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University of Chemical Technology and Metallurgy

8 Kl. Ohridski, 1756 Sofia, Bulgaria

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SELECTED ARTICLES

International Conference

**“Collaboration Seminar of Chemistry and
Industry (CoSCI-2016)”**

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Surabaya, Indonesia

Invited Editor

Dr. Purkan Purkan

[Primary study of cellulose acetate hollow fiber as a green membrane applied to hemodialysis](#)

Yanuardi Raharjo, Siti Wafiroh, Mahdya Nayla, Vita Yuliana, Mochamad Zakki Fahmi

[Composite beads of chitosan/bentonite as a matrix for phosphate fertilizer controlled-release](#)

Bambang Piluharto, Veinardi Suendo, Ida Maulida, Asnawati

[Serum acetaldehyde as a potential biomarker for the detection of pathogenic biofilm formation by *Candida albicans*](#)

Masfufatun, Sumayyah Luqman Bayasud, Mei Shirli Yasinta, Ni'matuzahro, Afaf Baktir

[The influence of ascorbic acid, creatine, and creatinine on the uric acid analysis by potentiometry using a carbon paste modified imprinting zeolite electrode](#)

Miratul Khasanah, Muji Harsini, Alfa Akustia Widati, Prihantari Mukti Ibrani

[A novel spectrophotometric method for determination of histamine based on its complex reaction with Cu\(II\) and alizarin red S](#)

Miftakhul Jannatin, Ayu Nabila I.L, Ganden Supriyanto, Pratiwi Pudjiastuti

[Application of ionic liquid dispersive liquid-liquid microextraction for analysis of n-nitrosodipropylamine in salted fish](#)

Aning Purwaningsih, Yanuardi Raharjo, Hendarta Agasi

[Determination of chlorpyrifos pesticide by effervescence liquid phase microextraction HPLC](#)

[UV-Vis](#)

Usreg Sri Handajani, Yanuardi Raharjo, Bagas Wantoro

[Effect of aliphatic and aromatic hydrocarbons on the oxygenase production from hydrocarbonoclastic bacteria](#)

Sri Sumarsih, Ni'matuzahroh, Fatimah, Miranti Puspitasari, Meilisa Rusdiana

[Identification of *Candida* species by assimilation and Multiplex-PCR methods](#)

Hermansyah, Nurmalina Adhiyanti, Julinar, Kemas Yakub Rahadiyanto, Susilawati

[Xylanase enzyme from a local strain of *Pseudomonas stutzeri*](#)

Purkan Purkan, Emma Huruniawati, Sri Sumarsih

[Study of a catalyst of citric acid crosslinking on locust bean gum](#)

Wuryanto Hadinugroho, Suwaldi Martodihardjo, Achmad Fudholi, Sugeng Riyanto

[Production and characterization of sulfonated chitosan-calcium oxide composite membrane as a proton exchange fuel cell membrane](#)

Siti Wafiroh, Abdulloh, Winda Kusuma Wardani

[An excellent way to prepare conductive glass using a simple glass plate aiming a promising solar cell](#)

Harsasi Setyawati, Handoko Darmokoesoemo, Hamami, Faidur Rochman, Ahmadi Jaya
Permana

[Partial oxidative synthesis of fluorescent carbon derived from local bamboo leaves](#)

Ahmadi Jaya Permana, Abdul Haris, Harsasi Setyawati, Mochamad Zakki Fahmi

[Stability of coordination compounds obtained by reduction of copper\(II\) halide and 1,3-bis\(diphenylphosphino\)propane \(DPPP\)](#)

Nike Prilil Puspita Sari, Lis Siaturohmah, Effendy, Fariati

[Phenolic compounds from Aquilaria microcarpa stem bark](#)

Alfinda Novi Kristanti, Mulyadi Tanjung, Okky P. Rahayu, Erika Herdiana

[Electrochemical degradation of naphthol AS-BO batik dyes](#)

Muji Harsini, Suyanto, Yhosep Gita Y. Y., Lilik Rhodifasari, Handoko Darmokoesomo

[Silica-methyltrimethoxysilane based hydrophobic coatings on a glass substrate](#)

Alfa A. Widati, Nuryono Nuryono, Indriana Kartini, Noah D. Martino

[Chitosan-based neem seed extract nanocapsules: a new approach on enhancing its effectiveness as an insecticide delivery agent](#)

