

Materials Science Forum

 **TRANS TECH PUBLICATIONS**

Engineering Series

Advances in Science and Technology

Construction Technologies and Architecture

Books

Special Book Collections

Foundations of Materials Science and Engineering

Specialized Collections

Retrospective Collection

Materials Science Forum - Editorial Board

ISSN: 1662-9752

Details

Volumes

Editorial Board

Founding Editor

Fred H. Wohlbiert

Honorary Editor

Prof. Graeme E. Murch

University of Newcastle, Centre for Mass and Thermal Transport in Engineering Materials, School of Engineering; Callaghan, Australia, NSW 2308;

Editor(s) in Chief

Prof. Iulian Antoniac

University Politehnica of Bucharest, Faculty of Materials Science and Engineering; 313 Splaiul Independentei, Bucharest, 060042, Romania;

Prof. Guillermo Requena[ORCID](#)

German Aerospace Center (DLR), Institute of Materials Research ; Köln, DE-51170, Germany;

Editorial Board

Prof. Dezső L. Beke

University of Debrecen, Department for Solid State Physics; Bem tér 18/b, Debrecen, 4026, Hungary;

Prof. Giorgio Benedek

University of Milano Bicocca, Department of Materials Science; U5, Università di Milano-Bicocca, Via R. Cozzi 55, Milano, 20125, Italy;

Dr. Giacomo Benvenuti[ORCID](#)

ABCD Technology; Switzerland;

Prof. Anil K. Bhatnagar

University of Hyderabad, School of Physics and School of Engineering; Hyderabad, India, 500046;

Prof. Chi Ming Chan

Hong Kong University of Science and Technology, Department of Chemical and Biomolecular Engineering, Clear Water Bay; Kowloon, China;

Dr. Abel S. Fenta[ORCID](#)

CERN; Genève, CH-1211, Switzerland;

Roberto B. Figueiredo

Federal University of Minas Gerais, Department of Metallurgical and Materials Engineering; Belo Horizonte, MG, 30, Brazil, 31270-901;

Prof. Hermann G. Grimmeiss

Lund University, Department of Solid State Physics; Box 118, Lund, 221 00, Sweden;

Prof. Jerzy Jedlinski

AGH University of Science and Technology, Faculty of Materials Science and Ceramics, Department of Physical Chemistry and Modeling of Processes and Surface Engineering; al. Mickiewicza 30, Kraków, 30-059, Poland;

Prof. Megumi Kawasaki[ORCID](#)

Oregon State University, School of Mechanical, Industrial and Manufacturing Engineering; 204 Rogers Hall, Corvallis, USA, 97331;

Prof. Terence G. Langdon

University of Southampton, Faculty of Engineering and the Environment; Lanchester Building (Bldg. 7), Highfield Campus, Southampton, United Kingdom, SO17 1BJ;

Prof. Jai Sung Lee

Hanyang University, Department of Metallurgy and Materials Science; 55 Daehak-no, Sangnok-gu, Ansan, Korea, South, 426-791;

Prof. Eric J. Mittemeijer

Max Planck Institute for Intelligent Systems; Heisenbergstrasse 3, Stuttgart, 70569, Germany;

Prof. Stephen J. Pearton

University of Florida, Department of Materials Science and Engineering; Gainesville, USA, 32611-6400;

Prof. Vassilis Pontikis

Commissariat à l'Energie Atomique et les Energies Alternatives (CEA), CEA-Saclay; Bdg. 524, Gif-sur-Yvette, 91191, France;

Prof. András Roósz

Hungarian Academy of Sciences, Miskolc University (HAS-MU); Miskolc-Egyetemváros, 3515, Hungary;

Prof. David N. Seidman

Northwestern University, Department Materials Science and Engineering; Cook Hall, 2220 Campus Drive, Evanston, USA, 60208;

Dr. Ching Hua Su

NASA/Marshall Space Flight Center, EM31 NASA/Marshall Space Flight Center; Huntsville, USA, 35812;

Prof. David Tomanek

Michigan State University, Physics and Astronomy Department; 567 Wilson Road, East Lansing, USA, MI 48824-6455;

Prof. A.S. Wronski

University of Bradford, School of Engineering, Design and Technology; West Yorkshire, Bradford, United Kingdom, BD7 1DP;

Emeritus Prof. David J. Young

University of New South Wales, School of Materials Science and Engineering; Sydney, Australia, NSW 2052;

Table of Contents

Preface

Chapter 1: Advanced and Functional Materials

The Study on Tuning Photoluminescence of Colloidal Graphene Quantum Dots Synthesized through Laser Ablation	
F.H. Murdaka, A.A. Nugroho, A. Kusumaatmaja, Isnaeni and I. Santoso	3
Crystal Structure and Electrical Properties of (1-x) (Ba_{0.85}Sr_{0.15})TiO₃ - x(K_{0.5}Na_{0.5})NbO₃ System	
U. Nuraini, Y.N. Kaukaba, Mashuri and Suasmoro	8
Precipitated Silica from Sodium Silicate by CO₂ on Fixed Bed Column	
R. Dewati, Suprihatin, K. Sumada and S. Muljani	14
The Morphology of Si-K-HAs Composite Prepared by Spray Drying	
S. Muljani, H. Setyawan and K. Sumada	19
Mechanical Exfoliation of Reduced Graphene Oxide From Old Coconut Shell as Radar Absorber in X-Band	
A.F. Kurniawan, M.S. Anwar, K. Nadiyyah, Mashuri, Triwikantoro and Darminto	25
Characterization of TiN Oxide Doping Antimony Thin Layer with Sol- Gel Spin Coating Method for Electronic Device	
A. Doyan, Susilawati, A. Harjono, S. Azzahra and M. Taufik	30
The Effects of Layer Thickness of Radar Absorbing Materials Prepared by Double Layer Method on X-Band Wavelength Frequency	
M. Zainuri, R.F. Puspitasari, D. Ristiani and Triwikantoro	35
Geopolymer Concrete for Radiation Shielding Application	
Nurhasmi, D. Tahir, B. Abdullah, A. Ansar, S. Ilyas, I. Mutmainna and W.I. Madda	41
Effects of Spin-Orbit Coupling on the Electronic and Excitonic Structures of Monolayer WS₂	
B.E. Dharma, A. Syahroni and M.A. Majidi	48
Characterization of BaM and PaNi-Based Radar Absorbency (RAM) Behavior with Multilayer Geometry Structure for X-Band Absorption	
M. Zainuri and D. Andryani	54
Preparation and Characterization of Electrospun Composite Fiber of Polymer-TiO₂	
G. Yudoyono, Sudarsono and D. Anggoro	60
Structural Analysis and Electrical Properties of Amorphous Carbon Thin Films	
D.I. Pamungkas, Mukarromah, B. Priyanto, H. Nakajima, S. Tunmee and Darminto	66
Optical Transmission of p-Type a-Si:H Thin Film Deposited by PECVD on ITO-Coated Glass	
S. Prayogi, M.A. Baqiya, Y. Cahyono and Darminto	72
Synthesis of Silica-Potassium-Nitrogen from Carbamide and Potassium Silicate by CO₂ Precipitator	
K. Sumada, S. Muljani and C. Pujiastuti	77
Effect of Modified SiO₂ on the Hydrophobic Properties as Self-Cleaning Materials	
L. Silvia, A.H. Wardani, Y. Dwihapsari and M. Zainuri	83
Particle Size Analysis of the Synthesised ZrO₂ from Natural Zircon Sand with Variation of pH Deposition Using Alkali Fusion-Coprecipitation Method	
C.F.K. Murti, H. Aldila, Endarko and Triwikantoro	89
Fabrication of Amorphous Carbon Thin Film from CH₄ Using PEVCD	
B. Priyanto, M. Saleh, S. Tunmee, C. Euaruksakul, Y. Cahyono, Triwikantoro and Darminto	95
Low Temperature Graphene Growth Effort on Corning Glass Substrate by Using VHF-IP HWC-PECVD	
M.A. Yusuf, A. Rosikhin, J.D. Malago, F.A. Noor and T. Winata	100
Electrochemical Deposition of Polyaniline on Carbon Steel for Corrosion Study in Geothermal Solution	
G.A. Aristia, L.Q. Hoa and R. Baessler	107

