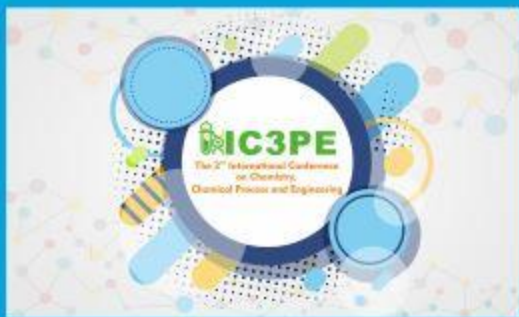


2nd International Conference on Chemistry, Chemical Process and Engineering (IC3PE)



Yogyakarta, Indonesia

14 August 2018

Editors

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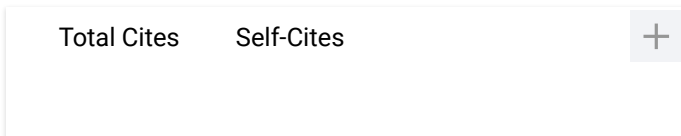
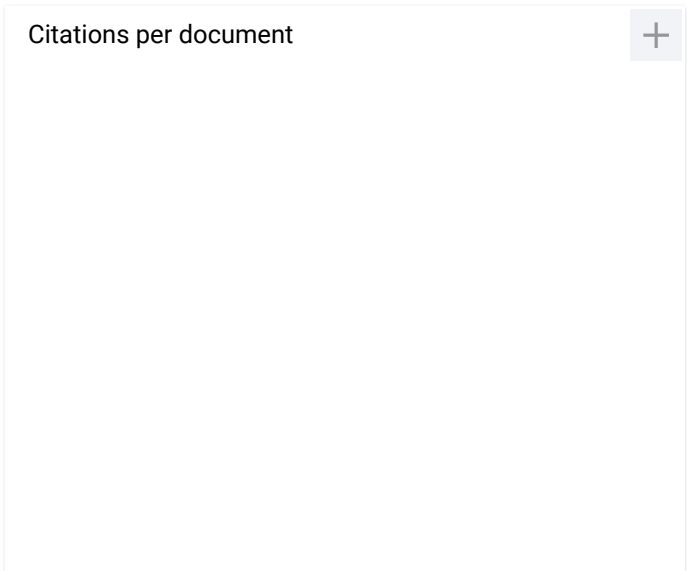
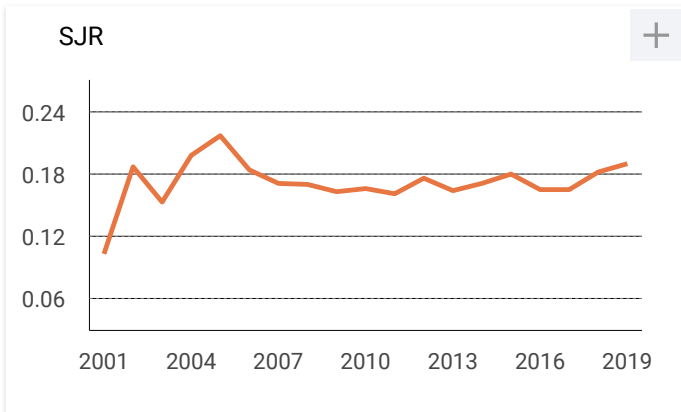


