 98% and SS 99%. This paper also documents the socio-techno-economic and environmental benefits for adoptability of the system in developing countries so that this alternative can meet a sustainable wastewater management requirement especially for countries like India, where the water and sanitation issues are becoming a more and more important issue and are under new period of infrastructure development.

INTRODUCTION

The existing field facility with 329 dwellings has been installed at Tsunami Rehabilitation Colony at Kolachel in Tamildau, India and commissioned in July 2007. The existing rate of water supply is 90 lpcd. The system consists of (a) on-site sanitation to receive and treat the night soil and ablution in order to reduce the BOD (biochemical oxygen demand) load to a centralized downstream treatment unit, (b) addition of an upflow filter to the on site sanitation effluent, (c) a set of roadside drains covered with removable slabs and

(d) waste stabilization ponds (WSP) and maturation ponds. In the existing system, each dwelling had a dual system of internal sewerage whereby the toilet wastewater was exclusively collected in a septic tank followed by an upflow filter and the effluent from the same was blended with the grey water from the other uses in the dwelling and the blended sewage exited the dwelling. The blended sewage was intercepted in masonry drains running on both sides of the roads and these were networked to discharge into a WSP followed by maturation pond before discharging into the backwaters. The drains were however provided with

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Adsorption of methylene blue from aqueous solution onto a waste aquacultural shell powders (prawn waste)

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Key Words: Prawn waste, bioadsorption, methylene blue, kinetic modeling, isotherm

ABSTRACT

The adsorption of Methylene Blue from aqueous solution onto prawn shell (raw sample and acid treated prawn shell) was investigated. The effects of pH, dye and solid concentration and contact time on adsorption were evaluated. Adsorption experiments were analyzed in the light of zeta potential measurements. Experimental data were analyzed using three adsorption kinetic models, of which a pseudo-second-order kinetic model was found to be superior. Experimental equilibrium data were fitted to Langmuir adsorption isotherm model from which the free energy of the adsorption processes was determined. The Fourier Transform Infrared Spectroscopy was used to elucidate the adsorption mechanism.

INTRODUCTION

Organic dyes are an integral part of many industrial effluents and demand for appropriate methods to dispose them is urgent. Most commercial dyes are chemically stable and are difficult to be removed from wastewater [1]. At present, more than 10,000 dyes have been effectively commercialized [2]. The release of colored wastewater from these industries may present an eco-toxic hazard and introduce the potential danger of bioaccumulation, which may eventually affect man through the food chain. There are various conventional methods of removing dyes from waters. Among these methods, adsorption is by far the most versatile and widely used method because of its low cost and ease of operation. A number of agricultural waste and by-products of cellulose origin have been studied for their capacity to remove dyes from aqueous solutions, such as peanut hulls [3], maize bran [4], sawdust [5], sugar beet pulp [6], crab shell [7], cornstarch [8], rice husk [9], chitin [10], orange waste [11], lemon peel [12], granular kohlrabi peel [13], raw barley straw [14], eggshell [15] and aqua cultural shell powders [16].

Methylene Blue (MB) is selected as a model compound for evaluating the potential of prawn waste to remove dye from wastewaters. MB is a thiazine (cati-

onic) dye, which is most commonly used for coloring paper, temporary hair colorant, dyeing cottons, wools and so on. Although MB is not considered to be a toxic dye, it can reveal harmful effects on living things. After inhalation, symptoms such as difficulties in breathing, vomiting, diarrhea and nausea can occur in humans [17]. Due to increase of shellfish consumption in the past decade, the derived shell from the aquaculture farming and commercial market has become one of the most significant wastes in Nagapattinam, Tamil Nadu. Most were locally dumped into public waters and lands without proper treatment, causing a serious odor problem as a result of the remaining attached to the shell.

In this study, low cost locally available prawn waste was studied for its potential use as an adsorbent for removal of a cationic dye (MB) from aqueous solution. Factors affecting adsorption, such as initial dye concentration, pH, contact time and adsorbent dose, were evaluated. The equilibrium of adsorption was modeled by using the Langmuir, Freundlich and Dubinin-Radushkevich isotherms models. The kinetic parameters and intraparticle diffusion were determined for the MB-prawn waste system. Results of this study will be useful for future scale up using this prawn

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Analysis of international GHGs-related indicators in Taiwan

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Key Words: Greenhouse gases (GHGs), indicator, environmental sustainability index (ESI), environmental performance index (EPI), climate analysis indicators tool (CAIT)

ABSTRACT

This research aimed to define the greenhouse gases (GHGs) related indicators from three systems: environmental sustainability index (ESI), environmental performance index (EPI) and climate analysis indicators tool (CAIT). Comparative analysis provides information on policy options, a context for evaluating performance, and a basis for holding governments accountable for environmental results in Taiwan. During the 19-yr period from 1988 to 2006, the trend demonstrated a gradual move away from sustainable development in the areas of environmental pollution and economic pressure in Taiwan. The present paper reviews the background information given on the GHGs related assessment framework recently used within three indicator systems: ESI, EPI, and CAIT. The results are presented, with a thorough discussion of GHGs related indicators consisting of current statistical data in Taiwan and international index comparison. Also, the definition and category of GHG indicators from these systems' indicators are discussed. The paper aimed to use the international data to describe the direct relationship between GHG emission reduction (particularly the reduction of carbon dioxide emissions) and individual nation's energy structure and energy utilization. Taiwan is a significant source of global GHG emissions. A comparison, using the Taiwan's actual data of the past two decades, was conducted.

INTRODUCTION

Since energy consumption is a significant driver of carbon dioxide (CO₂) emissions, levels of energy use may suggest the ability of a society to mitigate its emissions [1]. Such emissions are largely influenced by country's energy use and production systems, industrial structure, transport system, agricultural and forestry sectors, and consumption patterns of consumers. Greenhouse gases (GHGs) as a policy issue should be placed in the current context of the international development of human activities. Given the clear growing need for sustainable development, one of the most urgent tasks currently at hand for all developed and developing countries is to create a set of sustainable development indicators. But the aggravated impacts of environment in particular material emissions and energy by anthropogenic activities (emissions) have been identified as a source of climate change. Because these studies [2-13] complement one another, the compatibility of the results is very impressive. It is similar to the previous researchers' discussion that factors

which determine adaptive capacity to GHG emission reduction should include economic wealth, technology and infrastructure, information, knowledge and skills, institutions, equity and social capital under a conceptual framework of environmental socio-economic indicators.

Energy policies are crucially linked with GHG emission reduction policies as well as with development policies. At the Energy Council held by the EU in 1999, approval was given for the relative list of energy indicators; including overview indicators, energy supply indicators, final energy consumption indicators, energy industry indicators, renewable energy indicators, energy efficiency, energy price and pollutant emission indicators. It is anticipated that establishing and observing these indicators would make it possible to achieve a better understanding of changes in the energy market, of the upgrading of energy efficiency and of energy policy implementation performance, which in turn would enable governments to undertake an overall appraisal to gauge whether their energy policy is contributing to sustainable development.

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Pollution characteristics of urban surface runoff in a street community

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Key Words: Urban runoff, total pollution characteristics, event mean concentration (EMC), dynamic EMC, split-out flow control

ABSTRACT

The pollution of urban stormwater runoff discharged to river cannot be ignored. Through a mixed stormwater sampling strategy at discharge outlet adjacent to river, this study assessed the urban surface runoff pollution characteristics caused by a variety of land uses in a small urban watershed in the city of Shenzhen in China. The rainfall events were monitored from Oct. 2007 to Sep. 2008. Results show that the pollution caused by the urban surface runoff in studied area is serious and needs to be treated. The first flushes of chemical oxygen demand (COD), suspended solids (SS), biochemical oxygen demand, especially COD and SS, were apparent, but total nitrogen and total phosphorus were not evident. The event mean concentrations (EMCs) of COD were about two times of the value of the nearby cities, Macao and Zhuhai. Comparing with other counties, the EMCs of different pollutants in the studied area in Shenzhen were much higher than the values of South Korea, USA and Canada. In order to treat surface runoff pollution, the values from first 30-40% runoff volume can be considered as split-flow control criteria to enable more effective and economical design of best management practice facilities.

INTRODUCTION

Stormwater runoff from urban areas contains a variety of pollutants and carries a large pollutant load, so it greatly influences the receiving water quality [1]. The first flush is generally defined as the first portion of the runoff volume, accounting for the majority of the related pollutant load [2,3]. A review of urban surface runoff shows that most sampling sites are located on surfaces identified by their different land uses, such as typical residential areas, commercial areas, industrial areas, road areas, etc. In a given location, we cannot separately treat the stormwater runoff by best management practices (BMPs) due to conditions such as

the high intensity of land uses, insufficient land space, insufficient capital, etc. The sample site must be considered as an aggregate treatment object with a need for removal of pollutants due to surface runoff. Therefore, the pollutant loads at this location must be known.

Drainage systems can be almost completely separate systems in a modern city. Since their operation lasts for many years, many pollutants have been accumulated inside of storm sewers. When rain water flows through these sewers, the runoff washes those pollutants accumulated inside of sewers, and the pollutants are discharged into urban rivers together with surface pollutants. These pollutants from storm sewers cannot be ignored since they influence water quality of urban

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Characteristics of N-doped titanium oxide and photodegradation of formaldehyde using visible light lamp and light emitting diode

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Key Words: Formaldehyde, N-doped oxide photocatalyst, light emitting diode, indoor pollution, energy effectiveness

ABSTRACT

This study investigates the surface modification of N-doped TiO₂ and the photodecomposition of formaldehyde from indoor pollution sources using a visible light lamp and a light emitting diode (LED). An X-ray single crystal diffractometer, scanning electron microscope, ultraviolet/visible spectroscopy and BET are used to measure the surface characteristics of the N-doped TiO₂. The operation parameters which affect the formaldehyde decomposition in the photodecomposition reaction are also examined. The parameters include different light sources, fabrication methods of N-doped TiO₂ and the mass of the photocatalysts. The results show that the TiNH₄₀₀ prepared by Ti(SO₄)₂ and ammonia liquor calcined at 400 °C (673 K) has the finest size of about 30-40 nm and the largest surface area (99 m² g⁻¹) of the modified TiO₂ examined in this study. The TiNH₄₀₀ has a red shift absorption spectra of about 400-440 nm in the lower energy region, which reveals its ability to adsorb the visible light and near UV light. Light sources of blue LED (BLED), white LED (WLED) and green LED are tested for the photodecomposition of formaldehyde. The results show that the decomposition efficiency of formaldehyde increases with the higher light energy and shorter wavelength of the light sources. The energy effectiveness of the BLED and WLED is about 40 times higher than that of traditional lamps. Therefore, in applying this technology to indoor air pollutant cleaners, a potentially high market value for them can be anticipated in the near future.

INTRODUCTION

Heating, ventilation, and air conditioning (HVAC) systems are essential for maintaining good indoor air quality. The primary function of typical HVAC systems is to control the temperature and humidity of the supply air; however, most indoor air pollutants, such as volatile organic compounds (VOCs), cannot be removed by typical HVAC systems. Thus, some air handling units for removing VOCs need to be added to typical HVAC systems. Of all the air cleaning techniques used to remove indoor VOCs, photocatalytic

oxidation is an attractive alternative technique for indoor air purification and deodorization. It has the advantages of using an inexpensive photocatalyst, such as titanium dioxide (TiO₂), operating under room temperature and atmospheric pressure, and nearly complete oxidation of carbon- and hydrogen-containing pollutants into CO₂ and H₂O [1]. The applications of TiO₂ to environmental cleanup through the use of solar energy or visible light have become active field in TiO₂ research [2,3]. However, its intrinsic wide band-gap nature (3.0-3.2 eV) keeps TiO₂ from playing a more important role, because it only allows TiO₂ to absorb

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Kinetic decomposition of ozone, geosmin, and 2-methylisoborneol during catalytic ozonation

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Key Words: Taste, odor, geosmin, 2-methylisoborneol, zinc oxide, catalytic ozonation, hydroxyl radical

ABSTRACT

Two taste and odor (T&O) causing compounds, geosmin (GSM) and 2-methylisoborneol (2-MIB) were oxidized by zinc oxide (ZnO) catalyzed ozonation. The use of a 2.5 mg O₃ L⁻¹ (52 μM) and 500 mg ZnO L⁻¹ catalyst yields 96-97% GSM and 2-MIB conversion in 30 min; this experimental result compares favorably with the 53-58% obtained without a catalyst. The overall reaction rate was enhanced by the presence of ZnO; the most significant improvement in the overall rate constants ($k_{overall}$) was observed at 500 mg ZnO L⁻¹, whereby over four-fold increases in $k_{overall}$ value was observed. The experimental electron paramagnetic resonance (EPR) spectra confirmed that the formation of more hydroxyl radicals (•OH) in the ZnO catalytic ozonation process increases the T&O removal rate. Based on ozone decomposition kinetics and adsorption capacity of ZnO, the initial rate of disappearance of T&O correlates with the Langmuir-Hinshelwood kinetic model. The relationships between reaction rates and reactant concentrations were derived from the kinetic parameters determined experimentally for each reaction system. A comparison indicates that the kinetic rate constant for catalytic ozonation is 175-260% higher than that of the system of ozonation process due to increased production of hydroxyl radicals by an ozone combined with ZnO catalyst.

INTRODUCTION

Taste and odor (T&O) episodes at water treatment facilities during algal blooms are well documented [1-3]. The compounds that most cause earthy and musty odors are geosmin (GSM) or 2-methylisoborneol (2-MIB). GSM is the common name for (E)-1,10-dimethyl-9-decanol. It is formed by both actinomycetes and various blue-green algae. Safferman et al. first isolated GSM from blue-green algae (cyanobacteria) [4], which were known to generate GSM, including *Anabaena macrospora* [5], *Oscillatoria borneyi* and *Oscillatoria brevis* [6]. The earthy odor of GSM is detectable in aqueous samples at 1.3 ng L⁻¹ [7]. The other compound associated with odor, 2-MIB, is a methylated monoterpene alcohol that is generated by both actinomycetes and blue-green algae. The musty odor of this compound can be detectable in aqueous samples at 6.3 ng L⁻¹ [7].

Several water treatment strategies have been adopted to remove cyanobacteria and/or tainted compounds from water. These strategies include the reduction of cyanobacteria using algaecides; however, this process can have limited efficacy, because it results in the lysis of cyanobacterial cells and the subsequent release of GSM or 2-MIB into water. Various treatment methods, including the application of activated carbon and chemical oxidation, have successfully reduced levels of taint in drinking water [8-11]. The previous research and operational experiences suggest that removing intact cyanobacterial cells obviously reduces concentrations of T&O metabolites in water [1,2]. Although doing so does not completely eliminate the need for further treatment, treatment effectiveness is improved and costs reduced by minimizing the dosage of oxidant/powdered activated carbon and/or extending the effective lifetime of granular activated carbon filters.

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Sodium acetate method for determining CEC of cadmium-contaminated soil

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Key Words: Soil, cation exchange capacity, cadmium, remediation

ABSTRACT

Ion exchange is commonly adopted to measure the cation-exchange capacity (CEC) of soil and to remediate soil that is contaminated by heavy metals. The sodium acetate-method is the most common method for determining soil CEC in Taiwan. Based on ion exchange theory, Na^+ is not an ion with high exchange potential, which in fact raises a question regarding the effectiveness of the sodium acetate method to determine the CEC of soils that are contaminated by heavy metals. This investigation utilizes the chlorides and acetates of metal ions Na^+ , K^+ , NH_4^+ , Mg^{+2} , Ca^{+2} , Al^{+3} and Fe^{+3} to extract cadmium from Cd-contaminated soils. The results indicate that sodium acetate extracts only 55% of exchangeable Cd, whereas FeCl_3 and AlCl_3 extract 86 and 83% respectively. These results indicate that a method in which FeCl_3 is used to determine the Cd-contaminated soil CEC outperforms the sodium acetate method. For contaminated soils with a large amount of Cd that are bound to a fraction of Fe-Mn oxides, preliminary results suggest the use of AlCl_3 and CaCl_2 for sequential washing remediation can provide a high washing efficiency and avoid soil acidification.