Mochamad Zakki Fahmi, Hery Suwito, Achmadi Susilo, Elika Joeniarti, Anninda Mughniy
Rahayu Jaswadi, Nindayu Indrasari

[Confusarin and nudol, two phenanthrene group compounds, from *Dioscorea esculenta* L. and their antioxidant activities](#)

Nanik Siti Aminah, Ratih Hidayah, Mulyadi Tanjung

[Drug delivery hard shell capsules from seaweed extracts](#)

Pratiwi Pudjiastuti, Muhammad Al Rizqi Dharma Fauzi, Handoko Darmokoesoemo

[Organic template free hierarchical ZSM-5 prepared by desilication](#)

Hartati, Alfa Akustia Widati, Aning Purwaningsih, Alfinda Novi Kristanti, Anggarani Nur Oktavia

[Modification of gresik's dolomite to CaO•MgO nanocomposite as a catalyst for synthesis of biodiesel from tamanu oil](#)

Abdulloh Abdulloh, Alfa Akustia Widati, Oditio Arizal

[Guide for Authors](#)

THE INFLUENCE OF ASCORBIC ACID, CREATINE, AND CREATININE ON THE URIC ACID ANALYSIS BY POTENTIOMETRY USING A CARBON PASTE MODIFIED IMPRINTING ZEOLITE ELECTRODE

Miratul Khasanah, Muji Harsini, Alfa Akustia Widati, Prihantari Mukti Ibrani

Department of Chemistry, Faculty of Science and Technology
Universitas Airlangga, Surabaya 60115 Indonesia
E-mail: miratul-k@fst.unair.ac.id

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ABSTRACT

The high level of uric acid in the body is often associated with some diseases such as hyperuricemia, hypertension, renal and cardiovascular disease. Therefore early detection of the levels of uric acid is required. Spectrophotometry is the method commonly used in the medical field to determine the uric acid level. Its detection limit refers to a low uric acid level in a serum sample as the complexity of the serum matrices decreases its selectivity. The development of an imprinted zeolite based sensor to analyze uric acid by potentiometry is conducted. The carbon paste-IZ electrode shows a range of measurement of 10^{-6} M - 10^{-4} M, a Nernst factor of 28.2 mV decade⁻¹, and response time of 34 s - 44 s. The developed electrode has a high selectivity towards uric acid. Ascorbic acid, creatine, or creatinine do not interfere with uric acid analysis using the electrode suggested as the value of the selectivity coefficient (K_{ij}) is less than 1. The method recovery equals (113.18 ± 14.79) % ($n = 3$). The developed method is compared to the spectrophotometric one and shows an accuracy of (94.47 ± 14.64) % ($n = 7$).

Keywords: uric acid, carbon paste-IZ, selectivity, potentiometry.

INTRODUCTION

Uric acid is the end product of purine metabolism. The normal level of uric acid in the blood is in the range of 2.4 mg/dL to 5.7 mg/dL for women and 3.4 mg/dL to 7.0 mg/dL for men [1]. Uric acid has been used as a biomarker diagnosing health problems because of its ability to cause some dangerous diseases. Thus, the levels of uric acid in the body should always be controlled. Spectrophotometry using a chemical reagent or the enzymatic method are the common current methods used in field of medicine to analyze uric acid content. The method used to determine uric acid levels must be selective because uric acid is found together with other interfering compounds [2]. Creatine and creatinine are also potentially interfering uric acid analysis because of the similarity of their functional groups and structure. These compounds presence hamper obtaining accurate

results in respect to uric acid levels.

Various electrochemical methods are developed to solve the problem of uric acid analysis. Voltammetry application presents a definite interest because it requires less chemicals and time compared to the colorimetric and enzymatic methods [3, 4]. However, the major problem encountered by this method is the interference of ascorbic acid and urine which can be oxidized at the potentials close to that of the uric acid [5].

