LEMBAR
HASIL PENILAIAN SEJAWAT SEBIDANG ATAU *PEER REVIEW*
KARYA ILMIAH : *PROSIDING*

Judul karya ilmiah (paper) : Mass Transfer Coefficient of Ozone in a Bubble Column
Jumlah Penulis : 4 orang (**Ratnawati Ratnawati**, Dyah Arum Kusumaningtyas, Purbo Suseno, Aji Prasetyaningrum)
Status Pengusul : Penulis pertama / penulis korespondensi
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g. Terindeks di (jika ada) : SCOPUS, dengan SJR 2018 = 0,169

Kategori Publikasi Makalah (beri √ pada kategori yang tepat)

[√] Prosiding Forum Ilmiah Internasional
[ ] Prosiding Forum Ilmiah Nasional

Hasil Penilaian *Peer Review*:

Komponen yang dinilai	Nilai Reviewer		Nilai rata-rata
	Reviewer 1	Reviewer 2	
a. Kelengkapan unsur isi artikel (10%)	3,0	3,0	3,00
b. Ruang lingkup dan kedalaman pembahasan (30%)	6,6	8,1	7,35
c. Kecukupan dan kemutakhiran data /informasi dan metodologi (30%)	6,5	8,4	7,45
d. Kelengkapan unsur dan kualitas terbitan/prosiding (30%)	8,0	7,5	7,75
Total (100%)	24,1	27,0	25,55
Nilai Pengusul (60% × total nilai)	**14,46**	**16,2**	**15,33**

Semarang, 20 Mei 2020

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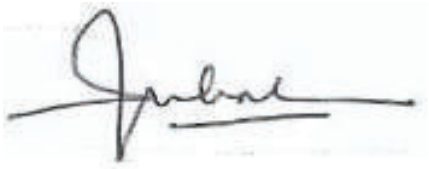

Prof. Dr. I Nyoman Widiasa, S.T., M.T.
NIP 197004231995121001
Unit Kerja : Fak. Teknik Undip
Bidang Ilmu : Teknik Kimia

Reviewer 2

Prof. Dr. Mohamad Djaeni, ST, M.Eng
NIP 197102071995121001
Unit Kerja : Fak. Teknik Undip
Bidang Ilmu : Teknik Kimia

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Hasil Penilaian *Peer Review*:

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	Internasional [√]	Nasional [ ]	
a. Kelengkapan unsur isi paper (10%)	3		3,0
b. Ruang lingkup dan kedalaman pembahasan (30%)	9		6,6
c. Kecukupan dan kemutahiran data/informasi dan metodologi (30%)	9		6,5
d. Kelengkapan unsur dan kualitas terbitan/prosiding (30%)	9		8,0
Total (100%)	30		24,1
Nilai Pengusul = 60% × 24,1			**14,46**

Catatan Penilaian oleh Reviewer:

a. Unsur isi paper lengkap
b. Ruang lingkup dan kedalaman pembahasan:
   - tidak ada Fig. 3 dan Fig. 6.
   - Literatur 15 tidak disitasi.
   - Sitasi tidak urut nomornya; Egorova et al. bukan [13] tapi [14].
   - Lebih dari 40% references disitasi dalam pembahasan.
   - Lingkup kajian cukup.
c. Metodologi perhitungan konsentrasi ozon tidak jelas. Kecukupam dan kemutakhiran data bersifat komplementer.
d. Kelengkapan unsur dan kualitas terbitan/prosiding cukup baik.