INTRODUCTION

Cation-exchange capacity (CEC) is an important factor in the characterization of contaminated soil and the selection of remedial technology. CEC is the amount of exchangeable cations that can be retained by a given mass of soil [1]. Two common methods for measuring CEC exist. In the first, the soil sample is saturated with a selected cation solution; then, a second selected cation solution is used to exchange and remove the first exchangeable cation from the soil. Finally, the amount of the first selected cation that is removed by the second solution is measured as the CEC of the soil sample. In the second method, a particular species of cation is used to replace the cations in the soil. The amounts of the exchanged cations, including Ca, Mg, and K, are measured individually [1-4].

Some of the chemical/physical properties of cations reveal its exchangeability. Highly charged cations are retained more tightly than less strongly charged cations; for example, $\text{Al}^{+3} > \text{Ca}^{+2} > \text{Na}^+$. For a given

positive charge, cations with a smaller hydration radius are retained more tightly [1,5-7]. For example, hydration radii of $\text{K}^+ = \text{NH}_4^+$ (0.331 nm) < Na^+ (0.358 nm); Ca^{+2} (0.412 nm) < Mg^{+2} (0.428 nm) [8]. Potassium ions have a greater exchange potential than sodium ions. Several factors influence the measured CEC, including the nature of the cation that is being exchanged, the ionic strength of the reagent solution, the pH of that solution, the contact time, and the soil:solution ratio [9,10]. The major components of soil are clay mineral, organic matter, carbonate and Fe/Mn oxides; the first two components dominate the CEC [1,7]. Schnitzer and Hansen [11] ranked the stability constants of metal-humic substance complexes as $\text{Fe}^{+3} > \text{Al}^{+3} > \text{Cu}^{+2} > \text{Ni}^{+2} > \text{Co}^{+2} > \text{Pb}^{+2} > \text{Ca}^{+2} > \text{Zn}^{+2} > \text{Mn}^{+2} > \text{Mg}^{+2}$. Yong [6] noted that a highly charged cation has a great replacing capacity, which follows the order $\text{Na}^+ < \text{Li}^+ < \text{K}^+ < \text{Rb}^+ < \text{Cs}^{+2} < \text{Mg}^{+2} < \text{Ca}^{+2} < \text{Ba}^{+2} < \text{Cu}^{+2} < \text{Al}^{+3} < \text{Fe}^{+3} < \text{Th}^{+4}$.

Ammonium acetate and sodium acetate are two common CEC test reagents, and recommended by the Environmental Protection Administration of Taiwan

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Study on recycled waste foundry sand as raw materials of cement additives

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Key Words: Waste foundry sand, eco-cement, clinker, hydrates

ABSTRACT

The goal of this study is to identify the optimal component ratios for making cement that maximize the amount of cement clay that can be replaced by recycled waste foundry sand, limestone and ferrate as raw materials. A computational model was utilized to determine the composition of raw clinkers. In this study, the amount of free CaO was < 1% and the loss on ignition parameter met eco-cement criteria of CNS 61. Results demonstrate that the major components of ordinary Portland cement, such as C₃S, C₂S, C₃A, and C₄AF, were in all eco-clinkers. The Fourier Transform Infrared Spectroscopy analysis identified the wavenumber was at roughly 990-970 cm⁻¹, and mainly due to Si-O bonds of calcium silicate hydrates. The heavy metal leaching concentrations for different clinkers complied with regulatory thresholds developed by Taiwan's Environmental Protection Agency. Thus, this study demonstrates the feasibility and safety in utilizing waste foundry sand in cement additives.

INTRODUCTION

Large amounts of waste foundry sand are generated in Taiwan. Costs of disposing waste foundry sand have become a burden on city governments, as are shortages of landfill space. Increasing demands on natural resources and a scarcity of acceptable solid waste disposal sites are forcing many local governments to consider resources recovery.

In Taiwan, 1.5 Mt of waste foundry sand are produced annually by foundry plants. Currently, landfilling remains the common method for disposing of waste foundry sand. Recently, various studies have explored the use of waste foundry sand as a construction material. A multi-disciplinary approach, based on topographical and in-field geophysical investigations, excavation of trenches, and laboratory characterization of waste material has been successfully applied to foundry wastes at an industrial waste landfill [1]. Waste foundry sand has been used in insulating structures, as pipe bedding [2], and as a construction material (sub-base) for roads and parking lots. Additionally, foundry sand has been utilized as a capped embank-

ment or ground and site barriers [3]. The US Environmental Protection Agency estimated that much of land-filled foundry sand can be used by industries outside the foundry industry. Waste foundry sands are suitable for geotechnical applications (e.g., road bases and structural fill) and as an aggregate for manufactured products (e.g., cementitious materials, concrete, asphalt, and soil) [4-6]. Although many US states have beneficial use regulations for industrial byproducts, the most stringent state requirements apply to byproducts used on land applied or as ingredients in soil blends, amendments, or composts [7,8].

On the other hand, Portland cement clinker production consumes massive amounts of raw materials (limestone, clay, etc.), and large amounts of energy (850 kcal kg⁻¹ of clinker) and increases the emissions of greenhouse gases (around 0.85 kg of CO₂ kg⁻¹ of clinker). Therefore, looking for other new, economical raw materials is also becoming an immediate concern [9]. The main chemical compounds of waste are Al₂O₃, Fe₂O₃ and SiO₂, which are also the main chemical compounds of some raw materials in cement production. Thereby, at least in theory, it can be used as an

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Optimization of incubation factors for fermentative hydrogen production from agricultural wastes

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Key Words: Hydrogen production, agricultural waste, experimental design method

ABSTRACT

Untreated agricultural wastes are most harmful to the environment. Three large quantities of agricultural wastes including water hyacinth, oil extraction residue and mushroom waste were selected to investigate the potential for biohydrogen production. A full factor experimental design was used to investigate the effects of four key environmental factors on the H₂ production from these agricultural wastes with sewage sludge inoculum in batch fermentors. A two-level factorial design experiment was carried out to optimize the initial cultivation pH, substrate concentration, temperature and nutrient addition. All the three agricultural wastes showed hydrogen production potential via anaerobic fermentation using mixed microflora. The maximum hydrogen yield (HY) of 51 mL H₂ g⁻¹ substrate for mushroom waste and 17 mL H₂ g⁻¹ substrate for water hyacinth were obtained at pH 8.0, substrate concentration 30 g COD L⁻¹, temperature 55 °C and without nutrient addition. The peak HY of 27 mL H₂ g⁻¹ substrate¹ for oil extraction residue was obtained at pH 8.0, substrate concentration 15 g COD L⁻¹, temperature 55 °C and without nutrient addition. According to signal to noise ratio analysis, the significant ones among the four tested factors for hydrogen production from the three agricultural wastes were nutrient addition and temperature.

INTRODUCTION

Hydrogen is an effective energy carrier when compared with petrol or natural gas. Hydrogen is a renewable energy. The heat value of hydrogen is 142 MJ kg⁻¹ which is 3 times of gasoline and 3.5 times of nature gas. Currently a great deal of attention is being paid to the utilization of hydrogen as alternative and eco-friendly fuel throughout the world, because it does not emit carbon, sulfur or nitrogen that cause pollution

during combustion [1]. A large number of microorganisms, including significantly different taxonomic and physiological types can produce molecular hydrogen. Biological hydrogen production processes can be classified as follows: (1) direct biophotolysis, (2) indirect biophotolysis, (3) photo-fermentation, and (4) dark-fermentation. Dark hydrogen fermentation is an ubiquitous phenomenon under anoxic or anaerobic conditions. When bacteria grow on organic substrates (heterotrophic growth), these substrates are degraded

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Interaction between zero-valent iron and hydrogen in anaerobic degradation of tetrachloroethylene

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Key Words: Cathodic hydrogen, dechlorinators, hydrogen gas addition

ABSTRACT

The study demonstrates that both hydrogen gas and zero-valent iron enhance the process of anaerobic dechlorination of tetrachloroethene (PCE) in an anaerobic mixed culture. Experimental results show that the addition of iron powder not only increases the degradation of PCE but also reduces the formation of chlorinated intermediates. Ethene is the major end product, while either *cis*-dichloroethene or vinyl chloride is under the detection limit for all processes. The pseudo-first-order rate coefficients are 0.037, 0.048 and 0.078 d⁻¹ for anaerobes alone, Fe⁰ alone, and for the combination of zero valence iron and anaerobes, respectively. However, the interaction effect on PCE degradation between anaerobes and iron is insignificant. The half-velocity constant of hydrogen-utilizing-dechlorination for PCE is estimated to be 47 ppmv in this system.

INTRODUCTION

Halogenated aliphatic compounds are prevalent groundwater contaminants and significant components found in hazardous wastes and landfill leachates. Chlorinated compounds, e.g., pesticides such as chlorodiphenyltrichloroethane and numerous industrial solvents used in dry-cleaning operations and semiconductor manufacturers are the best known and most studied volatile organic compounds (VOCs), because of their highly publicized potential causing environmental and health-related problems.

Halogenation is often implicated as a reason for the persistence of these VOCs. Microbial transformations of polychlorinated hydrocarbons, e.g., carbon tetrachloride, tetrachloroethylene (PCE), and 1,1,1-trichloroethane, are catalyzed only under anaerobic conditions by dehalogenation mechanisms [1,2]. The hydrogen might play a key role in dechlorination of halogenated aliphatic compounds [3].

The addition of zero-valent iron (ZVI) is often reported to enhance the anaerobic dechlorination of PCE [4-7]. Corrosion of the zero-valent iron by the

chlorinated hydrocarbon can promote a reductive dechlorination reaction as follows:



Moreover, water can oxidize ZVI and release cathodic hydrogen into the aqueous solution under anaerobic condition. The process is known as the "anaerobic corrosion" of iron (Eq. 2). The cathodic hydrogen is available as energy source for pure culture of methanogenic, homoacetogenic, and sulfate-reducing bacteria [8].



However, in anaerobic cultures, H₂-utilizing methanogens might compete with H₂-utilizing dechlorinator for hydrogen. Under this condition, hydrogen molecules in the system will be transformed into methane, dechlorination products, or both. Based on the results, Weathers et al. [8] demonstrate the effect of hydrogen on anaerobic PCE degradation and reductive biodechlorination. Lee et al. [9] found that nano-Fe⁰ caused significant physical disruption of the cell membranes in *Escherichia coli* and dissolved iron enhanced

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Adsorption of hazardous cationic dyes from aqueous solution onto *Acacia nilotica* leaves as an eco friendly adsorbent

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Key Words: *Acacia nilotica*, crystal violet, rhodamine B, equilibrium, adsorption kinetics and adsorption isotherm

ABSTRACT

The adsorption of Crystal Violet (CV) and Rhodamine B (RHB) onto abundantly available *Acacia nilotica* leaves (RVM) was studied. The effect of solution pH, agitation time and initial dye concentration was evaluated. The RVM were characterized by scanning electron microscope and Fourier Transform Infrared analysis. The adsorption studies included both equilibrium adsorption isotherms and kinetics. The applicability of Langmuir, Freundlich, Dubinin-Radushkevich, and Temkin equations was investigated, and the Langmuir isotherm exhibited the best fit with the experimental data. The maximum monolayer capacity obtained from Langmuir is 33 mg g^{-1} for CV and 37 mg g^{-1} for RHB. The kinetic data well described by the pseudo-second-order kinetic model with intraparticle diffusion as one of the rate limiting steps. Therefore, RVM has the potential to be used as a low-cost eco friendly adsorbent for the removal of CV and RHB dyes from aqueous solution.

INTRODUCTION

The discharge of highly colored effluents into natural water bodies is not only aesthetically displeasing, but also impedes light penetration, thus upsetting biological processes within a stream. Dyes are synthetic aromatic water soluble and dispersible organic compounds, which cause coloration of natural water bodies when released into the environment [1]. Dyes used in textile industry may be toxic to aquatic organisms and can be resistant to natural biological degradation. Hence, the removal of synthetic organic dyestuff from waste effluents becomes environmentally important [2]. The valorization of agricultural wastes into valuable materials without generating pollutants is a major challenge and recommended for an industrial sustainable development in order to preserve the environment [3].

Adsorption has been shown to be one of the most promising and extensively used methods for the removal of both inorganic and organic pollutants from contaminated water [4]. Adsorption onto activated carbon is proven to be effective in treating textile wastes. However, in view of the high cost and associated problems of regeneration, there is a constant

search for alternate low-cost adsorbents [5]. Such alternatives include coffee ground [3], spent tea leaves [2], aerobic granules [4], palm ash [6,7], wheat straw [8], pomelo (*Citrus grandis*) peel [9], pine-cone [10], pumpkin seed hull [11], ginger waste [12], skin almonds [13], and rice husk [14]. But those adsorbents were chemically activated and after the use of those adsorbents, they will be discarded to our environment and may cause other environmental hazards.

Acacia nilotica is native to Africa and the Indian subcontinent. It grows throughout the drier parts of India. In Haryana, *A. nilotica* based agro forestry systems reduce the yield of wheat [15]. In this paper the preparation, characterization and adsorption properties of non activated *A. nilotica* leaves (RVM) were reported. The RVM were used because of its one-step simple process, high yield, very short activation time, and there is no use of chemicals. Batch processes were used to study the adsorption process.

Discharge of Crystal Violet (CV) into the hydrosphere can cause environmental degradation, because CV is readily absorbed into fish tissue from water exposure and is reduced metabolically by fish to the leuco moiety, leucocrystal violet. Several studies by the National Toxicology Program reported that the

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Polyhydroxyalkanoate (PHA) production from tapioca industrial wastewater treatment: Influence of operating conditions on PHA content

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Key Words: Chemical oxygen demand (COD), polyhydroxyalkanoates (PHA), sequencing batch reactor (SBR), tapioca industrial wastewater

ABSTRACT

The aims of these experiments were treating tapioca processing waste water to produce polyhydroxyalkanoates (PHAs) and removal of chemical oxygen demand (COD). The experiments were conducted in a sequencing batch reactor with a volume of 6 L. The entire experimental condition was anaerobic-aerobic-anaerobic. Experiment 1, 2 and 3 had the first 2 h for feeding time while Experiment 4 had 3 h. The 4 h between feeding time and settling time were variation of aeration time and without aeration. Experiment 1 had 2 h aeration time and 2 h without aeration. Experiment 2 has 1 h aeration and 3 h without aeration. Experiment 3 had 1 h interval alternating between aeration time and no aeration. Experiment 4 had 2 h aeration and 1 h no aeration. The first 6 h was mixing, the last 3 h was settling and draining time with total operating time 9 h.

The experiments found that the average of PHA contents in Experiment 1, 2, 3, and 4 were 0.102, 0.043, 0.04, and 0.031 g PHA g⁻¹ MLSS (mixed liquor suspended solids), respectively. The maximum value in Experiment 1 was 0.3 g PHA g⁻¹ MLSS. The average COD removal of experiment 1, 2, 3, and 4 was 26, 37, 23, and 18%, respectively.