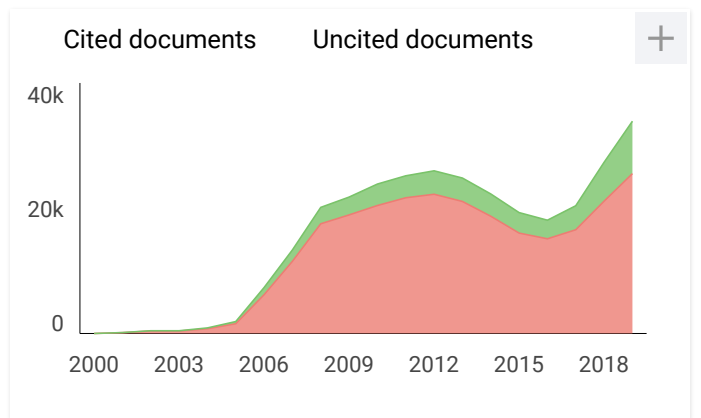
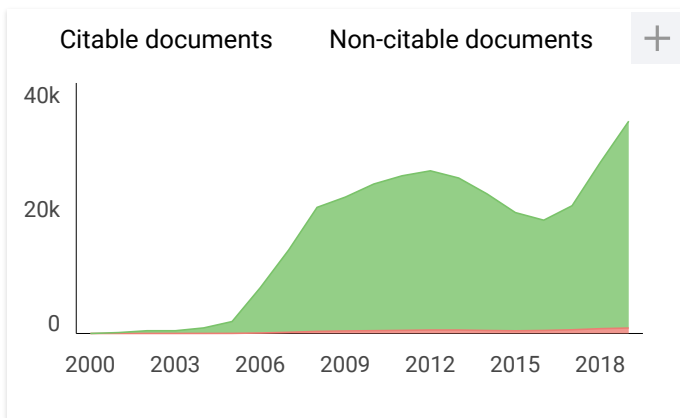
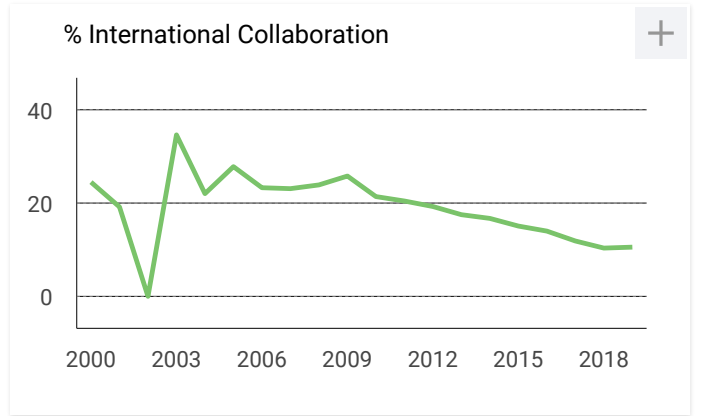
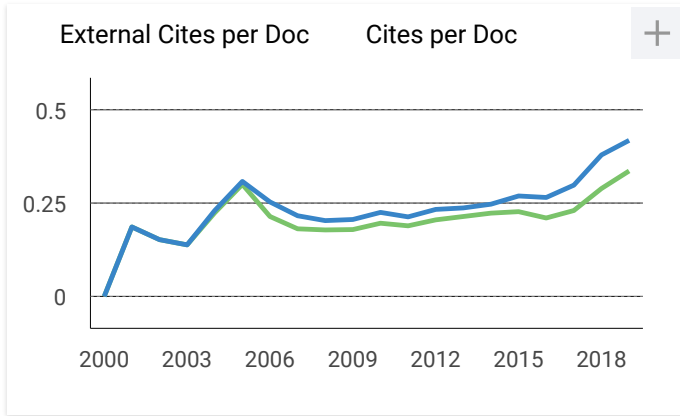
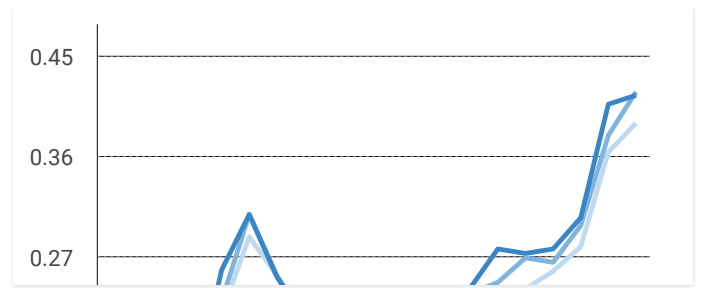
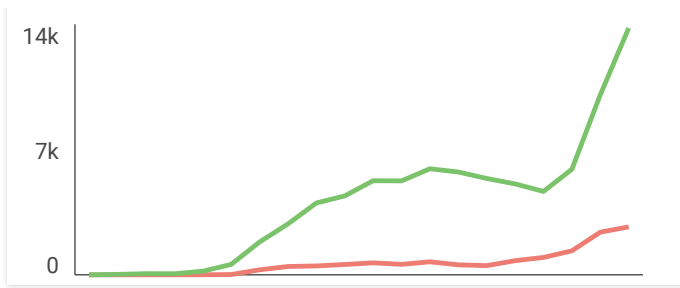
AIP Conference Proceedings

64

H Index

Country	United States - SIR Ranking of United States
Subject Area and Category	Physics and Astronomy Physics and Astronomy (miscellaneous)
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Preface: 2nd International Conference on Chemistry, Chemical Process and Engineering 2018

The 2nd International Conference on Chemistry, Chemical Process and Engineering 2018 was held on 14 August 2018 in Eastparch Hotel, Yogyakarta, Indonesia. The conference was part of biannually agenda of IC3PE conference, jointly-organized by Chemistry Department, Universitas Islam Indonesia in collaboration with Indonesian Chemical Society. Sustainable development and green technology are two of big issues in recent years, as part of our growing world; those issues are inseparable from chemistry, chemical processes and engineering. There are many fields of researches within the chemistry and chemical engineering as well as chemical education which contribute to the sustainable development for our society. In order to make issues bring positive impact for further step in developing knowledge and technology, sharing and discussion among scientists including researchers from academia, government, industries and private sectors are required. In order to facilitate them, Chemistry Department, Universitas Islam Indonesia and The Indonesian Chemical Society were very delighted to witness the conference of International Conference on Chemistry, Chemical Process and Engineering. Discussion on research, brainstorming ideas and very attractive initiation for further collaboration has been successfully conducted. In order to provide the output of those positive activities, this proceeding of the conference is presented with the hope that it will impact to the continual development of our society, nations and environment for brighter future.