Semarang, Februari 2020
Reviewer 1,

Prof. Dr. I Nyoman Widiasa, ST, M.T
NIP 197102071995121001
Unit Kerja : Fak. Teknik Undip
Bidang Ilmu : Teknik Kimia

LEMBAR
HASIL PENILAIAN SEJAWAT SEBIDANG ATAU *PEER REVIEW*
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Komponen yang Dinilai	Nilai Maksimal Prosiding		Nilai Akhir yang Diperoleh
	Internasional [√]	Nasional [ ]	
a. Kelengkapan unsur isi paper (10%)	3		3,0
b. Ruang lingkup dan kedalaman pembahasan (30%)	9		8,1
c. Kecukupan dan kemutahiran data/informasi dan metodologi (30%)	9		8,4
d. Kelengkapan unsur dan kualitas terbitan/prosiding (30%)	9		7,5
Total (100%)	30		27,0
Nilai Pengusul = 60% × 27,0			**16,2**

Catatan Penilaian oleh Reviewer:

a. **Kelengkapan unsur isi paper (10%)**
Artikel memiliki unsur lengkap (Introduction, Material & Methods, Results & Discussion, Conclusions, Acknowledgement, References). Isi artikel sesuai dengan bidang ilmu penulis. State of the art, tujuan dan kesimpulan dinyatakan dengan jelas. Pengecekan plagiarism dengan Turnitin menunjukkan similaritas sebesar 17%. → (nilai = 10%)

b. **Ruang lingkup dan kedalaman pembahasan (30%)**
Paper ini membahas mengenai hal yang fundamental yaitu besarnya constanta perpindahan masa ozon pada reaktor gelembung. Beberapa variasi dilakukan untuk mendapatkan data konstanta yang sahih diantaranya adalah waktu pelarutan ozon, laju alir udara dan pH. Hasil menunjukkan koefisien perpindahan masa bertambah dengan turunnya nilai pH,serta kondisi terbaik pada laju udara sebagai sumber bahan baku ozon 4 liter per menit. Hasil ini cukup bermanfaat untuk perancangan reaktor cair-gas yang melibatkan reaksi yang melibatkan ozon dalam industri. Data-data yang ada juga cukup banyak dan dibahas dengan cukup mendalam dengan mensitasi referensi yang relevan. → (nilai = 27%)

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Nilai novelty artikel ini cukup baik dimana referensi yang disitasi dalam artikel ini berjumlah 23 dengan 17 (73,9%) di antaranya merupakan artikel baru (10 tahun terakhir). Metode penelitian ditulis dengan baik dan rinci, sehingga dapat diikuti. → (nilai = 28%)

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Semarang, 15 Mei 2020
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Prof. Dr. Mohamad Djaeni, S.T., M.Eng.
NIP 197102071995121001
Unit Kerja : Fak. Teknik Undip
Bidang Ilmu : Teknik Kimia

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In the 24th Regional Symposium on Chemical Engineering (RSCE)

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MATEC Web of Conferences
Volume 156, 14 March 2018, Article number 02015
24th Regional Symposium on Chemical Engineering, RSCE 2017; Patra Hotel and ConventionSemarang; Indonesia; 15 November 2017 through 16 November 2017; Code 135293

Mass transfer coefficient of ozone in a bubble column

(Conference Paper) (Open Access)

Ratnawati, R. ✉, Kusumaningtyas, D.A., Suseno, P., Prasetyaningrum, A.

Department of Chemical Engineering, Diponegoro University, Jl. Prof. Soedarto, SH, Semarang, 50275, Indonesia

Abstract

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The effect of flow rate of ozone-containing gas and pH on the mass transfer coefficient of ozone through water in a bubble column reactor has been studied. Ozone was generated from air using a corona discharge ozone generator. The flow rate of air was varied from 2 to 5 L min^{-1}, while pH was varied from 4 to 10. The gas containing ozone was bubbled to the reactor containing 1.5 L of 2% KI solution. The temperature was set at 28±1°C. The concentration of ozone was determined using titrimetric method every 5 minutes. The results show that the concentration of ozone increases with time, and it reaches a steady-state concentration after 30 minutes of ozonation. The gas flow rate and pH apparently affect both the concentration and the k_La. The highest k_La of 2.1 X 10^{-2} s^{-1} is obtained at pH 4 with a gas flow rate of 4 L min^{-1}. © The Authors, published by EDP Sciences, 2018.