INTRODUCTION

Indonesia is the third largest cassava producer in the world [1] with the total production in 2007 20 Mt [2]. Tapioca industry production plants are part of a small-scale industry. In general, tapioca industry plants are located in residential areas and do not have wastewater treatment plants [3]. Typically, tapioca starch processing releases about 30% of the raw materials in wastewater. Washing and settling process in tapioca industry produces wastewater. It contains a considerable amount of organic material. In general, tapioca industry discharged wastewater into the aquatic environment without treatment. As a result, tapioca industrial wastewater pollutes natural water sources around

the industry location. The pollution causes odors and disturbs the surrounding environment [4]. We consider that treating tapioca wastewater would help improve the environment condition and produce useful material, or polyhydroxyalkanoates (PHAs).

PHA is one of biodegradable plastic types. PHA has a great potential to replace conventional plastics. Until now, more than 60 PHA syntheses have been found and cloned from various microorganisms [5]. A wide variety of bacteria both Gram negative and Gram positive such as *Pseudomonas*, *Bacillus*, *Ralstonia*, *Aeromonas*, *Rhodobacter* and certain Archaea, especially members of the Halobacteriaceae, like *Haloferax sulfurifontis*, synthesise PHAs. The PHAs as energy storage compounds are presented in the cells as insoluble granules in the cytoplasm [6].

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Bioflocculant produced from bacteria for decolorization, Cr removal and swine wastewater application

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Key Words: Compound bioflocculant, wastewater treatment, swine wastewater, flocculation

ABSTRACT

Bacteria strains, xn11 + xn7, which produce flocculating substances, were isolated from activated sludge from local hoggery. The optimal conditions for production of xn11 + xn7 were as follow: initial pH 3-7, inoculum volume 0.3 + 0.3 mL, cultivating temperature 30 °C, culture time 2.5-5 d. The extracellular polymers of xn11 and xn7 are mainly non-ketose polysaccharides, not proteins. Xn11 + xn7 had strong thermal stability and kept flocculating effect in a wide range (pH 2-10). Comparison to other cations, Ca²⁺, Al³⁺ and Mg²⁺ had obvious effect on enhancing flocculating activity. In wastewater application, xn11 + xn7 had high efficiency in decolorizing dye solutions of basic fuchsin (93%), and removing efficiency was 28% for removing Cr(VI) (280 mg L⁻¹). It was also used to swine wastewater treatment with removing efficiency of turbidity and chemical oxygen demand 91 and 42%, respectively, which was better than polyaluminium chloride alone.

INTRODUCTION

Flocculation is an effective and convenient method of removing suspended solids, colloids and cell debris. Generally speaking, the flocculants were classified into three groups of flocculants: inorganic, organic and natural or bioflocculants [1]. Although chemical flocculants have been widely used for their effective flocculating and low cost, they have threatened human health and increased environmental risk, such as polyacrylamide including acrylamide monomers which are demonstrated to be both neurotoxin and strong carcinogens to human and their dosages are restricted [2].

Bioflocculant is a kind of metabolite produced by microorganisms during their growth. It is mainly composed of high polymers as extracellular polysaccharide, glycoprotein, protein, cellulose and nucleic acid [3-5]. Bioflocculants have gained much wider attention due to their biodegradability and safety. In wastewater treatment, bioflocculants have been used to treat dye solutions [6], inorganic solid suspensions [5,7], downstream processing, food and industry wastewater [4,8,9], heavy metals [10,11], among others.

In previous studies, the bioflocculant emphasis was mainly placed on sole microorganisms; many

bioflocculant-producing microorganisms have been reported including bacteria, fungi and yeast [4]. But the study of specific compounds produced from microbes was less. Some researchers found that the flocculating activity for those bioflocculant compounds was better than that of any pure strains [12]. The aim of this study was to isolate the bacteria that produce bioflocculant compounds from activated sludge of local hoggery. A series of experiments were then performed to investigate optimized culture condition for these strains, flocculation characteristics, and applications in wastewater treatment.

MATERIALS AND METHODS

1. Bioflocculant-producing Medium

The composition of the culture medium (in g L⁻¹): glucose, 20; yeast extract, 0.5; urea, 0.5; NaCl, 0.1; K₂HPO₄, 5; KH₂PO₄, 2; (NH₄)₂SO₄, 0.2; MgSO₄·7H₂O, 0.2, and the initial pH of medium was adjusted to 7-7.5. The composition of the seed medium (in g L⁻¹) is: peptone, 10; beef extract, 5; NaCl, 5 with the initial pH of medium adjusted to 7.

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Adsorptive characteristics in a system consisting of iron-coated sands, arsenic and humic acid

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Key Words: Adsorption, arsenic, coating, humic acid, iron oxide

ABSTRACT

Iron oxide-coated sand (IOCS) was used as an adsorbent for removing As(V) from water in which the adsorption capabilities of IOCS for As(V) were examined under different environmental conditions. A synthetic water sample was used to study the impact of humic acid (HA) on the adsorption capabilities of IOCS for As(V). Results showed that the adsorptive characteristics of IOCS on As(V) fairly obey the pseudo-second order kinetic adsorption behavior. In addition, the adsorption mechanisms of IOCS for As(V) appeared to be governed by the physical and chemical adsorption. HA plays an essential role in competitive adsorption with As(V) on IOCS surface. The adsorption capacities of IOCS for As(V) under different environmental conditions are ranked in terms of magnitude as follows: single As(V) adsorption system > As(V)/HA + IOCS adsorption system > HA/IOCS + As(V) adsorption system. Langmuir adsorption isotherm regression results show that at 25 °C and pH = 3.0, the maximum adsorption capacities of IOCS for As(V), As(V)/HA + IOCS and HA/IOCS + As(V) are 1,667, 1,000 and 714 $\mu\text{g As g}^{-1}$ IOCS, respectively.

INTRODUCTION

Arsenic in groundwater may come from natural sources or from improper discharge of wastewater from semiconductor, glass, or pesticide industrial production, which leads to arsenic pollution in surface water or groundwater. Presence of arsenic in natural waters is a worldwide problem. Arsenic pollution has been reported in Canada, China, India, Japan, New Zealand, Taiwan, and USA [1]. There are evidences that long-term exposure to arsenic-polluted water bodies can lead to blackfoot disease or cancer [2]. The WHO provisional guideline of 0.01 mg L⁻¹ has been adopted as drinking water standard. Depending on environmental conditions, arsenic may exist in the form of As(III) or As(V). Because arsenic cannot be decomposed further, current methods of treating water

containing trace levels of arsenic include adsorption, ion exchange and membrane treatment [3-6].

Iron oxides have a relatively high surface area and surface charge, and often regulate free metal and organic concentrations in water through adsorption reactions [7-12]. Many researchers have used iron oxide to remove heavy metals and organic matters from tap water or wastewater [13-17]. Furthermore, some researchers have developed techniques for coating iron oxide onto sand surface in order to overcome the difficulties of using iron oxide powders in water treatment. The iron oxide-coated sand (IOCS) has been tested for removal of cationic as well as anionic metals from synthetic and real wastes. The results from their studies confirmed that the utilization of IOCS is worth developing for heavy metal removal from water [18-24].

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Rapid on-site monitoring of cylindrospermopsin-producers in reservoirs using quantitative PCR

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Key Words: Rapid on-site monitoring, cylindrospermopsin-producer, quantitative PCR, *Cylindrospermopsis raciborskii*

ABSTRACT

Recently the cyanobacterium *Cylindrospermopsis raciborskii* has become a major concern in water quality monitoring and control perspective due to the toxicity of cylindrospermopsin. To minimize the harmful effects of cylindrospermopsin, an effective and efficient on-site monitoring method of *C. raciborskii* is needed to assess the risk of public health and activities associated with drinking and recreational water. Although bio-molecular detection methods have become popular because of its specificity and speed, only very few studies have focused on the quick monitoring of cylindrospermopsin-producers in reservoirs. In this study, we tested quantitative polymerase chain reaction (qPCR) method coupled with microwave pretreatment for the extraction and quantification of targeted DNA, including *rpoCI* for total *C. raciborskii* and polyketide synthase (*pks*) for cylindrospermopsin-producer. The method was successfully tested with laboratory cultures and then applied to 10 reservoirs in Taiwan. It was found that the method was able to quantify total *C. raciborskii* and cylindrospermopsin producers within 2 h after sampling with detection limit at about 1,000 cells mL⁻¹. Total *C. raciborskii* (*rpoCI*) and cylindrospermopsin producer (*pks*) were detected in 3 and 2 reservoirs, respectively, all in Kinmen Island. Microscopic measurement and cylindrospermopsin concentrations measured in the reservoir samples were in accordance with the detection of total and toxigenic *C. raciborskii* cells, respectively. This study successfully showed the applicability of the qPCR method for rapid on-site detection of *C. raciborskii* in reservoirs. In addition, the results also suggest that cylindrospermopsin is an important cyanotoxin in the reservoirs in Kinmen Island.

INTRODUCTION

The cyanobacterium *Cylindrospermopsis raciborskii*, widely distributed across the temperate, subtropical and tropical world, has become a major concern in water quality monitoring and control perspective due to its production of an alkaloid hepatotoxin, called cylindrospermopsin, which may cause liver injury, in freshwater bodies. This cylindrospermopsin-producer may grow abundantly in lakes and reservoirs, particularly under conditions of

eutrophication, potentially affecting the health of human and animals [1-4]. According to the monitoring result of water quality from 2000 to 2004 conducted by Taiwan Environmental Protection Administration, approximately half of Taiwan's 20 major reservoirs were categorized as eutrophic based on the Carlson's Trophic State Index [5]. These eutrophic reservoirs provide excellent environments for many cyanobacteria, such as *Microcystis* and *Cylindrospermopsis*, to grow. Yen et al. [6] analyzed water samples from 3 eutrophic lakes, 2 water treatment plants and 15 distri-

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Anti-bacterial study using nano silver-doped high density polyethylene pipe

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Key Words: Nano-silver particle, disinfection, HDPE-Ag

ABSTRACT

In the study, the addition of silver nanoparticle onto the wall of high density polyethylene (HDPE) pipe under some controlled conditions has been conducted. The anti-bacterial ability for the nano-silver HDPE (HDPE-Ag) pipe to avoid the formation of biofilms has also been evaluated by continuously passing test water. Scanning Electron Microscope and X-ray Diffraction were employed to characterize the deposition of nanosilver film on the HDPE pipe and the results indicated that nano-silver was unevenly distributed on the surface of inner pipe wall. When using HDPE-Ag containing *Escherichia coli* (1.6×10^2 CFU mL⁻¹), it resulted in the death of 55% *E. coli* within 2 h. The test water containing total bacterial count of 3.7×10^3 CFU mL⁻¹ was continuously passed through the simulated water distribution system of HDPE and HDPE-Ag pipes, respectively, with the flowing velocity of 2 cm s⁻¹. It was found that the change of outlet total bacterial count was not significant after 32 d. However, when the velocity was decreased to 0.15 cm s⁻¹, total count would be 40 times lower in the outlet water from the HDPE-Ag pipes (3.5×10^2 CFU mL⁻¹) than HDPE pipes (1.4×10^4 CFU mL⁻¹) after 8 d. These results have substantially demonstrated that HDPE-Ag pipes have potential bactericidal activity.

INTRODUCTION

Disinfection is the most important process to reduce the waterborne pathogen contamination in potable water. Although chlorination is regarded as the essential unit for disinfection purpose, it may cause some unwanted chemical reactions associated with the formation of carcinogenic and mutagenic disinfection by-products; among them trichloromethane and haloacetic acids are ranked the most [1,2]. Therefore, other disinfectants, which might produce less adverse or side effects, are worthy to be considered. Silver has long been used by humans in silver vessels for the storage of liquids in order to prevent putrefaction [3]. It serves as potent antibacterial agent acting against an exceptionally broad spectrum of bacteria [4]. Silver-containing materials have been used for water treatment [5-7]. Since nanotechnology has been developed recently, the use of nano-silver, which has higher activated surface area for water purification and disease control, is recognized with no residual toxics to human

beings [3].

It is estimated that 95% of the overall biomass in water distribution systems is located on the inner surface of the pipe walls as a biofilm, while only 5% occurs in the water phase [8]. It is also known that biofilms affect microbiological quality of drinking water in water distribution systems [9]. The formation of biofilms depends on disinfectants, nutrients, pipe material, corrosion and hydraulic effects [10-12].

High-density polyethylene (HDPE) is a thermoplastic polyethylene made from petroleum. In 2007, the global HDPE market reached a volume of more than 30 Mt [13]. Because HDPE is well resistant to many different solvents, it has a wide variety of applications including container, storage shed, plastic bag, water pipes, etc. In this study, nanosilver particles doped on the inner surface of HDPE pipe is tested for the antimicrobial properties, which would enable its potential use in the water distribution system and reduce the risks of biofilms growth that usually happens in conventional distribution pipelines.

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Engine exhaust noise feedback to traffic flow and vehicle emission control on-road: A case study in Taichung City

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Key Words: Vehicle emission control, engine exhaust noise, traffic flow, vehicle fuel consumption

ABSTRACT

The paper investigates the relationship between vehicle average speed with low frequency engine exhaust noise (< 400 Hz) and CO₂ concentration. Field measurements reveal a greater relationship between vehicle speed and noise intensity ($R^2 = 0.811$), and not relationship between vehicle speed and CO₂ concentration ($R^2 = 0.152$). The optimum measuring post of a noise monitor is approximately 8 m before the stop sign. The critical point for a traffic jam is 820 Passenger Car Unit h⁻¹ lane⁻¹ with a speed of 25 km h⁻¹, after which the speed quickly reduces to 10 km h⁻¹. This study evaluated increasing the time of green light operation to avoid this critical point. The study set up a real-time monitoring-response traffic signal control system and demonstrated the success of low frequency noise sensors as a real-time vehicle monitor. This investigation calculated reduced amounts of air pollutants and CO₂ from vehicle emission and vehicle fuel consumption on six crowded roads, while avoiding the critical point. The results indicate that engine exhaust noise feedback to traffic flow and on-road vehicle emission control is useful and accurate. Finally, this paper suggests an easy and inexpensive method for light control of urban traffic signal.

INTRODUCTION

Researchers have long identified motor vehicles as major sources of urban air pollution [1,2]. Emissions from vehicle exhaust generally have contributed to 52-85% of air pollution [2-7]. Vehicle pollutants primarily occur during startup (hot and cold starts from tailpipe emissions), shutdown (hot soak emissions), and parking (diurnal breathing and evaporative losses). Therefore, road transport is a key focus of air quality strategy in many countries.

Although the department of environmental protection in many countries has introduced several subsidiary measures and guidelines for low-pollution vehicles, the rapid increase of on-road travel volume has created severe impact on air quality and public health in urban areas. A suitable road transport strategy is an important policy for reducing urban air pollution. Governments have actively sought for solutions to the problem of

urban road congestion, not only to ensure shorter and more reliable travel times, but to also diminish the adverse effects on air pollution and wasted fuel consumption [8,9].

The conventional traffic flow control system, usually including signal devices, detectors, and traffic management computer, is efficient [8-12], but vehicle sensors need further promotion [13-15]. Vehicle detection is one of the key technologies in an Intelligent Transportation System, which measures vehicle flow, vehicular speed, and on-road vehicle density [16]. The five common traffic sensors (including inductive loop [17], microwave sensor [18], video image detection [19], far infrared sensor [20], and machine vision sensor [21]) do not respond quickly enough to traffic conditions and are expensive [19,22,23]. Finding a more responsive and inexpensive vehicle sensor and a real-time monitoring-response traffic signal control system to improve traffic flow and air quality is

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Visible-light photocatalytic conversion of CO₂ to methanol using dye-sensitized mesoporous photocatalysts

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Key Words: Mesoporous silica, photocatalytic, dye-sensitized, CO₂ reduction

ABSTRACT

Dye-sensitized TiO₂/SBA-15 was prepared using a two-step route, including grafting a thin layer of TiO₂ onto SBA-15 and then impregnating it with 2,9-dichloro quinacridone (DCQ) molecules. The prepared material was characterized by X-ray diffraction (XRD), High-resolution transmission electron microscopy, atomic absorption spectroscopy, nitrogen sorption isotherm, Thermal gravimetric analyses, UV-Vis. The XRD patterns of SBA-15 and TiO₂/SBA-15 exhibit a peak of (100), which is the characteristic of a highly ordered hexagonal structure. UV-Vis spectrum of TiO₂/SBA-15 shows the band edge of 400 nm. After functionalized by DCQ, a new band between 500 and 600 nm emerges, which enables the catalyst to absorb visible light. For photocatalytic reduction of CO₂ into methanol in water under 100 W halide lamp illumination, DCQ-TiO₂/SBA-15 exhibits superior methanol yield (0.44 μmol g⁻¹-cat h⁻¹) than that (0.16 μmol g⁻¹-cat h⁻¹) of DCQ-P25 TiO₂ due to larger amounts of adsorbed DCQ.