On behalf of the Editorial Board and the committee of the event, we gratefully thank for all participants, keynote speakers and invited speakers.

Editor

Is Fatimah

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HOME

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Table of Contents

2ND INTERNATIONAL CONFERENCE ON CHEMISTRY, CHEMICAL PROCESS AND ENGINEERING (IC3PE)

< PREV NEXT >



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 No Access . October 2018


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Determination of order reaction on hydrolysis reaction of pineapple leaf

Muhaimin Muhaimin, Bayu Wiyantoko, Rahma Novia Putri and Rika Rusitasari

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Implementation of cooperative learning through collaboration with foreign lecturer to improve students' understanding and soft skills in the course of drug delivery system

Yandi Syukri and Bambang Hernawan Nugroho

AIP Conference Proceedings 2026, 020051 (2018); <https://doi.org/10.1063/1.5065011>

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Recrystallization of sodium chloride as the candidate of in-house reference material

Yuli Rohyami, Ade Irma Yuliani and Hezna Intan Firdiyanti

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A preliminary study on Ru/TiO₂ as heterogeneous catalyst for the depolymerization of empty fruit bunch-derived organosolv lignin

Nurita Sari, Adid Adep Dwiarmoko, Sudiyarmanto Sudiyarmanto, Nanda Saridewi, Fauzan Aulia and Nino Rinaldi

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Preparation of TiO₂ nanorods as a coating material on Pt electrode for electrodegradation of methyl orange

Ganjar Fadillah, Sayekti Wahyuningsih and Ari Handono Ramelan

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SHOW ABSTRACT



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Comparative analysis method of C-organic in fertilizers by gravimetry and spectrophotometry

Tri Esti Purbaningias, Nursi Biwi Qayyumah, Puji Kurniawati, Bayu Wiyantoko and Alfa Akustia Widati

AIP Conference Proceedings **2026**, 020055 (2018); <https://doi.org/10.1063/1.5065015>



No Access . October 2018

Implementation of laboratory-based active knowledge sharing

Beta Wulan Febriana, Widinda Normalia Arlianty, Artina Diniaty and Lina Fauzi'ah

AIP Conference Proceedings 2026, 020056 (2018); <https://doi.org/10.1063/1.5065016>

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Analysis of students learning style preference as initial steps in determining strategy of learning

Artina Diniaty, Lina Fauzi'ah, Beta Wulan Febriana and Widinda Normalia Arlianty

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Application of Taguchi optimization for nickel electrowinning using batch recycle methods

Sudiby Sudiby, A. Junaedi, M. Amin, A. S. Handoko, S. Sumardi, F. Nurjaman, B. B. Aji, Y. I. Supriyatna and L. Hermida

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Separating target components in corn (*Zea mays* var. *indentata*) hydrolyzed by *Rhizopus oligosporus* strain C₁ through ultrafiltration membrane for fortificant of natural folic acid

Aspiyanto Aspiyanto, Agustine Susilowati and Yati Maryati

AIP Conference Proceedings 2026, 020059 (2018); <https://doi.org/10.1063/1.5065019>

SHOW ABSTRACT



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Pattern analysis on staff of work accident handling using Chi-squared automatic interaction detection and log linear models

Jaka Nugraha

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Cyclization reaction of 4-nitro-3'-4'-dimethoxychalcone and phenylhydrazine as antibacterial candidate

Lina Fauzi'ah and Tutik Dwi Wahyuningsih

AIP Conference Proceedings 2026, 020061 (2018); <https://doi.org/10.1063/1.5065021>

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Utilization of bamboo leaves wastes for methylene blue dye adsorption

Kuntari Kuntari and Febi Indah Fajarwati

AIP Conference Proceedings 2026, 020062 (2018); <https://doi.org/10.1063/1.5065022>

SHOW ABSTRACT



 No Access . October 2018


Student profile in completing questions based on cognitive level of bloom's taxonomy by Anderson and Krathwohl

Widinda Normalia Arlianty, Beta Wulan Febriana, Artina Diniaty and Lina Fauzi'ah

AIP Conference Proceedings 2026, 020063 (2018); <https://doi.org/10.1063/1.5065023>

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 No Access . October 2018


Fermentation of pitaya (*Hylocereus polyrhizus*) juice by *L. acidophilus* in metabolism of sugars for cholesterol removal

Yati Maryati and Agustine Susilowati

AIP Conference Proceedings 2026, 020064 (2018); <https://doi.org/10.1063/1.5065024>

SHOW ABSTRACT



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Comparison of volumetric and FT-NIR method on iodine value of RBDPO and stearin