Chapter 2: Bio- and Food Technologies, Materials in Biomedicine

Relationship between the Structure and Electrical Conductivity of 12-Mer Single-Stranded Polyadenine Studied by Scanning Tunnelling Microscope H. Rozak, W.N. Zaharim, I. Miyazaki, N.E. Ismail, S.N. Abu Bakar, D. Kernain, R. Samian, K. Ichimura, M.I. Mohamed-Ibrahim, S. Sulaiman and I. Watanabe	119
Study of Carbonated Calcium Phosphate Precipitation on Collagen R. Tasomara, S. Julia, Y.W. Sari, Nurlily and D.S. Soejoko	126
Physicochemical and Cytotoxicity Characterization of Injectable Bone Substitute Based on Hydroxyapatite - Chitosan - Streptomycin for Spinal Tuberculosis Cases S.A. Rachmawati, D. Hikmawati, A.S. Budiati and A.P. Putra	133
Quality Improvement of Biomaterial of <i>Lemna Sp</i> Y. Andriani, Iskandar, I. Zidni and Risdiana	139
Hydroxyapatite-Collagen Composite Made from Coral and Chicken Claws for Bone Implant Application Siswanto, D. Hikmawati, Aminatun and M. Zamawi Ichsan	145
Study on Formalization of Oil Palm Trunk Modified by Melamine Formaldehyde T.N. Manik, Mashuri and Darminto	151
The Role of Relative Humidity on Physical Characteristics of Poly Vinyl Alcohol-<i>Aloe vera</i> Fiber Membrane by Using Electrospinning Methods D. Hikmawati, E.F. Adiputri, A.P. Putra and J. Ady	157
Synthesis of Carbon Nanosphere at Low Temperatures Based on Bamboo Fiber Y.K. Lahsmin, D. Tahir, B. Abdullah, S. Ilyas and I. Mutmainna	163
Irradiation Effect on the Structural Properties of <i>Ipomoea batatas L</i> as a Function of Temperature and Time S. Fatimah, M. Nur, S.D.A. Ilyas and D. Tahir	169
Sorption Efficiency in Dye Removal and Thermal Stability of Sorghum Stem Aerogel E.L. Septiani, O.P. Prastuti, Y. Kurniati, M. Fauziyah, Widiyastuti, H. Setyawan, Wahyudiono, H. Kanda and M. Goto	175
Investigation of Structural and Antifungal Behaviors of Nano-Sized Anatase Titanium Dioxide Synthesized by Co-Precipitation Route A. Taufiq, D. Arista, Sunaryono, R.E. Saputro, N. Hidayat, S. Soontaranon, E. Handoko and Darminto	181
Optimization of Polydimethylsiloxane Synthesized Parameters as Vitreous Humour Substitutes S. Setiadji, Fitrilawati, A.N. Fauza, A. Ardi, R.M. Novianti, N. Syakir, Wasluluddin, I. Rahayu, A.S. Kartasasmita and Risdiana	189
Physical Characteristics of Soft Tissue Phantom from Silicone Rubber Based Vulcanization System A. Ansar, D. Tahir, B. Abdullah, Nurhasmi, S. Fatimah and Jusmawang	194
Synthesis of Precipitate Calcium Carbonate with Variation Morphology from Limestone by Using Solution Mixing Method Z. Arifin, Triwikantoro, B.A. Subagyo, M. Zainuri and Darminto	200
Banana Peel Activated Carbon in Removal of Dyes and Metals Ion in Textile Industrial Waste O.P. Prastuti, E.L. Septiani, Y. Kurniati, Widiyastuti and H. Setyawan	204
The Analysis of Composite Particle Board Based on Mushroom Growing Media Waste T.P. Harmi, Sutarman, W. Edi, A. Faldy, A. Syamsul and G.A.N. Fitri	210
Solvent Effect on Bond Dissociation Enthalpy (BDE) of Tetrahydrocurcumin: A Theoretical Study L.S.P. Boli, N.D. Aisyah, V. Khoirunisa, H. Rachmawati, H.K. Dipojono and F. Rusydi	215
The Effects of Split Valence Basis Sets on Muon Hyperfine Interaction in Guanine Nucleobase and Nucleotide Structures W.N. Zaharim, S. Sulaiman, S.N. Abu Bakar, N.E. Ismail, H. Rozak and I. Watanabe	222
Predicting Notable Radical Scavenging Sites of Gnetin C Using Density Functional Theory V. Khoirunisa, L.S.P. Boli, R. Nur Fadilla, A.G. Saputro, H. Rachmawati, H.K. Dipojono and F. Rusydi	229