INTRODUCTION

The rapid increase in anthropogenic CO₂ emission is a matter of great concern. To solve this problem, new strategies for CO₂ capture and storage are under development [1,2]. One possibility is the use of photocatalysts for the conversion of CO₂ into a high-energy-content fuel via renewable solar energy. The process for carbon cycle involves only water, carbon dioxide, and sunlight just as photosynthesis process does. Titania (TiO₂) is the most common used photocatalyst [3-5] in such artificial photosynthesis process because of its chemical stability, non-toxicity and reasonably low cost. However the wide band-gap of TiO₂, ~3.0 eV for rutile and 3.2 eV for anatase, limits its activation to UV radiation, which is less than 5% in sunlight. Hence achieving significant hydrocarbon yields requires shifting the band-gap of TiO₂ in order to utilize a maximum amount of solar energy.

Efforts to reduce band-gap of TiO₂ via, for ex-

ample, substitutional doping (e.g., C, N) [6,7] and combining TiO₂ with photosensitive dyes [8-10] or narrow-gap semiconductor quantum dots (e.g., CdS, CdSe) [11] have been developed. However, beyond a minimal concentration, the dopants serve as recombination centers for photogenerated electron-hole pairs. Narrow-gap semiconductor quantum dots successfully extend the photoresponse to visible light, but not maintaining its charge-transfer properties and photocorrosion stability. Surface modification of TiO₂ photocatalyst using dye molecules is driven by electron injection from photoexcited dye into the conduction band of TiO₂ when it is exposed to light irradiation with suitable energy. These photogenerated electrons quickly reduce the reactants at the TiO₂ surface and the dye molecules can be regenerated by the additions (e.g., sulfate) in the water. Dye-sensitized TiO₂ supported on mesoporous materials facilitating the availability of high surface areas for reaction has been recognized to be preferable because these applications

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PM₁₀ particulate emissions from stack flue gas in Taiwan

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Key Words: PM₁₀, stack sampling, American Method 201A, Japanese JIS K 0302

ABSTRACT

The aim of this research was to study total particulate matter (TPM) and PM₁₀ characteristics with American Method 201A and the Japanese JIS K 0302 methods and compare particle emissions from stacks in nine industries. This research examined the differences between two standard test methods for TPM and PM₁₀ emission concentrations. The reasonable control methods were suggested from TPM and PM₁₀ emission characteristics. The results showed that the food industry had the highest PM₁₀ concentration at 115 mg Nm⁻³, whereas the cement industry had the lowest PM₁₀ concentration, 15 mg Nm⁻³, with the American Method 201A. Furthermore, the asphalt cement industry had the highest PM₁₀/TPM ratio at 0.92, with the food industry the lowest ratio of 0.71. The ratios obtained using the Japanese standard sampling method was lower than those determined using the American standard sampling method.

INTRODUCTION

Particulate concentration provides one of the important pollution indexes for judging air quality. In order to provide improvement strategies for preventing and managing pollution, it is important to measure particulate emission characteristics before choosing suitable air pollution control devices which will meet air pollutant emission standards. It is therefore necessary to study suitable measuring methods for examining particulate emission characteristics, such as particle size distribution and concentration in flue gases. In this study, American and Japanese national standard methods for particulate diameter and mass concentration analysis were chosen in order to determine the differences between the two types of flue gas analysis. The average diameter of flue particulates in the ceramics, asphalt cement and textile dyeing industry was about 2.5 [1], 3.9 [2] and 0.5-2.9 μm [3,4], respectively. The results of Menichini [5] showed that flue gas temperatures affected particulate size when the emitted particles were organic particulates.

It is important to note that the bending tube radius, direction of the sampling tube, flue gas direction angle, diameter of the sampling tube, material of the sampling tube made from, and whether or not isokinetic sampling was carried out, all greatly influence the sampling results. Gusev et al. [6] and Wong and Heryanto [7] indicated that two methods, centrifugal collection and impactor collection, were suitable for measuring particulate matter smaller than 10 μm (PM₁₀) from different industries. The first one can be subject to the USA national standard test method, Method 201A [8], with 10 μm cut-off size cyclone. The other one can be subject to the Japanese national standard test method, JIS K 0302 [9], with 10 μm cut-off size impactor. Therefore, it is necessary to examine and compare the differences between the American and Japanese national standard methods for analysis of particle emission concentrations in order to provide a reference for analysis of particulate size.

MATERIALS AND METHODS

In selecting polluting sources for the purposes of

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Process simulation of rice straw torrefaction

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Key Words: Rice straw, torrefaction, combustibility, energy model, autothermal operation

ABSTRACT

Crop residues are considered to be important feedstocks for partial fossil fuel substitution in energy production. Therefore, utilizing crop residues such as rice straw which is abundant in Taiwan has been proposed for electricity generation that enhances energy security and sustainability. However, the high moisture content and low heating value of rice straw affect its biomass utilization efficiency. Furthermore, poor grindability of rice straw decreases rates of co-milling with coal at coal-fired power plants. Torrefaction is a thermal pretreatment technology which improves the properties of biomass in order to deal with the above problems. Simulation of the process which produces biocoal from rice straw by torrefaction was conducted in this paper. It was found that the volatile gas is combustible even though the gas consists of 49 wt% non-combustible content. Results also show that the process which is carried out at 250 °C for 30 min can be operated autothermally when the input (wet rice straw) moisture content is less than 12 wt%. The process product yield increases with decreasing wet rice straw moisture content. Moreover, the process thermal energy efficiency was estimated to be 0.85 when the process was operated above the point of autothermal operation. According to the results, rice straw could be sun dried off in the field to reduce moisture content before transport to the torrefaction plant in order to improve process performance. The obtained information should be useful for the design of logistic studies of biomass, or future applications of rice straw torrefaction for energy production.

INTRODUCTION

1. Torrefaction

The utilization of crop residues as raw materials in a bioenergy supply chain is considered to be an alternative to energy crops. Crop residue such as rice straw is produced in abundance in Taiwan, and can provide a sustainable biomass resource used to make biocoal for producing bioelectricity enhancing energy security in Taiwan. However, biomass has high moisture content and low energy density [1,2]. These properties have negative impacts during thermochemical conversion. Moreover, rice straw has lignocellulosic structure which is more tenacious than coal. This characteristic makes it less grindable when it is to be used for cofiring with coal in pulverized coal power plants [3]. The pretreatment of biomass can resolve the drawbacks of raw biomass mentioned above. One of the pretreatment methods is torrefaction [4]. Torrefaction

is a thermochemical treatment method which is conducted under standard atmospheric pressure conditions in the absence of oxygen. Operating temperature is within the range of 200 to 300 °C. A lower heating rate ($< 50 \text{ }^\circ\text{C min}^{-1}$) and a longer residence time (typically 1 h) are typical operation conditions for this process [5]. Numerous reaction products are formed during the process. The products are divided into solid char (torrefied biomass), aqueous compounds, and gases [6]. For wood briquette, torrefied biomass's heating value may increase by 15%, and the moisture content decreases by 73% [7]. Furthermore, torrefied biomass showed better grinding properties [8]. Bridgeman et al. [9] also conclude that torrefied biomass can be successfully pulverized. The fuel characteristics obviously improved following torrefaction processes. Biomass loses relatively more oxygen and hydrogen compared to carbon. Consequently, the lower heating value (LHV) of torrefied biomass is within the range of 18 to 23 MJ kg⁻¹ (dry basis) depending on the torrefaction

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Nitrate probe for quantifying reducing power of nanoscale zero-valent iron

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Key Words: Nanotechnology, nanoparticles, nitrate, zero-valent iron

ABSTRACT

Nano zero-valent iron (NZVI) has been extensively researched for treatment of hazardous and toxic wastes. In particular, it can be applied to remediate contaminated sites directly. In this study, the NZVI was synthesized by using chemicals of NaBH_4 and FeCl_3 . The conditions for NZVI synthesis were varied by such parameters as air exposure, pumping rate of NaBH_4 ($4\text{--}8\text{ mL min}^{-1}$), and agitation power ($100\text{--}300\text{ rpm}$). Right after synthesis of NZVI particles of different varieties, nitrate of 50 ppm was used to probe its reducing power quantitatively. As a result of factorial design analysis, it appears that the agitation of reaction solution plays a major role in determining its reducing power of NZVI particles. In addition, air exposure of reaction also posed noticeable decrease of the final residual nitrate, whereas the reducing capacity of NZVI synthesized was elevated with lower NaBH_4 pumping rate.

INTRODUCTION

Zero-valent iron (ZVI) was common and often used as a remediation agent in contaminated groundwater. In early 1990s, it was applied first in permeable reactive barrier system [1-3]. ZVI has gained increasing attention for remediation process because of its being inexpensive and nontoxic [4]. ZVI can react to transform the mobile contaminants into immobile and less harmful species, which will be treated more easily [5]. There are two major mechanisms for aqueous contaminant removal by elemental iron, including (1) physicochemical adsorption and (2) oxidation and reduction reaction [6]. Contaminants removed by ZVI include halogenated hydrocarbons such as trichloroethylene, perchloroethylene, anions (e.g., NO_3^- , $\text{Cr}_2\text{O}_7^{2-}$), heavy metal, arsenic, and organic compound [7-11]. However, the problems associated with the use of micro-scale ZVI are that the reaction time required is in days, and a considerable amount of iron is needed

for complete removal of target compounds [10,12]. This serves to address the need of more efficient nanoscale ZVI (NZVI) synthesis development.

Currently, the NZVI has received widespread attention from field researchers for groundwater treatment because of its extremely small particle size, large surface area, high *in situ* reactivity, and high mobility in groundwater [13]. There were many techniques and methods for NZVI synthesis such as chemical method [7,14], sono-chemical method [15], and thermal decomposition [16]. The sono-chemical method will generate toxic by-product, CO, because this method uses $\text{Fe}(\text{CO})_5$ as a raw material [17]. As for the thermal decomposition method, the produced NZVI particles tend to aggregate, due to the loss of the stabilization ability caused by the disappearance of the initial reactant chemicals during the heating process [16].

Since the NZVI has high reactivity with oxygen and water, inappropriate conditions for synthesis may result in the decrease of reducing capacity of NZVI

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Indirect contact of bio-transformation of lepidocrocite: Role of electron transfer mediator

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Key Words: *Shewanella putrefaciens* CN32, bio-transformation, electron transfer mediator, 9,10-anthraquinone-2-carboxylic acid

ABSTRACT

The sole effect of 9,10-anthraquinone-2-carboxylic acid (AQC) on transformation of lepidocrocite was studied to investigate interaction mechanisms between an electron transfer mediator and an iron bearing soil mineral. Our experiment demonstrated that 0.2 μm -sized membrane filter controlled direct bacterial contact with lepidocrocite. The reduction of Fe(III) to Fe(II) of lepidocrocite through electron shuttling of AQC was 55 mM over 91 d. X-ray diffraction analysis confirmed that lepidocrocite was changed into carbonate green rust. Scanning electron microscope analysis indicated that hexagonal shaped particles of carbonate green rust were formed from rectangular shaped particles of lepidocrocite in 91 d. The results suggest that carbonate green rust can be formed from lepidocrocite by indirect contact of bio-transformation between AQC and lepidocrocite.

INTRODUCTION

Fe(III) respiration of microorganisms is a significant process to sustain iron redox cycling in terrestrial, freshwater and marine environments accompanying decomposition of organic sources and energy flux [1]. A wide range of microorganisms from hyperthermophilic archaea to proteobacteria undergo microbial Fe(III) respiration obtaining energy by consuming organic compounds and resulting in reduction of Fe(III) to Fe(II) on iron bearing soil minerals (IBSMs) [2]. Dissimilatory iron(III)-reducing bacteria (DIRB) have gained extensive attention due to coupling oxidation of carbon sources to reduction of electron deficient IBSMs such as goethite, hematite, and lepidocrocite [1,3]. Biogeochemical reaction induced by DIRB plays a significant role in Fe cycling, therefore, the verification of interactions between DIRB and IBSM has been extensively researched.

It has been reported that DIRB transform crystal structure of IBSMs through continuous Fe(III) reduction over time [4]. O'Loughlin et al. [3] showed that *Shewanella putrefaciens* CN32 could transform lepidocrocite to green rust, and Plymadle et al. [5] demonstrated that *Geobacter* could transform goethite

to magnetite. This bacterial transformation is called bio-transformation which has been intensively studied. Bio-transformation can be explained with two pathways, direct contact and indirect contact of bio-transformation [1]. An enzyme called Fe reductase is located on a surface of an outer membrane and inside of bacteria. This enzyme is capable of reducing Fe(III) to Fe(II) [6]. A nano-wire, a long and flagella-looking structure stemmed out of a membrane, can transfer electrons to Fe(II) [6]. Reduction of IBSM occurs on its surface through presence of electrons by DIRB, and Fe(III) on IBSM is subsequently reduced into Fe(II) (Fig. 1a). This electron donation from DIRB to IBSMs has been known as direct electron transfer via physical contact between DIRB and IBSMs [1]. On the other hand, an electron transfer mediators (ETMs) have enhanced the bioreduction of IBSMs via indirect electron transfer pathway. ETM receives electrons from DIRB as an intermediate step and ultimately transfers electrons from DIRB to IBSM (Fig. 1b). Transformation of IBSM conclusively takes place by reduction of Fe(III) on its surface. Several studies have examined the effects of various ETMs such as quinone groups [1], natural organic matters, oxyanions [3], and organic and inorganic ligands [7] on bio-transforma-

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Kinetic model for sulfate/hydroxyl radical oxidation of methylene blue in a thermally-activated persulfate system at various pH and temperatures

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Key Words: Sodium persulfate, chemical oxidation, groundwater, remediation

ABSTRACT

Sulfate and hydroxyl radicals ($\text{SO}_4^{\cdot-}$ and $\cdot\text{OH}$) can be generated in the thermally activated persulfate oxidation system depending upon pH conditions. The objective of this study was to derive a kinetic model for the reaction of $\text{SO}_4^{\cdot-}$ and $\cdot\text{OH}$ with a model compound, methylene blue (MB), and to determine the reaction rate constant, radical concentrations and activation energies under various temperatures (60, 70 and 80 °C) and pH levels (pH 3, 7, and 11). Experiments performed and data analyzed using the developed kinetic model exhibited second-order rate constants for the reaction of MB with the predominant $\text{SO}_4^{\cdot-}$ at pH 3 of 0.34×10^8 , 1.01×10^8 , and $2.20 \times 10^8 \text{ M}^{-1} \text{ s}^{-1}$ at 60, 70, and 80 °C, respectively. Average steady state concentrations of $\text{SO}_4^{\cdot-}$ and $\cdot\text{OH}$ were determined: $4.36 \times 10^{-6} \text{ M}$ for predominant $\text{SO}_4^{\cdot-}$ at acidic pH; 6.68×10^{-11} and $1.18 \times 10^{-10} \text{ M}$, respectively, for simultaneous presence of $\text{SO}_4^{\cdot-}$ and $\cdot\text{OH}$ at neutral pH; 2.68×10^{-12} and $1.15 \times 10^{-6} \text{ M}$, respectively, for $\text{SO}_4^{\cdot-}$ and $\cdot\text{OH}$ at basic pH. Furthermore, activation energies were determined over the temperature range 60-80 °C: 87, 109, and 90 kJ mol^{-1} at pH 3, 7, and 11, respectively. This study successfully derived a kinetic model which can be used in a thermally-activated persulfate oxidation system for treating different compounds.