SciVal Topic Prominence

Topic: Henry Law | Solubility | Nonpolar Gas

Prominence percentile: 51.556

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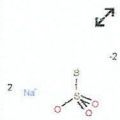

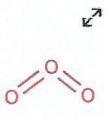

potassium iodide

Indexed keywords

Engineering controlled terms: Bubble columns, Electric corona, Flow of gases, Flow rate, Mass transfer, Ozone water treatment, Ozonization, pH effects

Engineering uncontrolled terms: Bubble column reactors, Corona discharges, KI solution, Ozone generator, Steady state concentration

Engineering main heading: Ozone

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Ratnawati, R.; Department of Chemical Engineering, Diponegoro University, Jl. Prof. Soedarto, SH, Semarang, Indonesia;
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Enhancing Properties and Performance of Cellulose Acetate/Polyethylene Glycol (CA/PEG) Membrane with the addition of Titanium Dioxide (TiO_2) by Using Surface Coating Method 08016

Siti Nurkhamidah, Yeni Rahmawati, Ignatius Gunardi, Pitsyah Alifiyanti, Krisna Dimas Priambodo, Ryanda Luthfi Zaim and Wahyuni Eka Muqni

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Process Design of Virgin Coconut Oil (VCO) Production Using Low-Pressure Oil Extraction

Patricia Janelle Ferrer[1], *Vanessa Ferl* Quilinguen[1], *Jeremiah* Rosario[1], and *Lola Domnina* Pestaño[1,2*]

[1]Chemical Engineering Department, Faculty of Engineering, University of Santo Tomas
[2]Research Center for the Natural and Applied Science, University of Santo Tomas
España Boulevard 1015 Manila, THE PHILIPPINES

Abstract. Virgin coconut oil (VCO) has become one of the most prominent high-value coconut product in coconut producing countries because of its versatility. This research attempts to design a fresh-dry process based on the Low-Pressure Oil Extraction Method for the production of VCO to reduce the settling time of the oil after extraction, that usually takes 1-2 weeks. Different parameters, such as drying temperature, centrifuge speed, and centrifugation time were varied and analysed. Three mathematical models were examined to describe the drying behaviour of the grated coconut meat at 65, 70, and 75°C using a tray dryer. A VCO production fresh-dry process based on the Low-Pressure Oil Extraction Method was developed through the employment of a centrifuge. The modified method lessens the settling time while still producing standard quality VCO. As predicted by the Laplace Transform Model, the shortest time for the comminuted coconut meat to reach a moisture content of 11% at which oil from nuts can be extracted using low pressure is at 29.07 minutes using a tray dryer. The best setting of VCO production using the modified method is at a drying temperature of 70°C and at 2700 RPM and 60 minutes of centrifugation as it produced the clearest oil with a yield of 92.84 % v/v and a recovery of 18.43%. The produced VCO was tested for free fatty acid (FFA), moisture and volatile matter, colour, peroxide value, and iodine value, and the results are 0.03%, 0.11%, 0R/0.3Y, 0, and 5.77, respectively, which all passed the Philippine National Standards for VCO.

1 Introduction

The purest type of coconut oil, virgin coconut oil (VCO), was introduced to the world market at the end of the 20th century. It is considered one of the products of great value derived from the fresh coconut [1]. VCO, the clear, high value oil resulting from the fresh and mature kernel of coconut (*Cocos nucifera L.*), is obtained through mechanical and natural means, with or without the use of heat, without undergoing chemical refining, bleaching or deodorizing, which does not lead to alteration or transformation of the natural characteristics of oil [2]. It is now gaining a worldwide popularity because of its wide range of applications in medicine, food, cosmetics and the like [3].

VCO processing technologies can be generally categorized into fresh-dry process and fresh-wet process. The term fresh-wet is for the VCO process in which the VCO is obtained from the coconut milk by a variety of means after it has been extracted from freshly comminuted coconut kernel. The term fresh-dry on the other hand, is for the VCO process where VCO is obtained directly from the fresh coconut kernel which requires drying of the kernel in comminuted form before the extraction of oil [1].

