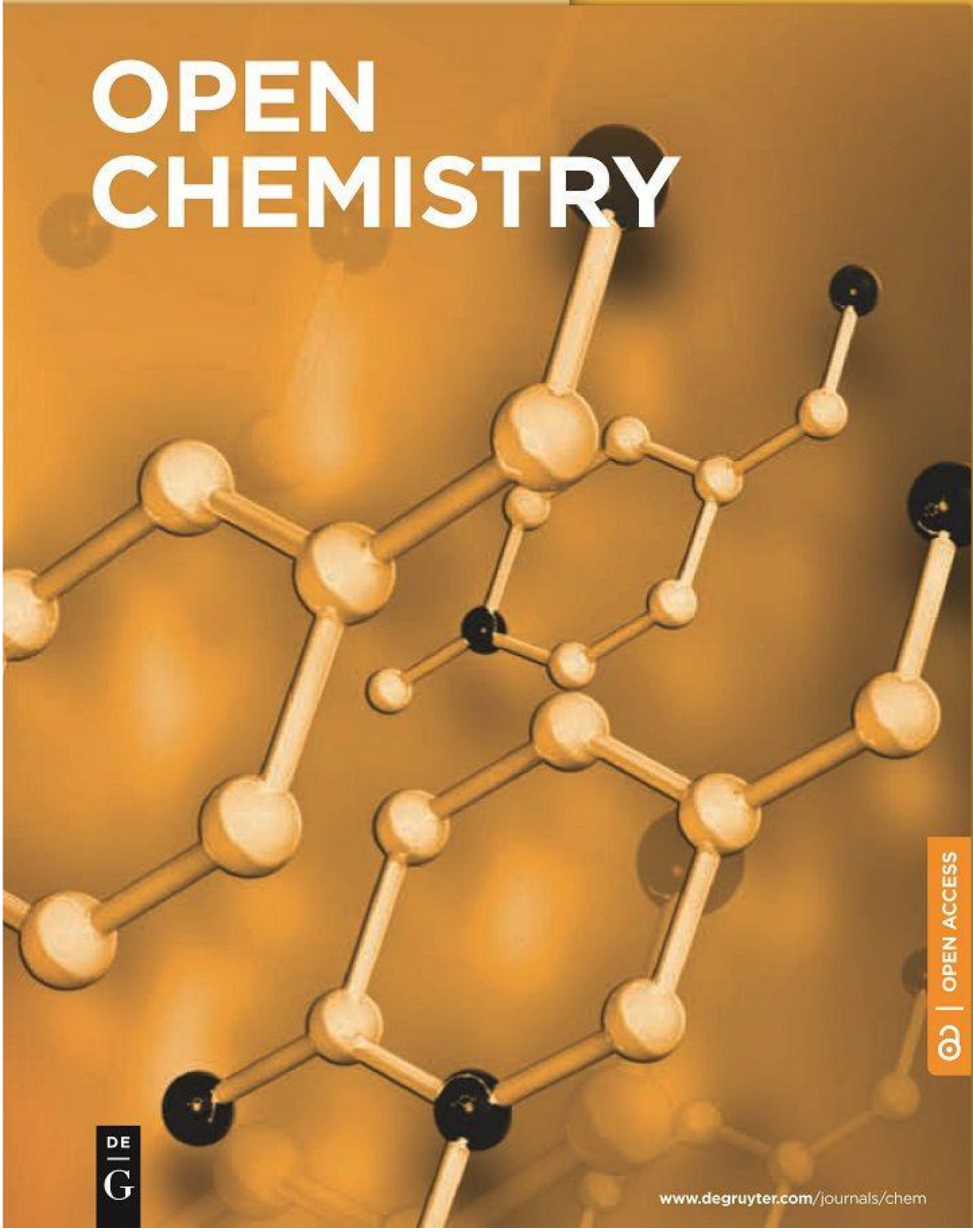
DE GRUYTER

2020 · VOLUME 18
e-ISSN 2391-5420

OPEN CHEMISTRY

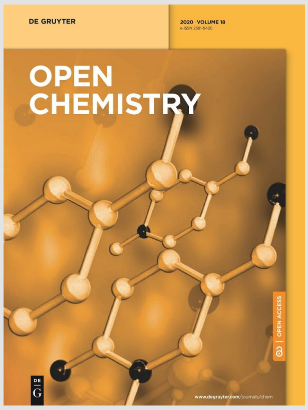


OPEN ACCESS

www.degruyter.com/journals/chem

DE GRUYTER

OPEN CHEMISTRY



Open Chemistry aims to publish high quality research in the following areas:

- Analytical Chemistry
- Biochemistry & Biological Chemistry
- Bioorganic Crystal Chemistry
- Biophysics
- Catalysis
- Chemical Kinetics and Reactivity
- Chemical Physics
- Coordination Chemistry
- Crystallography
- Electrochemistry
- Electrochemical Modelling
- Environmental Chemistry
- EPR Specroscopy
- Fluorescence Spectroscopy
- Hydrogen technologies, hydrogen storage
- Inorganic Chemistry
- Macromolecules & Polymers
- Materials
- NMR Spectroscopy
- Nucleation and Growth of New Phases
- IR and Raman Spectroscopy
- Organic Chemistry
- Organometallic Chemistry
- Pharmaceutical Chemistry
- Photochemistry
- Physical Chemistry
- Physical Organic Chemistry
- Radiochemistry & Nuclear Chemistry

Open Access
Online ISSN: 2391-5420
Language of publication: English
Subjects:
Chemistry › Inorganic Chemistry
Chemistry › Organic Chemistry
Chemistry › Chemistry, other
Covered by: SCOPUS & ESCI

IMPACT FACTOR 2018: 1.512
5-year IMPACT FACTOR: 1.599

CiteScore 2018: 1.58

SCImago Journal Rank (SJR) 2018: 0.345
Source Normalized Impact per Paper (SNIP) 2018: 0.684

ICV 2018: 163.25

Journal

*Prices in US$ apply to orders placed in the Americas only. Prices in £ apply to orders placed in Great Britain only. Prices in € represent the retail prices valid in Germany (unless otherwise indicated). Prices are subject to change without notice. Prices do not include postage and handling if applicable. Free shipping for non-business customers when ordering books at De Gruyter Online. RRP: Recommended Retail Price.

Order now! orders@degruyter.com

degruyter.com

- Supramolecular Chemistry and Nanochemistry
- Solid State Chemistry
- Spectroscopy
- Surface Chemistry & Colloids
- Thermodynamics
- Biomaterials
- Natural Product Chemistry
- Medicinal Chemistry

Publication costs are covered by so called Article Processing Charges (APC), paid by authors' affiliated institutions, funders or sponsors. Starting from 2020 the APC's will be 1200 euro. Find our more here.

Open Chemistry is a peer-reviewed, open access journal that publishes original research, reviews and communications in the fields of chemistry in an ongoing way. Our central goal is to provide a hub for researchers working across all subjects to present their discoveries, and to be a forum for the discussion of the important issues in the field.

Our journal is the premier source for cutting edge research in fundamental chemistry and it provides high quality peer review services for its authors across the world. Moreover, it allows for libraries everywhere to avoid subscribing to multiple local publications, and to receive instead all the necessary chemistry research from a single source available to the entire scientific community.

