



## Jurnal Kimia Valensi

**Jurnal Kimia Valensi** is a double blind peer-reviewed and open access journal published by Department of Chemistry, Faculty of Science and Technology Syarif Hidayatullah Jakarta State Islamic University. This journal focuses on chemical research, particularly research related to the use of Indonesia's natural resources in the development of nanomaterials, pharmaceutical and food industries. We welcome articles coming from Indonesia and overseas, capturing the rapid development of chemistry, including:

- Theoretical and computational chemistry
- Environmental chemistry
- Material, composite dan polymer chemistry
- Organic synthesis and natural product chemistry
- Food and medical chemistry
- Biochemistry, and
- Analytical chemistry

**Jurnal Kimia VALENSI** has become a **CrossRef Member** since May 2015. Therefore, all articles published by Jurnal Kimia VALENSI will have unique DOI number.

Jurnal Kimia VALENSI was **accredited by Ministry of Research, Technology, and Higher Education Republic of Indonesia: SK Dirjen Dikti No. 51/E/KPT/2017**. Jurnal kimia valensi is a biannual journal published on May and November. Jurnal Kimia Valensi accept articles written in Bahasa Indonesia and English (preferable). Although we accept the manuscript in Indonesian, however we encourage the authors to write manuscripts in English.

## Jurnal Kimia Valensi

**Country of Publication:** Indonesia

**Publisher:** Department of Chemistry, Faculty of Science and Technology Syarif Hidayatullah Jakarta State Islamic University

**Partnership:** Himpunan Kimia Indonesia | **Format:** Print & Online

**ISSN:** P-ISSN: 2460-6065; E-ISSN: 2548-3013 | DOI: 10.15408/jkv

Jurnal Kimia Valensi had accredited by Ministry of Research, Technology and Higher Education Republic of Indonesia **SINTA 2 (a nationally-accredited journal)**

**Frequency:** Biannual | **Publication Dates:** May & November | **Advance Access:** Yes

**Scope:** Theoretical and computation chemistry, Environmental chemistry, Material, composite dan polymer chemistry, Organic synthesis and natural product chemistry, Food and medical chemistry, Biochemistry, Analytical chemistry.

**Article Processing Charges:** Yes | **Types of Journal:** Academic/Scholarly Journals | **Open Access:** Yes

**Indexed & Abstracted:** Yes | **Policy:** [Peer-reviewed](#) | **ReviewTime:** Eight Weeks Approximately

**Licensed under:** CC-BY-SA | **Contact & Submission e-mail:** kimia@uinjkt.ac.id

**Alternate e-mail:** hermantokimia@uinjkt.ac.id; tarso.rudiana@uinjkt.ac.id

Home (<https://journal.uinjkt.ac.id/index.php/valensi/index>) / About the Journal

(<https://journal.uinjkt.ac.id/index.php/valensi/about>) / Editorial Team

(<https://journal.uinjkt.ac.id/index.php/valensi/about/editorialTeam>)

## Editorial Team

### Editor in Chief

---

- Dr. Sandra Hermanto, (SCOPUS ID: 57194427604) Department of Chemistry Faculty of Science and Technology UIN Syarif Hidayatullah Jakarta, Indonesia

### Associate Editor

---

- Prof. Dr. Unang Supratman, Department of Chemistry Faculty of Mathematics and Natural Sciences Universitas Padjadjaran, Indonesia
- Prof. Dr. Irmanida Batubara, Department of Chemistry Faculty of Mathematics and Natural Sciences IPB University, Indonesia
- Rani Maharani Ph.D, Departemen Kimia Fakultas Matematika dan Ilmu Pengetahuan Alam Universitas Padjadjaran, Indonesia
- Fitri Khoerunnisa, Ph.D, Department of Chemistry Faculty of Mathematic and Natural Sciences Indonesia University of Education, Indonesia
- Dr. Soja Siti Fatimah, Department of Chemistry Faculty Mathematic and Natural Sciences Universitas Pendidikan Indonesia, Indonesia
- Dr. Hendrawati Hendrawati, Program Studi Kimia Fakultas Sains dan Teknologi Universitas Islam Negeri Syarif Hidayatullah Jakarta, Indonesia
- Dr. Sri Yadi Chalid, Program Studi Kimia Fakultas Sains dan Teknologi Universitas Islam Negeri Syarif Hidayatullah Jakarta, Indonesia
- Dr. La Ode Sumarlin, Program Studi Kimia Fakultas Sains dan Teknologi UIN Syarif Hidayatullah Jakarta, Indonesia

### Advisory Editorial Board

---

- Prof. Dr. Hadi Nur, (SCOPUS ID: 6602169746; h-index: 23) Ibnu Sina Institute for Scientific and Industrial Research, Universiti Teknologi Malaysia, 81310 UTM Skudai, Johor, Malaysia, Malaysia, Malaysia

- Prof. Dr. Yoshihito Shiono, (SCOPUS ID: 56682677900; h-index: 16) Faculty of Agriculture Yamagata University Japan, Japan
- Prof. Dr. rer.nat Nuryono MS, (SCOPUS ID: 20635404100; h-index: 9) Jurusan Kimia Fakultas Matematika dan Ilmu Pengetahuan Alam Universitas Gadjah Mada, Indonesia
- Prof. Dr. Taghreed Hashim Al-Noor, Ibn-Al-Haitham Education College /University of Baghdad, Iraq, Iraq
- Prof. Dr. Yahya Güzel, (SCOPUS ID: 56919842500, h-index: 8) Department of Chemistry, Faculty of Science, Erciyes University, Turkey, Turkey
- Prof. Dr. Mostafa Barigou, (SCOPUS ID: 7003356054; h-index : 25) School of Chemical Engineering, University of Birmingham; Edgbaston, Birmingham B15 2TT, United Kingdom, United Kingdom
- Prof. Dr. Didik Prasetyoko, (SCOPUS ID: 6507890461; h-index: 10) Departemen Kimia Fakultas Matematika dan Ilmu Pengetahuan Alam Institut Teknologi Sepuluh Nopember, Indonesia
- Prof. Dr. Taslim Ersam, (SCOPUS ID: 6503957222; h-index: 7) Department of Chemistry Faculty of Mathematics and Natural Sciences Institut Teknologi Sepuluh Nopember, Indonesia
- Dr. Mohamad Nurul Azmi, (SCOPUS ID: 36672506900; h-index: 8) Pusat Pengajian Sains Kimia Universiti Sains Malaysia, Malaysia
- Dr. Winifred U Anake, (SCOPUS ID: 35219535800; h-index : 5) Department of Chemistry, College of Science and Technology, Covenant University, P.M.B 1023, Ota Ogun State, Nigeria., Nigeria
- Dr. Tutik Dwi Wahyuningsih, (SCOPUS ID: 8898697300; h-index: 5) Departemen Kimia FMIPA Universitas Gadjah Mada, Indonesia
- Dr.rer.nat Arli Aditya Parikesit, Institut Bio Scientia Internasional, Indonesia
- Ambara Rachmat Pradipta, Ph.D, (SCOPUS ID: 36185578800; h-index: 11) Biofunctional Synthetic Chemistry Laboratory RIKEN, Japan

## Assistant Editor

---

- Tarso Rudiana, Department of Chemistry Faculty of Science and Technology UIN Syarif Hidayatullah Jakarta, Indonesia
- Isalmi Aziz, Program Studi Kimia Fakultas Sains dan Teknologi Universitas Islam Negeri Syarif Hidayatullah Jakarta, Indonesia
- Ahmad Fathoni, Department of Chemistry Faculty of Science and Technology UIN Syarif Hidayatullah Jakarta, Indonesia
- Agus Rimus Liandi, Department of Chemistry Faculty of Science and Technology UIN Syarif Hidayatullah Jakarta

## Administration Support

---

- Nurhasni Nurhasni, (SCOPUS ID: 57189211265; h-index: 1) Program Studi Kimia Fakultas Sains dan Teknologi Universitas Islam Negeri Syarif Hidayatullah Jakarta, Indonesia
- Adawiah Adawiah, Program Studi Kimia Fakultas sains dan teknologi Universitas Islam Negeri Syarif Hidayatullah Jakarta, Indonesia

Editorial Team (/index.php/valensi/about/editorialTeam)