Chapter 3: Investigation of Magnetic and Superconducting Properties

Synthesis and Characterization of Magnetic Rubidium Superoxide, RbO₂ F. Astuti, M. Miyajima, T. Fukuda, M. Kodani, T. Nakano, T. Kambe and I. Watanabe	237
Electrical Transport Properties of Perovskite La_{0.7}Sr_{0.2}Ba_{0.1}Mn_{1-x}Ni_xO₃ (x = 0 and 0.1) Manganite D.R. Munazat, B. Kurniawan and A. Imaduddin	243
The Doping Effects of SiC and Carbon Nanotubes on the Manufacture of Superconducting Monofilament MgB₂ Wires A. Imaduddin, Samsulludin, M.R. Wicaksono, I. Saefuloh, S. Herbirowo, S.D. Yudanto, Hendrik, H. Nugraha, Lusiana, E. Mabruri, N. Darsono and A.W. Pramono	249
Magnetic Properties of YBa₂Cu₃O₆ Studied by Density Functional Theory Calculations I. Ramli, S.S. Mohd-Tajudin, M.R. Ramadhan, D.P. Sari, S. Sulaiman, M.I. Mohamed-Ibrahim, B. Kurniawan and I. Watanabe	257
Enhanced Room-Temperature Ferromagnetism in Superconducting Pr_{2-x}Ce_xCuO₄ Nanoparticles M.A. Baqiya, P.E.D. Putra, R. Irfanita, Suasmoro, Darminto, T. Kawamata, T. Noji, H. Sato, M. Kato and Y. Koike	263
Magnetic Properties of Hole-Doped Pyrochlore Iridate (Y_{1-x-y}Cu_xCa_y)₂Ir₂O₇ J. Angel, R. Asih, H. Nomura, T. Taniguchi, K. Matsuhira, M.R. Ramadhan, I. Ramli, M. Wakeshima, Y. Hinatsu, M.I. Mohamed-Ibrahim, S. Sulaiman and I. Watanabe	269
Physical Properties of Encapsulated Iron Oxide T. Saragi, B. Permana, A. Therigan, S. Hidayat, N. Syakir and Risdiana	277
Characterization of Barium M-Hexaferrite with Doping Zn and Mn for Microwaves Absorbent Susilawati, A. Doyan, M. Taufik, Wahyudi, E.R. Gunawan, A. Fitriani and Nazarudin	282
Comparative Study on Magnetism of Reduced Graphene Oxide (rGO) Prepared from Coconut Shells and the Commercial Product R. Asih, E.B. Yutomo, D. Ristiani, M.A. Baqiya, T. Kawamata, M. Kato, I. Watanabe, Y. Koike and Darminto	290
Magnetic Study of the Lower Critical Field of Organic Superconductor λ-(BETS)₂GaCl₄ D.P. Sari, K. Hiraki, T. Nakano, M. Hagiwara, Y. Nozue, T. Kusakawa, A. Hori, A. Yamamoto, I. Watanabe and Y. Ishii	296
Complex Permittivity, Permeability and Microwave Absorption Studies of Double Layer Magnetic Absorbers Based on BaFe₁₂O₁₉ and BaFe₁₀CoZnO₁₉ E. Handoko, I. Sugihartono, M.A. Marpaung, U. Cahyana, S. Aritonang, Z. Jalil, Rusmono, A. Taufiq, Sunaryono, M. Randa and M. Alaydrus	302
Preparation of Local Raw Material for α-Fe₂O₃ Nanoparticles Powder from Mineral Extraction of Iron Sand M.P. Izaak, H. Sitompul, W.A. Adi and Y.E. Gunanto	308
Study of Magnetic Properties in Electron Doped Superconductor Eu_{2-x}Ce_xCuO_{4+α} Y. Maryati, N. Nafisah, D.G. Auliya, E. Nurwati, T. Amalia, Y.R. Tayubi, T. Saragi and Risdiana	314
Crystal Structure and Magnetic Properties of Non-Stoichiometric Co₂MnGa Heusler Alloy M.Y. Pandu Akbar, R.R. Sihombing, A. Sakai, A.A. Nugroho and S. Nakatsuji	319
Analysis of Physical Properties, Crystal Structure and Magnetic Properties of Barium Hexaferrite Doped with 2 % wt. of SrO and Prepared by Coprecipitation Method Suprapedi, Muljadi, Djuhana and Ramlan	325
Effect of Copper Substitution on the Electrical Transport Properties of La_{0.7}Ba_{0.1}Sr_{0.2}Mn_{1-x}Cu_xO₃ (X = 0 and 0.05) Manganites B. Kurniawan, D.S. Razaq and A. Imaduddin	331
Enhanced Microwave Absorbing Capabilities of Multilayer Absorbers Based on BaFe₁₂O₁₉ and Fe₃O₄ E. Handoko, I. Sugihartono, M.A. Marpaung, U. Cahyana, S. Aritonang, Z. Jalil, Rusmono, A. Taufiq, Sunaryono and M. Alaydrus	338
The Effect of Freezing-Thawing Route Number on Magnetic Properties and Nanostructural of Fe₃O₄/ Carboxymethyl Cellulose/Polyvinyl Alcohol Magnetic Hydrogel Sunaryono, M.N. Kholifah, A. Taufiq and E. Handoko	344

Synthesis and Characterization of Nd₂Fe₁₄B Powder Prepared by Using Milling and Heat Treatment	
Ramlan, P. Sardjono, Muljadi, D. Setiabudidaya and F. Gulo	352
Growth of Free-Standing La_{2-x}Sr_xCuO₄ Nanoparticles	
S. Winarsih, F. Budiman, H. Tanaka, T. Adachi, T. Goto, B. Soegijono, B. Kurniawan and I. Watanabe	357
Study of Magnetoresistance Effect and Magnetic Properties of La_{0.67}Sr_{0.33}Mn_{1-x}Ni_xO₃ (x = 0 and 0.2) Material Prepared by Sol-Gel Method	
U. Widyaiswari, B. Kurniawan, A. Imaduddin and I. Watanabe	363
 Chapter 4: Materials for Technologies of Energy Storage and Conversion	
Characteristics of Large Area Perovskite Solar Cells from Electrodes of Used Car Batteries	
A. Bahtiar, C. Agustin, E.S. Nurazizah, A. Aprilia and D. Hidayat	373
Study of Electrochemical Deposition Process of Graphene Oxide on DSSC TiO₂ Based Photoanode	
A. Aprilia, V. Marcelina, F. Yuliasari, Y.W. Hartati, Fitrilawati, L. Safriani and R.E. Siregar	378
The Effect of Reduced Graphene Oxide (rGO) Coating on Electrical Conductivity of Lithium Ferro Phosphate (LFP) as an Alternative Cathode for Li-Ion Battery	
E. Suarso, A.Z. Laila, F.A. Setyawan, M. Zainuri, Z. Arifin and Darminto	386
Preparation of Lithium Iron Phosphate-Carbon Composite as a Cathode for Lithium Ion Battery	
I. Rahayu, A.R. Noviyanti, D. Rakhmawaty, A. Anggraeni, H.H. Bahti, S. Hidayat and Risdiana	392
Analysis of Defects and Surface Roughness on the Hydrogenated Amorphous Silicon (a-Si:H) Intrinsic Thin Film for Solar Cells	
Y. Cahyono, N. Dwi Purnamasari, M. Zainuri, S. Pratapa and Darminto	398
μSR Study with Light Irradiation of P3HT:ZnO Nanoparticles as Active Material of Hybrid Solar Cells	
L. Safriani, Risdiana, Fitrilawati, A. Bahtiar, A. Aprilia, R.E. Siregar, M. Manawan, D. Puspitasari Sari, J. Angel and I. Watanabe	404
Band Gap Optimization of Thin Film a-Si:H Bifacial Solar Cells (BFSCs) Using AFORS-HET	
D. Hamdani, Y. Cahyono, G. Yudoyono and Darminto	409
Structure, Chemical Stability and Magnetic Properties of Lanthanum Silicate Oxide Apatite Synthesized by Hydrothermal Method	
Y.T. Malik, A.R. Noviyanti, N. Akbar, I. Hastiawan, T. Saragi and Risdiana	415
Effect of Electrical Resistance of TiO₂ Layer Characteristics of Dye Sensitized Solar Cell Using Chlorophyll as a Sensitizer	
N. Puspitasari, N.Y. Cahaya, G. Yudoyono, G. Prajitno and Darminto	422
Energy Storage Characteristics of Electrochemically Deposited Graphene Oxide on ITO and Cu Substrates	
Fitrilawati, V. Marcelina, D.U. Dzujah, A. Bahtiar, Y.W. Hartati and N. Syakir	428
Characteristics of CMC from Corncob and its Application as Electrode Binder in Lithium Ion Battery	
S. Hidayat, I. Mubarak, B. Adiperdana, B.J. Suroto, N. Raveli, Y.W. Hartati and I. Rahayu	433
Synthesis of n-Doped Reduced Graphene Oxide from Coconut Shell as Supercapacitors	
I. Khambali, I.S. Ardiani, A.R. Kurniawan, Triwikantoro, M. Zainuri and Darminto	437
Synthesis and Characterization of Supercapacitor Electrode from Fiber of <i>Borassus flabelifer</i> L by Activation Method	
F.A. Prasetya, U. Anggarini, Y. Zakaria and R.D.S. Putri	444
Bi Doping Effect on the Conductivity of Lanthanum Silicate Apatite	
A.R. Noviyanti, N. Akbar, I. Hastiawan, I. Rahayu, Haryono, Y.T. Malik and Risdiana	451
Effect of Ni Doping Variations on Microstructure and Conductivity of Cathode LiNi_xFe_{1-x}PO₄/C Materials	
M. Zainuri, B.A. Anang and E. Novialent	456