A previous study [6] have advances a method of uric acid content determination by potentiometry using ZnO nano wires electrode immobilized by the enzyme uricase. Its measurement range refers to 1.0×10^{-6} M – 6.5×10^{-4} M which makes it very suitable for uric acid determination in the blood serum. Glucose, ascorbic acid and urea do not interfere in case of this method application. Another study reports the potentiometric use of a ZnO nanoflakes-based sensor immobilized by

the enzyme uricase [7]. The results show that the sensor has a measuring range of 5.0×10^{-7} M – 1.5×10^{-3} M and a detection limit of 5.0×10^{-7} M. The sensor function is not interfered by the presence of ascorbic acid, glucose and urea. A potentiometric method using carbon paste electrodes modified by imprinting zeolite (carbon paste-IZ) is also developed to measure uric acid levels [8]. Its application is not affected by the presence of urea. The zeolite has a rigid structure and it can maintain the shape and size of its pores (i. e. its selectivity) [9] in an aqueous medium. The conformity of the zeolite print size and shape and those of the uric acid molecule increases zeolite's adsorption capacity which in turn provides high sensitivity in respect to uric acid determination.

The present work reports a study on the influence of ascorbic acid, creatinine and urea on uric acid analysis by potentiometry using a carbon paste electrode modified by an imprinting zeolite. The preparation of latter is already described [8]. The Iof ascorbic acid, creatinine and creatine is followed by introducing each compound of a varying concentration to the uric acid standard solution.

EXPERIMENTAL

Material and methods

Uric acid (Fluka), creatine and creatinine (Sigma-Aldrich), ascorbic acid, acetic acid, sodium acetate, and sodium hydroxide trihydrate, carbon powder, solid paraffin, tetraethyl orthosilicate (TEOS), tetrabutyl orthotitanate (TBOT), tetrapropyl ammonium hydroxide (TPAH) (all products of Merck) were used. They were of an analytical grade. Distilled water was used as a solvent. The stock solution of 10^{-2} M uric acid was prepared by dissolving 0.1680 g uric acid in about 10 mL 50 % (w/w) aqueous solution of sodium hydroxide (a 100 mL volumetric flask was used for the preparation of the latter). The standard 10^{-8} M - 10^{-3} M solutions of uric acid were prepared by diluting appropriate uric acid working solutions, and their pH were adjusted through the addition of acetate buffer of pH 5. Urine from patients of a local pathological clinic was used as a sample.

Fabrication of carbon paste – IZ electrode

Carbon paste electrode was manufactured by mix-

ing carbon powder, imprinting zeolite and paraffin in a mass ratio of 40:25:35 [8]. The process was assisted by heating. The zeolite was synthesized by mixing TEOS, TBOT and TPAH in mole ratios reported in a previous study [10]. The uric acid was then extracted from the zeolite framework using warm water to produce imprinting zeolite. The electrode investigated was prepared by inserting a silver (Ag) wire in a micropipette tube filled to its 3/4 by solid paraffin and subsequent introduction of by the paste already described.

Determination of the measurement range, the Nernst factor and the response time of the electrode

Measurement range was determined by measuring the electrode potential in a uric acid solution of a concentration ranging from 10^{-8} M to 10^{-3} M and the subsequent presentation of the dependence of the logarithm of uric acid concentration ($\log [\text{uric acid}]$) on the electrode potential (E). The measurement range referred to the concentration interval where the relation pointed above was linear, while the slope of that line was equal to the Nernst factor value. The response time of electrode was determined by the time required to obtain a potential value referring to uric acid presence.

Selectivity of the electrode

The selectivity of the electrode, expressed by the selectivity coefficient (K_{ij}), was studied through the addition of ascorbic acid, creatine and creatinine, compounds which always coexist with uric acid in urine or in a serum sample. Uric acid used was 10^{-4} M, while the ascorbic acid, the creatine and the creatinine were added in varying concentrations. The K_{ij} value was calculated by Matched Potential Method (MPM) [11].

Method recovery and comparative test

The recovery of the method was followed by measuring the potential in a urine sample, a uric acid standard solution, and urine samples spiked by a uric acid standard solution. The urine samples were taken from the urine of adults collected over 24 hours. The potential of the carbon paste-IZ electrode was read and its value was substituted into the linear regression equation describing the standard curve aiming to obtain the concentration of