Reviewers (/index.php/valensi/pages/view/Reviewers)

Author Guidelines (/index.php/valensi/about/submissions#authorGuidelines)

Focus and Scope (/index.php/valensi/about/editorialPolicies#focusAndScope)

Publication Ethics (/index.php/valensi/pages/view/Publication%20Ethic)

Online Submissions (/index.php/valensi/about/submissions#onlineSubmissions)

Author Fees (/index.php/valensi/about/editorialPolicies#custom-1)

Plagiarism Policy (/index.php/valensi/about/editorialPolicies#custom-2)


Copyright Notice (/index.php/valensi/about/submissions#copyrightNotice)

Peer Review Proces (/index.php/valensi/about/editorialPolicies#peerReviewProcess)

Retraction (/index.php/valensi/about/editorialPolicies#custom-3)

Indexing (/index.php/valensi/pages/view/Indexing%20and%20Abstracting)

Scopus Citation Analysis (<https://drive.google.com/file/d/1aHknmF22S0eyebIIIs9FZgMcAiChqTUs/view?usp=sharing>)

 (https://drive.google.com/file/d/18sZ480GuZu2syYqK1l4Bnp6o\_fz\_WAcu/view?usp=sharing)

Grammar Check & plagiarism checker

 **grammarly** (<https://app.grammarly.com/>)

 (<https://www.turnitin.com>)

 (<https://plagiarismcheckerx.com/>)

Reference Manager

**zotero** (<https://www.zotero.org/>)

 (<https://www.mendeley.com/>)  
MENDELEY

User

---

Username

Password

☐ Remember me

Login



(<http://info.flagcounter.com/cDrF>)

**00582172** (<https://www.statcounter.com/>)

View My Stats (<http://statcounter.com/p11917097/?guest=1>)

Supported By:



(<https://www.hki.or.id/>)



(<http://creativecommons.org/licenses/by-sa/4.0/>)

This work is licensed under a **CC-BY-SA** (<https://creativecommons.org/licenses/by-sa/3.0/>)

## Journal Content

---

### Search

### Search Scope

All

Search

### Browse

By Issue (<https://journal.uinjkt.ac.id/index.php/valensi/issue/archive>)

By Author (<https://journal.uinjkt.ac.id/index.php/valensi/search/authors>)

By Title (<https://journal.uinjkt.ac.id/index.php/valensi/search/titles>)

Other Journals (<https://journal.uinjkt.ac.id/index.php/index>)

Categories (<https://journal.uinjkt.ac.id/index.php/index/search/categories>)

## Policies

---

### Focus and Scope

(<https://journal.uinjkt.ac.id/index.php/valensi/about/editorialPolicies#focusAndScope>)

Section Policies (<https://journal.uinjkt.ac.id/index.php/valensi/about/editorialPolicies#sectionPolicies>)

### Peer Review Process

(<https://journal.uinjkt.ac.id/index.php/valensi/about/editorialPolicies#peerReviewProcess>)

### Publication Frequency

(<https://journal.uinjkt.ac.id/index.php/valensi/about/editorialPolicies#publicationFrequency>)

### Open Access Policy

(<https://journal.uinjkt.ac.id/index.php/valensi/about/editorialPolicies#openAccessPolicy>)

## Submissions

---

### Online Submissions

(<https://journal.uinjkt.ac.id/index.php/valensi/about/submissions#onlineSubmissions>)

### Author Guidelines

(<https://journal.uinjkt.ac.id/index.php/valensi/about/submissions#authorGuidelines>)

Copyright Notice (<https://journal.uinjkt.ac.id/index.php/valensi/about/submissions#copyrightNotice>)

### Privacy Statement

(<https://journal.uinjkt.ac.id/index.php/valensi/about/submissions#privacyStatement>)

## Other

---

Journal Sponsorship (<https://journal.uinjkt.ac.id/index.php/valensi/about/journalSponsorship>)

Journal History (<https://journal.uinjkt.ac.id/index.php/valensi/about/history>)

Site Map (<https://journal.uinjkt.ac.id/index.php/valensi/about/siteMap>)

### About this Publishing System

(<https://journal.uinjkt.ac.id/index.php/valensi/about/aboutThisPublishingSystem>)

## Share

---

 Tweet

 Share 0

ISSN: 2548-3013

Publisher Department of Chemistry, Faculty of Science and Technology, Syarif Hidayatullah Jakarta State Islamic University,

.Jl. Ir. H. Juanda No. 95, Ciputat, Jakarta 15412, Indonesia, Telp. 021-7492855, Fax. 021-7493351, website: [http://journal.uinjkt.ac.id/index.php/valensi \(/index.php/valensi\)](http://journal.uinjkt.ac.id/index.php/valensi (/index.php/valensi)), e-mail: [kimia@uinjkt.ac.id](mailto:kimia@uinjkt.ac.id) (<mailto:kimia@uinjkt.ac.id>)

**00582173** (<https://www.statcounter.com/>)

View My Stats (<http://statcounter.com/p11917097/?guest=1>)

Managed Hosting, Support, and OJS Responsive Theme by: [OpenJournalSystems.com](http://openjournalssystem.com)  
(<http://openjournalssystem.com>)





# JURNAL KIMIA VALENSI

e-ISSN: 2548-3013  
p-ISSN: 2460-6065

Home (<https://journal.uinjkt.ac.id/index.php/valensi/index>) / Archives

(<https://journal.uinjkt.ac.id/index.php/valensi/issue/archive>) / Jurnal Kimia VALENSI Volume 6, No. 1,  
May 2020 (<https://journal.uinjkt.ac.id/index.php/valensi/issue/view/1040>)

## Jurnal Kimia VALENSI Volume 6, No. 1, May 2020

The Starting Material Concentration Dependence of Ag<sub>3</sub>PO<sub>4</sub> Synthesis for Rhodamine B Photodegradation  
under Visible Light Irradiation (<https://journal.uinjkt.ac.id/index.php/valensi/article/view/14837>)

Febiyanto Febiyanto, Uyi Sulaeman

PDF (<https://journal.uinjkt.ac.id/index.php/valensi/article/view/14837/pdf>) | 1-9

Characteristics of Glucose Oxidase Gene (GGOx) from *Aspergillus niger* IPBCC 08.610

(<https://journal.uinjkt.ac.id/index.php/valensi/article/view/9440>)

Popi Asri Kurniatin, Laksmi Ambarsari, Annisa Dhiya Athiyyah Khanza, Inda Setyawati, Djarot Sasongko  
Hami Seno, Waras Nurcholis

PDF (<https://journal.uinjkt.ac.id/index.php/valensi/article/view/9440/pdf>) | 10-19

Nanoporous Carbon Prepared with MOF-5 as a Template and Activated using KOH for Hydrogen Storage

(<https://journal.uinjkt.ac.id/index.php/valensi/article/view/13621>)

Ratna Ediaty, Tri Ana Mulyati, Amirul Mukminin, Dety Oktavia Sulistiono, Naimatul Khoiroh, Hamzah  
Fansuri, Didik Prasetyoko

PDF (<https://journal.uinjkt.ac.id/index.php/valensi/article/view/13621/pdf>) | 20-31

Characteristic of Allergen Protein of Nila Baby Fish (*Oreochromis niloticus*) and Its Processed Product

(<https://journal.uinjkt.ac.id/index.php/valensi/article/view/12885>)

Hendra Wijaya, Sri Yadiyal Chalid, Ning Ima Arie Wardayanie, Widyaningsih Widyaningsih, Santi Ariningsih

PDF (<https://journal.uinjkt.ac.id/index.php/valensi/article/view/12885/pdf>) | 32-39

Preconcentration of Ion Ni(II) using Ca-Alginate Modified Resin with Dimethylglyoxime as a Filler Material  
of Column (<https://journal.uinjkt.ac.id/index.php/valensi/article/view/7700>)



Aman Sentosa Panggabean, Wirdhaningsih Wirdhaningsih, Subur P. Pasaribu

PDF (<https://journal.uinjkt.ac.id/index.php/valensi/article/view/7700/pdf>) | 40-46

---

The Effect of Single Co-expression of The DnaK-DnaJ-GrpE and GroEL/ES Chaperones and Their Combination on Expression Intein-pretrombin-2 in Escherichia coli ER2566