Duii Kurniawati, Cita Anggelina, Dadan Hamdani, Tri Esti Durbaningtias and Bayu

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AIP Conference Proceedings **2026**, 020065 (2018); <https://doi.org/10.1063/1.5065025>

SHOW ABSTRACT



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Determination of ash content in coal using in-house reference materials

Bayu Wiyantoko, Tri Esti Purbaningtias and Puji Kurniawati

AIP Conference Proceedings **2026**, 020066 (2018); <https://doi.org/10.1063/1.5065026>

SHOW ABSTRACT



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Characterization of solid product from bamboo waste (*Gigantochloa apus*) by hydrothermal treatment

Rizka Lestari, Agus Prasetya, Hary Sulistyono and Ahmad T. Yuliansyah

AIP Conference Proceedings **2026**, 020067 (2018); <https://doi.org/10.1063/1.5065027>

SHOW ABSTRACT



 No Access . October 2018

High-yield co-solvent free electrochemical production of biodiesel from waste cooking oil using waste concrete as heterogeneous catalyst


Wiyogo P. Wicaksono, Ardhika L. Marcharis, Yerika P. Sari, Putwi W. Citradewi and Grandprix T. M. Kadja

AIP Conference Proceedings **2026**, 020068 (2018); <https://doi.org/10.1063/1.5065028>

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Potential identification of landfill mining result in zone 1 Piyungan landfill using composition analysis, waste characteristic analysis and soil stability analysis

Sheilla Nandya Parimita, Fatimah Nurul Tzaty, Hijrah Purnama, Arif Hidayat, Baskoro Lokahita and Fumitake Takahashi

AIP Conference Proceedings **2026**, 020069 (2018); <https://doi.org/10.1063/1.5065029>

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The influence of papain concentration on deacetyllation degree of chitin

Yuli Rohyami, Reni Banowati Istiningrum and Ifa Puspasari

AIP Conference Proceedings **2026**, 020070 (2018); <https://doi.org/10.1063/1.5065030>

SHOW ABSTRACT



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The effect of bromo chalcone [1-(4'-bromophenyl)-3-(4-hydroxy-3-methoxyphenyl)-2-propene-1-on] on T47D breast cancer cells

Retno Arianingrum and Indyah Sulistyo Arty

AIP Conference Proceedings **2026**, 020071 (2018); <https://doi.org/10.1063/1.5065031>

SHOW ABSTRACT



 No Access . October 2018


Hydroxyapatite prepared from snail (*Pilla ampulacea*) and scallop (*Anadara granosa*) shells as low cost-renewable catalyst in biodiesel conversion

Is Fatimah, Rico Nurillahi, Della Fahrani, Tia Harmawantika, Greef Rose Aulia and Wellyana Puspitasari

AIP Conference Proceedings **2026**, 020072 (2018); <https://doi.org/10.1063/1.5065032>

SHOW ABSTRACT



 No Access . October 2018


Project-based learning in chemical cosmetics course

Widinda Normalia Arlianty

AIP Conference Proceedings **2026**, 020073 (2018); <https://doi.org/10.1063/1.5065033>

SHOW ABSTRACT



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Essential oils from rhizomes of five Zingiberaceae species in Meru Betiri National Park

Ika Oktavianawati, Hani Indah Kurniati, Khozinatul Maghfiroh, Nadhirotul Hanifah, Wuryanti Handayani and I. Nyoman Adi Winata

AIP Conference Proceedings **2026**, 020074 (2018); <https://doi.org/10.1063/1.5065034>

SHOW ABSTRACT





No Access . October 2018

The Cu-doped cryptomelane-type octahedral molecular sieve manganese oxide synthesized by sol-gel for the degradation of methylene blue

Amir Awaluddin, Lia Astuti, Amilia Linggawati, Siti Saidah Siregar, Prasetya Prasetya and Leo Saputra

AIP Conference Proceedings **2026**, 020075 (2018); <https://doi.org/10.1063/1.5065035>

SHOW ABSTRACT



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Preparation and characterization of gold nanoparticles Lamtoro extract (*Leucaena leucocephala* (Lam.) de Wit) with eco-friendly biosynthesis process

Bambang Hernawan Nugroho, Suparmi Suparmi and Muhammad Rizal Syifaudin

AIP Conference Proceedings **2026**, 020076 (2018); <https://doi.org/10.1063/1.5065036>

SHOW ABSTRACT



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Superhydrophobic coatings and self-cleaning through the use of geothermal scaling silica in improvement of material resistance

Ari Purnomo, Febio Dalanta, Adelia Dian Oktaviani and Silviana Silviana

AIP Conference Proceedings **2026**, 020077 (2018); <https://doi.org/10.1063/1.5065037>

SHOW ABSTRACT





No Access . October 2018

Extraction of yttrium from yttrium concentrate (YPO₄) using aliquat 336 (tryoctylmethylammonium chloride)