INTRODUCTION

In situ chemical oxidation (ISCO) is a remediation technology that utilizes oxidants (e.g., permanganate (MnO_4^-), hydrogen peroxide (H_2O_2), persulfate ($\text{S}_2\text{O}_8^{2-}$), and ozone (O_3) [1-7]) to achieve destruction of contaminants. In recent years, sodium persulfate (SPS) has been an increasingly popular and effective ISCO reagent for treating subsurface contamination. However, although persulfate is a strong oxidant ($E^0 = 2.01 \text{ V}$), its oxidation reaction usually requires high activation energy [8] or additional catalytic assistance to initiate contaminant destruction. Hence, when persulfate is appropriately activated (e.g., using thermal activation), persulfate can decompose to produce sulfate radicals ($\text{SO}_4^{\cdot-}$) ($E^0 = 2.6 \text{ V}$), which rapidly react with most organic compounds with bimolecular reaction rate

constants in the range of 10^7 - $10^{10} \text{ M}^{-1} \text{ s}^{-1}$ [9,10].

Many studies have demonstrated the effectiveness of thermally-activated persulfate oxidation (Eq. 1, presented in Table 1) of organic contaminants such as methyl *tert*-butyl ether (MTBE) [11], trichloroethylene (TCE) and 1,1,1-trichloroethane (TCA) [8,12], polycyclic aromatic hydrocarbons [13], 59 mixed volatile organic compounds [14], benzene, toluene, ethylbenzene and xylene [6], perfluorooctanoic acids [15], polyvinyl alcohol [16], and Orange G [17], etc. Moreover, Liang and Su [18] researched active radical species in a thermally activated persulfate oxidation process under various pH conditions using a chemical probe method, which employed three chemical probe compounds including *tert*-butyl alcohol, nitrobenzene, and phenol. Their results revealed that $\text{SO}_4^{\cdot-}$ is the predominant oxidant radical at $\text{pH} < 7$; both $\text{SO}_4^{\cdot-}$ and

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Adsorption kinetics and isotherms for the removal methyl orange from wastewaters using copper oxide catalyst prepared by the waste printed circuit boards

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Key Words: Adsorption, methyl orange, copper oxide, waste printed circuit boards

ABSTRACT

The adsorption of methyl orange (MO) onto copper oxide (CuO) catalyst prepared by waste printed circuit boards from an aqueous solution by the batch adsorption technique was investigated at temperature 30 to 60 °C. The results showed that the adsorption capacity increases with increasing MO concentration and temperature but decreases with adsorbent dosage. In order to investigate the adsorption mechanisms, three simplified kinetic models, i.e., the pseudo-first-order, second-order kinetic models and intraparticle diffusion model were used to describe the kinetic data. The rate constants of intraparticle diffusion, the pseudo-second-order and pseudo-first-order reactions were compared; both Freundlich and Langmuir models were evaluated. The experimental data obtained with CuO fits best to the Langmuir isotherm model. It was found that the pseudo-second-order adsorption mechanism is predominant and the overall rate of the CuO adsorption process appears to be controlled by more than one step, namely both the external mass transfer and intraparticle diffusion mechanisms. The results indicate that CuO adsorbs MO efficiently and could be utilized as an alternative adsorbent for the removal of anionic dyes in wastewater treatment.

INTRODUCTION

A printed circuit board (PCB) is used to mechanically support and electrically connect electronic components using conductive traces etched from copper foils laminated onto an insulating polymeric substrate. Due to high demand from the electronic industry, PCBs are produced massively. However, the waste PCBs yield heavy metals and organic components which are harmful to the environment. In order to solve the pollution caused by the PCB wastes, considerable efforts have been devoted to develop recycling approaches to reuse the valuable components. If the waste PCBs are improperly disposed, hazardous materials could cause serious environmental problems and numerous valuable metals would be lost. Therefore, recovery of

valuable metals from waste PCBs is one of hot topics in industrial waste reclamation [1].

Many separation and recycling techniques for Cu in waste PCBs have been developed, such as pyrometallurgical [2], hydrometallurgical [3], bioleaching technology [4] and mechanical process [5]. Recently, to obtain high purity Cu products from waste PCBs, many researchers [6-8] proposed some new process such as leaching-electrowinning [6], mechanical-electrometallurgy [7] and vacuum metallurgy technology [8]. For example, Chien et al. [9] reported that supercritical water oxidation (SCWO) method can be used for simultaneously effectively removing brominated flame retardant Br species and oxidize metals in waste PCBs. On the other hand, electrokinetic processes (EK) have been widely used for metal recovery

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NO_x formation from the radiant tube burner in a continuous annealing line

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Key Words: Radiant tube burner, off-stoichiometric combustion, NO_x emission, continuous annealing furnace

ABSTRACT

Due to its simplicity and high productivity, continuous annealing lines (CAL) has been widely adopted as a method to anneal cold rolled steel strip. The China Steel Corporation (CSC) introduced CAL to its cold rolling mill in the 1980s to treat its cold rolled steel strip in order to take advantage of its high throughput benefits. In a CAL, steel strip is heated by a series of radiant tube (RT) burners which use fossil fuel gas (coke oven gas in the case of CSC). After some years of operation, the concentration of NO_x emitted from a CAL is sometimes up to the limit of the Taiwanese Environmental Protection Administration emission standards. To solve this problem, a series of tests have been conducted in CSC to investigate the influence of burner operating parameters on NO_x emissions. The investigated operating parameters include off-stoichiometric combustion, air/fuel ratio (Φ_T), primary air distribution (Φ_1), and secondary air swirl number (Sg).

Based on the results of a number of experiments, it has become apparent that NO_x concentration increases with burner load, that the initial left eccentric combustion has lower NO_x emissions than the bottom eccentric flame, that NO_x formation is quite low in the fuel-rich combustion region until the Φ_T reaches nearly 0.8, and that Φ_1 and Sg have lower and greater effects on the NO_x concentration for the left eccentric combustion, respectively. The suggested low NO_x operating parameters for the left and bottom eccentric combustion are $\Phi_1 = 0.54$ & Sg = 0.0 and $\Phi_1 = 0.35$ & Sg = 0.56, respectively. Regarding the temperature of the RT outer surface, the bottom eccentric flame has better temperature uniformity, even if it has a higher NO_x emission concentration, and the left eccentric flame has worse temperature uniformity due to its proximity to the RT, as well as to the production of a higher localized temperature.

INTRODUCTION

There are two main methods used for annealing

cold rolled mill steel strip, namely batch annealing (BA) and continuous annealing lines (CAL), and research has been carried out into parameter opti-

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Surface characteristics of particulate matter collected from industrial sources

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Key Words: Airborne particulate matter, surface characteristics, industrial sources

ABSTRACT

This study investigates surface characteristics of airborne particulate matter (PM) sampled from air pollution control devices of a number of industrial operations. The PM sources selected for this study comprise the following operations or processes: a coke oven, iron ore sintering furnace, blast furnace, and basic oxygen furnace from an integrated steelmaking plant; electric arc furnaces of two secondary steelmaking plants; a municipal solids waste incinerator; two oil-fired boilers; and a coal-fired power plant boiler. The collected PM samples were analyzed using a scanning electronic microscope and energy-dispersive X-ray spectroscope to determine their chemical composition and surface characteristics. Results for each PM sample regarding size, surface characteristics, and chemical compositions can be used to trace the related emission sources.

INTRODUCTION

Airborne particulates (particulate matter, PM) can be divided into two main categories, namely, naturally occurring and anthropogenic. Naturally produced PM include volcanic ash from volcanic explosions, smoke from forest fires, salt spray, soil particulates, and biological particulates, such as bacteria, pollen, spores, and insects. The primary sources of anthropogenic PM are industrial manufacturing processes, burning fuel, fly ash from chimneys and flue pipes, smoke from metal smelting, and soot emitted from vehicles. After PM are emitted, their small size and light weight allows them to be carried away. When PM is suspended in the atmosphere, the influences of various environmental factors can alter their physical and chemical characteristics.

PM in the atmosphere is among the primary air pollutants, and their sources are factories, vehicles, construction fields, vehicle exhaust dust, and aerosols derived from photochemical reactions. Numerous sources of environmental PM exist. Thus, the ability to rapidly determine the particulate type and source to adjust the controls and develop policies is an important issue for air quality management.

PM emitted by industrial processes (such as inte-

grated steelmaking, secondary iron and steel smelting, urban waste incineration, coal-fired power generation, oil-fired power generation, and oil-fired boilers) relate to the raw materials and physiochemical generation mechanisms, which provide PM with varied surface characteristics. This study primarily examines the surface characteristics and chemical composition of various particulate sources to construct a pollutant fingerprint database for tracing the sources of emissions.

To prevent occupational injuries, Mazumder [1] examined particulates emitted during the production of medium density fiberboards (MDFs) from urea formaldehyde resin. The results showed that most of the MDF particulates were smaller than 50 μm , with 10 to 15% smaller than 10 μm (PM_{10}). The median PM size was 6.5 μm . Using X-ray diffraction (XRD) and a scanning electron microscope (SEM), Abielaala et al. [2] found that fly ash from the incineration of waste of infectious risk cares contained Cu, Zn, Pd, Cd, and other trace elements.

Observing field emission SEM (FE-SEM) or transmission electron microscope (TEM) photographs, Lin et al. [3] identified pellet-like or irregularly shaped anatase-typed TiO_2 crystalline nanoparticles, approximately 30 to 40 nm in diameter. From FE-SEM

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Photocatalytic reduction of gaseous and solution CO₂ to energy products using Ag/TiO₂ and Cu/TiO₂ in CuCl₂ solution

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Key Words: Carbon dioxide, photocatalyst, reduction, Ag/TiO₂, Cu/TiO₂

ABSTRACT

This study investigates the surface modification of photocatalysts and the photoreduction of CO₂ to convert to useful fuels or chemicals under ultraviolet (UV) illumination. The photocatalysts used in this study are Ag/TiO₂ and Cu/TiO₂ made by the impregnation method, and the wavelength of UV irradiation is 254 nm. An X-ray single crystal diffractometer, scanning electron microscope, energy dispersive spectrometer, X-ray photoelectron spectroscopy or Electron Spectroscopy for Chemical Analysis and BET surface measurement devices are used for the characterization of Cu/TiO₂ and Ag/TiO₂. These analyses prove that the elements of Ag and Cu are all in the form of a zero charge, such as Ag⁰ and Cu⁰. The photocatalytic reductions of CO₂ are performed for three different cases. The major product in the Na₂CO₃ solution with the photocatalysts is methanol, and the gas product is methane with the yield 125 μg g⁻¹ at 1 M CuCl₂ and 0.1 M Na₂CO₃. For the reaction mechanism, CO₂ is assumed to be adsorbed on the surface of the photocatalysts and combines with the electron which is excited from the photocatalytic reaction via the forming of $\cdot\text{CO}_2^-$. After the forming of $\cdot\text{CO}_2^-$, the intermediates of $\cdot\text{CO}^+$ and OH⁻ produce the products of CH₃OH and CH₄. The results obtained from this study contribute to a better understanding of the UV/photocatalytic process for the reduction of CO₂. The technology for the reduction of CO₂ to useful fuels and chemicals as elucidated in this study is also environmentally beneficial.

INTRODUCTION

Greenhouse gases, such as CO₂, CH₄, and chlorofluorocarbons are the primary causes of global warming. The chemical conversion of CO₂ to fuels or chemicals is a challenging subject in connection with the mitigation of the greenhouse effect and the recovery of carbon resources after the exhaustion of fossil materials [1]. In the conversion of CO₂, some

factors are of significance, including a low energy requirement in the reaction, a high reaction rate, and high yields of valuable products. The use of fossil fuels to provide the required energy is not promising because the secondary generation of CO₂ from fossil fuel is another pollution factor. The advantage of the photoreduction of CO₂ is the use of inexhaustible solar energy. Plants can use solar energy to perform natural photosynthesis, but the rate of transformation is low.

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Soybean oil for biodiesel production assisted by a microwave system and sodium methoxide catalyst

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Key Words: Soy bean oil, microwave, sodium methoxide, yield, transesterification

ABSTRACT

Because of the high availability of the soybean oil, the soy-biodiesel has become the major alternative fuel in the world. Although there has been a lot of research into improving the yields of biodiesel and into the use of microwave heating systems for improving the yield of biodiesel, the topic of increasing the yields of soybean biodiesel using a microwave heating system and sodium methoxide, CH_3ONa has seldom been addressed. Experimental results indicate that the 0.75 wt% NaOH and 0.75 wt% (CH_3ONa) catalysts had better yields. The yields of soybean biodiesel produced with CH_3ONa catalyst are higher than those produced with NaOH catalyst. An increase in the reaction time from 1 to 3 min significantly increases the yield of soybean biodiesel, which decreases with a further increase to 6 min. A methanol-to-oil molar ratio of 6 is suitable for the synthesis of soybean biodiesel. The yields of soybean biodiesel increase with increasing microwave power. However, the microwave output must not be too high as it may damage the organic molecules. The best yield of soybean biodiesel was 99% under following reaction conditions: 0.75 wt% CH_3ONa catalyst, a methanol-to-oil molar ratio of 6, a reaction time of 3 min, and a microwave power of 750 W.

INTRODUCTION

Diesel-powered engines are used worldwide in heavy-duty buses, trucks, construction machines and generators. However, emissions of smoke, particulate matter, sulfur oxide (SO_x), polycyclic aromatic hydrocarbons (PAHs) and exhaust odor from the exhaust of a heavy duty diesel engines have always been a concern for the public and environmental researchers. Mobile sources are the major contributor in urban and suburban environments [1-4]. The development of biodiesel is being driven by the need to reduce emissions from diesel engines without modifying them. Biodiesel can be produced from animal fats or vegetable oils with methanol or ethanol as the catalyst via a transesterification reaction. Biodiesel used as alternative fuel can reduce emissions of hydrocarbons, CO, SO_2 , PAHs, and polychlorinated dibenzo-p-dioxin/dibenzofurans [5-11]. However, the major obstacle to biodiesel commercialization is its high cost, which is approximately 1.5 times higher than that of petroleum

diesel fuel [12,13]. Therefore, we need to increase biodiesel yield and reduce biodiesel cost.

One of the best ways to reduce the cost of biodiesel is to decrease reaction time of transesterification and to increase biodiesel yields. Reaction temperature, reaction time, catalyst amount, and the alcohol-to-oil ratio are important parameters in biodiesel production. Catalytic reactions can use alkali catalysts, acid catalysts, or enzymatic transesterification to achieve the best results. Biodiesel can be produced at a lower temperature and shorter reaction time with an alkali catalyst compared to those required for an acid catalyst [14-17]. The conventional heating of a sample has a few significant drawbacks, such as heterogenic heating of the surface, limitations dependent on the thermal conductivity of materials, specific heat, and density when compared to microwave irradiation [18,19], and thus many research groups have recently focused on the latter approach.