(<https://journal.uinjkt.ac.id/index.php/valensi/article/view/11333>)

Iman Permana Maksum, D Agus Yusuf Wildan, Khomaini Hasan, Toto Subroto

PDF (<https://journal.uinjkt.ac.id/index.php/valensi/article/view/11333/pdf>) | 47-54

---

Photocatalytic Degradation of Paraquat Dichloride using TiO<sub>2</sub>-Fe Nano Powder under Visible and Sunlight Irradiation (<https://journal.uinjkt.ac.id/index.php/valensi/article/view/13625>)

Linda J Kusumawardani, Yulian Syahputri, Ani Iryani

PDF (<https://journal.uinjkt.ac.id/index.php/valensi/article/view/13625/pdf>) | 55-61

---

Silver Recovery from X-ray Film Waste by Leaching and Precipitation Method Using Sodium Hydroxide and Sodium Sulfide (<https://journal.uinjkt.ac.id/index.php/valensi/article/view/13648>)

Soja Siti Fatimah, Wiwi Siswaningsih, Ali Kusrijadi, Fikri Aziz Shalahuddin

PDF (<https://journal.uinjkt.ac.id/index.php/valensi/article/view/13648/pdf>) | 62-69

---

Synthesis, Characterization and In Silico Study of Fe(III) Complex with N'-(4-Chlorobenzoyl)-Isonicotino-Hydrazide as Anti Tuberculosis Candidate

(<https://journal.uinjkt.ac.id/index.php/valensi/article/view/11788>)

Ruswanto Ruswanto, Fajar Setiawan, Nur Rahayuningsih, Richa Mardianingrum, Nur Laili Dwi Hidayati, Elsi Eryanti

PDF (<https://journal.uinjkt.ac.id/index.php/valensi/article/view/11788/pdf>) | 70-81

---

Ceftriaxone Degradation by Titanium Dioxide (TiO<sub>2</sub>) Nanoparticles: Toxicity and Degradation Mechanism (<https://journal.uinjkt.ac.id/index.php/valensi/article/view/12475>)

Mohammad Rofik Usman, Azmi Prasasti, Sovia Islamiah, Alfian Nur Firdaus, Ayu Wanda Marita, Syamsiyatul Fajriyah, Eka Fitri Yanti

PDF (<https://journal.uinjkt.ac.id/index.php/valensi/article/view/12475/pdf>) | 82-89

---

The Use of Rice Husk Silica in Modified Zinc Oxide Photocatalysts to Reduce Chromium Concentration (<https://journal.uinjkt.ac.id/index.php/valensi/article/view/12324>)

Diana Rakhmawaty Eddy, L Ahmad Na'ani, Rustaman Rustaman, Solihudin Solihudin

PDF (<https://journal.uinjkt.ac.id/index.php/valensi/article/view/12324/pdf>) | 90-95

---

Theoretical Study of Xanthone Derivative Corrosion Inhibitors Using Density Functional Theory (DFT) (<https://journal.uinjkt.ac.id/index.php/valensi/article/view/11953>)

Fitria Ramadhani, Emriadi Emriadi, Syukri Syukri

PDF ([https://journal.uinjkt.ac.id/index.php/valensi/article/view/11953/pdf\\_1](https://journal.uinjkt.ac.id/index.php/valensi/article/view/11953/pdf_1)) | 96-105

Microencapsulation of Lime Peel Essential Oils (*Citrus aurantifolia*) with Complex Coacervation Methods using Gelatin/Sodium Alginate Coating (<https://journal.uinjkt.ac.id/index.php/valensi/article/view/14618>)

Sandra Puspita, Diana Rakhmawaty Eddy, Tatang Wahyudi, Euis Juliaeha

PDF (<https://journal.uinjkt.ac.id/index.php/valensi/article/view/14618/pdf>) | 106-112

Ethyl Acetate Fraction of *Moringa oleifera* Leaves Induces Cell Cycle Arrest on T47D Breast Cancer Cell via G0/G1 through Cyclin D1 Expression (<https://journal.uinjkt.ac.id/index.php/valensi/article/view/15431>)

Riza Apriani, Tati Herlina, Shabarni Gaffar

PDF (<https://journal.uinjkt.ac.id/index.php/valensi/article/view/15431/pdf>) | 113-119

Potential Use of Indonesian Medicinal Plants for Cosmetic and Oral Health: A Review

(<https://journal.uinjkt.ac.id/index.php/valensi/article/view/16252>)

Irmanida Batubara, Muhammad Eka Prastya

PDF (<https://journal.uinjkt.ac.id/index.php/valensi/article/view/16252/pdf>) | 120-134

[Editorial Team \(/index.php/valensi/about/editorialTeam\)](/index.php/valensi/about/editorialTeam)

[Reviewers \(/index.php/valensi/pages/view/Reviewers\)](/index.php/valensi/pages/view/Reviewers)

[Author Guidelines \(/index.php/valensi/about/submissions#authorGuidelines\)](/index.php/valensi/about/submissions#authorGuidelines)

[Focus and Scope \(/index.php/valensi/about/editorialPolicies#focusAndScope\)](/index.php/valensi/about/editorialPolicies#focusAndScope)

[Publication Ethics \(/index.php/valensi/pages/view/Publication%20Ethic\)](/index.php/valensi/pages/view/Publication%20Ethic)

[Online Submissions \(/index.php/valensi/about/submissions#onlineSubmissions\)](/index.php/valensi/about/submissions#onlineSubmissions)

[Author Fees \(/index.php/valensi/about/editorialPolicies#custom-1\)](/index.php/valensi/about/editorialPolicies#custom-1)

[Plagiarism Policy \(/index.php/valensi/about/editorialPolicies#custom-2\)](/index.php/valensi/about/editorialPolicies#custom-2)

[Copyright Notice \(/index.php/valensi/about/submissions#copyrightNotice\)](/index.php/valensi/about/submissions#copyrightNotice)

[Peer Review Proces \(/index.php/valensi/about/editorialPolicies#peerReviewProcess\)](/index.php/valensi/about/editorialPolicies#peerReviewProcess)

[Retraction \(/index.php/valensi/about/editorialPolicies#custom-3\)](/index.php/valensi/about/editorialPolicies#custom-3)

[Indexing \(/index.php/valensi/pages/view/Indexing%20and%20Abstracting\)](/index.php/valensi/pages/view/Indexing%20and%20Abstracting)

[Scopus Citation Analysis \(https://drive.google.com/file/d/1aHknmF22S0eyebIIIs9FZgMcAiChqTUs/view?usp=sharing\)](https://drive.google.com/file/d/1aHknmF22S0eyebIIIs9FZgMcAiChqTUs/view?usp=sharing)



([https://drive.google.com/file/d/18sZ480GuZu2syYqK1l4Bnp6o\\_fz\\_WAcu/view?usp=sharing](https://drive.google.com/file/d/18sZ480GuZu2syYqK1l4Bnp6o_fz_WAcu/view?usp=sharing))

Grammar Check & plagiarism checker



**grammarly** (<https://app.grammarly.com/>)



(<https://www.turnitin.com>)



(<https://plagiarismcheckerx.com/>)

Reference Manager

**zotero** (<https://www.zotero.org/>)



(<https://www.mendeley.com/>)

User

---

Username

Password

☐ Remember me

Login



(<http://info.flagcounter.com/cDrF>)

**00587334** (<https://www.statcounter.com/>)

View My Stats (<http://statcounter.com/p11917097/?guest=1>)

Supported By:



(<https://www.hki.or.id/>)



(<http://creativecommons.org/licenses/by-sa/4.0/>)

This work is licensed under a **CC-BY-SA** (<https://creativecommons.org/licenses/by-sa/3.0/>)

## Journal Content

---

### Search

### Search Scope

All



Search

### Browse

By Issue (<https://journal.uinjkt.ac.id/index.php/valensi/issue/archive>)

By Author (<https://journal.uinjkt.ac.id/index.php/valensi/search/authors>)

By Title (<https://journal.uinjkt.ac.id/index.php/valensi/search/titles>)

Other Journals (<https://journal.uinjkt.ac.id/index.php/index>)

Categories (<https://journal.uinjkt.ac.id/index.php/index/search/categories>)