Under the fresh-dry technologies is the low pressure oil extraction method. This method is common among micro- and village-scale industries and works on the principle that oil from seeds or nuts can be extracted using low pressure at about 460 psi provided that the moisture content of the material is within the range of 10–13% [3].

This process, however, requires at least two weeks of settling time to separate the fine particles of dried kernel from the extracted oil. A centrifuge, which is commonly used for emulsion breaking of coconut milk in fresh-wet VCO processing technologies [4] may be utilized to greatly lessen the settling time while still producing VCO which passes the quality standards set by the Philippine National Standards (PNS) for VCO, as well as the Asian and Pacific Coconut Community (APCC). Other factors,

* Corresponding author: lbpestano@ust.edu.ph

Optimization of Supercritical Carbon Dioxide and Co-solvent Ethanol Extraction of Wasted Peanut Skin Using Response Surface Methodology

Nicky Rahmana Putra[1,2], Ahmad *Hazim* Abdul Aziz[1], Lee Nian *Yian*[1], Wan *Diyana* Ramli[1], and Mohd Azizi Che Yunus[1*]

[1] Centre of Lipid Engineering and Applied Research (CLEAR), Ibnu Sina Institute for Scientific and Industrial Research, Universiti Teknologi Malaysia, 81310, UTM Johor Bahru, Malaysia
[2]Faculty of Chemical and Energy Engineering, Universiti Teknologi Malaysia, 81310, Johor Bahru, Malaysia

Abstract. Peanut skin is a waste of peanut industries especially peanut butter industries. Peanut skin contain high antioxidant and high nutritional values. The objective of this study was to optimize the effect of parameters to obtain high extract yield and high antioxidant activity by using supercritical carbon dioxide and co-solvent ethanol. A Box-Behnken design (BBD) was used to optimize the extraction process at the condition temperature (40, 55 and 70 °C), rate of co-solvent ethanol (2.5, 5, and 7.5 % Vethanol/Vtotal), and extraction pressure (10, 20 and 30 MPa). The extraction time was 3 hours. The optimum condition to obtain yield of extraction and antioxidant activity 22.05 MPa, 62.76 °C and 6.03 %($V_{ethanol}/V_{solvent}$) with 15.404 % yield extract and 94.040 % antioxidant activity.

1 Introduction

Peanut is an agricultural product that has been used for many dishes in the asean country such as Indonesia, Malaysia and Philippines. In food industries, peanut skin is always removed from peanut due to taste of product. Peanut skin decreases the quality of product because peanut skin has astringent taste. Astringent taste indicates that peanut skin contains high antioxidant inside of its skin. Previous researcher has already found that peanut skin contains procyianidin, catechin, epicatechin, and anthocyanidin [1,2]. Most of this antioxidant of peanut skin extract reduced risk of cardiovascular diseases and cancers, anti-diabetic, anti-inflammatory [3].

Supercritical carbon dioxide is a green and safe technology to extract oil, bioactive compounds and antioxidant. Furthermore, supercritical carbon dioxide does not have residues after extraction process because carbon dioxide will be naturally separated from the extract. Moreover, supercritical carbon dioxide extraction has many advantages in food process extraction because unexpansive as solvent, and also has small critical temperature and pressure (304 K and 71 Bar). Although, supercritical carbon dioxide has many advantages, the built up the extraction apparatus is expensive but the extract of extraction has high quantity of bioactive compound and antioxidant activity compared with conventional extraction such as soxhlet extraction.

Many researchers has successfully used supercritical carbon dioxide extraction to extract bioactive compounds from herbs and plants effectively. Recently, pipper batle leaves, *Pithecellobium Jiringan* (Jack) prain seeds, palm oil, and rubber seeds oil are successfully extracted by supercritical carbon dioxide extraction [4,5,6,7,8]. Moreover, high selectivity and diffusivity to certain compound and condition in the solute are the significant advantages of using supercritical carbon dioxide. furthermore, the another advantages of supercritical carbon dioxide extraction is the solubility of solvent can be manipulated by pressure, rate of co-solvent and temperature [9].