Chapter 5: Modeling, Computational Procedures and Devices in Research of Functional Materials

Effects of the Supercell's Size on Muon Positions Calculations of La_2CuO_4 M.R. Ramadhan, I. Ramli, M.D. Umar, S. Winarsih, D.P. Sari, A. Manaf, B. Kurniawan, M.I. Mohamed-Ibrahim, S. Sulaiman and I. Watanabe	465
Study on the Diffusion Rate of the Charge Carrier Transport in Regio-Random P3HT N. Riveli, B. Adiperdana, L. Safriani, B.J. Suroto, A.R. Noviyanti, I.H. Mohammad, I. Rahayu, M. Manawan, T. Saragi and Risdiana	471
An Approach to the Intermediate State of the Distributed Internal Fields on Muon Site M.D. Umar and I. Watanabe	476
μSR Spectrum Reconstruction Using Monte Carlo Approach: A Preliminary Study B. Adiperdana and Risdiana	483
Optical Spectra of Bi_2Se_3: The Effects of Electron-Hole Interactions D.N. Asturo, A. Syahroni and M.A. Majidi	489
Effects of Polarization Function on the Spin Contamination and Distribution in β'-$\text{Me}_4\text{P}[\text{Pd}(\text{dmit})_2]_2$ S.N.A. Ahmad, S. Sulaiman, L.S. Ang and I. Watanabe	494
Numerical Simulation on Effects of TCO Work Function on Performance of a-Si:H Solar Cells A. Sholih, D. Hamdani, S.T. Wicaksono, M.I.P. Hidayat, Y. Cahyono and Darminto	501
A Potential Application of Photonic Jet in Observing Micro-Metric Materials A. Abdurrochman, M.O. Wahidullah, D. Naufal, D.S. Sofiati, A. Aprilia, L. Safriani, S. Perrin and S. Lecler	507

Physicochemical and Cytotoxicity Characterization of Injectable Bone Substitute Based on Hydroxyapatite - Chitosan - Streptomycin for Spinal Tuberculosis Cases

Systi Adi Rachmawati^{1,2,a} Dyah Hikmawati^{3,b,*}, Aniek Setiya Budiati^{4,c},
Alfian Pramudita Putra^{1,d}

¹Biomedical Engineering Study Program, Department of Physics, Faculty of Science and Technology, Universitas Airlangga, Surabaya, Indonesia

²Material Engineering, Faculty of Mechanical and Aerospace Engineering, Bandung Institute of Technology, Bandung, Indonesia

³Department of Physics, Faculty of Science and Technology, Universitas Airlangga, Surabaya, Indonesia

⁴Department of Clinical Pharmacy, Faculty of Pharmacy, Universitas Airlangga, Surabaya, Indonesia

^asystiara@gmail.com, ^bdyah.hikmawati@yahoo.co.id, ^canieksb@yahoo.co.id,
^dalfian.pramudita@fst.unair.ac.id

Keywords: chitosan, cytotoxicity, hydroxyapatite, injectable bone substitute, physicochemical, spinal tuberculosis, streptomycin

Abstract. Injectable bone substitute (IBS) based on hydroxyapatite, chitosan and streptomycin has been developed successfully. The IBS was made by mixing 20% w/v hydroxyapatite and varying the chitosan ratio of 60:40, 65:35, 70:30, 75:25 and adding streptomycin as antibiotic substance. The mixture was added with hydroxyl propyl methylcellulose. The synthesis process was steady and no chemical reaction occurred as proven by Fourier Transform Infrared Spectroscopy (FTIR). The in vitro characterization were acidity (pH) and cytotoxicity test (MTT assay), while the physical characterization performed included injectability test, setting time, and morphology. The acidity test showed that the pH samples reached the human normal pH (6.8-7.4) in seven days. The cytotoxicity test proved that the samples were non-toxic. The repasta test showed that the acidity reached the human pH and could release the IBS pasta around 111-150 seconds. The injectability test indicated that IBS had ability to be injected for 95-96%. The setting time in all samples needed 72-166 minutes when it was injected into human bone scaffold model that was able to coat the pore of its scaffold model which proven by Scanning Electron Microscope (SEM) imaging. The pore size of human bone scaffold model was decreased from $\pm 800 \mu\text{m}$ into $\pm 120 \mu\text{m}$. So, IBS pasta based on hydroxyapatite-chitosan-streptomycin in physicochemical and cytotoxicity behaviour is preferable to be applied for spinal tuberculosis cases.

Introduction

Based on World Health Organization (WHO) data in 2015, there were top 10 disease that causes death in the world was mostly dominated by pulmonary disease. Indonesia was placed on the second position on tuberculosis disease after India in 2017 [1]. Tuberculosis was caused by *Mycobacterium tuberculosis*. This bacteria not only attack human's lung but by the time it would attack human's spinal too. Human's spinal would be infected, got hyperemia, and also got edema [2]. Treating tuberculosis disease nowadays is by using first line of anti-TB drugs such as streptomycin (S), rifampicin (RIF), isoniazid (INH), etc. that should be consumed orally by patient 4 – 5 tablets per day until 6 – 9 months [3]. The second way to treat tuberculosis disease by doing medical operation that would take some part of the patient's infected bone. Not only oral treatment but also medical operation have some limitation. Consuming anti-TB drug is not effective because it is difficult to reach human's lung.

Improving the limitation of tuberculosis treatment, injection treatment is preferred to increase the effectivity of the drug to reach the bone directly and decrease patient's pain that caused by medical operation. The injection treatment or so-called injectable bone substitute (IBS) was made by nano hydroxyapatite (nano-HA) – chitosan as a bone filler for spinal and mixed with streptomycin as anti-TB drugs to inhibit the DNA formation of *Mycobacterium tuberculosis*. Adding hydroxypropyl methylcellulose (HPMC) as a suspending agent is very important to develop IBS pasta formation [4-5]. HPMC function not only as a crosslinker but also restrain the flow of IBS pasta that will be injected [6]. Nano-HA is a bio ceramic material contain calcium and phosphate that easily fabricated become IBS pasta. Nano-HA has a good stability, biocompatible, osteoconductive, and good bioactivity to be applied on human's bone. Nano-HA that contains inorganic material become a matrix for bone cell like osteoblast to proliferate [7-8]. Chitosan is the most abundant polysaccharides that has good biocompatibility, non-toxic, biocompatible, biodegradable, and good as drug carrier would protect nano-HA that contain streptomycin [9].

The combination of nano-HA – chitosan – streptomycin was chosen as the raw materials because nano-HA itself would attract osteoblast to proliferate, chitosan would protect the interaction between nano-HA – streptomycin, and the streptomycin itself as an anti-TB drug to destroy TBC's bacteria in the spinal and lung directly. The characterizations in this study were Fourier Transform Infrared (FTIR), injectability test by syringe, and setting time using Scanning Electron Microscope (SEM) as physical characterization. Acidity test and repasta test for chemical characterization. The biological test used was MTT-Assay for observing the degree of cytotoxicity.