Authors publishing in **Open Chemistry** benefit from:

- transparent, comprehensive and fast peer review
- efficient route to fast-track publication and full advantage of De Gruyter's e-technology
- secure archiving by De Gruyter and the independent archiving service Portico
- no submission charges
- worldwide distribution and promotion of articles
- comprehensive abstracting & indexing e.g. SCOPUS and Web of Science
- unrestricted access for all readers
- immediate publication upon completing the publishing process
- Authors retain the copyrights
- Increased and accelerated citations

Contact us:
openchemistry@degruyter.com

Special Issues:

*Prices in US$ apply to orders placed in the Americas only. Prices in £ apply to orders placed in Great Britain only. Prices in € represent the retail prices valid in Germany (unless otherwise indicated). Prices are subject to change without notice. Prices do not include postage and handling if applicable. Free shipping for non-business customers when ordering books at De Gruyter Online. RRP: Recommended Retail Price.

Order now! orders@degruyter.com

- Agriculture
- 100 Years of Polymers Science
- Energy Fuels Environment
- Electrochemical Amplified Systems
- Pharmacognosy 2020
- Ethnobotanical Phytochemical and Biological Investigation of Medicinal Plants
- Special Issue on the 14th Joint Conference on Chemistry (14th JCC)
- Special Issue on EMRS 2019 Fall Meeting
- Special Issue on the FUTURE MATERIALS 2020, Materials Science & Nanotechnology Conference - February 26-28 2020, Lisbon, Portugal

Journal Partners

If you organize the Conference and look for the media partner, please contact the Managing Editor (Agnieszka Topolska, Agnieszka.Topolska@degruyter.com)

Editor-in-Chief
Joaquín Plumet, Complutense University, Spain

Managing Editor
Agnieszka Topolska, Poland

Editorial Advisory Board
Metin Hayri Acar, Istanbul Technical University, Turkey
Sergei Aldoshin, Russian Academy of Sciences, Russia
Alexandru T. Balaban, Texas A&M University, USA
Roland Boese, University of Essen, Germany
Ronald Breslow, Columbia University, USA
Michel Che, Université Pierre et Marie Curie, France
Lew P. Christopher, Lakehead University, Canada
David C. Clary, University of Oxford, UK
Graham Cooks, Purdue University, USA
Elias J. Corey, Harvard University, USA
Carlos Fernandez , Robert Gordon University, UK
Karl Freed, University of Chicago, USA
Boris Furtula, University of Kragujevac, Serbia
Jean-François Gérard, SGM INSA Lyon, CNRS, ECNP, France
Raquel P. Herrera, Isqch (Csic-Uz) Instituto De Síntesis Química Y Catálisis Homogénea, Spain
Janusz Jurczak, Warsaw University and Institute of Organic Chemistry, Poland
Alexei Khokhlov, Moscow State University and Nesmeyanov Institute of Organoelement Compounds, Russia
Tamas Kiss, University of Szeged, Hungary
Alexander M. Klibanov, Massachusetts Institute of Technology, USA
Jacek Klinowski, University of Cambridge, UK
Shu Kobayashi, University of Tokyo, Japan
Pavel Kratochvil, Academy of Sciences of the Czech Republic, Czech

Republic
Janusz Lipkowski, Polish Academy of Sciences, Poland
Goverdhan Mehta, Indian Institute of Science, India
Marian Mikolajczyk, Centre of Molecular and Macromolecular Studies, Poland
Achim Müller, University of Bielefeld, Germany
Koji Nakanishi, Columbia University, USA
Stanislaw Penczek, Centre of Molecular and Macromolecular Studies, Poland
Chintamani Nagesa Ramachandra Rao, Jawaharlal Nehru Centre for Advanced Scientific Research, India
Thomas Rauchfuss, University of Illinois, USA
Vladimir Sklenar, Masaryk University, Czech Republic
Edward I. Solomon, Stanford University, USA
Frigyes Solymosi, University of Szeged, Hungary
Karel Stulik, Charles University, Czech Republic
Nurhayat Tabanca, USDA ARS, United States
Barry Trost, Stanford University, USA
Donald Truhlar, University of Minnesota, USA
Karel Ulbrich, Academy of Sciences of the Czech Republic, Czech Republic
Fosong Wang, Chinese Academy of Sciences, China
George Whitesides, Harvard University, USA
Frank Würthner, Institut für Organische Chemie & Center for Nanosystems Chemistry, Germany
Hisashi Yamamoto, University of Chicago, USA
Yoshinori Yamamoto, Tohoku University, Japan
Jung Woon Yang, Sungkyunkwan University, South Korea
Miguel Yus, University of Alicante, Spain
Qi-Feng Zhou, Peking University, China

Editors:

Analytical Chemistry
Ebaa Adnan Azooz, University of Kufa, Iraq
Darya Asheghali, Duke University, USA
Arindam Bose, Harvard University, USA
Domenico Cautela, Stazione Sperimentale per le Industrie delle Essenze e dei derivati dagli Agrumi (SSEA), Italy
Dariusz Guziejewski, University of Lodz, Poland
Chiara Fanali, Campus Bio-Medico University of Rome, Italy
Agata Jakóbik-Kolon, Silesian University of Technology, Poland
Peter Knittel, Fraunhofer IAF, Institute for Applied Solid State Physics, Germany
Xing Ma, Harbin Institute of Technology (Shenzhen), China
Antonio Martin-Esteban, National Institute for Agricultural and Food Research and Technology (INIA), Spain
Waqas Nazeer, University of Education, Pakistan
Jorge Pereira, Analytical Chemistry and Enology Lab (ACE-lab), Madeira University, Portugal
Francesco Siano, Consiglio Nazionale delle Ricerche (CNR) Istituto di Scienze dell'Alimentazione (ISA), Italy

*Prices in US$ apply to orders placed in the Americas only. Prices in £ apply to orders placed in Great Britain only. Prices in € represent the retail prices valid in Germany (unless otherwise indicated). Prices are subject to change without notice. Prices do not include postage and handling if applicable. Free shipping for non-business customers when ordering books at De Gruyter Online. RRP: Recommended Retail Price.

Order now! orders@degruyter.com

DE G

DE GRUYTER

Krishnamoorthy Sivakumar, SCSVMV University, India
Constantinos K. Zacharis, School of Pharmacy, Aristotle University of Thessaloniki (AUTh), Greece

Bioanalytical Chemistry
Silvana Andreescu, Clarkson University, USA
Murali Anuganti, University of Nevada, USA
Jorge Pereira, Analytical Chemistry and Enology Lab (ACE-lab), Madeira University, Portugal

Biochemistry and Biological Chemistry
Murali Anuganti, University of Nevada, USA
Arindam Bose - Harvard University, USA
Dibyendu Dana, Angion Biomedical Corporation,USA
Rajat Subhra Das, Omega Therapeutics, USA
Raj Mukherjee, Sanofi, CHC R&D, USA
Atul Srivastava, University of Chicago, USA

Biochemistry and Biotechnology
Costel C. Darie, Clarkson University, USA
Luyun Jiang, Oxford University, UK