Ethanol as co-solvent in the extraction process is needed for this extraction process to encourage the polarity of solvent. Therefore, with addition co-solvent ethanol in the supercritical carbon dioxide extraction can extract polar and non-polar compounds inside of the solute. Moreover, Ethanol is safer than other commonly co-solvent such as methanol, propanol and butanol because in the market, ethanol is sold with food grade quality.

To optimize and determine influences of variables and fitted the experimental data on the supercritical carbon dioxide extraction has successfully used by response surface methodology (RSM). Commonly, pressure, temperature and rate of co-solvent are the variables of extraction process. From previous studies shows that extraction of red-fleshed pitaya, piper battle linn leaveas[10], tomato skin[11], Passiflora seed oil,

* Corresponding author: azizi@cheme.utm.my

Mass Transfer Coefficient of Ozone in a Bubble Column

Ratnawati Ratnawati[1,*], *Dyah Arum* Kusumaningtyas[1], *Purbo* Suseno[1], and *Aji* Prasetyaningrum[1]

[1]Department of Chemical Engineering, Diponegoro University, Jl. Prof. Soedarto, SH, Semarang 50275, Indonesia

Abstract. The effect of flow rate of ozone-containing gas and pH on the mass transfer coefficient of ozone through water in a bubble column reactor has been studied. Ozone was generated from air using a corona discharge ozone generator. The flow rate of air was varied from 2 to 5 L min^{-1}, while pH was varied from 4 to 10. The gas containing ozone was bubbled to the reactor containing 1.5 L of 2% KI solution. The temperature was set at 28±1°C. The concentration of ozone was determined using titrimetric method every 5 minutes. The results show that the concentration of ozone increases with time, and it reaches a steady-state concentration after 30 minutes of ozonation. The gas flow rate and pH apparently affect both the concentration and the k_La. The highest k_La of 2.1 $\times 10^{-2}$ s^{-1} is obtained at pH 4 with a gas flow rate of 4 L min^{-1}.

1 Introduction

Ozone (O_3) is naturally formed in the stratosphere by chemical reactions involving oxygen with the aid of solar ultraviolet radiation (sunlight) of wavelengths below 240 nm [1]. The reaction can be simplified as Equation (1).

$$3O_2 + h\upsilon\ (\lambda<240\ nm) \rightarrow 2O_3 \quad (1)$$

Ozone can be generated using non-thermal plasma corona discharges at atmospheric pressure and room temperature where an extra-high voltage electrical current is passed from an electrode through a neutral fluid, which is usually air [2]. The current is able to ionize the fluid creating plasma around the electrode. Oxygen experiences ionization and the overall reaction that may occur is written as Equation (2) [3].

$$3O_2 + e^- \rightarrow 2O_3 + e^- \quad (2)$$

Ozone is a strong oxidant with a very high redox potential, i.e. 2.07 V [4]. Ozone is highly reactive that it readily reacts with various organic and inorganic substances [5]. It has been utilized in advanced oxidation process (AOP), without or with H_2O_2 or UV to disinfect microorganism [5], to eliminate pollutants [6, 7], and to control odor problem [8].

To implement AOP in a liquid phase, the ozone must be solubilized in the liquid. The solubility of ozone in water is very low [9]. The solubilization of ozone in water is influenced by mass transfer coefficient (k_La) of ozone in water. The k_La is affected by the ozone concentration in the gas phase, the gas flow rate, temperature, and pH of the liquid phase [10 – 12]. The objective of this work is to study the effect of pH of the water and the flow rate of the gas on the mass transfer coefficient of ozone in water.

2 Materials and Method

2.1. Materials

The materials used in this study included potassium iodide (Merck, Cat. No. 1.05043.0250), sulphuric acid (Merck, Cat. No. 1.12080.1000), sodium thiosulfate (Merck, Cat. No. 1.93248.0521), sodium hydroxide (Merck, Cat. No. 1.06498.050), and hydrochloric acid (Merck, Cat. No. 1.93401.0521). The materials were utilized without any treatment.