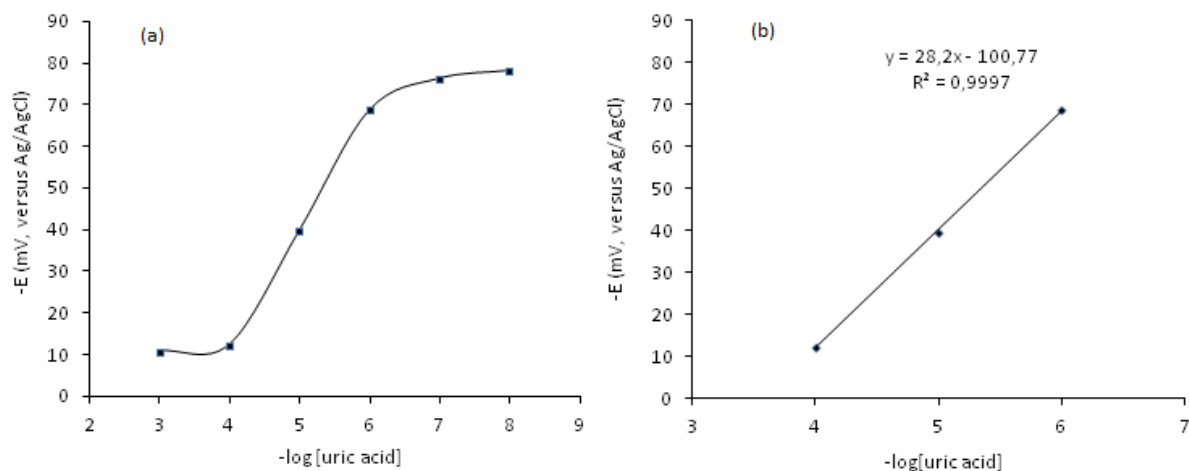


Fig. 1. Curve of $-E$ versus $-\log$ [uric acid] (a) and calibration curve (b).

each solution. The recovery (R) value was calculated by substituting the concentration of each solution into Eq. 1:

$$R = \frac{C_{ss} - C_{sp}}{C_{std}} \times 100\% \quad (1)$$

where R was the recovery, C_{ss} was the concentration of the spiked sample, C_{sp} was the concentration of the urine sample, while C_{std} was the concentration of the standard solution.

The method described was compared to the UV-Vis spectrophotometrical one to determine its accuracy. The latter was calculated by referring the concentration determined potentiometrically (C_{dev}) to that obtained spectrophotometrically (C_{std}) (Eq. 2):

$$A = \frac{C_{dev}}{C_{std}} \times 100\% \quad (2)$$

RESULTS AND DISCUSSION

Performance of the electrode

The performance of the electrode assembled is studied by measuring its potential in solutions of uric acid of a concentration ranging from 10^{-8} M to 10^{-3} M using Ag/AgCl as a reference electrode. The relationship between $-\log$ [uric acid] and $-E$ (potential) is presented in Fig. 1a.

The measurement range found refers to the concentration interval of 10^{-6} M - 10^{-4} M (Fig. 1b), where the linearity is characterized by r value of 0.9995. The

response time is found equal to 34 s - 44 s, while the Nernst factor estimated is equal to 28.2 mV decade⁻¹. In view of the fact that uric acid is a divalent molecule [12, 13], the Nernst factor is expected to be equal to (29.6±2) mV decade⁻¹. As previously reported the method has a limit of detection of 5.86×10^{-6} M. precision of 98.6 to 98.8 % (n=3), and a life time of 10 weeks [8].

Selectivity of the electrode

Selectivity is the ability of electrodes to measure an analyte selectively wherein the analyte coexist with other components in a sample. One of the most important characteristics in this respect electrode response to primary compound (i) in presence of other compounds (j), which is measured in terms of the potentiometric selectivity coefficient (K_{ij}). The estimation of the coefficient of selectivity is required due to the presence of uric acid in the body together with other molecules of functional groups similar to those of uric acid, such as urea, creatine, creatinine, and ascorbic acid [14]. The selectivity coefficient is determined in this research by the Matched Potential Method (MPM) [11]. If the selectivity coefficient value is less than 1, the analysis of uric acid is not hampered by the presence of the interfering compounds.

Creatine, creatinine, and ascorbic acid are the compounds used to study the effect of the matrix in this investigation. The concentration of uric acid used coincides with that in the body which is 10^{-4} M. The

Table 1. Coefficient of selectivity (K_{ij}) of carbon paste-IZ electrode obtained in the course of analysis of uric acid in presence of ascorbic acid, creatine, and creatinine as interfering compounds.