## Policies

---

Focus and Scope (<https://journal.uinjkt.ac.id/index.php/valensi/about/editorialPolicies#focusAndScope>)

Section Policies (<https://journal.uinjkt.ac.id/index.php/valensi/about/editorialPolicies#sectionPolicies>)

Peer Review Process

(<https://journal.uinjkt.ac.id/index.php/valensi/about/editorialPolicies#peerReviewProcess>)

Publication Frequency

(<https://journal.uinjkt.ac.id/index.php/valensi/about/editorialPolicies#publicationFrequency>)

Open Access Policy

(<https://journal.uinjkt.ac.id/index.php/valensi/about/editorialPolicies#openAccessPolicy>)

## Submissions

---

## Online Submissions

(<https://journal.uinjkt.ac.id/index.php/valensi/about/submissions#onlineSubmissions>)

Author Guidelines (<https://journal.uinjkt.ac.id/index.php/valensi/about/submissions#authorGuidelines>)

Copyright Notice (<https://journal.uinjkt.ac.id/index.php/valensi/about/submissions#copyrightNotice>)

Privacy Statement (<https://journal.uinjkt.ac.id/index.php/valensi/about/submissions#privacyStatement>)

## Other

---

Journal Sponsorship (<https://journal.uinjkt.ac.id/index.php/valensi/about/journalSponsorship>)

Journal History (<https://journal.uinjkt.ac.id/index.php/valensi/about/history>)

Site Map (<https://journal.uinjkt.ac.id/index.php/valensi/about/siteMap>)

About this Publishing System

(<https://journal.uinjkt.ac.id/index.php/valensi/about/aboutThisPublishingSystem>)

## Share

---

Tweet

Share 0

ISSN: 2548-3013

Publisher Department of Chemistry, Faculty of Science and Technology, Syarif Hidayatullah Jakarta State Islamic University,

.Jl. Ir. H. Juanda No. 95, Ciputat, Jakarta 15412, Indonesia, Telp. 021-7492855, Fax. 021-7493351,  
website: <http://journal.uinjkt.ac.id/index.php/valensi> (/index.php/valensi), e-mail: [kimia@uinjkt.ac.id](mailto:kimia@uinjkt.ac.id)  
(<mailto:kimia@uinjkt.ac.id>)

**00587335** (<https://www.statcounter.com/>)

View My Stats (<http://statcounter.com/p11917097/?guest=1>)

Managed Hosting, Support, and OJS Responsive Theme by: [OpenJournalSystems.com](http://openjournalsystems.com)  
(<http://openjournalsystems.com>)

# Indexing And Abstracting

**Jurnal Kimia Valensi** has been indexed by the following service (*click the link for the further information*):



← → ↻ [sinta.kemdikbud.go.id/journals/detail?id=1010](http://sinta.kemdikbud.go.id/journals/detail?id=1010)

[HOME](#) [ABOUT](#) [AUTHORS](#) [SUBJECTS](#) [AFFILIATIONS](#) [SOURCES](#) [REGISTRATION](#) [FAQ](#) [AUTHOR LOGIN](#)

[New! – Science And Technology Index \(SINTA\) Version 3.0](#) [Click Here](#)

Journal Profile

**Jurnal Kimia VALENSI**  
eISSN : 25483013 | pISSN : 25483013  
Science  
Universitas Islam Negeri Syarif Hidayatullah

<b>S2</b> Sinta Score	<b>GARUDA</b> Indexed by GARUDA
<b>25</b> H-Index	<b>22</b> H5-Index
<b>2021</b> Citations	<b>1695</b> 5 Year Citations

## The Starting Material Concentration Dependence of $\text{Ag}_3\text{PO}_4$ Synthesis for Rhodamine B Photodegradation under Visible Light Irradiation

Febiyanto and Uyi Sulaeman\*

Department of Chemistry Faculty of Mathematics and Natural Sciences Universitas Jenderal Soedirman  
Jl. Dr. Soeparno No. 61 Karangwangkal Purwokerto Central Java Indonesia 53123

\*Corresponding author: [uyi\\_sulaeman@yahoo.com](mailto:uyi_sulaeman@yahoo.com)

Received: February 2020; Revision: March 2020; Accepted: April 2020; Available online: May 2020

### Abstract

Synthesis of  $\text{Ag}_3\text{PO}_4$  photocatalyst under the varied concentrations of  $\text{AgNO}_3$  and  $\text{Na}_2\text{HPO}_4 \cdot 12\text{H}_2\text{O}$  as starting material has been successfully synthesized using the co-precipitation method. The concentration of  $\text{AgNO}_3$  is 0.1; 0.5; 1.0; and 2.0 M, whereas  $\text{Na}_2\text{HPO}_4 \cdot 12\text{H}_2\text{O}$  is 0.03; 0.17; 0.33; and 0.67 M, respectively. The co-precipitations were carried out under aqueous solution. As-synthesized photocatalysts were examined to degrade Rhodamine B (RhB) under blue light irradiation. The results showed that varying concentrations of starting materials affect the photocatalytic activities, the intensity ratio of [110]/[200] facet plane, and their bandgap energies of  $\text{Ag}_3\text{PO}_4$  photocatalyst. The highest photocatalytic activity of the sample was obtained by synthesized using the 1.0 M of  $\text{AgNO}_3$  and 0.33 M of  $\text{Na}_2\text{HPO}_4 \cdot 12\text{H}_2\text{O}$  (AP-1.0). This is due to the high [110] facet plane and increased absorption along the visible region of AP-1.0 photocatalyst. Therefore, this result could be a consideration for the improvement of  $\text{Ag}_3\text{PO}_4$  photocatalyst.

**Keywords:**  $\text{Ag}_3\text{PO}_4$ , co-precipitation method, photocatalytic activity, Rhodamine B.

**DOI:** 10.15408/jkv.v6i1.14837

### 1. INTRODUCTION

To date, silver orthophosphate or  $\text{Ag}_3\text{PO}_4$  photocatalyst has been promising visible light-activated photocatalyst material. This because of their small bandgap energy (~2.40 eV) and their quantum efficiency of nearly ~90% under visible light or above 520 nm (Yi *et al.*, 2010). In addition, it has greater photocatalytic efficiency than well-known traditional photocatalyst like doped- $\text{TiO}_2$  (Katsumata *et al.*, 2013),  $\text{TiO}_2$  commercial (P25) (Liu *et al.*, 2012), and  $\text{ZnO}$  (Khan *et al.*, 2012).

To enhancing their photocatalytic activities, some modifications have been prepared and investigated. They were doping (Song *et al.*, 2017; Xie and Wang, 2014; Yu *et al.*, 2015), composite fabrication (Chen *et al.*, 2013; Zhankui *et al.*, 2013) and morphology design (Dong *et al.*, 2014; Guo *et al.*, 2015; Sulaeman *et al.*, 2016; Vu *et al.*, 2013). The modifications were also carried out by using the addition of complex solution (Wang *et al.*, 2012; Xu and Zhang, 2013), the hydrophilic

polymer (Yang *et al.*, 2014), various reactant composition (Bozetine *et al.*, 2013), stirring time (Yan *et al.*, 2013) and temperature (Wang *et al.*, 2015). These modifications showed a significant effect on the photocatalytic activities of  $\text{Ag}_3\text{PO}_4$  photocatalyst.

Recently, the different morphology, particle size, crystallinity, and absorption profiles could be resulted in the different concentrations of  $\text{KH}_2\text{PO}_4$  as starting material in the  $\text{Ag}_3\text{PO}_4$  synthesis. This might be due to the different concentration influenced the nucleation and crystal growth during photocatalyst synthesis. However, the high photocatalytic activity of  $\text{Ag}_3\text{PO}_4$  photocatalyst can be found in the sample with smaller particle size, higher crystallinity, and UV-Vis absorption ability of  $\text{Ag}_3\text{PO}_4$  (Afifah *et al.*, 2019). Besides  $\text{KH}_2\text{PO}_4$ , the reactant of  $\text{Na}_2\text{HPO}_4 \cdot 12\text{H}_2\text{O}$  as a source of phosphate has been applied for  $\text{Ag}_3\text{PO}_4$  design synthesis (Chen, Dai, Guo, Bu, & Wang, 2016; Wang *et al.*, 2015; Wu *et al.*, 2013). Nevertheless, the investigation using the variation of



$\text{Na}_2\text{HPO}_4 \cdot 12\text{H}_2\text{O}$  concentration has not been reported. Based on these reports, it is a good idea to obtain high photocatalytic activity by using  $\text{Na}_2\text{HPO}_4 \cdot 12\text{H}_2\text{O}$ . Therefore, we have tried to observe the effect of the varied concentration of  $\text{AgNO}_3$  and  $\text{Na}_2\text{HPO}_4 \cdot 12\text{H}_2\text{O}$  as starting material for  $\text{Ag}_3\text{PO}_4$  co-precipitation. The activities of the products were investigated using the Rhodamine B (RhB) photodecomposition under blue light irradiation.