2.2 Method

The experiment was conducted by using equipment as depicted in Fig.1, which consisted of a bubble column (a glass cylinder of 10 cm diameter and 50 cm height) equipped with a bubble diffuser, a corona discharge (40 kV) ozone generator (Dipo Technology Indonesia), and a compressor.

Thirty grams of potassium iodide was dissolved in distilled water to form 1500 mL solution with a concentration of 2% (w/w). The pH of the solution was varied (3, 4, 5, 6, 7, 8, 9, and 10) and was adjusted using HCl or NaOH solution. The solution was then placed in the column of which the temperature was kept at 28 ± 1°C. Air was passed the corona discharge ozone generator using the compressor at a certain flow rate (2, 2.5, 3, 3.5, 4, 4.5, and 5 L min^{-1}), then it was bubbled

* Corresponding author: ratnawati.hartono@gmail.com

Adsorption of Nickel and Chromium Ions by Amine-Functionalized Silica Aerogel

Sudarat Sertsing[1], *Thanaphat* Chukeaw[1], *Sitthiphong* Pengpanich[2], and *Bawornpong* Pornchuti[1,*]

[1]Chemical Engineering Department, Mahanakorn University of Technology, Bangkok, Thailand
[2]PTT Global Chemical Public Company Limited, Rayong, Thailand

Abstract. In this study, silica aerogel was synthesized by drying at atmospheric pressure and modified further with aminopropyl triethoxysilane (APTES). The amine-functionalized silica aerogel was investigated as an adsorbent for removal of nickel and chromium ions. The effect of contact time, solution pH, and initial solution concentration were studied. The equilibrium was achieved within 60 min. The optimum pH was found to be 4. Adsorption equilibrium data were agreed fairly well with Langmuir isotherm model. Adsorption capacities for nickel and chromium ions were found to be 40.32 mg/g and 46.08 mg/g, respectively.

1 Introduction

Electroplating is one of the most hazardous chemical industries due to its metal-contaminated wastewater. Heavy metals cause environmental problems as pollutants because of their characteristics such as high toxicity, non-biodegradability, and accumulation in food chain [1]. Therefore, electroplating wastewater must be treated before discharge.

Treating electroplating wastewater can be employed by various techniques such as chemical precipitation, coagulation-flocculation, floatation, adsorption, ion-exchange, membrane filtration, and electrochemical processes. Among them, adsorption is one of the most promising techniques when initial heavy metal concentration below 100 ppm [2]. Adsorption process is simple design, easy to use, and flexible. Moreover, it has low operating cost, low fouling problems, and most economic for elimination of heavy metals from wastewater [3].

Many adsorbents have been developed in treatment of effluent comprising heavy metals. Because of high surface area and porous network, activated carbon has been investigated extensively. However, the adsorption capacity is quite low. This may be caused by lacking of surface affinity groups [4].

Aerogels are interesting material. They have extraordinary characteristics such as high porosity, low density, high specific surface area, with tailor-made surface chemistry [1, 4]. Normally, aerogels are prepared by a sol-gel technique followed by suitable drying methods. To conserve the three-dimensional and the highly porous structure, various procedures are employed such as supercritical drying, freeze drying, and drying at atmospheric pressure. In this study, silica aerogel was synthesized by drying at atmospheric pressure which is easy and safe. Furthermore, modification of adsorbents with some chemicals containing N, O, S, P in functional groups increases adsorption capacity of heavy metals [4]. The objective of this work was to study the adsorption of nickel and chromium from aqueous solutions by amine-functionalized silica aerogel.

2 Materials and methods

2.1. Chemicals

Tetraethylothosilicate (Sigma Aldrich), APTES (Sigma Aldrich), Cetyltrimethylammonium bromide (Fluka), isopropanol (Merck), toluene (Merck), hydrochloric acid (Carlo Erba), and ammonia (Labscan) were used without further purification.