Biomaterials
Murali Anuganti, University of Nevada, USA
Mazeyar Parvinzadeh Gashti, PRE Labs Inc, Canada
Saravana Kumar Jaganathan, Universiti Teknologi Malaysia, Johor
Xing Ma, Harbin Institute of Technology (Shenzhen), China

Biophysics and Chemical Physics in Biology
Atul Srivastava, University of Chicago, USA
Iveta Waczulikova, Comenius University, Slovakia

Catalysis
Diego Alonso, Alicante University, Spain
Xavier Companyó, University of Padua, Italy
Biswanath Dutta, University of California at Berkeley, USA
Tecla Gasperi, Università "Roma Tre", Italy
Awal Noor, COMSATS Institute of Information Technology, Abbottabad Campus, Paksitan
Navpreet Kaur Sethi, Zhejiang University, China

Chemical Kinetics and Reactivity
Khuram Shahzad Ahmad, Fatima Jinnah Women University, Pakistan
Sayak Bhattacharya, Galgotias University, India
Xavier Companyó, University of Padua, Italy
Zhien Zhang, Ohio State University, USA

Chemical Physics
Sayak Bhattacharya, Galgotias University, India
Mohsen Mhadhbi, National Institute of Research and Physical-chemical

*Prices in US$ apply to orders placed in the Americas only. Prices in £ apply to orders placed in Great Britain only. Prices in € represent the retail prices valid in Germany (unless otherwise indicated). Prices are subject to change without notice. Prices do not include postage and handling if applicable. Free shipping for non-business customers when ordering books at De Gruyter Online. RRP: Recommended Retail Price.

Order now! orders@degruyter.com

Analysis, Tunisia
Ponnadurai Ramasami, University of Mauritius, Mauritius

Clinical Chemistry
Arindam Bose - Harvard University, USA
Tingting Zheng, Peking University Shenzhen Hospital, China

Computational Chemistry, Chemometrics and QSAR
Robert Fraczkiewicz, Simulations Plus, Inc., USA
Jose Gonzalez-Rodriguez, University of Lincoln, UK

Coordination Chemistry
Awal Noor, COMSATS Institute of Information Technology, Abbottabad Campus, Paksitan

Crystallography
Awal Noor, COMSATS Institute of Information Technology, Abbottabad Campus, Paksitan

Electrochemistry
Dariusz Guziejewski, University of Lodz, Poland
Paweł Jeżowski, Poznan University of Technology, Poland
Luyun Jiang, Oxford University, UK
Peter Knittel, Fraunhofer IAF, Institute for Applied Solid State Physics, Germany
Hassan Karimi-Maleh, University of Electronic Science and Technology of China, China
Laszlo Peter, Hungarian Academy of Sciences, Hungary
Jose Gonzalez-Rodriguez, University of Lincoln, UK

Environmental Chemistry
Khuram Shahzad Ahmad, Fatima Jinnah Women University, Pakistan
Aleksander Astel, Pomeranian Academy, Poland
Sayak Bhattacharya, Galgotias University, India
Paolo Censi, University of Palermo, Italy
Christophoros Christophoridis, National Research Center "Demokritos", Greece
Ahmed S. Ibrahim, Qatar University, Qatar
Agata Jakóbik-Kolon, Silesian University of Technology, Poland
Luyun Jiang, Oxford University, UK
Fei Li Zhongnan, University of Economics and Law, China
Awal Noor, COMSATS Institute of Information Technology, Abbottabad Campus, Paksitan
Tanay Pramanik, Lovely Professional University, India
Daily Rodriguez-Padron, Universidad de Cordoba, Spain
Lakshmi Narayana Suvarapu, Yeungnam University, Republic of Korea
Zhien Zhang, Ohio State University, USA

Fluorescence Spectroscopy
Krishnamoorthy Sivakumar, SCSVMV University, India

*Prices in US$ apply to orders placed in the Americas only. Prices in £ apply to orders placed in Great Britain only. Prices in € represent the retail prices valid in Germany (unless otherwise indicated). Prices are subject to change without notice. Prices do not include postage and handling if applicable. Free shipping for non-business customers when ordering books at De Gruyter Online. RRP: Recommended Retail Price.

Order now! orders@degruyter.com

Inorganic Chemistry
Aharon Gedanken, Bar-Ilan University, Israel
Agata Jakóbik-Kolon, Silesian University of Technology, Poland
Zoran Mazej, Jozef Stefan Institute, Slovenia
Mohsen Mhadhbi, National Institute of Research and Physical-chemical Analysis, Tunisia
Awal Noor, COMSATS Institute of Information Technology, Abbottabad Campus, Paksitan
Tiefeng Peng, Southwest University of Science and Technology & Chongqing University, China
Snezana Zaric, University of Belgrade (Serbia) and Texas A&M University at Qatar

IR and Raman Spectroscopy
Xing Ma, Harbin Institute of Technology (Shenzhen), China
María Mar Quesada-Moreno, Max Planck Institute for the Structure and Dynamics of Matter, Germany

Macromolecules and Polymers
Iolanda Francolini, Sapienza University of Rome, Italy
Mazeyar Parvinzadeh Gashti, PRE Labs Inc, Canada
Saravana Kumar Jaganathan, Universiti Teknologi Malaysia, Johor
Tanay Pramanik, Lovely Professional University, India
Christian Schmitz, University Hochschule Niederrhein, Germany
Shin-ichi Yusa, University of Hyogo, Japan
Szczepan Zapotoczny, Jagiellonian University, Poland
Zhien Zhang, Ohio State University, USA

Materials
Csaba Balazsi, Centre for Energy Research, Hungarian Academy of Sciences, Hungary
Sergio Carrasco, University Rey Juan Carlos, Spain
Aharon Gedanken, Bar-Ilan University, Israel
Huanhuan Feng, Harbin Institute of Technology, China
Mazeyar Parvinzadeh Gashti, PRE Labs Inc, Canada
Saravana Kumar Jaganathan, Universiti Teknologi Malaysia, Johor
Mohsen Mhadhbi, National Institute of Research and Physical-chemical Analysis, Tunisia
Janos Szepvolgyi, Hungarian Academy of Sciences, Hungary

Medicinal Chemistry
Murali Anuganti, University of Nevada, USA
Dr Biljana Arsic, University of Nis, Republic of Serbia
Dibyendu Dana, Angion Biomedical Corporation,USA
Rajat Subhra Das, Omega Therapeutics, USA
Tecla Gasperi, Università "Roma Tre", Italy
Zoidis Grigoris, National and Kapodistrian University of Athens, Greece
Sravanthi Devi Guggilapu, University of Maryland-College Park, USA
Iryna Kravchenko, Odessa National Polytechnic University, Ukraina
Awal Noor, COMSATS Institute of Information Technology, Abbottabad

*Prices in US$ apply to orders placed in the Americas only. Prices in £ apply to orders placed in Great Britain only. Prices in € represent the retail prices valid in Germany (unless otherwise indicated). Prices are subject to change without notice. Prices do not include postage and handling if applicable. Free shipping for non-business customers when ordering books at De Gruyter Online. RRP: Recommended Retail Price.