Previous studies have indicated that microwave-assisted chemical reactions are better than those

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Simulation of a long narrow type constructed wetland using the stream model QUAL2K

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Key Words: Constructed wetland, QUAL2K model, biochemical oxygen demand (BOD), dissolved oxygen (DO)

ABSTRACT

Using a long narrow type wetland constructed along a seriously polluted creek for remediating the polluted creek water and treating it in the wetland has been reported in a previous paper. In this study, the plug-flow type constructed wetland is simulated using QUAL2K to develop a practical model for managing the water renovation system. The simulation results using influent flow rates varying from 20,000 to 50,000 m³ d⁻¹ indicate that even at 50,000 m³ d⁻¹, the wetland achieves 81-82% biochemical oxygen demand (BOD) removal with 0.2-0.5% dissolved oxygen (DO) consumption. On-site field data collected for the wetland system operated at flow rates between 20,000 and 50,000 m³ d⁻¹ show 72-84% of average BOD removal that is close to the QUAL2K simulated result. However, the simulated DO shows an initial rising and then decreasing trend; this is contradictory to the observed decreasing DO through the wetland system. In QUAL2K calculations, DO is related to k_1 (BOD reaction rate constant), k_2 (re-aeration rate constant) and BOD whereas BOD is related to k_1 . Hence, the complicated relationships among the various water quality parameters lead to DO simulation results not conforming to field data. The simulated results are conservative because all DO and BOD data of the samples collected at different locations of the wetland system are lower than the simulated values. Therefore, QUAL2K is considered an appropriate model for evaluating the efficiency of the long and narrow constructed wetland as a natural stream.

INTRODUCTION

The constructed wetland that mimics a natural wetland as an alternative to traditional secondary and tertiary wastewater treatment systems is an efficient and cost-effective emerging technology [1-4]. In addition to abating pollution, the constructed wetland also achieves other functions such as enhancing the natural ecological system, beautifying the environment, creating reusable water resources, and alleviating flood [5-7]. If the surrounding region has a natural wetland or agricultural field, the constructed wetland complements the ecological renovation and provide agricul-

tural irrigation water [8,9]. Additionally, the constructed wetland is less influenced by the geometric condition than conventional wastewater treatment systems [10]; it may be designed and built according to the geographic condition and location of the proposed construction site. Further, the operation of a constructed wetland does not require power for aerating, mixing and pressurizing nor need additions of chemicals and artificial media [11,12].

In a previous project, a plug-flow type constructed wetland that is long and narrow was proposed for renovating a seriously polluted creek. Instead of a pond-shaped body, the plug-flow type wetland that

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Technical Note**Economical analysis and performance evaluation for municipal wastewater treatment by an aerobic biofilm reactor using recycle materials as the contact media****Chihhao Fan,^{1,*} Wen-Ching Wang² and Shao-Tsai Cheng³**¹Graduate Institute of Environmental and Resource Engineering
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Hsinchu County 30012, Taiwan**Key Words:** Municipal wastewater, biofilm, recycle materials, wastewater treatment**ABSTRACT**

This study aimed to evaluate the contaminant removal from municipal wastewater by an aerobic biofilm system using recycle materials as the contact media. A pilot-scale biofilm system consisting of 5 channels was constructed using (1) natural gravels (size ranging between 5 and 10 cm), (2) glass bottles, (3) PET bottles, (4) construction and demolition waste (C&D waste), and (5) oyster shells as the contact media. The municipal wastewater used was collected from a drainage channel and directed into the system. The contaminant removal efficiencies at the retention times of 4, 6 and 8 h were investigated. The results showed that the increase in system retention time caused a slight removal improvement of suspended solids (SS), biological oxygen demand (BOD) and ammonium in general. Increase in aeration rate substantially enhanced the DO concentration, but no obvious improvement on contaminant removal was observed, implying that DO level was not the limiting factor for contaminant removal in the investigated system. The use of C&D waste demonstrated a better capability of removing SS, BOD and NH₃ from municipal wastewater among the tested materials. By considering a 20-yr life span of a biofilm system, using recycling materials as the contact media might reduce the average unit treatment cost for municipal wastewater from 1.5 to 1.2 NTD t⁻¹ compared to that using gravels as the contact media.

INTRODUCTION

Aquatic environment conservation is an important task for sustainable development, and much effort has been expended to ensure the quality of natural water bodies [1-7]. Meanwhile, many wastewater treatment technologies have been developed and applied to preserving the water environment [8-13]. Among the potential threats to the aquatic environment, municipal wastewater, a mixture of domestic sewage and surface runoff, was a significant pollution source, especially for the highly populated areas. Without proper treatment, the discharge of municipal wastewater may

significantly damage the aquatic environment and ecology. Also, the contaminants in the municipal wastewater may be an active spreading agent for many waterborne diseases [14,15].

Generally, the sewer system construction is considered as the most effective measure to prevent the aquatic environment from municipal wastewater contamination. Nevertheless, high costs for capital and operational investment become a financial constraint on expanding sewer system coverage. This constraint may be an even huge obstacle for the low-income, under-developed or developing countries [16]. To mitigate the aquatic pollution by municipal wastewater

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Short review: Current trends and future challenges in the application of sono-Fenton oxidation for wastewater treatment

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Key Words: Hydroxyl radicals, intermediate, mineralization, sono-Fenton oxidation, ultrasound

ABSTRACT

Currently, ultrasonic process has been widely used for research purposes, mostly in synthetic solutions spiked with one or several contaminants. Practical application of the ultrasonic process for wastewater treatment is often limited by its low mineralization efficiency on the target compound, formation of intermediate product(s), setup cost(s), and noise in operation. However, the combination of ultrasound and Fenton reagent, i.e., sono-Fenton oxidation, has great potential for rapid destruction of refractory organics in a short span of time through the mechanisms of thermal destruction and removal of free hydroxyl radicals. This review addresses the theory and the effects of operational parameters involved in sono-Fenton oxidation on various target pollutants. Finally, challenges in the application of sono-Fenton oxidation for wastewater treatment are critically assessed for future research.

INTRODUCTION

Theoretically, advanced oxidation processes (AOPs) are known to generate highly reactive and non-selective hydroxyl radicals ($\cdot\text{OH}$), which are able to oxidize almost all toxic organic compounds and non-biodegradable pollutants. Among the $\cdot\text{OH}$ producing AOPs, ultrasound is a novel method in which water molecules undergo molecular fragmentation and releases $\cdot\text{OH}$ owing to high-frequency acoustic cavitation. In the past several years, ultrasound has been utilized extensively for the removal/degradation of organic pollutants from water/wastewater [1-8]. The major disadvantage of water sonolysis is the insufficient generation of $\cdot\text{OH}$. Thus, ultrasound is often supplemented with other oxidants such as H_2O_2 , O_2 and various AOPs for developing advanced hybrid techniques to increase the pollutant degradation efficiency and also to decrease treatment time [9,10].

Several sonolysis studies conducted with chemicals addition such as Fenton's reagent with three states of iron (i.e., Fe^0 , Fe^{2+} and Fe^{3+}) have proven the improvement of pollutant degradation [10-14]. Although the efficacies of these hybrid techniques are significantly greater, their fundamental concepts and reaction

mechanisms still need to be researched. Furthermore, coupling of hydrodynamic cavitation in conjunction with the Fenton process is an effective method for the continuous remediation of aqueous organic compounds and non-biodegradable pollutants. Therefore, a proper understanding of sono-Fenton process, i.e., theory, optimal operating conditions, and future research challenges, will definitely improve its real-time application for the treatment of wastewaters or effluent containing organic pollutants.

THEORY OF SONO-FENTON OXIDATION

Sono-Fenton oxidation generates two mechanisms to degrade organic compounds: (1) reaction with $\cdot\text{OH}$ and (2) thermal cleavage. During sonication, extremely high temperature and pressure are generated with the collapse of the cavitation bubbles, which causes the rupture of O-H bond and results in the formation of $\cdot\text{OH}$ (Eq. 1), where $[\text{U}]$ denotes the ultrasound. The effects of sonolysis arise mainly from acoustic cavitation, namely the formation, growth, and implosive collapse of bubbles in a liquid, which produces unusual chemical and physical environments. The collapse of bubbles generates localized "hot spots" with transient

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Reclaiming municipal wastewater by submerged and side-stream ultrafiltration in parallel: A comparison of system performance, production quality, and cost

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Key Words: Futian Wastewater Treatment Plant, effluent reclamation, submerged membrane bioreactor, side-stream ultrafiltration, production quality, sludge reduction

ABSTRACT

Water scarcity has become a critical issue in central Taiwan as it influences the industrial development in that region. To evaluate the feasibility of reclaiming municipal wastewater for supplying the general industrial purpose, a pilot plant was installed in Futian Wastewater Treatment Plant in Taichung City. The results will be the basis for the future construction to upgrade the wastewater treatment plant as a water reuse center.

The pilot included two processes in parallel: (1) sand filter with side-stream ultrafiltration taking the effluent as the inlet ("SF-UF" in brief), while the effluent is discharged from the Futian Wastewater Treatment Plant using activated sludge process and clarifier; (2) submerged membrane bioreactor taking the supernatant of primary clarifier in the wastewater treatment plant as the inlet ("MBR" in brief).

In this study, we have conducted a comprehensive investigation on production quality of the two processes. The results revealed that the production of MBR has almost the same quality as that of the "SF-UF" process, including the total organic carbon (TOC), bacteria, nitrogen, and phosphorus. In both cases, TOC could be less than 2 mg L^{-1} , and $\text{NH}_3\text{-N}$ was lower than 0.5 mg L^{-1} . This level is suitable for the make-up water of the recirculation cooling system of many industries. The turbidity and silt density index of the production of the two processes were also acceptable for the influent of reverse osmosis, if further desalination is required.

When integrating the wastewater treatment plant and the subsequent effluent reclamation into one plant, the aforementioned two processes had their own advantages and disadvantages in the aspects of footprint, power consumption, chemicals usage, and cost. While setting the sludge retention time to 60 d, the system using MBR to reclaim municipal wastewater produced wasted sludge 40% less than the traditional wastewater treatment plant. On the other hand, the power and chemical consumptions were much higher in the case of MBR than those of SF-UF. In general, MBR system requires at least 10% more chemicals during the backwash and the cleaning-in-place than that of the side-stream UF. The power consumption was 5% higher in the MBR case due to the strong aeration required to maintain sufficient dissolved oxygen for the microbial system and prevent membrane fouling. Considering all the factors including the sludge disposal, the cost of treating wastewater and then reuse by UF is USD 0.6 m^{-3} for the SF-UF process, and USD 0.7 m^{-3} for the MBR process.

INTRODUCTION

In the recent decades, the water consumption in

Taiwan has gradually increased due to population growth, urbanization, and development of industries. However, the establishment of reservoirs and ground-

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Isolation of HAA degrading bacteria from drinking water using complex media

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Key Words: Haloacetic acid, biodegradation, drinking water, microbial cultivation

ABSTRACT

This study used alternative microbial cultivation methods other than enrichment cultures to explore haloacetic acid (HAA) degrading bacteria from both biofilm and free-floating bacteria in drinking water. Instead of enrichment culture with high HAA concentration, biofilm from the rapid sand surface and suspended cells in finished water were directly plated on three different media (Reasoner's 2A, nutrient agar, and Lysogeny broth agar). After bacterial purification, HAA biodegradability and degradation kinetics were investigated from each of the isolates. Thirty-four strains of bacteria were retrieved and 13 of them were successfully identified as HAA degraders. *Porphyrobacter* sp., *Sinorhizobium* sp., and *Aquabacterium* sp. showed higher monochloroacetic acid (MCAA) degrading rates (2.46-2.91 $\mu\text{g mg}^{-1}$ protein h^{-1}) among other isolated strains. In addition, *Porphyrobacter* sp. and *Aquabacterium* sp. also expressed higher dichloroacetic acid (DCAA) degrading rates (1.44 and 1.0 $\mu\text{g mg}^{-1}$ protein h^{-1}). For isolates with both MCAA and DCAA biodegradability, HAA degradation by bacterial isolates occurs in succession rather than in simultaneity. These results could provide a better understanding on HAA degrading bacteria in drinking water systems.

INTRODUCTION

Haloacetic acids (HAA) are a major group of disinfection by-products (DBP) commonly found in chlorinated water. The total concentration of five species HAA (HAA5) - monochloroacetic acid (MCAA), dichloroacetic acid (DCAA), trichloroacetic acid (TCAA), monobromoacetic acid, dibromoacetic acid - are regulated with 0.06 mg L^{-1} as the maximum contaminant limit under the United States National Primary Drinking Water Regulations [1]. Among them, chlorinated HAA such as MCAA, DCAA and TCAA are the most commonly observed HAA species in finished water. These non-volatile (boiling point = 189-250 $^{\circ}\text{C}$), highly hydrophilic and ionic HAAs cannot be removed effectively by conventional treatment processes. HAAs account for 20 and 30% of total detectable DBPs by weight within drinking water systems in Korea and Utah (USA) water treatment plants, respectively [2,3]. In Taiwan, the HAA5 concentrations ranged from 0.2-46.7 $\mu\text{g L}^{-1}$ in the distribu-

tion systems [4].

A small number of studies have investigated the HAA degradation in surface water treatment plants and drinking water systems, and have reported that biodegradation is an important mechanism of HAA loss [5-10]. Microbial cultivation is one of the methods to investigate the role, function and physical characteristics of bacteria in the environment. Enrichment culture has been commonly applied to isolate individual bacterium capable of metabolizing specific organics. Recent studies aimed to characterize the HAA-degrading bacteria in granular activated carbon (GAC) or tap waters have successfully isolated several bacteria strains. By enrichment cultures, HAA degradation ability was observed from various bacterial isolates such as *Burkholderia* sp., *Herminiimonas* sp., *Methylobacterium* sp. and *Afipia* sp. [8-11] However, the biofilm or free-floating bacteria existing in the drinking water distribution systems are commonly living a low-nutrient oligotrophic condition where the bioassimilable organic carbon are typically at low

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Abatement of gaseous VOCs using activated sludge systems: Technology feasibility and cost analysis

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Key Words: Volatile organic compounds (VOCs), emission, wastewater treatment plant (WWTP), VOC tax, Water 9

ABSTRACT

This study assessed the air exhaustion control of corrugated plate interceptor (CPI) oil separators in a refinery wastewater treatment plant for biodegradation of volatile organic compounds (VOCs) by deep activated sludge aeration systems. Three approaches were used to derive VOC emission factors: (a) Calculating using the aeration rate and VOC gas-liquid equilibrium concentration (C_g^*), (b) Simulation using the Water 9 model, and (c) VOC mass balance calculation. Based on field sampling and laboratory analysis, lipophilic alkanes (900-1,200 ppm as total hydrocarbons (THCs)) were removed by the activated sludge system and only 0.40-0.60 ppm THC VOCs were emitted, and VOC emission factors were 0.055-0.548 g m⁻³ wastewater using the different calculation approaches. We recommended using the C_g^* and installed air aeration rates as more effective accurate method for simulating VOC emissions rates than examining individual aqueous VOC concentrations for Water 9 model simulation. In comparing with the capital costs of reconstructing pipelines from CPI oil separators to the activated sludge system as well as those of sampling and analysis, to pay legal VOC taxes, the former demonstrates its economic efficacy of reducing the amount of VOC exhausts.

INTRODUCTION

Waste is a cost of industrial production. Many polluters, including sources of volatile organic compound (VOC) emissions, must now pay for their pollution [1]. Imposing pollution taxes may eventually reduce pollution. Among all pollution taxes, the gasoline tax and carbon dioxide tax are two useful tools because those can induce drivers to alter their behaviors and reduce carbon dioxide emissions, respectively [2,3].