Materials and Methods

Materials. Nano hydroxyapatite and chitosan was obtained from Badan Tenaga Nuklir Nasional (BATAN) Jakarta, Indonesia. The streptomycin sulfate (powder for injection) was obtained from PT. Meiji Indonesia. The hydroxypropyl methylcellulose (HPMC) was obtained from Sigma Aldrich H7509. The materials used for characterization were human bone scaffold model from Bank Jaringan Dr. Soetomo Hospital (Surabaya, Indonesia) for setting time test and SBF solution that contain from NaHCO_3 , NaCl , KCl , $\text{K}_2\text{HPO}_4 \cdot 3\text{H}_2\text{O}$, HCl , Na_2SO_4 , $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$, $\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$, and $(\text{HOCH}_2)_3\text{CNH}_2$.

Methods. The injectable bone substitute (IBS) was synthesized by dissolving 20% w/v chitosan in acetic acid at 40°C for one hour. The hydroxyapatite (HA) powder was added to that solution with several ratio of HA:chitosan (60:40, 65:35, 70:30 and 75:25). 10 wt% of streptomycin was added in the mixture. 4% w/v HPMC was dissolved into distilled water at 90°C. Then, the suspension of HPMC was added into hydroxyapatite-chitosan-streptomycin suspension at 40°C in six hours to generate white pasta of IBS.

The FTIR test was used to observed whether there was no interaction among the materials used in this study based on the functional groups. All the IBS pasta sample would be freeze-dried to make it solid. The solidified IBS was mixed with KBr and compressed into pellet to be characterized by FTIR tools.

The injectability test was aimed to observe the ability of the IBS to be extruded from a syringe within a range of time. The test used 10 cc syringe with the inner diameter of the needle was 1.2 mm [10]. The percentage of injectability could be calculated by measuring the weight before and after injection. By using Eq. 1, the injectability of the IBS could be obtained. The test was repeated five times.

$$\text{Injectability (\%)} = (\text{Mass extruded from syringe} / \text{Total mass before injection}) \times 100\% \quad (1)$$

The setting time test was performed by applying human bone scaffold model that was injected by IBS pasta vertically. In the setting time, the mass of human bone scaffold model was measured before and after injected IBS pasta and the morphology of the covered human bone scaffold model could be characterized by SEM.

The acidity test was used to observe the stability of the IBS pasta itself before injected into the human's body. The acidity of the IBS was measured overtime by using pH meter. The materials were considered on pH 6.8 – 7.4 as human's pH inside the body.

The repasta test was aimed to observe the needed time for solidify IBS becoming pasta again when the solidify IBS dissolved into Simulated Body Fluid (SBF). SBF is a solution that has some composition like human's body. The other purpose of this test also to observe the stability IBS pasta in pH compound between SBF and IBS pasta.

The four best samples based on all characterization mentioned above were continued to the biological characterization. The cytotoxicity test was performed by using MTT assay method which used 3-(4,5-dimethyl-2-thiazolil)-2,5-diphenil-2H-tetrazolium bromide (MTT reagent). This substance would give the information of viability cell while it changed to formazan salt due to the activity of mitochondria of living cell. The cell used in this test was fibroblast cell from Baby Hamster Kidney (BHK-21). The optical density of formazan salt would be measured by using Elisa Reader. The cell viability would be calculated by using Eq. 2. The materials were considered as not-toxic if the cell viability is more than 50% [11].

$$\text{Cell viability (\%)} = ((\text{OD}_{\text{treatment}} + \text{OD}_{\text{media}}) / (\text{OD}_{\text{cell}} + \text{OD}_{\text{media}})) \times 100\% \quad (2)$$

Result and Discussion

Functional Group Test. The IBS was synthesized in four variations, the hydroxyapatite-chitosan ratio in 75:25 ratio was used in this test. The FTIR test was performed at several variations shown in Fig. 1.

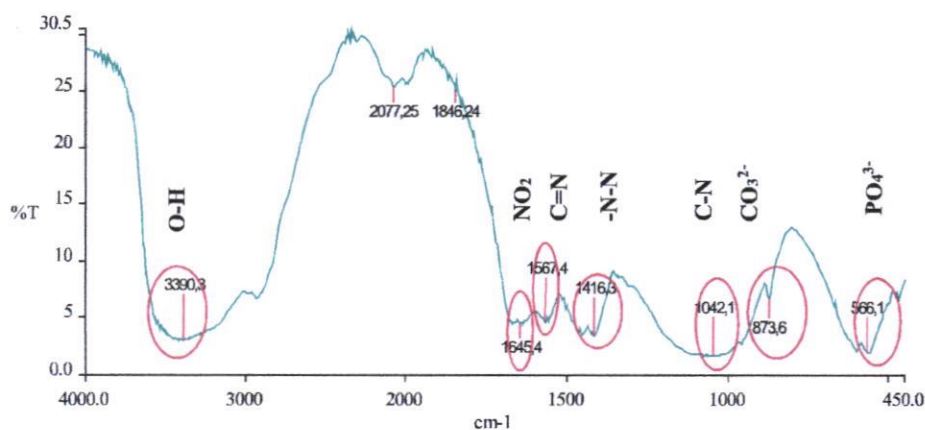


Fig. 1. The FTIR Result of IBS Sample with a Ratio of HA:chitosan (75:25)

The results show that there are several absorbance peaks related to some specific functional groups. The peak at wavenumber of 3390.3 cm^{-1} resembled the stretching vibration of hydroxyl group from the material used in this study; HA, chitosan, HPMC and streptomycin. The absorbance at wavenumber of 2077.25 cm^{-1} was the characteristic of stretching vibration C-C which was the specific functional group from HPMC and streptomycin. The peak at 1645.4 cm^{-1} showed the bonding between the carbonyl functional group originated from chitosan and the amine group from the streptomycin. Furthermore, the stretching vibration of carbonate (CO_3^{2-}) and phosphate (PO_4^{3-}) functional group which was the specific functional groups from HA showed at wavenumber of 873.6 cm^{-1} and 566.1 cm^{-1} [12].

Injectability Test. The injectability test was performed by using a 10 cc syringe. The four samples of IBS pasta show the good result which had percentage of injectability near to 100%. The best result was chosen in HA:chitosan ratio of 75:25 that had 96.24% in 15 seconds. This result was correlated with Shen et al. in 2014 who synthesized IBS based on calcium phosphate and alendronate 3% which has injectability result 96.88 % [4].

Setting Time Test. The setting time test was performed by using a freeze-dried HA scaffold as a model of human bone. The substrates had the same main component of the sample as the natural bone, such as the composition (hydroxyapatite) and the structure. The result of this test was shown

in Fig. 2. From the result of this result, all samples have long setting time over 1 hour. The fastest setting time occurred in nano HA: chitosan ratio on 75:25, it needs 72 minutes. The data mentioned below so fluctuating. By adding chitosan, the setting time should be decreased because chitosan was produced gel-like matrix which reduced the setting time of IBS based on their viscosity [13]. The fluctuating data may be caused by handling factor of IBS pasta into their injectability. Pasta injection through the needle based on the driving force that will be applied on bone will affect the setting time [13]. Based on the study of Thai in 2010, they mentioned that the setting time of the IBS sample with calcium phosphate, calcium sulphate, HPMC, and citric acid was 30 minutes with 20% of citric acid and less than 10 minutes with 40% of citric acid [14]. The setting time of IBS less than 10 minutes could be applied in the defect of the small bone, such as carpal bone, while the other one could be used in the bigger bone, such as clavicle bone.