Order now! orders@degruyter.com

Campus, Paksitan
Tanay Pramanik, Lovely Professional University, India
Tingting Zheng, Peking University Shenzhen Hospital, China

Natural Product Chemistry
Khuram Shahzad Ahmad, Fatima Jinnah Women University, Pakistan
Domenico Cautela, Stazione Sperimentale per le Industrie delle Essenze e dei derivati dagli Agrumi (SSEA), Italy
Łukasz Cieśla, The University of Alabama, USA
Przemysław Kowalczewski, Poznan University of Life Sciences, Poland
Iryna Kravchenko, Odessa National Polytechnic University, Ukraina
Chanchal Kumar Malik, Vanderbilt University, USA
Shagufta Perveen, King Saud University, Kingdom of Saudi Arabia
Riaz Ullah - King Saud University Riyadh, Saudi Arabia
Francesco Siano, Consiglio Nazionale delle Ricerche (CNR) Istituto di Scienze dell'Alimentazione (ISA), Italy
Nurhayat Tabanca, USDA-ARS, Subtropical Horticulture Research Station, Miami, USA

NMR Spectroscopy
Shagufta Perveen, King Saud University, Kingdom of Saudi Arabia
Atul Srivastava, University of Chicago, USA

Organic Chemistry
Anthony J. Burke - University of Évora, Portugal
Eugenijus Butkus, Vilnius University, Lithuania
Xavier Companyó, University of Padua, Italy
Dibyendu Dana, Angion Biomedical Corporation,USA
Tecla Gasperi, Università "Roma Tre", Italy
Sravanthi Devi Guggilapu, University of Maryland-College Park, USA
Chanchal Kumar Malik, Vanderbilt University, USA
Matthew O'Brien, Keele University, UK
Tanay Pramanik, Lovely Professional University, India
Praveen Kumar Sharma, Lovely Professional University, India
Konstantin Volcho, Vorozhtsov Novosibirsk Institute of Organic Chemistry SB RAS, Russia

Organometallic Chemistry
Awal Noor, COMSATS Institute of Information Technology, Abbottabad Campus, Paksitan
Cristian Silvestru, Babes-Bolyai University, Romania
Lakshmi Narayana Suvarapu, Yeungnam University, Republic of Korea

Pharmaceutical Chemistry
Arindam Bose - Harvard University, USA
Sravanthi Devi Guggilapu, University of Maryland-College Park, USA
Przemysław Kowalczewski, Poznan University of Life Sciences, Poland
Raj Mukherjee, Sanofi, CHC R&D, USA
Christos Petrou, University of Nicosia, Cyprus
Belgin Sever, Anadolu University, Turkey

*Prices in US$ apply to orders placed in the Americas only. Prices in £ apply to orders placed in Great Britain only. Prices in € represent the retail prices valid in Germany (unless otherwise indicated). Prices are subject to change without notice. Prices do not include postage and handling if applicable. Free shipping for non-business customers when ordering books at De Gruyter Online. RRP: Recommended Retail Price.

Order now! orders@degruyter.com

Photochemistry
Przemysław Kowalczewski, Poznan University of Life Sciences, Poland
Krishnamoorthy Sivakumar, SCSVMV University, India

Physical Chemistry
Ramesh Gardas, Indian Institute of Technology Madras, India
Huanhuan Feng, Harbin Institute of Technology, China
Luyun Jiang, Oxford University, UK
Mohsen Mhadhbi, National Institute of Research and Physical-chemical Analysis, Tunisia
Tiefeng Peng, Southwest University of Science and Technology & Chongqing University, China
María Mar Quesada-Moreno, Max Planck Institute for the Structure and Dynamics of Matter, Germany
Ponnadurai Ramasami, University of Mauritius, Mauritius
Catinca Secuianu, Imperial College London, UK

Physical Chemistry and Physical Organic Chemistry
Sayak Bhattacharya, Galgotias University, India
Ponnadurai Ramasami, University of Mauritius, Mauritius

Phytochemistry
Khuram Shahzad Ahmad, Fatima Jinnah Women University, Pakistan
Iryna Kravchenko, Odessa National Polytechnic University, Ukraina
Chanchal Kumar Malik, Vanderbilt University, USA
Shagufta Perveen, King Saud University, Kingdom of Saudi Arabia
Riaz Ullah - King Saud University Riyadh, Saudi Arabia

Radiochemistry and Nuclear Chemistry
Stefan Neumeier, Forschungszentrum Jülich, Germany

Solid State Chemistry
Sofoklis Makridis, University of Western Macedonia & Lawrence Berkeley National Laboratories, USA
Chanchal Kumar Malik, Vanderbilt University, USA
Mohsen Mhadhbi, National Institute of Research and Physical-chemical Analysis, Tunisia

Spectroscopy
Xavier Companyó, University of Padua, Italy
Huanhuan Feng, Harbin Institute of Technology, China
Mazeyar Parvinzadeh Gashti, PRE Labs Inc, Canada
Krishnamoorthy Sivakumar, SCSVMV University, India

Supramolecular Chemistry and Nanochemistry
Krishnamoorthy Sivakumar, SCSVMV University, India

Surface Chemistry and Colloids
Huanhuan Feng, Harbin Institute of Technology, China
Mazeyar Parvinzadeh Gashti, PRE Labs Inc, Canada
Xing Ma, Harbin Institute of Technology (Shenzhen), China

*Prices in US$ apply to orders placed in the Americas only. Prices in £ apply to orders placed in Great Britain only. Prices in € represent the retail prices valid in Germany (unless otherwise indicated). Prices are subject to change without notice. Prices do not include postage and handling if applicable. Free shipping for non-business customers when ordering books at De Gruyter Online. RRP: Recommended Retail Price.

Order now! orders@degruyter.com

Mohsen Mhadhbi, National Institute of Research and Physical-chemical Analysis, Tunisia
Raj Mukherjee, Sanofi, CHC R&D, USA
Tiefeng Peng, Southwest University of Science and Technology & Chongqing University, China
Christian Schmitz, University Hochschule Niederrhein, Germany
Jose Luis Toca-Herrera, University of Natural Resources and Life Sciences, Austria

Nanochemistry
Silvana Andreescu, Clarkson University, USA
Mazeyar Parvinzadeh Gashti, PRE Labs Inc, Canada
Omkar Singh Kushwaha, Chemical Engineering Department, Indian Institute of Technology, India
Jerzy Langer, Adam Mickiewicz University, Poland
Xing Ma, Harbin Institute of Technology (Shenzhen), China
Linda Mbeki, VU University Amsterdam, The Netherlands
Waqas Nazeer, University of Education, Pakistan
Gaweł Sołowski, Gdansk University Of Technology, Poland
Jose Luis Toca-Herrera, University of Natural Resources and Life Sciences, Austria
Tingting Zheng, Peking University Shenzhen Hospital, China

Thermodynamics
Sayak Bhattacharya, Galgotias University, India
Dominique Richon, University of KwaZulu-Natal, South Africa

Theoretical and Computational Chemistry
Sayak Bhattacharya, Galgotias University, India
Christiana Mitsopoulou, National and Kapodistrian University of Athens, Greece
Ponnadurai Ramasami, University of Mauritius, Mauritius

Language Editors
Kingsley K. Donkor, Thompson Rivers University, Canada
Emmanuel G. Escobar, University of Sheffield, UK
Marie Frusher, Defence Science & Technology Laboratory, UK
Victoria Guarisco, Macon State College, USA
Heidi Huttunen-Hennelly, Thompson Rivers University, Canada
Richard Johnson, UK
Kate Khan, Imperial College London, UK
Monika Marciniak, University of Washington, USA
Mayoorini Majuran, Monash University, Clayton, Australia
Vijaykumar D. Nimbarte, Goethe University Frankfurt am Main, Germany
Monica Ramirez, Broward College, USA
Maria Reiner, Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik, Germany
Andrea Renzetti, University of Cambridge, UK
Navpreet K. Sethi, Zhejiang University, Hangzhou, China
Bryan Spiegelberg, Rider University, USA
Michael Wentzel, University of Minesota, USA

*Prices in US$ apply to orders placed in the Americas only. Prices in £ apply to orders placed in Great Britain only. Prices in € represent the retail prices valid in Germany (unless otherwise indicated). Prices are subject to change without notice. Prices do not include postage and handling if applicable. Free shipping for non-business customers when ordering books at De Gruyter Online. RRP: Recommended Retail Price.