Mila Tria Nita, Tri Handini and Nurcahyo Iman Prakoso

AIP Conference Proceedings 2026, 020078 (2018); <https://doi.org/10.1063/1.5065038>

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Modified student teams-achievement divisions (STAD) with case-based learning to improve the quality of respiratory and gastrointestinal pharmacotherapy course

Chynthia Pradiftha Sari

AIP Conference Proceedings 2026, 020079 (2018); <https://doi.org/10.1063/1.5065039>

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Heavy metals (Fe and Cd) adsorption by natural zeolite from laboratory liquid waste of Institut Pertanian (INTAN)

Yogyakarta

Nia Silvia Sukma and Muhammad Arsyik Kurniawan

AIP Conference Proceedings 2026, 020080 (2018); <https://doi.org/10.1063/1.5065040>

SHOW ABSTRACT




Mechanical properties of bioplastic from jackfruit seed (*Artocarpus heterophyllus*) plasticized by 1.4-butanediol and polyethylene glycol (PEG) 1000

Argo Khoirul Anas, Nanang Rudianto Ariefta, Yuni Nurfiana and Eli Rohaeti

AIP Conference Proceedings 2026, 020081 (2018); <https://doi.org/10.1063/1.5065041>

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Validation method on sulfate determination of mortar sample from Mendut temple

Thorikul Huda, Destiana Murtiyani, Iskandar Mulia Siregar and Nahar Cahyandaru

AIP Conference Proceedings 2026, 020082 (2018); <https://doi.org/10.1063/1.5065042>

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Effect of hydrogen peroxide on edible film from cassava starch

Dewi Sondari and Imad Iltizam

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Isolation and identification of probiotics bacteria as a producer of protease enzyme from fermentation of papaya

Habibi Hidayat, Muhammad A. Auliya and Revita Anggreyani

AIP Conference Proceedings 2026, 020084 (2018); <https://doi.org/10.1063/1.5065044>

SHOW ABSTRACT



 No Access . October 2018


Preparation and characterization of cao catalyst - polyethersulfone (PES) membrane for biodiesel production and purification

Misbahudin Alhanif, Ari Purnomo, Ummi Az Zuhra and Andri Cahyo Kumoro

AIP Conference Proceedings 2026, 020085 (2018); <https://doi.org/10.1063/1.5065045>

SHOW ABSTRACT



 No Access . October 2018


Effect of slurry level error in flotation area against concentrate in process department Pt. Amman Mineral Nusa Tenggara

Tuti Purwaningsih and Johan Saputra

AIP Conference Proceedings 2026, 020086 (2018); <https://doi.org/10.1063/1.5065046>

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Cervical cancer model in Indonesia using geographically weighted regression (GWR)


Tuti Purwaningsih and Karina Noraprilia

AIP Conference Proceedings 2026, 020087 (2018); <https://doi.org/10.1063/1.5065047>

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Composites films conductivity of polyvinyl alcohol/graphene oxide with electrical properties

Muhammad Arsyik Kurniawan, Nadjib Mubarog, Sulis Nuke T., Yanti Apriani and M. Saleh Zamzamie

AIP Conference Proceedings **2026**, 020088 (2018); <https://doi.org/10.1063/1.5065048>

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Physicochemical character of nanoencapsulated *Kencur* (*Kaempferia galanga L.*) dreg extracts

Amri Setyawati, Nadha Yuliningtyas, Aulia Asyura Zamar and Muhammad Shaleh Zamzamie

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Problem based learning (PBL) method as a synchronization approach of chromatography course and chromatography laboratory work

Dwiarso Rubiyanto, Mai Anugrahwati and Nurcahyo Iman Prakoso

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Interaction study between 3,4,5-trihydroxy benzoic acid-modified Mg/Al-hydrotalcite with Au ions on the adsorption process of AuCl_4^-

Ika Yanti, Sri Juari Santosa and Indriana Kartini

AIP Conference Proceedings **2026**, 020091 (2018); <https://doi.org/10.1063/1.5065051>

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The effect of material electrode for removal of COD and ammonia in hospital liquid waste water using batch electrolysis

Riyanto Riyanto, Wardani Suryaningrum, Asjeni Putri, Putri Apriliani Suhartyna, Indah Setia Ningrum, Herliyana Herliyana, Meyta Zahrahayanti and Riasari Ayu Nurfatimah

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SHOW ABSTRACT




 No Access . October 2018

The properties of alginate/zeolite composite for Fe(III), Zn(II), and Fe-Zn storage

Muhammad Arsyik Kurniawan, Nia Silvia Sukma, Indah Rohmah W. and Dela Anggraini

AIP Conference Proceedings **2026**, 020093 (2018); <https://doi.org/10.1063/1.5065053>

 No Access . October 2018


Synthesis and characterization of composite of Al_2O_3 /activated carbon from palm oil shell by hydrothermal method