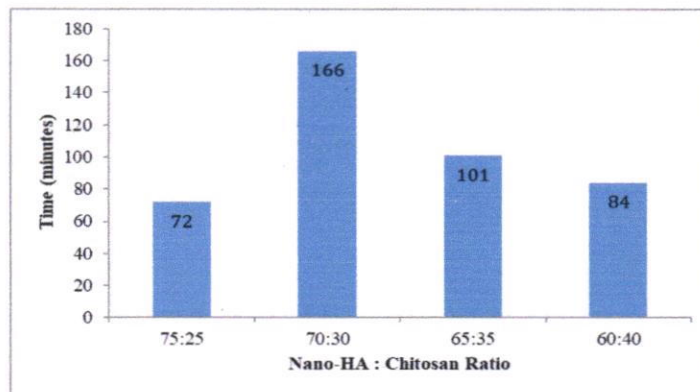


Fig. 2. The Setting time test results of IBS

After the result above, the four variations was tested with the change in the mass due to the presence of the IBS in the HA-collagen scaffold as a human bone model in dry condition comparing HA-collagen scaffold without IBS pasta. IBS pasta variations on 75:25, 70:30, 65:35, and 60:40 increasing the weight 0.0292 gr, 0.0463 gr, 0.0518 gr, and 0.0377 gr. This showed the ability of IBS pasta attached the HA-collagen scaffold. The morphology of human bone scaffold model that covered before and after injected IBS pasta was shown in Fig. 3 with the ratio of HA:chitosan on 60:40. The pore size of human bone scaffold model before injected IBS pasta about 780.8-835.4 μm and after injected become 99.76-134.2 μm . From the SEM imaging, it might be conclude that IBS pasta could spread into the human bone scaffold model and bounded the hydroxyapatite [12, 15]. Increasing of the weight and decreasing of the pore size diameter caused by apatite mineral of IBS pasta would imply the density of bone become higher. Apatite and chitosan formation would promote the osteoblast cell proliferation around spinal bone and then could heal the osteoporotic spinal bone.

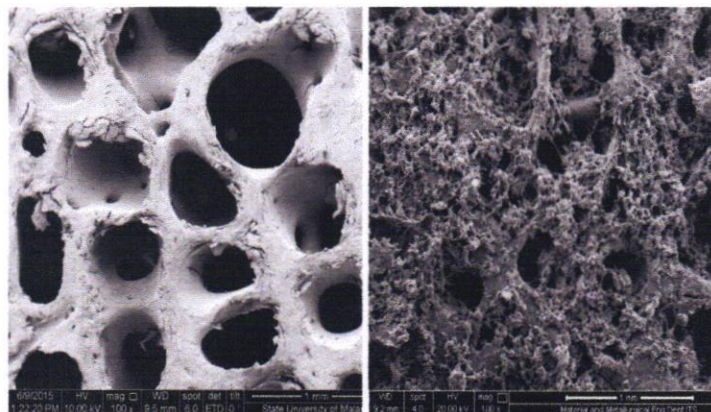


Fig. 3. Morphology of human bone scaffold model (a) Before injected IBS pasta (100X) (b) After injected IBS pasta (100X) using SEM

Acidity (pH) Test. The acidity of the sample is one of the important points in the evaluation of the performance of IBS. The result showed that the average pH of sample with HA-chitosan ratio of 75:25, 70:30, 65:35 and 60:40 (w/w) were 7.29, 6.91, 7.19, and 6.99, respectively. The IBS needed pH more than 6 to be set in the bone. This result was tolerable for the body and could give no pain effect.

Repasta Test. Repasta test was aimed to know the freeze-dried IBS pasta behaviour in human's body fluid using Simulated Body Fluid (SBF) solution as human's body fluid. Freeze dried IBS pasta used as the setting model of IBS pasta that harden in human's spinal. The other purpose of repasta test is for knowing the release function of streptomycin as anti-TB drug. The result could be seen on Fig. 4. Increasing the nano-HA concentration would increase the needed time to become IBS pasta again. The result of pH compound between 6.88 and 7.03 which was still preferable to be injected in the human's body. Streptomycin works on pH 3 – 7 to attack *Mycobacterium tuberculosis*, so the pH compound in repasta test of all samples preferable place for streptomycin doing its function [8].

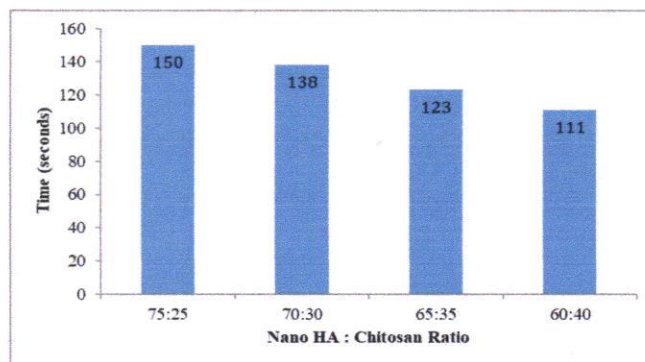


Fig. 4. Repasta time of the IBS sample with Several HA:Chitosan ratio

Cytotoxicity Test. The cytotoxicity test was conducted by using fibroblast cells from Baby Hamster Kidney (BHK-21). The MTT assay function is to quantify mitochondrial activity that would detect living cells [16]. From this test, the result depicted that the IBS samples were non-toxic, because the cell viability was more than 50% shown in Fig. 5. This result also showed the percentage which was more than 100%. That result meant that the IBS could be the place for the osteoblast cells to grow and promote proliferation of the cell [11].

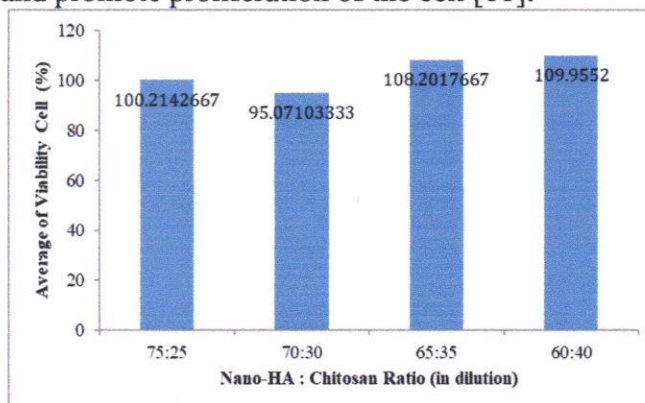


Fig. 5. The Cytotoxicity Test Result of the IBS sample with Several HA:Chitosan ratio

Summary

Injectable bone substitute based on nano-HA – chitosan – streptomycin with several concentration variation showed the best results in injectability test, acidity test, repasta test, and cytotoxicity test. In setting time test, there was a problem with the time when IBS paste was injected to the HA-collagen scaffold model. The failure could be reduced by considering the handling factor with some precision tools like extruder. FTIR result detected any functional group in the composition of IBS pasta. Sample with the ratio 60:40 shows the best result of all samples by considering cytotoxicity

test which has higher cell viability about $109.9552 \pm 6.6395\%$ that would provide osteoblast proliferate faster to improve osteoporosis healing in spinal tuberculosis.