## 2. MATERIALS AND METHODS

### Materials

Materials were used without further purification, such as a commercial textile dye of RhB, distilled water (DW),  $\text{AgNO}_3$  (Merck), and  $\text{Na}_2\text{HPO}_4 \cdot 12\text{H}_2\text{O}$  (Merck).

### Photocatalyst Characterization

Determination of crystallinity and purity of samples was done using X-ray diffraction (XRD) Bruker AXS D2 Phaser. UV and visible light absorption profiles were conducted using Diffuse Reflectance Spectroscopy (DRS) JASCO V-670. Photocatalyst samples were examined under blue light irradiation of LED SkyLED (3W/220V) for RhB photodegradation. Lamp-suspension surface distance was adjusted at 10 cm. The absorbance of filtrate after the photodegradation process was analyzed using UV-Visible spectroscopy Shimadzu 1800.

### Synthesis of $\text{Ag}_3\text{PO}_4$ Photocatalyst with The Varied Concentration of Reactants

Photocatalyst was synthesized using the co-precipitation method by reacting  $\text{AgNO}_3$  and  $\text{Na}_2\text{HPO}_4 \cdot 12\text{H}_2\text{O}$  with various concentrations of reactants. The concentration of  $\text{Na}_2\text{HPO}_4 \cdot 12\text{H}_2\text{O}$  was 0.03, 0.17, 0.33, and 0.67 M were slowly mixed drop by drop in room temperature into 0.1, 0.5, 1.0, and 2.0 M of  $\text{AgNO}_3$ , respectively. The reactants of  $\text{AgNO}_3$  and  $\text{Na}_2\text{HPO}_4 \cdot 12\text{H}_2\text{O}$  were stoichiometrically synthesized following the reaction as shown in Eq. 1 (molar concentration ratio of  $\text{Ag}^+$  to  $\text{HPO}_4^{2-}$  is 3:1) (Vogel, 1990) and separately dissolved in 25 mL volumetric flask using DW. Samples were stirred, and as-resulted yellow precipitates were collected, washed several times, and dried in the oven at 105 °C for 5-10 hours. Samples were labeled as AP-0.1, AP-0.5, AP-1.0, and AP-2.0, respectively.



### Photocatalytic Activity Analysis

An amount of 0.2 g of  $\text{Ag}_3\text{PO}_4$  photocatalyst was poured into 100 mL of 10 mg/L RhB under stirring condition. Initially, the reaction was carried out under the dark condition for 20 minutes to ensure the adsorption-desorption of dye and  $\text{Ag}_3\text{PO}_4$  photocatalyst. After that, the suspension was irradiated under blue light, and the sample was drawn  $\pm 5$  mL at a certain time. The suspension was centrifuged at 1.500 rpm, and the absorbance of the filtrate was measured (Febiyanto *et al.*, 2016).

## 3. RESULTS AND DISCUSSION

### XRD Analysis of $\text{Ag}_3\text{PO}_4$ Photocatalyst

The XRD profile of as-synthesized  $\text{Ag}_3\text{PO}_4$  was shown in Fig. 2. The diffraction of AP-0.1; AP-0.5; AP-1.0; and AP-2.0 are similar. As shown in Fig. 1, the photocatalysts synthesized under the varied concentration have a body-centered cubic of  $\text{Ag}_3\text{PO}_4$ . It is suitable with the JCPD #06-0505 (Huang *et al.*, 2019; Yan *et al.*, 2014). High intensities of peaks and no others peak except  $\text{Ag}_3\text{PO}_4$ , suggesting that the samples are highly crystalline and high purity (Ge, 2014).

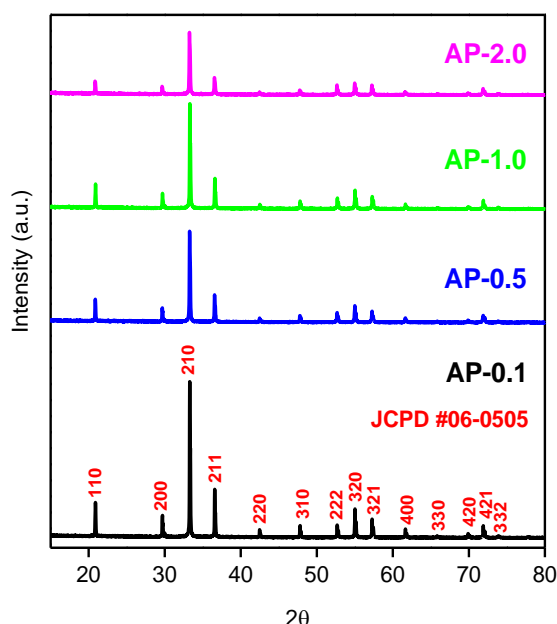
The crystallite size of samples was calculated using the Debye-Scherrer equation as follow (Bozetine *et al.*, 2013):

$$D = \frac{K\lambda}{\beta \cos \theta} \quad (2)$$

where  $D$ ,  $K$ ,  $\lambda$ ,  $\beta$ , and  $\theta$  were crystallite size (nm), Scherrer constant ( $\sim 0.9$ ), a wavelength of X-ray sources ( $\text{Cu } K\alpha = 0.15406$  nm), FWHM (radians), and peak position (radians). Relatively, the same average diameter of crystallite was observed in all samples. Further, the ratio intensity of [110]/[200] was also investigated and summarized in Table 1.

**Table 1.** Crystallite size and intensity ratio calculation of  $\text{Ag}_3\text{PO}_4$  photocatalyst samples

Samples	$D_{\text{average}}$ (nm)	Intensity ratio of [110]/[200]
AP-0.1	52.02	0.93
AP-0.5	46.86	1.67
AP-1.0	46.96	2.02
AP-2.0	46.16	1.50



**Figure 1.** XRD diffraction of samples.

According to Table 1, the intensity ratio of facet planes was affected by the varied molar concentrations of reactants. The highest intensity ratio of [110]/[200] was observed in the sample of AP-1.0, suggesting that their surfaces are dominated by the [110] facet plane. This facet plane is similar to the tetrapod and rhombic dodecahedron morphology types (Martin *et al.*, 2013; Wang *et al.*, 2014). Moreover, the highest [110] dominated-facet surfaces could contribute to the improvement of the photocatalysis activity of  $\text{Ag}_3\text{PO}_4$  photocatalyst (Bi *et al.*, 2012). Previously, the [110] facet plane of photocatalyst shows a high photocatalytic activity in the dye removal (Wang *et al.*, 2012; Zheng *et al.*, 2013).