France started charging for VOC emitted into the atmosphere in 1985; this was Europe's first VOC tax [4]. However, paying a tax based on real emission rates is problematic, as one cannot monitor all emissions at their sources [5]. Instead, governments impose pollution taxes at different rates for specific industries according to the characteristics of particular manufacturing and their pollution controlling processes.

Taiwan Environmental Protection Administration (TEPA) began imposing an air pollution tax on VOC emissions from stationary sources in 2007. As the imposed emission factors values are uniform and not practically suitable for each emission source; governmental estimated VOC emission rates generally exceed actual rates of recovery systems for skimmed oil from wastewater, or devices controlling VOC emissions. Thus, owners of facilities emitting VOCs can adopt alternative VOC emission rates; however, these rates must be approved by the TEPA as field VOC emission rates. In June 2009, TEPA revised its procedures for determining the VOC emission tax rates. Application and examination of alternative VOC emission factors are divided into two stages. First, a polluter must submit a proposal that lists the procedures for obtaining alternative VOC emission factors. VOC emission rates must be calculated using the aeration rates of aerators, or simulated by the model. Once the

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An assessment of influence of meteorological factors on PM₁₀ and NO₂ at selected stations in Malaysia

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Key Words: Air pollution, nitrogen dioxide, particulate matter, meteorological parameters, regression analysis

ABSTRACT

This study aims to determine the influence of meteorological parameters (ambient temperature, relative humidity and wind speed) based on a daily average computation of air pollutants PM₁₀ and NO₂ at three selected stations in Malaysia, namely Shah Alam and Johor Bahru on the Peninsular Malaysia, and Kuching on the island of Borneo. A three-year (2007-2009) database was statistically analysed using the Pearson Correlation and Multiple Linear Regression methods. The results obtained through these analyses show that at all the three stations, NO₂ has a reverse relationship with wind speed, while PM₁₀ has a negative relationship with relative humidity and wind speed, but a positive relationship with ambient temperature. The statistical model of NO₂ and PM₁₀ including meteorological parameters highlights that among the three stations, Shah Alam Station which is located near to Kuala Lumpur city centre, is most influenced by meteorological parameters. The coefficients of determination, R² for Shah Alam station model on NO₂ and PM₁₀ are 0.301 and 0.293 respectively. The results from this study could provide some useful input for Malaysian air quality management with respect to an ongoing plan to deal with increasing trend of PM₁₀ and NO₂ in the ambient air.

INTRODUCTION

In recent years, the deterioration of air quality in urban areas has been caused by continuous industrial and commercial development, population growth and an increase in energy consumption [1,2]. Among different environmental pollution problems, air pollution is reported to cause the greatest damage to health and loss of welfare as a result of environmental issues in Asian countries [3]. The concentration of air pollutants varies depending on meteorological factors, the source of pollutants and the local topography. However, of

these three factors, the one which most strongly influences variations in the ambient concentration of air pollutants is that of meteorological factors [4]. Meteorological factors experience complex interactions between various processes such as emissions, transport and chemical transformation, as well as wet and dry depositions [5,6]. In addition, the spatial and temporal behaviour of wind fields are characterized by the high coarseness of the surface and differences in thermal conditions [7,8]. These in turn have a further effect on the dispersion of pollutants [9]. A study by Bhaskar and Mehta [10] states that meteorology plays a crucial

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Particles size distribution of aerosols and associated metals, and source estimation in Delhi, India

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Key Words: PM_{2.5}, PM₁₀, PM_{>10}, metals, size distribution, source apportionment

ABSTRACT

Human exposure to particulate matter (PM) was determined in Urban Environment of Delhi, India. Samples were collected using eight stages impactor (Marple Cascade Impactor) at five sites during August to October 2011. Three samples were collected from each site; samples were analyzed in eight size ranges gravimetrically and chemically (for metals). Maximum (985 $\mu\text{g m}^{-3}$) exposure to PM was in Okhala an industrial site and minimum (404 $\mu\text{g m}^{-3}$) in Jawaharlal Nehru University, an educational Institute. The human exposure to metals (Cu, Cd, Mn, Pb, Ni, Co, Ca, Mg, K, Fe) at five locations (viz Okhala, Jawaharlal Nehru University, Dhaula Kuan, Hauz Khas and Kaushambi) was considered. It was observed that human exposure was mostly dominated by K, Ca, Mg, Fe and least dominated by Cd, Cu and Co. This study also observed that, Okhala was most polluted area and Jawaharlal Nehru University (forest area, out of industrial and commercial hub) was the least. A significant regression between coarse and super coarse size fraction of total suspended particulate matter was observed. It was also observed that very good correlation exists among 8 metals. Source apportionment was done by principle component Analysis (PCA) of SPSS. Source apportionment by PCA reveals that there are three major sources (crustal re-suspension, industries and trans-boundary movement). Result obtained by PCA shows the dominance of crustal re-suspension.

INTRODUCTION

Air pollution in Asian cities is closely tied to levels and trends in economic and social development. Besides, rapidly increasing industrialization, urbanization, population growth and demand for transportation along with meteorological conditions influence air pollution in many Indian cities especially Delhi. Air pollution is widespread in urban areas wherein vehicles are the major contributors and in a few other areas with a high concentration of industries and thermal power plants [1-5]. Vehicular emissions are of particular concern since these are ground level sources and thus have the maximum impact on the general population. Also, vehicles contribute significantly to the total air pollution load in many urban areas. An estimated 3000 t of air pollutants are pumped into the atmosphere every day in Delhi. Vehicular sources contribute about

63% of the total pollutants, followed by industries and thermal power plants (29%) and the rest (8%) from the domestic sector [6]. Air pollution is recognized as a major threat to human health. The World Health Organization has estimated that urban air pollution is responsible for approximately 800,000 deaths and 4.6 million lost life-years each year around the globe [7]. The burden of ill-health is not equally distributed as approximately two-thirds of the deaths and lost life-years occur in developing countries of Asia. The US Environmental Protection Agency has defined four terms for categorizing particles of different sizes: ultrafine < 0.1 μm , fine: 0.1 to 2.5 μm , coarse: 2.5 to 10 μm and supercoarse > 10 μm [8]. It is now well recognized that particulate matter (PM) with aerodynamic diameter of less than 10 μm (PM₁₀) and less than 2.5 μm (PM_{2.5}) are the primary mediators of toxicity in the lungs and the airways, while fine (PM_{2.5}) and

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Damage to a plant caused by construction-induced settlement

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Key Words: Geotechnical engineering, settlement, landfill, hazards

ABSTRACT

This study presents a case study regarding the damage to the Laboratory Waste Treatment Plant caused by construction-induced ground settlement. This plant is located in the Annan Campus of National Cheng Kung University in Tainan, Taiwan. The purpose of the plant is to treat the wastes produced by laboratories of universities and high schools in Taiwan. After the construction of this plant, the differential settlement of ground and slab around this plant was observed in 2006. A number of cracks can be found on the surface of ground slab. In addition, the tanks for storage of medicament and wastes tilt due to the differential settlement of slab. The facilities of this plant may be damaged and the leakage of hazardous waste may be triggered if no measures are given to deal with the settlement problem. This study investigates the settlement problem encountered in this plant and presents a procedure to effectively treat settlement-induced damage for preventing the probable hazards.

INTRODUCTION

Construction-induced ground settlement has received great attention due to damaged structures and buildings adjacent to the construction site caused by induced settlement. Although technologies and analytical methods for construction have been significantly improved or developed over the past decades, building damage incidents caused by construction-induced ground settlement are still reported occasionally. The factors causing the building damage are complicated. It would be desirable to learn the lessons through studying case histories, in which the detailed construction information and damage condition are available.

This paper investigates a forensic case regarding the damage to a laboratory waste treatment plant caused by construction-induced ground settlement. In this case, the laboratory waste treatment plant was constructed by the National Cheng Kung University based on a 10-yr project funded by the Ministry of Education, Taiwan. After completing the construction

of this plant, the considerable ground settlement was gradually observed and would potentially cause the damage to the treatment facilities. The owner of this plant (National Cheng Kung University) and the contractor have frequently negotiated to resolve this problem according to the contract of construction, but a conflict between two parties still exists. In this regard, it is necessary to conduct the complete site investigation and evaluate the damage potential of treatment facilities for discussing the subsequent means and process of settlement treatment.

A series of site and damage investigations have been conducted and measures for treating the settlement-induced problem proposed. This study first conducted the site investigation, including stratigraphy, damage evaluation, and structure safety analysis. The original design was reviewed as well as a series of consolidation tests were conducted for settlement analysis. Then, factors causing settlement-induced damage to the plant were comprehensively discussed. Finally, the measures for mitigating the settlement-induced damage to the plant were proposed.

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Effect of pH switch operation on anaerobic hydrogen production

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Key Words: Anaerobic fermentation, ethanol production, hydrogen production, switch strategy

ABSTRACT

Hydrogen is an intermediate product in anaerobic fermentation along with the production of soluble metabolic product such as ethanol (EtOH). Dark fermentation becomes more interesting due to its advantages of producing hydrogen rapidly when compared with other biological methods. This study aimed to investigate the effect of pH-switch operating strategy on biohydrogen production in a continuously stirred tank reactor (CSTR). The efficiencies of hydrogen and ethanol production by shifting the pH from 6.8 (I) to 6.0 (I) and 6.0 (II) to 6.8 (II) and vice versa were investigated in CSTR. At the optimal hydrogen production condition, hydrogen production yield 2.8 mol H₂ mol⁻¹ sucrose, hydrogen production rate 437 mmol H₂ L⁻¹ d⁻¹ and specific hydrogen production rate 224 mmol H₂ g⁻¹ VSS d⁻¹ were obtained at pH 6.0 (I). pH 6.8 (I) was the optimal condition for ethanol production with an ethanol concentration of 7743 mg COD L⁻¹. The bacterial community structure analysis showed that *Clostridium intestinale* and *Clostridium pasteurianum* were dominant in the fermenter. The bacterial activity decreased during the pH shift. Switching the pH from 6 to 6.8 back and forth could be an operation strategy for obtaining the production of hydrogen and ethanol separately in the same bioreactor.

INTRODUCTION

Renewable energy such as biohydrogen, bioethanol and biodiesel from biomass has received considerable attention because of high price of the fossil fuels and the environmental pollution problems associated with their utilization. Dark-fermentation technology offers the best potential for practical application with advantages of higher rates of hydrogen and ethanol production and utilization of low-value biomass like wood residues, municipal solid waste and agricultural residues as raw materials [1]. Anaerobic

hydrogen production process is an exciting research and development area that offers a promising industrial technology for generating hydrogen from a variety of renewable resources. Moreover, hydrogen produced from this process is clean, sustainable and has dual benefit of waste recycling and hydrogen production economically. Fermentative hydrogen production process is a tedious process and requires optimization of inoculums type, pretreatment, substrate nature and composition, pH and temperature to scale-up the process [2]. There are many reports focusing on developing the operation strategies which could improve hydrogen

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Copper, nickel and lead adsorption from aqueous solution using chitosan-immobilized on bentonite in a ternary system

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Key Words: Antagonistic, desorption, film diffusion, ionic strength, ternary system

ABSTRACT

In this study, the competitive removal of copper, nickel and lead from aqueous solution using chitosan immobilized on bentonite (ChB) has been investigated. The presence of Na⁺ ions was observed to suppress the adsorption capacity in the order of: Ni(II) > Cu(II) > Pb(II). Kinetics study revealed that adsorption of Cu(II), Ni(II) and Pb(II) in a multi-metal system onto ChB follows the pseudo-second order equation. This signifies that the rate-determining step is chemisorption, which means that covalent bonds are formed through sharing of electrons between ChB and metal ions. The isotherm study shows that Pb(II) and Cu(II) follow Freundlich isotherm while Ni(II) is best described with the Langmuir model. In addition, the values of the Langmuir constant, q_{ml} , for Cu(II), Ni(II) and Pb(II) are 12.6, 6.1 and 15.0 mg g⁻¹, respectively. The preferential adsorption of Pb(II) over Cu(II) and Ni(II) onto ChB is due to properties such as electronegativity, hydrolysis constant and softness value. In the regeneration study, HCl provided the highest desorption capacity but with most material damage to ChB. After three cycles of adsorption-desorption, % desorption using HCl was 79, 70 and 81% for Cu(II), Ni(II) and Pb(II), respectively.

INTRODUCTION

The presence of heavy metals in wastewater is mainly contributed by anthropogenic sources like mining activities, electroplating industry, battery manufacturing, pulp and paper industries, metal fabrication and electronics assembly [1]. Philippines contains a significant amount of copper and nickel ore deposits. Mining and metallurgical processing of Cu(II) and Ni(II) produce Pb(II) in wastewaters, as stated in the Philippine Clean Water Act 2004 RA 9275 [2].

Common treatment technologies used in the removal of heavy metals from waste effluents are electro-

deposition, ion exchange, chemical precipitation, reverse osmosis, and membrane separation. Among the physicochemical processes, adsorption removes contaminants in wastewater with high solute loading and even at dilute concentrations [3]. Typical commercialized adsorbent such as activated carbon, which is of mineral or organic origin, is expensive. Adsorbents such as starch, chitin, chitosan, non-living aquatic macrophyte, iron coated medium and cyclodextrin present a better alternative over the commercially-used adsorbents since they are abundant, biodegradable and have the capacity to physically or chemically interact with a variety of molecules [4,5].

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Quality investigation and disinfection of spring waters with different disinfectants

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Key Words: Spring water, chlorine dioxide, sodium hypochlorite

ABSTRACT

To study Taiwan spring water quality, a hot spring and a regular spring have been selected. The spring water samples are tested in terms of temperature, pH level, conductivity, levels of free chlorine, ammonia, nitrate, nitrite, total Colony Forming Unit (CFU), total coliforms, and fungi. The results indicate that both springs do not meet the Taiwan water quality standards. Thus, either chlorine dioxide or sodium hypochlorite is used to improve the water quality and its disinfection efficiencies compared. The data indicate that to meet the CFU standards issued by Taiwan Centers for Disease Control, it requires 5.3 mg L^{-1} (as Cl_2) of both disinfectants for the hot spring water. But, it just needs 2.6 mg L^{-1} for the regular spring water. To meet the total coliforms standards, it needs 2.6 mg L^{-1} for the regular spring water. However, it requires higher amount ($> 13.1 \text{ mg L}^{-1}$) for the hot spring water to eliminate the coliforms totally. The differences in disinfection efficiencies for the hot spring and regular spring water are attributable mostly to the sand particles contained in the hot spring water. It has been found that chlorine dioxide is a more efficient and safer disinfectant than sodium hypochlorite. Without disinfection, the hot spring water poses a higher risk to human than the regular spring water based on Gram's method.

INTRODUCTION

Taiwan is located in a geologically active zone. There are abundant natural geothermal resources in the island including more than 100 geothermal springs. Geothermal springs can be divided into 3 separate categories [1] according to water temperature, i.e., elevated temperature springs (higher than $75 \text{ }^\circ\text{C}$), moderate temperature springs (between 40 and $75 \text{ }^\circ\text{C}$), and low temperature springs (below $40 \text{ }^\circ\text{C}$). Most of the Taiwan geothermal springs belong to the 2nd category. In this research, a local hot spring and a regular spring (non-geothermal) are selected for studying their water quality. The spring water quality is monitored and methods of water quality improvement are explored. First, the spring water is tested for pH level. Based on pH level, geothermal springs can be partitioned into 3 categories, i.e., higher than pH 8 (alkalinic), between pH 6 and 8 (neutral), and below pH 6 (acidic). The Taiwan geothermal springs cover the full range. More tests are conducted to detect traces

of ammonia, nitrate, nitrite, among others. Spring water often contains microorganisms. Based on the temperature range in which they grow best, microorganisms are usually divided into 3 groups, i.e., Thermophiles (higher than $45 \text{ }^\circ\text{C}$), mesophiles (between 20 and $45 \text{ }^\circ\text{C}$), and psychrophiles (between 0 and $5 \text{ }^\circ\text{C}$) [1]. The microorganisms present in samples are categorized through incubation to find out which groups they belong. The spring water is monitored for levels of total CFU (Colony Forming Unit), total coliforms, and fungi to check with Taiwan water quality standards. The microorganisms will also be classified by Gram's method [2]. As a general rule, Gram-negative bacteria are more pathogenic than Gram-positive ones.