References

- [1] World Health Organization, GLOBAL TUBERCULOSIS REPORT 2017 (2017).
- [2] J. S. Mehta and S. Y. Bhojraj, Tuberculosis of the thoracic spine. A classification based on the selection of surgical strategies., *J. Bone Joint Surg. Br.* 83 (2001) 859–863.
- [3] D.-D. Pham, E. Fattal, and N. Tsapis, Pulmonary drug delivery systems for tuberculosis treatment., *Int. J. Pharm.* 478 (2015) 517–529.
- [4] Z. Shen, T. Yu, and J. Ye, Microstructure and properties of alendronate-loaded calcium phosphate cement., *Mater. Sci. Eng. C. Mater. Biol. Appl.* 42 (2014) 303–311.
- [5] P. Weiss, O. Gauthier, J.-M. Bouler, G. Grimandi, and G. Daculsi, Injectable bone substitute using a hydrophilic polymer, *Bone* 25 (1999) 67S–70S.
- [6] W. Liu *et al.* A novel injectable, cohesive and toughened Si-HPMC (silanized-hydroxypropyl methylcellulose) composite calcium phosphate cement for bone substitution., *Acta Biomater.* 10 (2014) 3335–3345.
- [7] A. S. Budiadin, M. Zainuddin, and J. Khotib, Biocompatible composite as gentamicin delivery system for osteomyelitis and bone regeneration, *Int. J. Pharm. Pharm. Sci.* 6 (2014) 223–226.
- [8] H. N. Maulida, D. Hikmawati, and A. S. Budiadin, Injectable Bone Substitute Paste Based on Hydroxyapatite, Gelatin and Streptomycin for Spinal Tuberculosis, *J. Spine* 4 (2015) 4–7.
- [9] N. M. Alves and J. F. Mano, Chitosan derivatives obtained by chemical modifications for biomedical and environmental applications., *Int. J. Biol. Macromol.* 43 (2008) 401–414.
- [10] E. J. Oswald and J. K. Nielsen, Studies on the Stability of Streptomycin in Solution., *Science* 105 (1947) 184–185.
- [11] C. Khoswanto, E. Arijani, and P. Soesilawati, Cytotoxicity test of 40, 50 and 60% citric acid as dentin conditioner by using MTT assay on culture cell line, *Dent. J. (Majalah Kedokt. Gigi)* 41 (2008) 103.
- [12] A. P. Putra, A. A. Rahmah, N. Fitriana, S. A. Rohim, M. Jannah, and D. Hikmawati, The Effect of Glutaraldehyde on Hydroxyapatite-Gelatin Composite with Addition of Alendronate for Bone Filler Application, *J. Biomimetics, Biomater. Biomed. Eng.* 37 (2018) 107–116.
- [13] H.-J. Lee, B. Kim, A. R. Padalhin, and B.-T. Lee, Incorporation of chitosan-alginate complex into injectable calcium phosphate cement system as a bone graft material, *Mater. Sci. Eng. C* 94 (2019) pp. 385–392.
- [14] V. V. Thai and B.-T. Lee, Fabrication of calcium phosphate-calcium sulfate injectable bone substitute using hydroxy-propyl-methyl-cellulose and citric acid., *J. Mater. Sci. Mater. Med.* 21 (2010) 1867–1874.
- [15] G. Hu, L. Xiao, H. Fu, D. Bi, H. Ma, and P. Tong, Study on injectable and degradable cement of calcium sulphate and calcium phosphate for bone repair., *J. Mater. Sci. Mater. Med.* 21 (2010) 627–634.
- [16] A. Iwasawa, M. Ayaki, and Y. Niwano, Cell viability score (CVS) as a good indicator of critical concentration of benzalkonium chloride for toxicity in cultured ocular surface cell lines., *Regul. Toxicol. Pharmacol.* 66 (2013) 177–183.

also developed by scimago:



SCIMAGO INSTITUTIONS RANKINGS

SJR

Scimago Journal & Co Enter Journal Title, ISSN or Publisher Name

[Home](#)[Journal Rankings](#)[Country Rankings](#)[Viz Tools](#)[Help](#)[About Us](#)

Materials Science Forum

COUNTRY[Switzerland](#)

Universities and research institutions in Switzerland

SUBJECT AREA AND CATEGORY

Engineering
 Mechanical Engineering
 Mechanics of Materials

Materials Science
 Materials Science (miscellaneous)

Physics and Astronomy
 Condensed Matter Physics

PUBLISHER[Trans Tech Publications](#)**H-INDEX****81****PUBLICATION TYPE**

Book Series

ISSN02555476,
16629752**COVERAGE**1984-1986,
1994-2021**INFORMATION**[Homepage](#)[How to publish in this journal](#)[Contact](#)

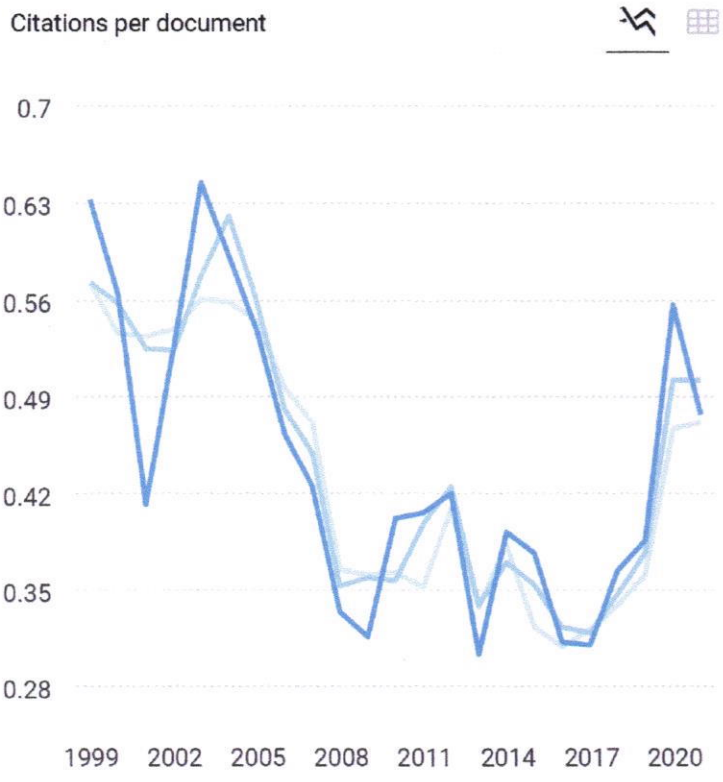
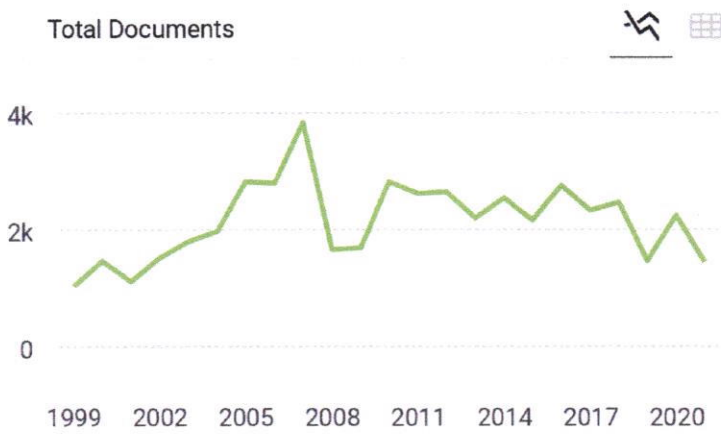
SCOPE

"Materials Science Forum" is a peer-reviewed journal which covers all aspects of theoretical and practical research of materials science: synthesis, analysis of properties, technology of materials processing and their use. "Materials Science Forum" is one of the largest periodicals in its field. "Materials Science Forum" specializes in the publication of thematically complete volumes from international conference proceedings and complete special topic volumes. We do not publish stand-alone papers by individual authors. Authors retain the right to publish an extended and significantly updated version in another periodical.