### Band gap energy analysis of $\text{Ag}_3\text{PO}_4$ photocatalyst

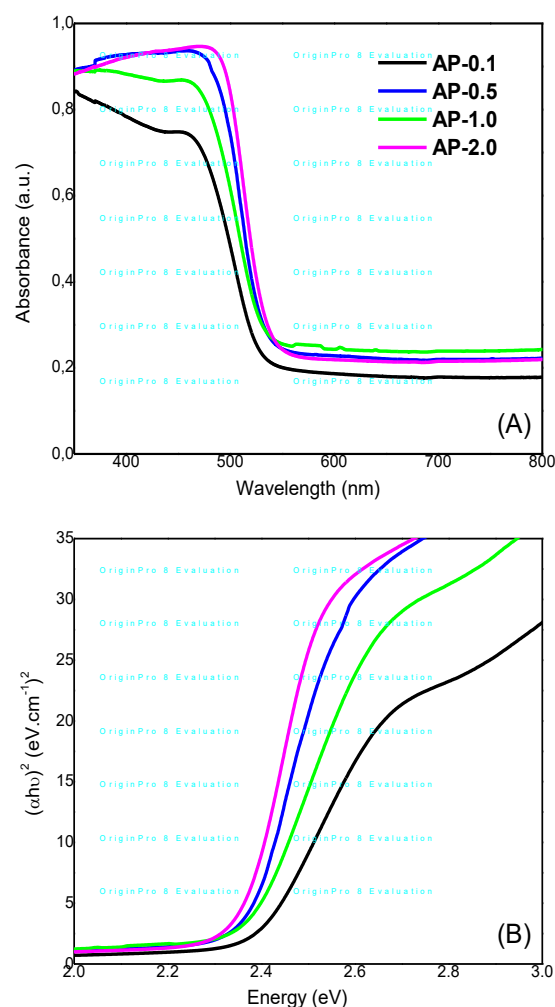
Analysis of UV-Vis absorption profiles of as-synthesized  $\text{Ag}_3\text{PO}_4$  photocatalyst was analyzed using DRS and depicted in Fig. 2 (A-B). Based on Fig. 2 (A), samples have a good-absorption ability on the UV up to visible light (<600 nm). In addition, the difference in absorption ability could also be found in the visible wavelength at around 400-500 nm. The sample of AP-1.0 showed the highest absorption in the visible region (540-800 nm).

Fig. 2 (B) showed the band gap energy profiles of AP-0.1, AP-0.5, AP-1.0, and AP-

2.0, respectively. The band energy of samples can be estimated using the formula as follows (Eq. 3) (Rawal *et al.*, 2012):

$$\alpha h\nu = A(h\nu - E_g)^{n/2} \quad (3)$$

where  $\alpha$ ,  $h$ ,  $\nu$ ,  $A$ ,  $E_g$ , and  $n$  are absorption coefficient, Planck's constant, light frequency, a constant number, band gap energy, and value depend on the direct ( $n=1$ ) and indirect ( $n=4$ ) characteristics of nature semiconductor transition. According to Eq. 3, the  $(\alpha h\nu)^2$  plot as a function of  $h\nu$  where the band gap energy of each sample was resulted using extrapolation of a straight line towards the axis (x)-direction. The direct band gap energy of samples was summarized in Table. 2. According to Table 2, the varied molar concentrations slightly affect the light absorption as same as the band gap energy of photocatalyst samples.



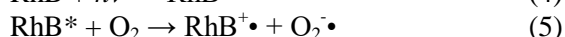
**Figure 2.** DRS spectra (A) and direct band gap energy characteristics (B) of samples.

**Table 2.** Sample characteristics of Ag<sub>3</sub>PO<sub>4</sub> photocatalyst

Sampl es	Band gap energy (eV)	Linearity (R <sup>2</sup> )
AP-0.1	2.38	0.987
AP-0.5	2.36	0.896
AP-1.0	2.36	0.960
AP-2.0	2.35	0.915

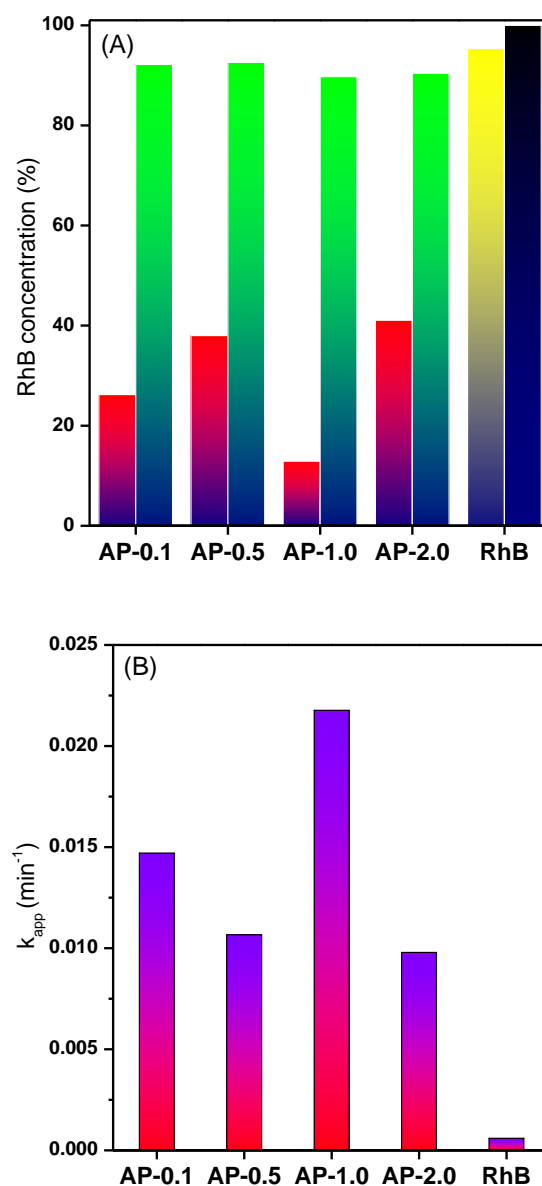
### Photocatalytic activity examination of Ag<sub>3</sub>PO<sub>4</sub> photocatalyst

Photocatalytic activity of as-synthesized Ag<sub>3</sub>PO<sub>4</sub> photocatalyst under the varied molar concentration of reactants was performed in Fig. 3. Based on Fig. 3 (A), the control or RhB photolysis process without the addition of photocatalyst material showed a small decrease in RhB concentration under blue light irradiation. The percent RhB degradation using photolysis reaction over 80 minutes of light exposure was less than 6% (yellow color). The slight decrease in RhB photodegradation without catalyst addition could be explained by Wilhelm and Stephan (Wilhelm and Stephan, 2007) as follows: the excitation of RhB compounds (Eq. 4) is followed by O<sub>2</sub> reduction to be O<sub>2</sub><sup>•-</sup> and photogenerated RhB<sup>+</sup>• (Eq. 5) under the light irradiation. The O<sub>2</sub><sup>•-</sup> radicals react with H<sup>+</sup> from H<sub>2</sub>O autoprotolysis, and then OOH• was resulted (Eq. 6). Subsequently, RhB cationic was degraded, resulting in CO<sub>2</sub>, H<sub>2</sub>O, and acid minerals (Eq. 7). Qu and Zhao reported that these reaction mechanisms are a very slow reaction, and the photocatalysis reaction using a catalyst is the best reason to explain a significant decrease in RhB photodecomposition (Qu and Zhao, 1998).



In addition, the same trends were also observed in the adsorption ability of photocatalysts under the dark condition, with a percent decrease of less than 10%, as shown in Fig. 3 (A) (green color). It concluded that RhB photodecomposition under blue light irradiation or photolysis and adsorption process at least could be neglected since there

is no apparent concentration changing compared to the RhB photodecomposition with the addition of Ag<sub>3</sub>PO<sub>4</sub> photocatalyst. However, the dye photodegradation using radical species that is resulted from light-activated photocatalyst was a plausible mechanism to decrease the absorbance or dye concentration than photolysis reaction (Febiyanto *et al.*, 2019).



**Figure 3.** Photocatalytic activities of RhB over 80 minutes of light exposure under blue light (red color) and adsorption ability (green color) over 20 min in the dark condition (A), and their pseudo-first-order rate constant (B). Black and yellow colors (A) are percent initial concentration and photolysis reaction of RhB, respectively.

A significant decrease in RhB concentration was found when the RhB sample was mixed with Ag<sub>3</sub>PO<sub>4</sub> photocatalyst, as shown in Fig. 3 (A). Fig. 3 (A) (red color) showed that all samples could effectively degrade the RhB dyes. The high photocatalytic activity can be found in the AP-1.0 sample, with the percent degradation of 82.5%. The high photocatalytic activity might be induced by the highest intensity of [110] facet plane and different properties obtained by co-precipitation under the starting material of AP-1.0 photocatalyst. This preparation generates high absorption along the visible region, as shown in Fig. 2 (A). The AP-1.0 is the high absorption in the visible region. This phenomenon increases the photogenerated electron and holes that lead to improving the photocatalytic activity. The percent degradation of 69.2, 57.4, and 54.3% could be observed in AP-0.1, AP-0.5, and AP-2.0, respectively. These photocatalytic activities were relatively similar and highly different from the AP-1.0 sample.