When there are excessive amounts of microorganisms, spring water is often chlorinated. However, its efficiency is limited. It can also produce unpleasant color, odor, and harmful by-products, such as trihalomethanes [3-5]. Another way is by using ozone. But, ozone is expensive, toxic, corrosive and lethal if

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Investigations of water purification performance for aquarium water filters

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Key Words: Aquarium, water purification, ammonium-nitrogen, filter

ABSTRACT

The water purification performance of commercial filter materials used in aquariums was investigated in the present study. Two experiments were conducted. In the first, duplicate batch tests determined the quantity of ammonium excreted daily from each experimental fish, chosen to be zebrafish (*Danio rerio*). In the second, removal efficiencies were determined for different combinations of three commercial filter materials: ceramic rings (CR), granular activated carbon (GAC) and artificial cotton fiber (ACF) and, a new filter material made in the present study, iron-oxide coated CR (IOCCR). Four sets of experimental filter systems composed of different filter materials and aquariums were used.

The hydraulic experimental results revealed the water quality in the external filter was almost the same as that in the aquarium within 152 s mixing time. The daily ammonium excrement for each zebrafish was 2.1 mg N. During the experimental period of 39 d, the electrical conductivities, which were initially 100 $\mu\text{S cm}^{-1}$, increased to 1011 $\mu\text{S cm}^{-1}$, an indication of ion accumulation. However, pH, dissolved oxygen, and oxidation-reduction potential maintained a relatively steady state. In addition to the accumulation of ions, total phosphorus also increased because there was no mechanism for its removal in the present study. Averages of biochemical oxygen demand (BOD) ranged from 1.0 to 1.6 mg L⁻¹ with a rather low level. BOD was found to not play an active role in the removal of NH₄⁺. Filter system C, composed of ACF, ACF, GAC, and ACF, showed superior capability for NH₄⁺ removal. After 172 d, and the NH₄⁺ removal efficiency remained 99% for system C. The daily cost of system was also the lowest, only USD 0.1 d⁻¹. During this operation period, pH had the greatest effect on NH₄⁺ removal by depressing the nitrification process.

INTRODUCTION

According to previous research, the 2007 annual production of ornamental fish industry is about a \$ 6 billion (in US dollars), and 90% of its retail sales come from fish aquaculture with the remainder from wild fish. However, the production of accessories for ornamental fish aquaculture is even higher, reaching \$ 8 billion annually [1]. The accessories can be categorized as hardware and consumable materials. The former includes aquariums, filter systems, light-

ing, stands and cabinets, pumping systems, heaters, decorations, and so on. Food, medicine, nutrients, and filter media are considered consumable materials. In Taiwan, an aquarium size of 45 x 30 x 21 cm costs about \$ 84; however, the cost of filter media exceeds that of the aquarium setup after 2-yr operations. Therefore, there is great market potential if better filter media can be developed though the proper combination of different filter materials.

The water quality in an aquarium is one of the key factors for the growth and health of fish and is mainly influenced by pollutants and environmental factors.

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Oxidation of 2,4,4'-trichloro-2'-hydroxydiphenyl ether (triclosan) by Fenton's reagents with the electrochemical system

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Key Words: 2,4,4'-trichloro-2'-hydroxydiphenyl ether (triclosan), Fenton's reagents with the electrochemical system, hydroxyl radicals, ROP ratio, H₂O₂ feeding mode

ABSTRACT

2,4,4'-Trichloro-2'-hydroxydiphenyl ether (triclosan), used as a substrate in the production of antimicrobials, is a high-priority target of pollution control. In this study Fenton's reagents were used for degrading triclosan with the electrochemical system to investigate the feasibility of the continuous electro-regeneration of ferrous ions. The pH, current density, H₂O₂ to Fe²⁺ (H/F) molar ratio, and H₂O₂ operation feeding mode were investigated to determine the optimum operating conditions. The result found that the current densities of 0.15 mA cm⁻² with 4 mM H₂O₂, 0.1 mM Fe²⁺ and pH 3 completely removed 1 mM triclosan by initial H₂O₂ feeding operation. The efficiency and stability of the process were increased by varying the H/F ratio and changing the H₂O₂ feeding mode from a single feeding to step feeding, along with reducing potential of toxicity formation and increasing the rate of mineralization. The initial degradation rate was investigated by a first-order model to indicate the process optimization. High performance liquid chromatography, ion chromatography and gas chromatography with mass spectrometry data were used to identify the generated intermediates. These were 2,4-dichlorophenol, 4-chloro-catechol, phenol, hydroquinone, p-benzoquinone, maleic, acetic, oxalic, and formic acids. The formation of some intermediate depended on H₂O₂ operating feeding mode. A degradation pathway for triclosan oxidation was proposed on the basis of detected intermediate compounds.

INTRODUCTION

Antimicrobial agents can be detected in municipal wastewaters. Their concentrations are usually from 0.5 to 5 µg L⁻¹ in the raw and primary wastewater [1]. 2,4,4'-Trichloro-2'-hydroxydiphenyl ether (triclosan) is an antimicrobial agent that is widely used in a range of personal health care products and has been detected

in wastewater. Triclosan is used in various personal care products, such as toothpaste, soaps, deodorants, shampoos, and cosmetics, as well as in consumer products (such as, plastic kitchenware and footwear). Although a significant amount of triclosan is eliminated from wastewater with an efficiency of 90% in sewage treatment plants, considerable quantities of triclosan still remain in the sewage effluent, probably

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Application of biomathematical model for Pb(II) biosorption and bioaccumulation

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ABSTRACT

Key Words: Adsorption isotherm, bioaccumulation, biomathematical model, biosorption, lead, modified Gompertz model

This study investigated the reduction of Pb(II) by bioaccumulation and biosorption in an artificial biosorbent. The biosorbent was prepared by mixing grounded manure and fine-grain sand at a ratio of 1:1 (w/w) with the media packed into a laboratory scale column (diameter of 4.7 cm). The sweet soy sauce (food grade) solution with pH ranged of 5.0-5.5 and the concentration of 15 g COD L⁻¹ was fed at a rate of 500 mL d⁻¹ to the column surface for a period of 101 d. The active biofilm was then acclimatised for another 79 d, by adding 0.2 mg L⁻¹ of Pb(NO₃)₂ into an acidic substrate solution. After 180 d, biofilm was matured as the removal efficiencies of COD and Pb(II) were constant at 30 and 60%, respectively. The rate of bioaccumulation was evaluated using the modified Gompertz model. The living microbes can gradually consume Pb(II) and the bioaccumulation efficiency is 14.0 mg Pb g⁻¹ organic matter (OM). The Pb(II) ions act as the trace element, which can enhance the growth of microbes in the biosorbent. The biosorption can be described using Freundlich model. Under the acidic Pb(II) solution (pH 4.0), the highest distribution coefficients of biosorption is 6.3 mg Pb g⁻¹ OM, and the sorbed Pb is biochemically fixed onto OM. The acidic Pb(II) solution can prevent the deposition of Pb(II) prior to biosorption. Pb(II) can be stored in accordance with the microbial cell activities by 56% of total Pb(II) removal. Approximately, 44% of Pb(II) is adhered on OM. At the active zone of biosorbent, the free Pb(II) species in the forms of soluble and exchangeable Pb(II) are well sorbed. The biosorbent could present the high benefit to bound the toxic Pb(II) even the contaminated water is highly acidic (pH = 4.0).

INTRODUCTION

The problem of lead contamination in groundwater is seriously concerned, particularly in the western region of Thailand, as a result of mining activities. The slag or residue contains high concentration of lead. The Pb contaminated wastes can be flushed to surface and groundwater resource. The extremely high concentration of lead is detected in water and crops, which

causes the lead poison in animals and human. Naturally, lead is mostly found in the form of inorganic lead and it is classified as the toxic heavy metal, which can pose the risk on human health and destroy the ecological system [1]. In order to prevent the movement of lead at source, the in-situ remediation technique might be employed. The permeable reactive barrier (PRB) is a novel technology, which can separate Pb(II) from aqueous solution by biosorption and bioaccumulation

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Study of recycled plastic aluminates relative to environmental physical stresses as barrier material

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Key Words: Barrier, environmental stresses, plastic aluminates, recycling

ABSTRACT

This study investigated the capability of recycled plastic aluminates (RPAs) against environmental stresses. These environmental physical stresses of concern are: water, leachate and gas vapour permeation; thermal conductivity, and environmental stress cracking (ESC). RPAs possess properties potential as environmental protection material. The permeation properties with respect to water, gas, leachate, as well as thermal insulation and ESC, that would aid in concluding that RPAs as a barrier material has not been investigated. Hence, this study was carried out with the objective to investigate the above mentioned properties. Flexible plastic aluminium laminate trimmings (FPALTs) and variable weight percentages of organoclay (OC) were formulated, processed, characterized and examined. Methods of examination followed those procedures of American Society for Testing and Materials and International Standards Organization. Fourier Transformed Infrared (FTIR) approach was used for the investigation of ESC resistance. Results showed that impregnation of OC improved the water vapour permeability and thermal insulation property. RPA with 10% OC is the best performing RPAs for thermal insulation. All RPAs batches are considered water and leachate vapour barrier, gas vapour retarder, and moderate thermal insulator. FTIR showed that all pristine RPAs, i.e., regardless of thickness and FPALT particle size, are ESC resistant. With the above mentioned results of the study, it was concluded that RPAs are indeed a barrier and moderate insulator material that would have potential economic value for public consumption. However, it is recommended to conduct further investigation to fully understand the effects of OC concentration in reduced permeability of RPAs. Also, detailed study on economic related analysis and risk assessment is necessary to ensure environmental and public health safety.

INTRODUCTION

Global production of plastic continues to rise by an average of almost 10% every year [1]. This may cause problems in the environment and public health if

not given the necessary recycling study and related mitigation initiatives. Due to increasing demand of plastics that is forecasted to remain in the market even for 50 yr or beyond, recycling of plastic wastes has received increasing attention all over the world [2-4].

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Hydrocracking of oil residue from palm oil mill effluent to biofuel

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Key Words: Biofuel, palm oil, monmorillonite, hydrocracking, catalyst

ABSTRACT

The total palm oil production has increased in the last few years, as a result, palm oil waste which is a by-product of the milling process will also increase. The palm oil production process in mills consists of several unit operations. The processing of fresh fruit bunches of palm results in the generation of different types of residue. Among the waste generated, palm oil mill effluent (POME) is considered as the most harmful waste for the environment if discharged untreated. POME is a thick brownish liquid that contains high solids, oil and grease. Several treatment technologies have been used for POME treatment, since the direct discharge of POME adversely affects the environment. Due to the presence of high oil residue in POME, attempts have been made to recover and convert it into valuable products such as useful chemicals and biofuel. Recovery process of oil residue from POME is difficult and not economical; therefore, its alternative usage is explored. In a preliminary study, we observed that it was possible to produce various types of liquid hydrocarbons fuel (biofuel) from oil residue from POME. Oil residue from POME has been catalytically hydrocracked to biofuel by Ni/Mo-ZrO₂ pillared monmorillonite catalyst in fixed bed micro reactor. The data show that the catalytic activity of ZrO₂ pillared montmorillonite (ZM) is more active than parent monmorillonite. While, catalyst Ni/Mo loaded on ZM can increase the catalytic activity for hydrocracking of oil residue from POME into biofuel. The products were mainly gases, biofuel and solid coke. The biofuel products consist of gasoline, kerosene and diesel oil fraction.

INTRODUCTION

Palm oil industry has resulted sludge waste. Palm oil mill effluent (POME) which contains a significant amount of oil residue. Oil residues contained in the palm oil sludge could be potentially processed as an energy resource. The success of treating palm oil waste sludge into fuel oil will be significant in resolving the dependence of fuel oil from fossils and reducing environmental burdens. Processing of oil residues from POME into qualified fuel oil can be conducted through two processes at once, that are process of cracking and process of hydrogenation or hydrocracking. Hydrocracking oil residues in POME is conducted by

catalytic thermal hydrodecomposition which is able to alter fat and fatty acids with long carbon chains into the oil fraction with a shorter hydrocarbon chains and high potential as a fuel. The study of the conversion of vegetable oil into fuel is interesting because the materials of vegetable oils do not contain nitrogen, sulfur and heavy metals so that the resulting oil become an environmentally friendly oil.

Studies on catalytic cracking of vegetables oil into hydrocarbon fuels have been done, such as Candelilla oil [1], rapeseed oil [2], palm oil [3,4], soybean oil [5] and jatropha oil [6]. The result of these studies concluded that the main content of triglycerides in vegetables oil can be converted into hydrocarbon fuel,

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Reflection effect on the decomposition of gas-phase trichloroethene by 254 nm UV photolysis and advanced oxidation processes (AOPs)

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Key Words: Direct photolysis, UV/TiO₂, UV/O₃, trichloroethene (TCE)

ABSTRACT

The decomposition of gas-phase trichloroethene (TCE) in air streams by direct photolysis, the UV/TiO₂ and UV/O₃ processes with a low-pressure 254 nm UV lamp in an annular photoreactor was studied. The experiments were carried out under various UV light intensities and reactor dimensions to investigate and compare the removal efficiency of the pollutant and the mineralization and dechlorination of organic intermediates by photolysis and advanced oxidation processes (AOPs). A photoreactor design equation for the photolysis of gaseous TCE in air streams by the 254 nm UV irradiation was developed without and with the consideration of the reflection effect by combining the continuity equation of the pollutant and the empirical rate expression for the photolysis of TCE. By the proposed design scheme, the temporal distribution of trichloroethene at various operation conditions by 254 nm UV photolysis can be well modeled. The UV/TiO₂ process was found to be superior in mineralization efficiency for the decomposition of TCE as compared to the UV/O₃ process. However, the dechlorination efficiency for the decomposition of TCE by UV/TiO₂ process is comparable with the UV/O₃ process. The individual contributions to the decomposition of TCE by direct photolysis and hydroxyl radical destruction in the UV/TiO₂/TCE and UV/O₃/TCE systems were differentiated to discuss the quantum efficiency. The ozone utilization for the decomposition of TCE by the UV/O₃ process was investigated based on the elemental mass balances.

INTRODUCTION

The decontamination of exhaust air and wastewaters enriched especially with chlorinated hydrocarbons is of increasing importance in industrial application and sanitation of polluted soil. Using conventional techniques for air purification like incineration or adsorption, problems frequently arise in the formation of noxious by-product (e.g., dioxins), in high energy consumption, or in creating a solid hazardous waste with its own handling problems. Ultraviolet technologies offer the advantage of being very effective when compared to other processes mentioned above because the UV-aided process totally destroys the contaminants

leaving no residual [1].

The results obtained by previous studies on the direct photolysis of several volatile organic compounds (VOCs) by the use of pulsed xenon lamps or KrBr excimer lamps have shown that the UV irradiation was capable of efficiently decomposing gaseous VOCs in air [2,3]. These lamps are more suited to direct photolysis of VOCs than commercial mercury lamps because their emission spectrum is shifted to the region of shorter wavelengths. However, direct photolysis usually cannot compete with adsorption or catalytic/thermal oxidation because of the weak absorbance of most contaminants at the wavelengths radiated by the more efficient commercial lamps. Nevertheless, in

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