Allwar Allwar and Meidita Kemala Sari

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Impact of early clinical exposure on learning achievement of pharmacy students

Yosi Febrianti

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Project based learning model integrated with lesson study to increase student's learning outcome on buffer solution topic

Retno Dwi Suyanti and Yovy Ardianti Sinuraya

AIP Conference Proceedings **2026**, 020096 (2018); <https://doi.org/10.1063/1.5065056>

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Validation method of cis and trans fatty acids determination in vegetable oils using gas chromatography for food products

Yus Maria Novelina and Sumi Hudiyono

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Removal of Ni (II) and Cu (II) ions from aqueous solution using rambutan fruit peels (*Nephelium lappaceum L.*) as adsorbent

Rinaldi Rinaldi, Yasdi Yasdi and Winny Laura Christina Hutagalung

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Application of Taguchi Optimization for Nickel Electrowinning Using Batch Recycle Methods

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Abstract. Low-grade laterite which has nickel content 0.5% has been processed using solvent extraction and followed by electrowinning process. Cyanex which diluted in toluene was used as an organic solvent to separated cobalt from nickel solvent. In this work, nickel solvent which frees from cobalt was processed using electrowinning. Electrowinning was conducted using batch recycle methods to ensure the electrowinning performed well. Meanwhile, cylindrical cathode electrode was used to increase the performance of electrowinning, easy to operate and easy to harvest. The parameters which have a significant effect in batch recycle methods such as flow rate, voltage and process duration. Taguchi analysis showed the optimum condition and the parameter which has the highest effect towards the mass of nickel electrodeposits.

INTRODUCTION

Low-grade laterite which contains nickel less than 0.5% is very difficult to process using pyrometallurgy. Solvent extraction has become the methods chosen for the separation of cobalt and nickel from low-grade laterite [1–5]. At the end of the solvent extraction process, the nickel should separate from acid solution. One of the methods which able to take a nickel from solution is electrowinning. This method is more effective than other methods take positive electroactive ions such nickel ions [6–8]. In this work, electrowinning was conducted using batch recycle methods, hence able to treat the solvent optimally. The cylinder electrode type as a cathode was chosen in batch recycle electrowinning process because low operational cost, friendly for the environment, easy to install, design is compatible, it can be operated in large-scale process, acid electrolyte can be recycle, it can produce high purity of metal and it can be operated in low concentration of metal solution [6].

Cyanex in toluene was chosen in the solvent extraction process prior to the electrowinning. Cyanex good performance to separate cobalt from nickel solution [1–5]. Hence, higher purity of nickel able to recover using electrowinning. The batch recycle method was used in the nickel electrowinning to increase the nickel recovery. In this batch recycle methods, the electrolyte enters from the bottom of electrowinning cell using a pump, then the effluent of the electrolyte at top of electrowinning cell flowed back to electrolyte tank as shown in Fig. 1. This batch recycle method was conducted for certain duration of time to ensure the electrowinning was performed well.

In this research, parameters which affected the nickel electrodeposits amount at cathode were studied and optimized using Taguchi method. The parameters which studied in this research such as the flow rate, the process duration, and the voltage. Taguchi is one of the designs of an experiment which use few numbers of experiments to analyze the effect of each parameter towards the performance of the process and also to optimize the parameters simultaneously [9,10].

EXPERIMENTAL PROCEDURE

In this research, laterite from south-east Sulawesi (from Integra Mining Co. Ltd) was sieved using a sieve tray (mesh 150). Leaching process was conducted using vat leaching (atmospheric pressure) to leach 700 gram of laterite in 7 liters 1 M H₂SO₄ (from Sigma Aldrich Co. ltd.). Leaching process was ended until cobalt present in leaching solvent. Then the leaching solvent was filtered using filter press. This leaching solvent was extracted using Cyanex 272 (10% v/v) in toluene (70%) and the comparison of the organic/aqueous volume was ³/₄. Aqueous solvent of extraction process was processed using electrowinning. In this research, electrowinning process was operated using batch recycle methods, meanwhile, the cathode was aluminum cylindrical electrode as shown in Fig. 1. The direct current (DC) power supply was used in this study. In this method, the electrolyte was pumped from the bottom electrowinning reactor and the outlet electrolyte was recycled from the top of electrowinning reactor. In this work, the voltage from DC power supply was monitored using a potentiometer. The parameters were optimized using Taguchi methods such as flow rate, operation duration, and voltage as shown in Table 2.