2.2 Preparation and modification of the adsorbent

Silica aerogel was synthesized by a procedure adjusted from that of Aravind et al. [5]. Briefly, 4.66 g Tetraethylothosilicate (TEOS), 5.37 g isopropanol, 6.44 g HCL solution were mixed together. Then, gelation was conducted by adjusting pH to 5 using ammonia solution. The resulted hydrogel was kept at 50°C for 1 day. After that, the pore liquid was replaced with isopropanol. The alcogel was then aged further with TEOS solution. After silylation, replace unreacted TEOS with 0.05% CTAB in isopropanol and dry slowly at 70°C.

* Corresponding author: bawornpong@yahoo.com

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Solvent Development for Post-Combustion CO_2 Capture: Recent Development and Opportunities

Anggit Raksajati[1,*], *Minh* Ho[2], and *Dianne* Wiley[2]

[1]Department of Chemical Engineering, Institut Teknologi Bandung, Bandung 40132, Indonesia
[2]School of Chemical and Biomolecular Engineering, The University of Sydney, Sydney NSW 2006, Australia

Abstract. Chemical absorption is widely regarded as the most promising technology for post-combustion CO_2 capture from large industrial emission sources with CO_2 separation from natural gas using aqueous amine solvent system having been applied since the 1930s. The use of monoethanolamine (MEA) in CO_2 absorption system possesses several drawbacks, such as high regeneration energy, high solvent loss, and high corrosion tendency. Various solvents have been developed for post-combustion CO_2 capture application including the development of aqueous solvents and phase-change solvents. Some of these alternate solvents have been reported to have better solvent properties, which could improve the CO_2 absorption system performance. This paper reviews key parameters involved in the design improvement of several chemical absorption process systems. In addition, some novel solvent systems are also discussed, for example encapsulated solvents systems. Some of the key solvent parameters that affect the capture performance, such as heat of reaction, absorption rate, solvent working capacity, solvent concentration, and solvent stability, are discussed in this paper, particularly in relation to the economic viability of the capture process. In addition, some guidelines for the future solvent development are discussed.

1 Introduction

A CO_2 reduction scheme that is gaining growing interest is Carbon Capture and Storage (CCS) [1]. Within the CCS process chain, CO_2 capture is the costliest stage and therefore it is important to develop the technologies that can reduce costs. Among all CO_2 capture methods, post-combustion CO_2 capture using chemical absorption has been recognized as the most commercially ready technology. The concept of this technology has been applied, albeit at different feed gas sources, in natural gas industry since the 1930s, where CO_2 is absorbed using aqueous amine solvent system [2]. Many researchers suggested that other CO_2 removal methods, such as membranes and adsorption, are not likely to be competitive because of compression work [2]. The application of physical absorbents in post-combustion CO_2 capture is likely to be more limited than that of chemical absorbents because of the low CO_2 partial pressure in the flue gas [3]. The future development of chemical absorption will be the focus of this paper. This paper aims to review the key parameters involved in the design improvement of several chemical absorption process systems. In particular, the recent updates on solvent development are presented for two solvent classes (aqueous solvents and phase-change solvents). In addition, some novel solvent systems are also discussed, for example encapsulated solvents systems.

2 Post-combustion CO_2 Capture using Chemical Absorption

In CO_2 capture using chemical absorption, weak chemical bonds between CO_2 from emission gases and a solvent solution is formed. Heat is then typically provided in the regeneration column in order to reverse this reaction. A simplified schematic of the post-combustion CO_2 capture process using chemical absorption is shown in Figure 1. Various solvents have been developed for post-combustion CO_2 capture application in order to improve the performance of the absorption system compared to MEA [4]. Typically, these alternate solvents have better solvent properties..