Order now! orders@degruyter.com

DE GRUYTER

Publisher
DE GRUYTER Poland
Bogumiła Zuga 32A Str.
01-811 Warsaw, Poland
T: +48 22 701 50 15

Editorial Contact
Agnieszka Topolska
Agnieszka.Topolska@degruyter.com

*Prices in US$ apply to orders placed in the Americas only. Prices in £ apply to orders placed in Great Britain only. Prices in € represent the retail prices valid in Germany (unless otherwise indicated). Prices are subject to change without notice. Prices do not include postage and handling if applicable. Free shipping for non-business customers when ordering books at De Gruyter Online. RRP: Recommended Retail Price.

Order now! orders@degruyter.com

DE GRUYTER

*Prices in US$ apply to orders placed in the Americas only. Prices in £ apply to orders placed in Great Britain only. Prices in € represent the retail prices valid in Germany (unless otherwise indicated). Prices are subject to change without notice. Prices do not include postage and handling if applicable. Free shipping for non-business customers when ordering books at De Gruyter Online. RRP: Recommended Retail Price.

Order now! orders@degruyter.com

DE GRUYTER

*Prices in US$ apply to orders placed in the Americas only. Prices in £ apply to orders placed in Great Britain only. Prices in € represent the retail prices valid in Germany (unless otherwise indicated). Prices are subject to change without notice. Prices do not include postage and handling if applicable. Free shipping for non-business customers when ordering books at De Gruyter Online. RRP: Recommended Retail Price.

Order now! orders@degruyter.com

DE GRUYTER

*Prices in US$ apply to orders placed in the Americas only. Prices in £ apply to orders placed in Great Britain only. Prices in € represent the retail prices valid in Germany (unless otherwise indicated). Prices are subject to change without notice. Prices do not include postage and handling if applicable. Free shipping for non-business customers when ordering books at De Gruyter Online. RRP: Recommended Retail Price.

Order now! orders@degruyter.com

Volume 18 (2020): Issue 1 (Jan 2020)

in Open Chemistry

REGULAR ARTICLES

Electrochemical antioxidant screening and evaluation based on guanine and chitosan immobilized MoS_2 nanosheet modified glassy carbon electrode (guanine/CS/MoS_2/GCE)

Ping Tang, Xiaosheng Tang, Shiyong Mei, Yixi Xie, Liangliang Liu and Licheng Ren

Article Category: Research Article | Pages: 1–9 | Published online: 13 Feb 2020

ABSTRACT

In this study, an electrochemical biosensor based on guanine and chitosan immobilized MoS_2 nanosheet modified glassy carbon electrode (guanine/CS/Mo

... Show More

PDF

Kinetic models of the extraction of vanillic acid from pumpkin seeds

Milan Mitić, Sonja Janković, Pavle Mašković, Biljana Arsić, Jelena Mitić and Jovana Ickovski

Article Category: Research Article | Pages: 22–30 | Published online: 30 Jan 2020

ABSTRACT

Vanillic acid is used in the food industry and perfumery, and the optimization of its extraction process from the natural source is important fo

... Show More

PDF

On the maximum *ABC* index of bipartite graphs without pendent vertices

Zehui Shao, Pu Wu, Huiqin Jiang, S.M. Sheikholeslami and Shaohui Wang

Article Category: Research Article | Pages: 39–49 | Published online: 10 Mar 2020

ABSTRACT

For a simple graph G, the atom–bond connectivity index (ABC) of G is defined as $ABC(G)$ = ∑uv∈E(G)d(u)+d(v)−2d(u)d(v),where $d(v)$ denotes the degr

... Show More

PDF

Estimation of the total antioxidant potential in the meat samples using thin-layer chromatography

Paweł Piszcz, Magdalena Tomaszewska and Bronisław K. Głód

Article Category: Research Article | Pages: 50–57 | Published online: 28 Feb 2020

ABSTRACT

There is limited literature on the antioxidative properties of food of animal origin. Measurements of antioxidative properties are usually performe

... Show More

PDF

Molecular dynamics simulation of sI methane hydrate under compression and tension

Qiang Wang, Qizhong Tang and Sen Tian

Article Category: Research Article | Pages: 69–76 | Published online: 20 Feb 2020

ABSTRACT

Molecular dynamics (MD) analysis of methane hydrate is important for the application of methane hydrate technology. This study investigated t

... Show More

PDF

Spatial distribution and potential ecological risk assessment of some trace elements in sediments and grey mangrove (*Avicennia marina*) along the Arabian Gulf coast, Saudi Arabia

Hameed Alsamadany, Hassan S. Al-Zahrani, El-Metwally M. Selim and Mohsen M. El-Sherbiny

Article Category: Research Article | Pages: 77–96 | Published online: 10 Mar 2020

ABSTRACT

To assess trace element concentrations (Zn, Cu, Pb, Cr, Cd and Ni) in the mangrove swamps along the Saudi coast of the Arabian Gulf, thirteen sam

... Show More

PDF

Amino-functionalized graphene oxide for Cr(VI), Cu(II), Pb(II) and Cd(II) removal from industrial wastewater

Huayu Huang, Yang Wang, Yubin Zhang, Zhiying Niu and Xinli Li

Article Category: Research Article | Pages: 97–107 | Published online: 10 Mar 2020

ABSTRACT

Amino-functionalized graphene oxide (GO-NH_2) was synthesized by grafting (3-aminopropyl) triethoxysilane on the graphene oxide (GO) surface. The GO

... Show More

PDF

Chemical composition and *in vitro* activity of *Origanum vulgare* L., *Satureja hortensis* L., *Thymus serpyllum* L. and *Thymus vulgaris* L. essential oils towards oral isolates of *Candida albicans* and *Candida glabrata*

Tomasz Baj, Anna Biernasiuk, Rafał Wróbel and Anna Malm

Article Category: Research Article | Pages: 108–118 | Published online: 10 Mar 2020

ABSTRACT

The purpose of this research was to investigate the chemical composition of essential oils (EOs) from: *Origanum vulgare* L., *Satureja hortensis* L.,

... Show More

PDF

Effect of excess Fluoride consumption on Urine-Serum Fluorides, Dental state and Thyroid Hormones among children in "Talab Sarai" Punjab Pakistan

Sadia Zulfiqar, Humayun Ajaz, Shafiq ur Rehman, Shan Elahi, Amer Shakeel, Farhat Yasmeen and Shehnila Altaf