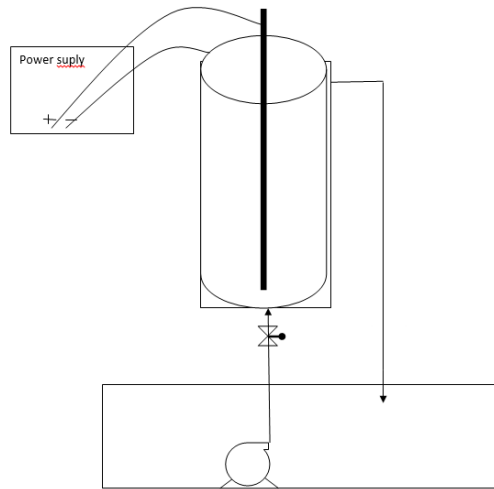


FIGURE 1. Batch recycling electrowinning scheme

TABLE 1. Design of experiment using Taguchi method

Run	Flowrate (Litre/minute)	Process Duration (Hour)	Voltage (V)
1	0,5	2	2
2	1	3	2
3	1,5	4	2
4	1	2	3
5	1,5	3	3
6	0,5	4	3
7	1,5	2	4
8	0,5	3	4
9	1	4	4

TABLE 2. The result of an experiment using Taguchi method

Run	Electrodeposit weight (gr)	Ni composition (%)	Ni (mg)
1	8	2.16	172.8
2	0.5	0.8	4
3	2	2.02	40.4
4	1	1.52	15.2
5	17.41	2.95	513.6
6	2	2.02	40.4
7	1	7.15	71.5
8	4	4.69	187.6
9	15	14.59	2188.5

RESULTS AND DISCUSSION

Analysis of Experimental Design

An orthogonal array was used to discover the optimal condition and to choose the parameters that have the biggest effect on the nickel electrodeposit. 9 runs were conducted in order to optimize the parameters used as shown in Table 1. The results of electrowinning experiments were electrodeposited in the cathode electrode. The total mass of electrodeposits was calculated from a weight of cathode after electrowinning minus the weight before electrowinning. Meanwhile, Nickel concentration was calculated using XRF. Hence, total nickel mass on electrodeposits can be determined as listed in Table 2.

The experiment results were analyzed using the signal/noise (S/N) ratio of larger the better which calculated using following equation:

$$S/N = -10 \cdot \log(\Sigma(1/Y^2)/n) \quad (1)$$

where Y = responses for the given factor level combination and n = number of responses in the factor level combination [9]. The value of S/N ratios were listed in Table 3. A delta value was the highest S/N ratio value minus the lowest S/N ratio value in the same parameter. The highest value of delta indicate the most significant parameters towards the mass of nickel electrodeposits. The table shows that the most significant parameter is the flow rate followed by the process duration and the last is the voltage.

TABLE 3. Data Response Tabel Signal to Noise Ratios Larger is better

Level	flowrate	Process Duration	Voltage
1	29.6399	35.158	40.7811
2	36.659	37.2394	34.1603
3	49.7846	43.6861	41.1421
Delta	20.1447	8.5281	6.9817
Rank	1	2	3

The Effect of Flow Rate towards the Mass of Nickel Electrodeposits (% Ni)

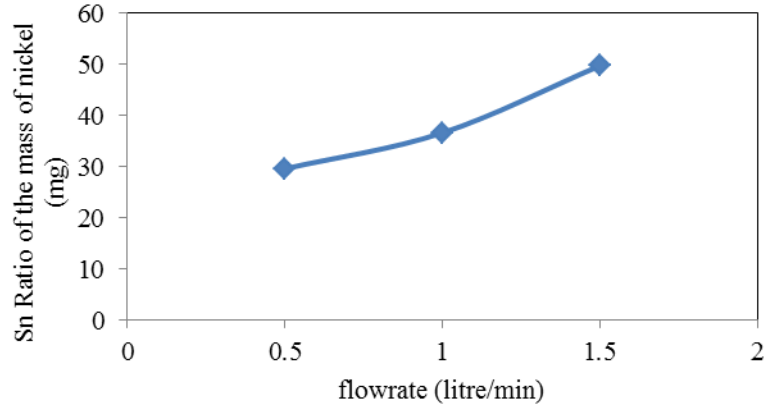


FIGURE 2. The effect of the flow rate towards the SN ratio of the mass of nickel electrodeposits (% Ni)

Electrowinning using cylindrical electrode able to process a large volume of electrolyte since electrolyte was pumped into the electrochemical reactor from electrolyte vessel. The electrolyte inlet was from the bottom of the electrochemical reactor. In this work, the volume of electrolyte is 2 liter, meanwhile, the electrochemical capacity was 1 liter as shown in Fig. 1. In order to know the effect of electrolyte flow rate towards the mass of nickel electrodeposits, the electrolyte flow rate was varied from 0.5 to 1.5 liter as shown in Fig. 2. The Figure shows that the increase in flow rate will increase the mass of nickel electrodeposits. In the batch recycle methods, increasing of flowrate will increase the volume of electrolyte which through the electrochemical reactor, hence it will increase the contact of the electroactive ions inside the electrolyte with the electrically charged electrode [11]. The positive electroactive ions as like nickel will be deposited into the negative electrode (cathode) [7–9]. This cathode was the cylindrical electrode which the electrolyte has flowed between the cathode and anode. The S/N ratio analysis was determined that the optimum flow rate was at 1.5 liters/minute as shown in Fig. 2.