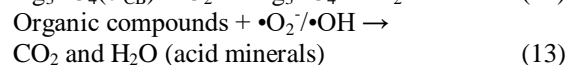
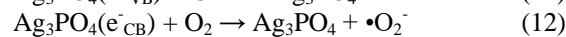
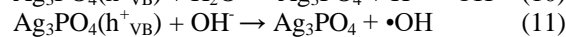
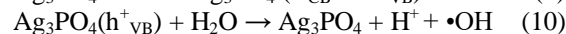
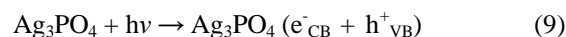
Photocatalytic kinetic analysis of Ag<sub>3</sub>PO<sub>4</sub> photocatalyst with varied molar concentrations was performed in Fig. 3 (B). Rate constant can be determined from a slope that is resulted from linear regression. These can be determined using a formula as follows (Eq. 8):

$$\ln(C_o/C) = kt \quad (8)$$

where  $C_o$ ,  $C$ ,  $t$ , and  $k$  are initial concentration, the concentration at a certain time, irradiation time, and a rate constant of pseudo-first-order kinetic (Yan *et al.*, 2014). Based on Fig. 3 (B) and Table 2, the rate constant of samples shows a good-linearity and following the pseudo-first-order rate kinetic (Pradhan *et al.*, 2014). However, the sample with AP-1.0 showed a high photocatalytic rate kinetic of 0.0218 min<sup>-1</sup>, whereas samples of AP-0.1, AP-0.5, and AP-2.0 were 0.0147, 0.0107, and 0.0098 min<sup>-1</sup>, respectively. The results showed that varying molar concentrations affect the rate constant, as same as photocatalytic activities of Ag<sub>3</sub>PO<sub>4</sub> photocatalyst.

The RhB oxidation and reduction mechanism chain of photocatalyst generally might be happened on the photocatalyst surfaces of Ag<sub>3</sub>PO<sub>4</sub> under visible light irradiation. This following the

photodegradation mechanisms below (Guo *et al.*, 2015):



Photocatalyst under blue light excites electron (e<sup>-</sup>) from valence band (VB) to the conduction band (CB) resulted in electron (e<sup>-</sup><sub>CB</sub>) and hole (h<sup>+</sup><sub>VB</sub>) (Eq. 9). The electron-hole pairs transferred to the Ag<sub>3</sub>PO<sub>4</sub> surfaces and oxidation/reduction of water molecules (H<sub>2</sub>O) (Eq. 10) and OH<sup>-</sup> ions or dissolved oxygen (O<sub>2</sub>) (Eq. 11-12) can take place. Subsequently, this can produce a radical species of hydroxyl (•OH) and superoxide (•O<sub>2</sub><sup>-</sup>). The benefits of this chemical radical decompose the RhB dye structures to be small molecules such as H<sub>2</sub>O, CO<sub>2</sub>, and acid minerals (Eq. 13).

#### 4. CONCLUSION

The photocatalyst of Ag<sub>3</sub>PO<sub>4</sub> under the varied concentration of starting materials have been successfully synthesized using the co-precipitation method. The results showed that the varied concentrations of starting materials affect the photocatalytic activities, the intensity ratio of [110]/[200] facet plane, and their bandgap energies of Ag<sub>3</sub>PO<sub>4</sub> photocatalyst. Photocatalyst synthesized using 1.0 M of AgNO<sub>3</sub>, and 0.33 M of Na<sub>2</sub>HPO<sub>4</sub>·12H<sub>2</sub>O (AP-1.0) showed the highest photocatalytic activity with the percent photodegradation of 82.5%. This is due to the high [110] facet plane and the absorption along a visible region of AP-1.0 photocatalyst. However, the [110] dominated-facet plane which is similar to the tetrapod or dodecahedron morphology structure could contribute to the improvement of photocatalysis reaction of Ag<sub>3</sub>PO<sub>4</sub> photocatalyst in the RhB photodegradation.

#### ACKNOWLEDGMENT

This research was partly financially supported by the Directorate of Research and Community Service, Deputy of Strengthening Research and Development, Ministry of Research and Technology/National Research and Innovation Agency, Number: 176/SP2H/ADM/LT/DRPM/2020.

## REFERENCES

- Afifah K, Andreas R, Hermawan D, Sulaeman U. 2019. Tuning the morphology of  $\text{Ag}_3\text{PO}_4$  photocatalysts with an elevated concentration of  $\text{KH}_2\text{PO}_4$ . *Bulletin of Chemical Reaction Engineering & Catalysis*. 14(3): 625–633. <https://doi.org/10.9767/bcrec.14.3.4649.625-633>
- Bi Y, Hu H, Ouyang S, Lu G, Ye J. 2012. Photocatalytic and photoelectric properties of cubic  $\text{Ag}_3\text{PO}_4$  sub-microcrystals with sharp corners and edges. *Chem. Commun.*, 48: 3748–3750. <https://doi.org/10.1039/c2cc30363a>
- Bozetine I, Boukenous Y, Trari M, Moudir N. 2013. Synthesis and characterization of orthophosphate silver powders. *Energy Procedia*. 36: 1158–1167. <https://doi.org/10.1016/j.egypro.2013.07.131>
- Chen G, Sun M, Wei Q, Zhang Y, Zhu B, Du B. 2013.  $\text{Ag}_3\text{PO}_4$ /graphene-oxide composite with remarkably enhanced visible-light-driven photocatalytic activity toward dyes in water. *Journal of Hazardous Materials*, 244–245: 86–93. <https://doi.org/10.1016/j.jhazmat.2012.11.032>
- Chen X, Dai Y, Guo J, Bu F, Wang X. 2016. Synthesis of micro-nano  $\text{Ag}_3\text{PO}_4/\text{ZnFe}_2\text{O}_4$  with different organic additives and its enhanced photocatalytic activity under visible light irradiation. *Materials Science in Semiconductor Processing*. 41: 335–342. <https://doi.org/10.1016/j.mssp.2015.10.010>
- Dong P, Yin Y, Xu N, Guan R, Hou G, Wang Y. 2014. Facile synthesis of tetrahedral  $\text{Ag}_3\text{PO}_4$  mesocrystals and its enhanced photocatalytic activity. *Materials Research Bulletin*. 60: 682–689. <https://doi.org/10.1016/j.materresbull.2014.09.047>
- Febiyanto, Eliani IV, Riapanitra A, Sulaeman U. 2016. Synthesis and visible light photocatalytic properties of iron oxide-silver orthophosphate composites. *AIP Conference Proceedings*. 020021: 1–7. <https://doi.org/10.1063/1.4945475>
- Febiyanto F, Soleh A, Amal MSK, Afif M, Sewiji S, Riapanita A, Sulaeman U. 2019. Facile synthesis of  $\text{Ag}_3\text{PO}_4$  photocatalyst with varied ammonia concentration and its photocatalytic activities for dye removal. *Bulletin of Chemical Reaction Engineering & Catalysis*. 14(1): 42–50. <https://doi.org/10.9767/bcrec.14.1.2549.42-50>
- Ge M. 2014. Photodegradation of rhodamine B and methyl orange by  $\text{Ag}_3\text{PO}_4$  catalyst under visible light irradiation. *Chinese Journal of Catalysis*. 35(8): 1410–1417. [https://doi.org/10.1016/S1872-2067\(14\)60079-6](https://doi.org/10.1016/S1872-2067(14)60079-6)
- Guo X, Chen C, Yin S, Huang L, Qin W. 2015. Controlled synthesis and photocatalytic properties of  $\text{Ag}_3\text{PO}_4$  microcrystals. *Journal of Alloys and Compounds*. 619: 293–297. <https://doi.org/10.1016/j.jallcom.2014.09.065>
- Huang X, Gu X, Zhao Y, Qiang Y. 2019. Photoelectrochemical performance of  $\text{Ag}_3\text{PO}_4/\text{Ag}$  membranes synthesized by grind coating. *Journal of Materials Science: Materials in Electronics*. 30: 19487–19492. <https://doi.org/10.1007/s10854-019-02314-9>
- Katsumata H, Taniguchi M, Kaneco S, Suzuki T. 2013. Photocatalytic degradation of bisphenol A by  $\text{Ag}_3\text{PO}_4$  under visible light. *Catalysis Communications*. 34: 30–34. <https://doi.org/10.1016/j.catcom.2013.01.012>
- Khan A, Qamar M, Muneer M. 2012. Synthesis of highly active visible-light-driven colloidal silver orthophosphate. *Chemical Physics Letters*. 519–520: 54–58. <https://doi.org/10.1016/j.cplett.2011.11.015>
- Liu R, Hu P, Chen S. 2012. Photocatalytic activity of  $\text{Ag}_3\text{PO}_4$  nanoparticle/ $\text{TiO}_2$  nanobelt heterostructures. *Applied Surface Science*. 258: 9805–9809. <https://doi.org/10.1016/j.apsusc.2012.06.033>
- Martin DJ, Umezawa N, Chen X, Ye J, Tang J. 2013. Facet engineered  $\text{Ag}_3\text{PO}_4$  for efficient water photooxidation. *Energy & Environmental Science*. 6: 3380–3386. <https://doi.org/10.1039/c3ee42260g>
- Pradhan GK, Reddy KH, Parida KM. 2014. Facile