Article Category: Research Article | Pages: 119–128 | Published online: 18 Mar 2020

ABSTRACT

190 children aged 7-18 years from an endemic fluorotic village "Talab Sarai (n = 130) and a non-fluorotic, control, village "Ottawa" (n = 60)

... Show More

PDF

Design, Synthesis and Characterization of Novel Isoxazole Tagged Indole Hybrid Compounds

Raed A. Al-Qawasmeh, Louy A. Al-Nazer, Sarah A. Dawlat-Kari, Luay Abu-Qatouseh, Salim S. Sabri, Murad A. AlDamen and Mutasem Sinnokrot

Article Category: Research Article | Pages: 138–148 | Published online: 25 Mar 2020

ABSTRACT

Sixteen new isoxazole tagged indole compounds have been synthesized *via* copper (I) catalyzed click chemistry of the aryl hydroxamoyl chloride

... Show More

PDF

Comparison of kinetic and enzymatic properties of intracellular phosphoserine aminotransferases from alkaliphilic and neutralophilic bacteria

Marianne Koivulehto, Natalia Battchikova, Saara Korpela, Elvira Khalikova, Anton Zavialov and Timo Korpela

Article Category: Research Article | Pages: 149–164 | Published online: 24 Mar 2020

ABSTRACT

Intracellular pyridoxal 5´-phosphate (PLP) -dependent recombinant phosphoserine aminotransferases (PSATs; EC 2.6.1.52) from two alkaliphilic

... Show More

PDF

Green Organic Solvent-Free Oxidation of Alkylarenes with *tert*-Butyl Hydroperoxide Catalyzed by Water-Soluble Copper Complex

Abdelaziz Nait Ajjou and Ateeq Rahman

Article Category: Research Article | Pages: 165–174 | Published online: 24 Mar 2020

ABSTRACT

Different benzylic compounds were efficiently oxidized to the corresponding ketones with aqueous 70% *tert*-butyl hydroperoxide (TBHP) and the cata

... Show More

PDF

***Ducrosia ismaelis* Asch. essential oil: chemical composition profile and anticancer, antimicrobial and antioxidant potential assessment**

Ramzi A. Mothana, Fahd A. Nasr, Jamal M. Khaled, Omar M. Noman, Nael Abutaha, Adnan J. Al-Rehaily, Omar M. Almarfadi and Mine Kurkcuoglu

Article Category: Research Article | Pages: 175–184 | Published online: 02 Apr 2020

ABSTRACT

The essential oil of *Ducrosia ismaelis* Asch. (Apiaceae) that grows wild in Saudi Arabia was investigated utilizing gas chromatography (GC)

... Show More

PDF

DFT calculations as an efficient tool for prediction of Raman and infra-red spectra and activities of newly synthesized cathinones

Maja Vujović, Venkatesan Ragavendran, Biljana Arsić, Emilija Kostić and Milan Mladenović

Article Category: Research Article | Pages: 185–195 | Published online: 07 Apr 2020

ABSTRACT

Initially made for medical treatment for Parkinsonism, obesity, and depression, cathinones have become illegal drugs for the “recreational u

... Show More

PDF

Influence of Chemical Osmosis on Solute Transport and Fluid Velocity in Clay Soils

Zhihong Zhang, Gailei Tian and Lin Han

Article Category: Research Article | Pages: 232–238 | Published online: 07 Apr 2020

ABSTRACT

Solute transport through the clay liner is a significant process in many waste landfills or unmanaged landfills. At present, researchers main

... Show More

PDF

A New fatty acid and some triterpenoids from propolis of Nkambe (North-West Region, Cameroon) and evaluation of the antiradical scavenging activity of their extracts

Abakar Ali Mahamat, Jean Noël Nyemb, Isaac Silvère Gade, Alfred Tamfu Ngenge, Emmanuel Talla, Henoumont Céline, Laurent Sophie and Joseph Tanyi Mbafor

Article Category: Research Article | Pages: 239–243 | Published online: 02 Apr 2020

ABSTRACT

The aim of this work was to evaluate *in vitro* antiradical scavenging activity of propolis from Nkambe (North-West, Cameroon). The polypheno

... Show More

PDF

Antiplasmodial Activity of Stigmastane Steroids from *Dryobalanops oblongifolia* Stem Bark

Indriani Indriani, Nanik Siti Aminah and Ni Nyoman Tri Puspaningsih

Article Category: Research Article | Pages: 259–264 | Published online: 07 Apr 2020

ABSTRACT

Three stigmastane steroids: 6-hydroxystigmast-4-en-3-one (1), stigmast-4-en-3-one (2), and 3-hydroxystigmast-5-en-7-one (3) were successfully isol

... Show More

PDF

Rapid identification of direct-acting pancreatic protectants from *Cyclocarya paliurus* leaves tea by the method of serum pharmacochemistry combined with target cell extraction

Wei-hong Chen, Zhen Luo, Zi-Wan Ning, Jiao Peng, Xiao-peng Hu, Li-xiang Zhai, Bo Wen, Hai-tao Xiao and Zhao-xiang Bian

Article Category: Research Article | Pages: 265–274 | Published online: 07 Apr 2020

ABSTRACT

Extracts of *Cyclocarya paliurus* (CP) leaves, a popular sweet tea, inhibit pancreatic β cell apoptosis and have potent hypoglycemic effects, bu

... Show More

PDF

Immobilization of *Pseudomonas aeruginosa* static biomass on eggshell powder for on-line preconcentration and determination of Cr (VI)

Aamir Rasheed, Tahseen Ghous, Sumaira Mumtaz, Muhammad Nadeem Zafar, Kalsoom Akhter, Rabia Shabir, Zain-ul-Abdin and Syed Salman Shafqat

Article Category: Research Article | Pages: 303–313 | Published online: 20 Apr 2020

ABSTRACT

In the present work, a novel continuous flow system (CFS) is developed for the preconcentration and determination of Cr (VI) using *Pseudomonas aer*

... Show More

PDF

Assessment of methyl 2-({[(4,6-dimethoxypyrimidin-2-yl)carbamoyl] sulfamoyl}methyl)benzoate through biotic and abiotic degradation modes

Mahwash Mahar Gul and Khuram Shahzad Ahmad

Article Category: Research Article | Pages: 314–324 | Published online: 20 Apr 2020

ABSTRACT

Detoxification and management of environmental contaminants is an exigent issue of current times. Sulfonylurea herbicide, Bensulfuron-methyl was

... Show More

PDF

Stability of natural polyphenol fisetin in eye drops Stability of fisetin in eye drops

Kristína Krajčíková, Mária Suváková, Gabriela Glinská, Jana Ohlasová and Vladimíra Tomečková

Article Category: Research Article | Pages: 325–332 | Published online: 20 Apr 2020

ABSTRACT

Fisetin is a polyphenolic compound with anti-inflammatory and antioxidant properties. Inflammation and reactive oxygen species play a major role in

... Show More

PDF

Production of a bioflocculant by using activated sludge and its application in Pb(II) removal from aqueous solution

Zibo Yan, Li Peng, Miao Deng and Jinhui Lin

Article Category: Research Article | Pages: 333–338 | Published online: 04 May 2020