Interfering compound (M)	K_{ij}
Ascorbic acid	
5.0×10^{-6}	0.1769
1.0×10^{-5}	0.3847
1.0×10^{-4}	0.7273
5.0×10^{-4}	0.2597
Creatine	
1.0×10^{-5}	0.2002
3.0×10^{-5}	0.1004
1.0×10^{-4}	0.0870
3.0×10^{-4}	0.1749
Creatinine	
1.0×10^{-5}	0.3267
3.0×10^{-5}	0.2093
1.0×10^{-4}	0.1023
3.0×10^{-4}	0.2059

*) Concentration of uric acid used was 10^{-4} M

concentrations of creatine and creatinine used are 1×10^{-5} M, 3×10^{-5} M, 1×10^{-4} M, and 3×10^{-4} M, while those of ascorbic acid refer to 5×10^{-6} M, 1×10^{-5} M, 1×10^{-4} M, and 5×10^{-4} M. The choice of the concentrations values pointed above is determined by these substances low, normal and high levels in real urine and serum samples. The value of the selectivity coefficient (K_{ij}) for each concentration is shown in Table 1.

It is seen that the selectivity coefficient is less than 1

Table 2. Values of the electrode potential obtained in the course of analysis of a urine sample.

Solution	E (mV, vs Ag/AgCl)
Urine	23.90
Urine + uric acid 10^{-6} M	23.91
Uric acid 10^{-6} M	-62.70
Urine + uric acid 10^{-5} M	24.01
Uric acid 10^{-5} M	-37.20
Urine + uric acid 10^{-4} M	25.00
Uric acid 10^{-4} M	-7.60

for each concentration of the compounds suspected to interfere with the analysis of uric acid. This means that creatine, creatinine, as well as ascorbic acid do not hamper uric acid analysis by potentiometry using the electrode assembled. It is so because the electrode recognizes specific molecules, namely uric acid.

Comparative test and recovery of the method

The recovery of the method applied is identified by measuring the electrode potential in a uric acid standard solution, a urine sample, and a urine sample spiked by a uric acid standard solution. The concentration of the uric acid standard solution used is 10^{-6} M - 10^{-4} M. The electrode potential values obtained are listed in Table 2.

The data referring to the juxtaposition of the method considered and the spectrophotometrical analysis usually applied are summarized in Table 3. It is evident that 3 the recovery of the method advanced reaches 96.18 - 123.04 % in case of spiking uric acid solutions of three different concentrations to a urine sample. The results

Table 3. Data illustrating the potentiometric method recovery and its juxtaposition to spectrophotometry.

Sample	Concentration (M)		Recovery (%) Potentiometry	Accuracy (%) Toward spectrophotometry
	Potentiometry	Spectrophotometry (*)		
Urine	1.89×10^{-3}	2.39×10^{-3}		79.00
Urine + uric acid 10^{-6} M	1.89×10^{-3}	1.94×10^{-3}	96.18	97.28
Uric acid 10^{-6} M	1.61×10^{-6}	1.92×10^{-6}		83.51
Urine + uric acid 10^{-5} M	1.91×10^{-3}	2.30×10^{-3}	120.34	82.80
Uric acid 10^{-5} M	1.29×10^{-5}	1.31×10^{-5}		98.42
Urine + uric acid 10^{-4} M	2.08×10^{-3}	2.10×10^{-3}	123.04	98.41
Uric acid 10^{-4} M	1.44×10^{-4}	1.18×10^{-4}		121.89

*) data from clinical laboratory

referring to the comparative testing of potentiometry and spectrophotometry in case of 7 sample solutions show accuracy of 79.00 % - 121.89 %. The range of accuracy required by the Association of Official Analytical Chemist (AOAC) for the concentration range of 10^{-6} M - 10^{-4} M is 80-110 % [15].

CONCLUSIONS

A carbon paste electrode modified by an imprinting zeolite is prepared. It has a high selectivity towards uric acid. The presence of ascorbic acid, creatine, or creatinine does not affect uric acid analysis by potentiometry using the electrode assembled. The recovery of the potentiometry method amounts to $(113.18 \pm 14.79) \%$ ($n=3$). The comparison of the method to the spectrophotometrical analysis usually applied shows an accuracy of $(94.47 \pm 14.64) \%$ ($n=7$). It is concluded that the method can be applied to determine uric acid in urine or a serum sample.