The Effect of Operation Duration towards the Mass of Nickel Electrodeposits (% Ni)

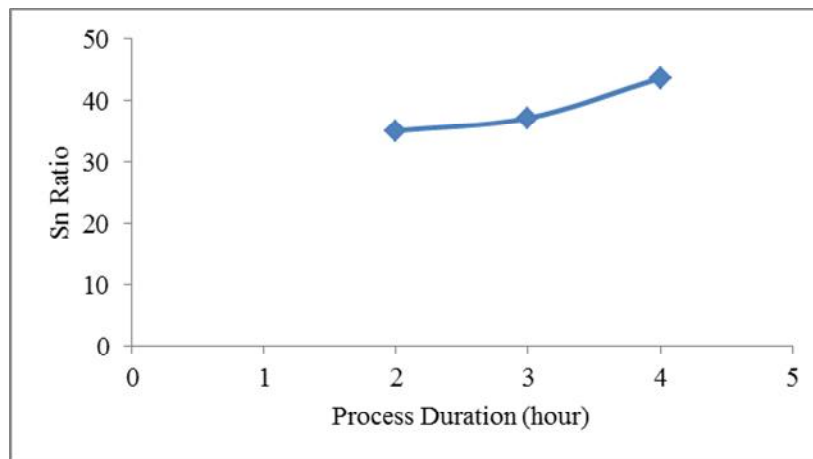


FIGURE 3. The effect of the process duration towards the SN ratio of the mass of nickel electrodeposits (% Ni)

In order to study the effect of process duration towards the mass of nickel electrodeposits (% Ni), the process duration was varied from 2 until 4 hours as shown in Fig. 3. The figure shows that the increase of process duration will enhance the mass of nickel electrodeposits. The increasing of process duration will increase the volume of electrolyte which flows in the electrochemical reactor. This will increase the contact between the electroactive ions inside the electrolyte with the electrode⁷. Hence, the number of nickel ions electrodeposits at the cathode increased. The Taguchi analysis result confirms that the optimum process duration is at 4 hours as shown in Fig. 3.

The Effect of Voltage towards the Mass of Nickel Electrodeposits (% Ni)

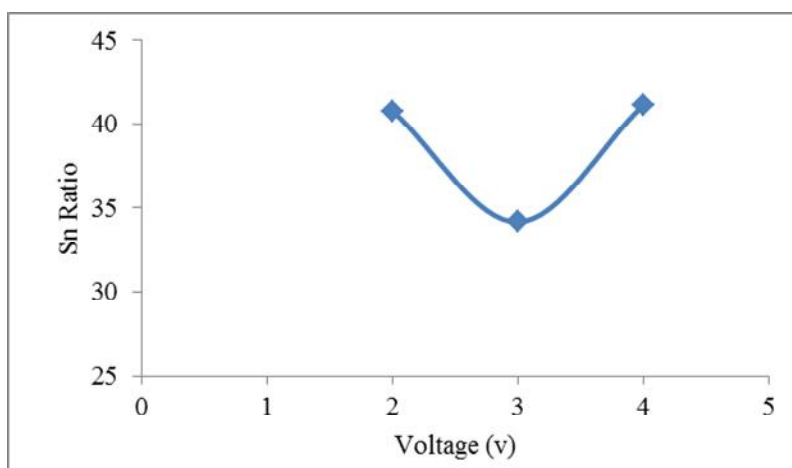


FIGURE 4. The effect of the voltage towards the SN ratio of the mass of nickel electrodeposits (% Ni)

In order to identify the effect of voltage towards the mass of nickel electrodeposits (% Ni), the voltage was varied from 2 to 4 volt as shown in Fig. 4. The figure shows that the increase in voltage will increase the mass of nickel electrodeposits (% Ni). The increasing of voltage will increase the mass transport of ions from anode to cathode. Hence, it will increase the electroactive ions in the electrolyte which be deposited at the cathode [7]. However, the mass of nickel electrodeposited at 3 V was decreased from 2 V. Since at that voltage, the hydrogen evolution reactions were dominant, hence it will disturb the deposition process of electroactive ions at the cathode [8,9]. The Fig. 4 also shows that the optimum voltage is at 4 V.

CONCLUSION

Nickel electrowinning from low-grade laterite has been conducted using the cylindrical cathode electrode which operated using batch recycle methods. Optimum condition of this process has been determined using Taguchi methods. The Taguchi analysis methods show that the optimum conditions are at 1.5 liters/minute of flow rate, 4 hours of process duration and 4 voltage. The Taguchi analysis also shows the first, second, third and fourth ranks of a parameter which affects the mass of nickel electrodeposits are flowrate, process duration, and voltage, respectively.

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