 Join the conversation about this journal

 Quartiles





us® data as of April 2022

Yahva Khalaf Khalid 1 year ago
External Cites per Doc Cites per Doc



our esteemed magazine .. How many days

SCImago Team

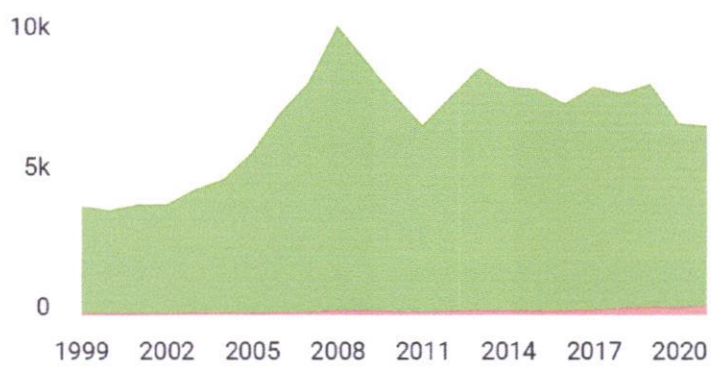
Melanie Ortiz 1 year ago
Dear Yahva



Journal & Country Rank is not a journal. indicators of journals indexed in

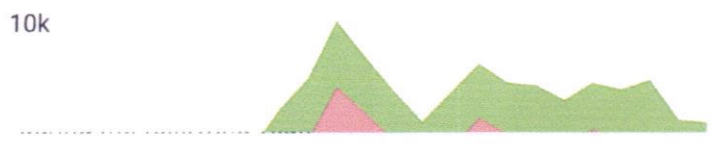
with your request, we suggest you visit the journal's editorial staff, so they could inform

Citable documents Non-citable documents



change Publication Type from 'Journal' to

Cited documents Uncited documents



SCImago Team



Melanie Ortiz 2 years ago

Dear Sir/Madam,

thank you very much for your comment, unfortunately we cannot help you with your request. We suggest you contact Scopus support:

https://service.elsevier.com/app/answers/detail/a_id/14883/kw/scimago/supporthub/scopus/

Best Regards, SCImago Team



Just copy the code below and paste within your html code:

```
<a href="https://www.scim
```

als Science Forum.

SCImago Graphica

Explore, visually communicate and make sense of data with our

new data tool.



Melanie Ortiz 2 years ago

Dear Wissem, 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

SCImago Team

R Rufus 2 years ago

I am about starting my masters in material science and technology but don't know which area is good for me to specialise in. My school have the following specialisations-

1)Synchrotron, neutron and electronic methods of materials research

2)High energy technologies

3?Materials science, technology for obtaining and processing materials with special properties. Please advise me on these specialities, I am concerned about the future of the programme.

reply

SCImago Team

**Melanie Ortiz** 2 years ago

Dear Rufus,

Thank you for contacting us. Unfortunately, SCImago cannot help you with your request. SJR is committed to help decision-making through scientometric indicators.

Best Regards, SCImago Team

D Dr safwan Al-qawabah 2 years ago

Dear Sir;

Could you please inform me ie it far that Materials science form become indexed in science citation expanded database

Kind regards

reply

SCImago Team

**Melanie Ortiz** 2 years ago

Dear Safwan,

Thank you for contacting us. SJR is a portal with scientometric indicators of journals indexed in Elsevier/Scopus. Unfortunately, we cannot help you with your request referring to the index status. We suggest you consult the mentioned database directly. Best Regards, SCImago Team

G Gowthaman Ganesh 2 years ago

Material science forum is scopus index journal or not

reply

SCImago Team

**Melanie Ortiz** 2 years ago

Dear Gowthaman , thank you very much for your comment, unfortunately we cannot help you with your request. We suggest you to consult the Scopus database directly. Keep in mind that the SJR is a static image (the update is made one time per year) of a database (Scopus) which is changing every day.
Best Regards, SCImago Team

C Chiranth 2 years ago

Dear madam

May I know Materials Science Forum has what type of indexing ??

reply

SCImago Team



Melanie Ortiz 2 years ago

Dear Chiranth,

Thank you for contacting us. SJR is a portal with scientometric indicators of journals indexed in Elsevier/Scopus. Unfortunately, we cannot help you with your request referring the index status. We suggest you to consult Scopus database (see the current status of the journal) or other databases (like WoS) for further information. You can also check that information in the journal's website or contact directly with the editorial staff. Best Regards, SCImago Team

O Olga 3 years ago

Good afternoon,

Will Materials Science Forum be indexed in Scopus in 2020 ? Thank you

reply

SCImago Team



Melanie Ortiz 3 years ago

Dear Olga, thank you very much for your comment, unfortunately we cannot

help you with your request. We suggest you to consult the Scopus database directly. Remember that the SJR is a static image of a database (Scopus) which is changing every day. Best regards, SCImago Team

N **Nguyen Hoc Thang** 3 years ago

"Materials Science Forum" is a peer-reviewed journal and has three kinds of ISSN numbers: ISSN print 0255-5476; ISSN web 1662-9752; ISSN cd 1662-9760 as known in <https://www.scientific.net/MSF/Details>

But <https://www.scimagojr.com/journalsearch.php?q=28700>

reply

T **taiful** 2 years ago

Dear Nguyen, may I know is materials science forum is indexed as ISI during 2016-2017?



Melanie Ortiz 3 years ago

SCImago Team

Dear Nguyen, SJR is a portal with scientometric indicators of journals indexed in Scopus. SJR has no authority over the data of the journals; they are the ones that Scopus sends to us. The metadata are property of Scopus. SCImago has a signed agreement that limits our performance to the generation of scientometric indicators derived from the metadata sent in the last update. We suggest you to contact Scopus through this link to report the inconsistencies or modifications that you want to make in SCImago:

https://service.elsevier.com/app/answers/detail/a_id/14883/kw/scimago/supporthub/scopus/. Best Regards, SCImago Team

M **Manuel Carsí** 4 years ago

When the works of Thermec 2018 will be published?

reply



Elena Corera 4 years ago

SCImago Team

Please, contact Materials Science Forum, you are contacting Scimago Journal and Country Rank.

Best,
SCImago Team

T **Taras Dochynets** 4 years ago

International scientific and practical conference: "Directions and modern factors of development of international relations: economic and political aspects"

Start Date : December 7

Uzhgorod, Ukraine

more <https://www.uzhnu.edu.ua/uk/anounce/1095.htm>

reply

Leave a comment

Name

Email

(will not be published)

[Submit](#)

The users of Scimago Journal & Country Rank have the possibility to dialogue through comments linked to a specific journal. The purpose is to have a forum in which general doubts about the processes of publication in the journal, experiences and other issues derived from the publication of papers are resolved. For topics on particular articles, maintain the dialogue through the usual channels with your editor.

Developed by:



Powered by:



Follow us on @ScimagoJR

Scimago Lab, Copyright 2007-2022. Data Source: Scopus®

EST MODUS IN REBUS
Horatio (Satire 1.1, 106)

[Edit Cookie Consent](#)