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H-INDEX

22

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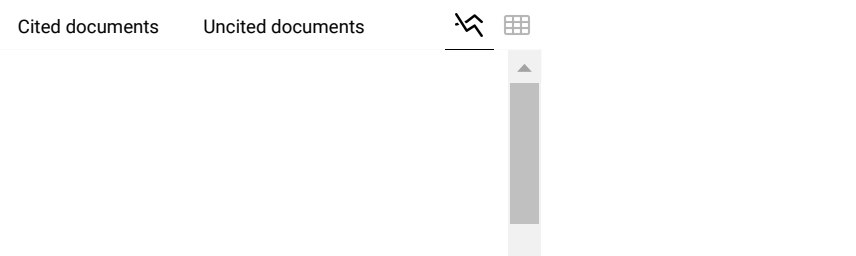
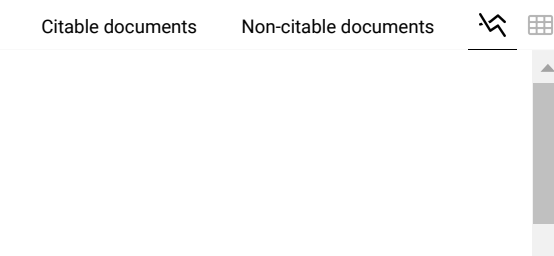
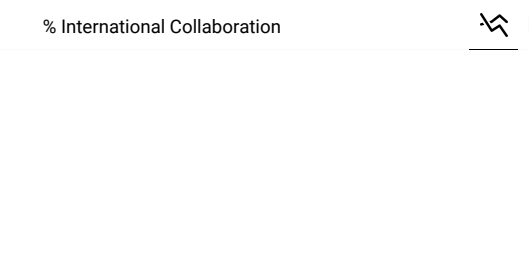
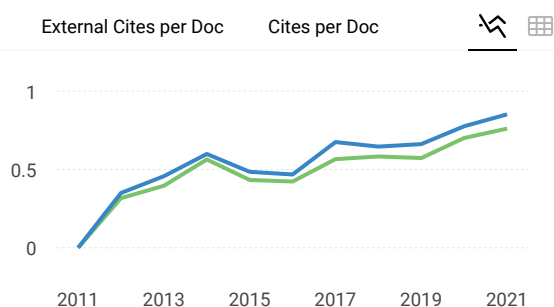
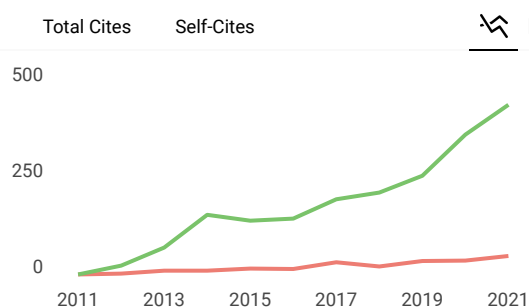
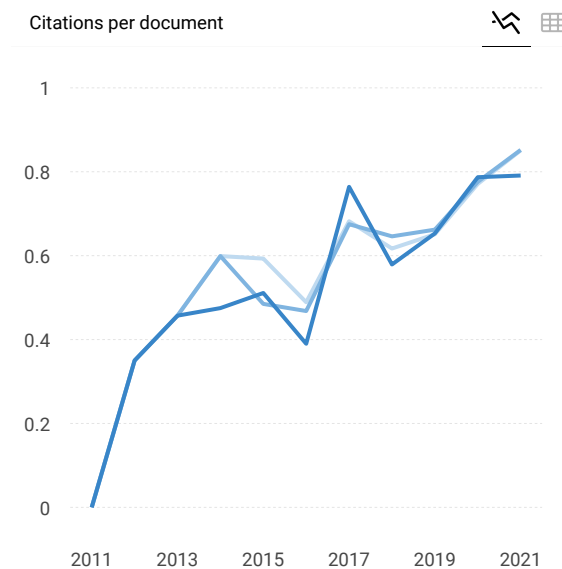
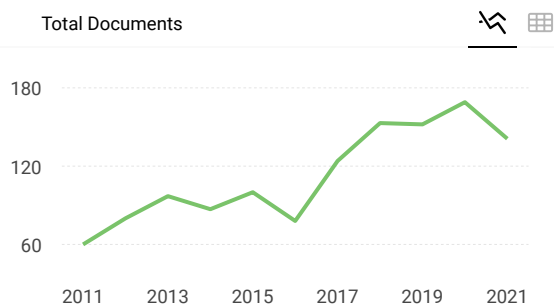
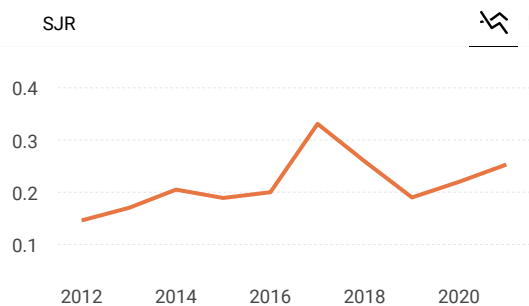
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Journal of Chemical Technology and Metallurgy