ABSTRACT

In this study, the characteristics of a bioflocculant produced by using activated sludge as raw materials were investigated. The performanc

... Show More

PDF

Molecular Properties of Carbon Crystal Cubic Structures

Hong Yang, Muhammad Kamran Siddiqui, Muhammad Naeem and Najma Abdul Rehman

Article Category: Research Article | Pages: 339–346 | Published online: 27 May 2020

ABSTRACT

Graph theory assumes an imperative part in displaying and planning any synthetic structure or substance organizer. Chemical graph theory facili

... Show More

PDF

Synthesis and characterization of calcium carbonate whisker from yellow phosphorus slag

Qiuju Chen, Wenjin Ding, Tongjiang Peng and Hongjuan Sun

Article Category: Research Article | Pages: 347–356 | Published online: 21 Apr 2020

ABSTRACT

In this study, a procedure for producing calcium carbonate whisker through yellow phosphorus slag carbonation without adding any crystal control

... Show More

PDF

Study on the interaction between catechin and cholesterol by the density functional theory

Kaiwen Zheng, Kai Guo, Jing Xu, Wei Liu, Junlang Chen, Can Xu and Liang Chen

Article Category: Research Article | Pages: 357–368 | Published online: 28 May 2020

ABSTRACT

Catechin – a natural polyphenol substance – has excellent antioxidant properties for the treatment of diseases, especially for cholesterol lowe

... Show More

PDF

Analysis of some pharmaceuticals in the presence of their synthetic impurities by applying hybrid micelle liquid chromatography

Dina El Sherbiny and Mary E. K. Wahba

Article Category: Research Article | Pages: 377–390 | Published online: 23 May 2020

ABSTRACT

A stability-indicating hybrid micelle liquid chromatography accompanied by UV detection was developed for the simultaneous analysis of either par

... Show More

PDF

Two mixed-ligand coordination polymers based on 2,5-thiophenedicarboxylic acid and flexible N-donor ligands: the protective effect on periodontitis via reducing the release of IL-1β and TNF-α

Shao-Hsuan Wu and Jun-Hui Huang

Article Category: Research Article | Pages: 391–398 | Published online: 21 Apr 2020

ABSTRACT

Two novel mixed-ligand coordination polymers, $\{[Co(tdc)(btrp)]\cdot 0.67DMF\}_n$ (1) and $\{[Zn_2(bimb)_2(tdc)_2]\cdot 2H_2O\}_n$ (2) involving 2,5-thioph

... Show More

PDF

Incorporation of silver stearate nanoparticles in methacrylate polymeric monoliths for hemeprotein isolation

Eman Alzahrani

Article Category: Research Article | Pages: 399–411 | Published online: 27 Apr 2020

ABSTRACT

A unique method was used to synthesize extremely stable silver stearate nanoparticles (AgStNPs) incorporated in an organic-based monolith. Th

... Show More

PDF

Development of ultrasound-assisted dispersive solid-phase microextraction based on mesoporous carbon coated with silica@iron oxide nanocomposite for preconcentration of Te and Tl in natural water systems

Luthando Nyaba, Buyile Dubazana, Anele Mpupa and Philiswa N. Nomngongo

Article Category: Research Article | Pages: 412–425 | Published online: 26 Apr 2020

ABSTRACT

The main objective of this study was to develop an ultrasound-assisted dispersive solid-phase microextraction (UADSPME) method for separ

... Show More

PDF

***N*,*N′*-Bis[2-hydroxynaphthylidene]/[2-methoxybenzylidene]amino]oxamides and their divalent manganese complexes: Isolation, spectral characterization, morphology, antibacterial and cytotoxicity against leukemia cells**

Ayman H. Ahmed

Article Category: Research Article | Pages: 426–437 | Published online: 18 May 2020

ABSTRACT

Manganese(II) complexes of oxalic dihydrazones {*N*,*N′*-bis[2-hydroxynaphthylidene]amino]oxamide (BHO) and *N*,*N′*-bis[2-methoxybenzylidene]amino]oxamid

... Show More

PDF

Determination of the content of selected trace elements in Polish commercial fruit juices and health risk assessment

Grażyna Kowalska, Urszula Pankiewicz, Radosław Kowalski and Artur Mazurek

Article Category: Research Article | Pages: 443–452 | Published online: 26 Apr 2020

ABSTRACT

The objective of the study was to determine the content of cadmium (Cd), lead (Pb), arsenic (As), aluminium (Al), thallium (Tl), antimony (Sb) an

... Show More

PDF

Diorganotin(IV) benzyldithiocarbamate complexes: synthesis, characterization, and thermal and cytotoxicity study

Jerry O. Adeyemi, Damian C. Onwudiwe, Nirasha Nundkumar and Moganavelli Singh

Article Category: Research Article | Pages: 453–462 | Published online: 18 Jun 2020

ABSTRACT

Ammonium benzyldithiocarbamate, represented as NH_4L, was prepared and used in the complexation reaction involving three organotin(IV

... Show More

PDF

Keratin 17 is induced in prurigo nodularis lesions

Li-Li Yang, Hai-Yan Huang, Zhen-Zhen Chen, Ran Chen, Rong Ye, Wei Zhang and Bo Yu

Article Category: Research Article | Pages: 463–471 | Published online: 18 Jun 2020

ABSTRACT

Prurigo nodularis (PN) is a highly pruritic chronic inflammatory dermatosis with unknown pathogenesis. It is characterized by the existen

... Show More

PDF

Anticancer, antioxidant, and acute toxicity studies of a Saudi polyherbal formulation, PHF5

Nael Abutaha, Mohammed Al-zharani, Amin A. Al-Doaiss, Almohannad Baabbad, Ahmed Mfreh Al-malki and Hafedh Dekhil

Article Category: Research Article | Pages: 472–481 | Published online: 18 May 2020

ABSTRACT

A popular polyherbal formulation prepared from five plants (PHF5) may have anticancer effects. However, there is a lack of adequate scientific e

... Show More

PDF

$LaCoO_3$ perovskite-type catalysts in syngas conversion

Gulim Danebaevna Jetpisbayeva, Eugene Vladimirovich Dokuchits, Angelina Nikolaevna Tafilevich, Tatyana Petrovna Minyukova, Bakytgul Kabykenovna Massalimova and Vladislav Aleksandrovich Sadykov

Article Category: Research Article | Pages: 482–487 | Published online: 26 May 2020

ABSTRACT

$LaCoO_3$ samples were obtained by the hydrothermal and citrate methods. The dynamics of the phase transformations of the initial hydroxo compounds

... Show More

PDF

Comparative studies of two vegetal extracts from *Stokesia laevis* and *Geranium pratense*: polyphenol profile, cytotoxic effect and antiproliferative activity

Lucia Pirvu, Georgeta Neagu, Iulian Terchescu, Bujor Albu and Amalia Stefaniu

Article Category: Research Article | Pages: 488–502 | Published online: 02 Jun 2020

ABSTRACT

In this study, two ethanolic extracts, from *Stokesia aster* (Slae26) and *Geranium pratense* (Gpre36) respectively, were evaluated in order to as

... Show More

PDF

Fragmentation pattern of certain isatin-indole antiproliferative conjugates with application to identify their *in vitro* metabolic profiles in rat liver microsomes by liquid chromatography tandem mass spectrometry