* Corresponding author: anggit@che.itb.ac.id

Optimized Ultrasound-Assisted Oxidative Desulfurization Process of Simulated Fuels over Activated Carbon-Supported Phosphotungstic Acid

Peniel Jean Gildo[1], *Nathaniel* Dugos[1,*], *Susan* Roces[1] and *Meng-Wei* Wan[2]

[1]Chemical Engineering Department, De La Salle University – Manila, 2401 Taft Avenue, Malate, Manila, Philippines, 0922
[2]Department of Environmental Resources Management, Chia Nan University of Pharmacy and Science, 60 Erh-Jen Rd., Sec. 1, Jen-Te, Tainan, Taiwan, 71710

Abstract. Recent technological advancements respond to the call to minimize/eliminate emissions to the atmosphere. However, on the average, fuel oils which is one of the major raw materials, is found to increase in sulfur concentration due to a phenomenon called thermal maturation. As such, a deeper desulfurization process is needed to obtain low/ultra-low sulfur fuel oils. In the present study, the ultrasound assisted oxidative desulfurization (UAOD) processes using the H_2O_2 and HPW-AC oxidizing system applied to simulated fuel (~2800 ppm sulfur in the form of dibenzothiophene, benzothiophene, and thiophene dissolved in toluene), were optimized. After the pre-saturation of the HPW-AC with the simulated fuel, H_2O_2 was added just before the reaction was commenced under ultrasonic irradiation. After the application of both 2^k-factorial design of experiment for screening and Face-Centered Design of Experiment for optimization, it was found that 25.52 wt% of H_2O_2 concentration, 983.9 mg of catalyst dose, 9.52 mL aqueous phase per 10 mL of the organic phase and 76.36 minutes of ultrasonication time would render 94.74% oxidation of the sulfur compounds in the simulated fuel. After the application of the optimized parameters to kerosene and employing a 4-cycle extraction using acetonitrile, 99% of the original sulfur content were removed from the kerosene using the UAOD optimized parameters. The desulfurization process resulted in a low-sulfur kerosene which retained its basic fuel properties such as density, viscosity and calorific value.

1 Introduction

Sulfur oxides (SO_x) and particulate matter (PM) are one of the criteria pollutants set by the United States Environmental Protection Agency that significantly contributes to air pollution. These are particularly emitted by processes utilizing raw materials such as crude oils and metal ores – in which sulfur is prevalent. Legislative efforts have been exerted by various countries and regions to prevent the addition of these criteria pollutants to the atmosphere. Developed countries such as Japan, USA, Canada and the European Union have set a 50 ppm sulfur (low-sulfur oil, Euro IV) limit for its petroleum products while Taiwan has implemented a 10 ppm sulfur limit (ultra-low sulfur oil, Euro V). The Philippines has recently implemented its Euro IV Standard in the mid-2016s.

Although efforts have been done to decrease the emission of sulfur pollutants, scientists and engineers have to continually develop the process they utilize to meet these standards because of thermal maturation – the natural increase in the sulfur concentration of crude oil obtained from sources [1]. Thus, the existing technologies for desulfurization needs to be intensified to be able to handle the increasing sulfur concentration of the crude oil as well as the increasingly stringent legislation against sulfur emissions.

Because of this, the currently applied industrial process of fuel desulfurization, which is hydrodesulfurization (HDS) is operated using extreme conditions – high temperatures and high pressures [2]. Also, the most common sulfur compounds in a fuel, which are dibenzothiophenes (DBT), benzothiophenes (BT), and thiophenes (T) – refractory compounds – were found to be less reactive to HDS [3]. It is for these reasons that HDS needs either an assistance or replacement and intensification.

Oxidative desulfurization (ODS) has gained interest in the recent years because of its potential to answer the concerns in HDS. For one, ODS can be accomplished using ambient conditions and without the use of the expensive hydrogen gas. The use of heteropolyacids (HPAs), particularly phosphotungstic acid, as catalysts in a hydrogen peroxide oxidizing system has proved to be effective (more than 99% efficient) in oxidizing the sulfur compounds [4]. Supporting this HPA can improve its catalytic activity by increasing the effective surface area and making it more economical because less HPW is utilized in the process and the catalyst may be recovered by simpler separation methods.

In this paper, the application of ultrasonication as assistance to ODS process – Ultrasound-Assisted Oxidative Desulfurization or UAOD – was investigated. Ultrasonic irradiation creates fine emulsions that

* Corresponding author: nathaniel.dugos@dlsu.edu.ph