Q3 Chemical Engineering (miscellaneous) best quartile

SJR 2021 0.25

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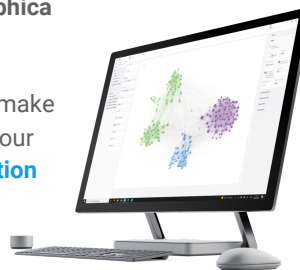
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IJRTI Research Journal

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Metrics based on Scopus® data as of April 2022

G **Gulnoz** 1 year ago

Assalomu alaykum Hurmatli redaksiya bu journal scopusda indexed qilinganmi

reply



Melanie Ortiz 1 year ago

Dear Gulnoz,

Thank you very much for your comment.

All the metadata have been provided by Scopus /Elsevier in their last update sent to SCImago, including the Coverage's period data. The SJR for 2020 was released on 17 May 2021. We suggest you consult the Scopus database directly to see the current index status as SJR is a static image of Scopus, which is changing every day.

Best Regards, SCImago Team

M

Mohsen afrouzeh 2 years ago

Hi

could you please let us to know about the ranking of this journal on 2020?

best wishes

reply



Melanie Ortiz 2 years ago

Dear Mohsen,

Thank you for contacting us. Our data come from Scopus, they annually send us an update of the data. This update is sent to us around April / May every year. The SJR for 2019 was released on 11 June 2020. Therefore, the indicators for 2020 will be available in June 2021.

Best Regards, SCImago Team

R

Ralitsa 2 years ago

Hello,

I could not find any information about the IF of this journal.

Does the journal have such an index?

Regards!

reply



Melanie Ortiz 2 years ago

SCImago Team

Dear Ralitsa, thank you very much for your comment. SCImago Journal and Country Rank uses Scopus data, our impact indicator is the SJR (Check it on our website). We suggest you consult the Journal Citation Report for other indicators (like Impact Factor) with a Web of Science data source. Best Regards, SCImago Team

G

Galina Seitmagzimova 3 years ago

Please, can you give an information on the Journal quartile in 2019?

reply



Melanie Ortiz 3 years ago

SCImago Team

Dear Galina,
Thank you for contacting us. Our data come from Scopus, they annually send us an update of the data. This update is sent to us around April / May every year. Thus, the indicators for 2019 will be available in June 2020 and before that date we can't know what will happen with this journal.
Best Regards, SCImago Team

B

Bilal 5 years ago

Dear Sir/M'am,

Can you please let me know why I can't open the website of the journal?

reply

SCImago Team



Elena Corera 5 years ago

Dear Bilal,

sorry, but unfortunately we cannot help you with your request, SJR has no relation with journal's website.

Best regards,
SCImago Team

S **Salim Kaiser** 5 years ago

let me know the present status of my manuscript "Corrosion behaviour of Al-12Si-1Mg automotive alloy in acidic, alkaline and salt media with trace of Zr"

reply

S **Salim Kaiser** 5 years ago

Dear Sir

Please let me know the present status of my manuscript entitle

"Corrosion behaviour of Al-12Si-1Mg automotive alloy in acidic, alkaline and salt media with trace of Zr"

kind regards.

Salim Kaiser

reply



Elena Corera 5 years ago

SCImago Team

Dear Salim, we suggest you contact the journal directly. Best Regards, SCImago Team

V **Vinay** 5 years ago

Dear Sir/M'am,

Can you please let me know the procedure for publishing a research paper in your journal.

Regards

Vinay

reply



Elena Corera 5 years ago

SCImago Team

Dear Vinay, in the link below you will find the information corresponding to the author's instructions of this journal. Best regards, SCImago Team
<http://dl.uctm.edu/journal/node/61>

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