- fabrication of mesoporous  $\alpha\text{-Fe}_2\text{O}_3/\text{SnO}_2$  nanoheterostructure for photocatalytic degradation of malachite green. *Catalysis Today*. 224: 171–179. <https://doi.org/10.1016/j.cattod.2013.10.038>
- Qu P, Zhao J. 1998.  $\text{TiO}_2$ -assisted photodegradation of dyes: A study of two competitive primary processes in the degradation of RB in an aqueous  $\text{TiO}_2$  colloidal solution. *Journal of Molecular Catalysis A: Chemical*. 129: 257–268.
- Rawal SB, Sung SD, Lee WI. 2012. Novel  $\text{Ag}_3\text{PO}_4/\text{TiO}_2$  composites for efficient decomposition of gaseous 2-propanol under visible-light irradiation. *Catalysis Communications*. 17: 131–135. <https://doi.org/10.1016/j.catcom.2011.10.034>
- Song L, Chen Z, Li T, Zhang S. 2017. A novel  $\text{Ni}^{2+}$ -doped  $\text{Ag}_3\text{PO}_4$  photocatalyst with high photocatalytic activity and enhancement mechanism. *Materials Chemistry and Physics*. 186: 271–279. <https://doi.org/10.1016/j.matchemphys.2016.10.053>
- Sulaeman U, Febiyanto F, Yin S, Sato T. 2016. The highly active saddle-like  $\text{Ag}_3\text{PO}_4$  photocatalyst under visible light irradiation. *Catalysis Communication*. 85: 22–25. <https://doi.org/10.1016/j.catcom.2016.07.001>
- Vogel. 1990. *Buku Teks Analisis Anorganik Kualitatif Makro dan Semimikro*. Jakarta: PT. Kalman Media Pustaka.
- Vu TA, Dao CD, Hoang TTT, Nguyen KT, Le GH, Dang PT, Tran HTK, Nguyen TV. 2013. Highly photocatalytic activity of novel nano-sized  $\text{Ag}_3\text{PO}_4$  for Rhodamine B degradation under visible light irradiation. *Materials Letters*. 92: 57–60. <https://doi.org/10.1016/j.matlet.2012.10.023>
- Wang B, Wang L, Hao Z, Luo Y. 2015. Study on improving visible light photocatalytic activity of  $\text{Ag}_3\text{PO}_4$  through morphology control. *Catalysis Communications*. 58: 117–121. <https://doi.org/10.1016/j.catcom.2014.09.013>
- Wang H, He L, Wang L, Hu P, Guo L, Han X, Li J. 2012. Facile synthesis of  $\text{Ag}_3\text{PO}_4$  tetrapod microcrystals with an increased percentage of exposed {110} facets and highly efficient photocatalytic. *CrystEngComm*. 222: 8342–8344. <https://doi.org/10.1039/c2ce26366a>
- Wang L, Li N, Zhang Q, Lou S, Zhao Y, Chen M, Teng F. 2014. An innovative glycine complexing approach to silver phosphate myriapods with improved photocatalytic activity. *CrystEngComm*. 16: 9326–9330. <https://doi.org/10.1039/C4CE01296H>
- Wilhelm P, Stephan D. 2007. Photodegradation of rhodamine B in aqueous solution. *Journal of Photochemistry and Photobiology A: Chemistry*. 185: 19–25. <https://doi.org/10.1016/j.jphotochem.2006.05.003>
- Wu A, Tian C, Chang W, Hong Y, Zhang Q, Qu Y, Fu H. 2013. Morphology-controlled synthesis of  $\text{Ag}_3\text{PO}_4$  nano/microcrystals and their antibacterial properties. *Materials Research Bulletin*. 48(9): 3043–3048. <https://doi.org/10.1016/j.materresbull.2013.04.054>
- Xie YP, Wang GS. 2014. Visible light responsive porous lanthanum-doped  $\text{Ag}_3\text{PO}_4$  photocatalyst with high photocatalytic water oxidation activity. *Journal of Colloid and Interface Science*. 430: 1–5. <https://doi.org/10.1016/j.jcis.2014.05.020>
- Xu YS, Zhang WD. 2013. Morphology-controlled synthesis of  $\text{Ag}_3\text{PO}_4$  microcrystals for high performance photocatalysis. *CrystEngComm*. 15: 5407–5411. <https://doi.org/10.1039/c3ce40172c>
- Yan X, Gao Q, Qin J, Yang X, Li Y, Tang H. 2013. Morphology-controlled synthesis of  $\text{Ag}_3\text{PO}_4$  microcubes with enhanced visible-light-driven photocatalytic activity. *Ceramics International*. 39: 9715–9720. <https://doi.org/10.1016/j.ceramint.2013.04.044>
- Yan Y, Guan H, Liu S, Jiang R. 2014.  $\text{Ag}_3\text{PO}_4/\text{Fe}_2\text{O}_3$  composite photocatalysts with an n-n heterojunction semiconductor structure under visible-light irradiation. *Ceramics International*. 40: 9095–9100. <https://doi.org/10.1016/j.ceramint.2014.01.123>
- Yang Z, Tian Y, Huang G, Huang W, Liu Y, Jiao C, Wan Z, Yan X, Pan A. 2014. Novel 3D

- flower-like  $\text{Ag}_3\text{PO}_4$  microspheres with highly enhanced visible light photocatalytic activity. *Materials Letters*. 116: 209–211. <https://doi.org/10.1016/j.matlet.2013.11.041>
- Yi Z, Ye J, Kikugawa N, Kako T, Ouyang S, Stuart-williams H, Yang H, Cao J, Luo W, Li Z, Liu Y, Withers RL. 2010. An orthophosphate semiconductor with photooxidation properties under visible-light irradiation. *Nature Materials*. 9: 559–564. <https://doi.org/10.1038/nmat2780>
- Yu H, Kang H, Jiao Z, Lü G, Bi Y. 2015. Tunable photocatalytic selectivity and stability of Ba-doped  $\text{Ag}_3\text{PO}_4$  hollow nanosheets. *Chinese Journal of Catalysis*. 36: 1587–1595. [https://doi.org/10.1016/S1872-2067\(15\)60938-X](https://doi.org/10.1016/S1872-2067(15)60938-X)
- Zhankui C, Mengmeng S, Zhi Z, Liwei M, Wenjun F, Huimin J. 2013. Preparation and characterization of  $\text{Ag}_3\text{PO}_4/\text{BiOI}$  composites with enhanced visible light driven photocatalytic performance. *Catalysis Communications*. 42: 121–124. <https://doi.org/10.1016/j.catcom.2013.08.011>
- Zheng B, Wang X, Liu C, Tan K, Xie Z, Zheng L. 2013. High-efficiently visible light-responsive photocatalysts:  $\text{Ag}_3\text{PO}_4$  tetrahedral microcrystals with exposed {111} facets of high surface energy. *Journal of Materials Chemistry A*. 1: 12635–12640. <https://doi.org/10.1039/c3ta12946b>