Maha S. Almutairi, Adnan A. Kadi, Reem I. Al-Wabli, Mohamed W. Attwa and Mohamed I. Attia

Article Category: Research Article | Pages: 503–515 | Published online: 09 Jun 2020

ABSTRACT

The fragmentation pattern of certain isatin-based compounds was carried out using collision-induced dissociation inside the triple quadrupole mass

... Show More

PDF

Investigation of polyphenol profile, antioxidant activity and hepatoprotective potential of *Aconogonon alpinum* (All.) Schur roots

Muhammad Zakryya Khan, Muhammad Imran Shabbir, Zafeer Saqib, Syed Aneel Gilani, Naqeeb Ullah Jogezai, Mubin Mustafa Kiyani and Muhammad Arshad Malik

Article Category: Research Article | Pages: 516–536 | Published online: 02 Jun 2020

ABSTRACT

Liver plays vital role in detoxification of exogenous and endogenous chemicals. These chemicals as well as oxidative stress may cause liver diso

... Show More

PDF

Lead discovery of a guanidinyl tryptophan derivative on amyloid cascade inhibition

Piyapan Suwanttananuruk, Jutamas Jiaranaikulwanitch, Pornthip Waiwut and Opa Vajragupta

Article Category: Research Article | Pages: 546–558 | Published online: 09 Jun 2020

ABSTRACT

Amyloid cascade, one of pathogenic pathways of Alzheimer's disease (AD), was focused as one of drug discovery targets. In this study, β-secretase

... Show More

PDF

Physicochemical evaluation of the fruit pulp of *Opuntia* spp growing in the Mediterranean area under hard climate conditions

Mohammed Bourhia, Hamza Elmahdaoui, Riaz Ullah, Samir Ibenmoussa and Abdelaaty Abdelaziz Shahat

Article Category: Research Article | Pages: 565–575 | Published online: 02 Jun 2020

ABSTRACT

Barbary fig called prickly pear is a plant belonging to family Cactaceae growing under hard climate conditions. A spiny variety of prickly pea

... Show More

PDF

Electronic structural properties of amino/hydroxyl functionalized imidazolium-based bromide ionic liquids

Xiaoling Hu, Xingang Jia, Kehe Su and Xuefan Gu

Article Category: Research Article | Pages: 576–583 | Published online: 09 Jun 2020

ABSTRACT

Electronic structural properties of the three different imidazolium-based ionic liquids, namely, 1-butyl-3-methyl imidazolium bromide (C_4mimB

... Show More

PDF

New Schiff bases of 2-(quinolin-8-yloxy)acetohydrazide and their Cu(II), and Zn(II) metal complexes: their *in vitro* antimicrobial potentials and *in silico* physicochemical and pharmacokinetics properties

Hanan A. Althobiti and Sami A. Zabin

Article Category: Research Article | Pages: 591–607 | Published online: 09 Jun 2020

ABSTRACT

The purpose of this work was to prepare Schiff base ligands containing quinoline moiety and using them for preparing Cu(II) and Zn(II) complexes.

... Show More

PDF

Treatment of adhesions after Achilles tendon injury using focused ultrasound with targeted bFGF plasmid-loaded cationic microbubbles

Yuzhou Shen, Jiancheng Ma, Junsheng Jiang, Zhilin Chen, Wenzhu Yan, Yue Wang, Feng Wang and Li Liu

Article Category: Research Article | Pages: 608–619 | Published online: 13 Jun 2020

ABSTRACT

Nonviral targeting technology has become promising as a form of gene therapy for diseases and injuries, such as Achilles tendon injuries. In this

... Show More

PDF

Synthesis of orotic acid derivatives and their effects on stem cell proliferation

Saeed Ali Syed, Amer Mahmood, Musaad Alfayez, Eric C. Hosten, Richard Betz, Abdulrahman M. Al-Obaid, Abdulrahman Ghadeer and Ahmed Bari

Article Category: Research Article | Pages: 620–627 | Published online: 20 Jun 2020

ABSTRACT

Orotic acid, a natural product, is involved in many biological processes. Human mesenchymal stem cells (hMSCs) have the potential of self

... Show More

PDF

Chirality of β_2-agonists. An overview of pharmacological activity, stereoselective analysis, and synthesis

Čižmáriková Ružena, Valentová Jindra and Horáková Renáta

Article Category: Review Article | Pages: 628–647 | Published online: 18 Jun 2020

ABSTRACT

β_2-Agonists (β_2-adrenergic agonists, bronchodilatants, and sympathomimetic drugs) are a group of drugs that are mainly used in asthma and obstruc

... Show More

PDF

Fe_3O_4@urea/HITh-SO_3H as an efficient and reusable catalyst for the solvent-free synthesis of 7-aryl-8*H*-benzo[*h*]indeno[1,2-*b*]quinoline-8-one and indeno[2′,1′:5,6]pyrido[2,3-*d*]pyrimidine derivatives

Shenghao Jiang, Macheng Shen and Fatima Rashid Sheykhahmad

Article Category: Research Article | Pages: 648–662 | Published online: 18 Jun 2020

ABSTRACT

In this study, Fe_3O_4@urea/HITh-SO_3H MNPs as a new, efficient, and recyclable solid acid magnetic nan

... Show More

PDF

Adsorption kinetic characteristics of molybdenum in yellow-brown soil in response to pH and phosphate

Zhaojun Nie, Jinfeng Li, Haiyang Liu, Shiliang Liu, Daichang Wang, Peng Zhao and Hongen Liu

Article Category: Research Article | Pages: 663–668 | Published online: 18 Jun 2020

ABSTRACT

Molybdenum (Mo) adsorption by acidic yellow-brown soil was investigated as a function of a pH (1–13) and the equilibrium of P solution (0, 3.1,

... Show More

PDF

Enhancement of thermal properties of bio-based microcapsules intended for textile applications

Virginija Skurkytė-Papievienė, Aušra Abraitienė, Audronė Sankauskaitė, Vitalija Rubežienė and Kristina Dubinskaitė

Article Category: Research Article | Pages: 669–680 | Published online: 23 Jun 2020

ABSTRACT

The thermal properties of bio-based phase change material (PCM) microcapsules and their separate components, core and shell, were investigated

... Show More

PDF

Exploring the effect of khat (*Catha edulis*) chewing on the pharmacokinetics of the antiplatelet drug clopidogrel in rats using the newly developed LC-MS/MS technique

Hassan A. Alhazmi, Adnan A. Kadi, Mohamed W. Attwa, Waquar Ahsan, Manal Mohamed Elhassan Taha and Asaad Khalid

Article Category: Research Article | Pages: 681–690 | Published online: 23 Jun 2020

ABSTRACT

Clopidogrel (CLOP) is widely used worldwide for cardiovascular complications. CLOP is highly metabolized in the liver to its active m

... Show More

PDF

A green strategy for obtaining anthraquinones from *Rheum tanguticum* by subcritical water

Guoying Zhang and Xiaofeng Chi

Article Category: Research Article | Pages: 702–710 | Published online: 23 Jun 2020

ABSTRACT

Rheum tanguticum is a traditional Chinese herbal medicine, which contains abundant anthraquinones. In this study, anthraquinones were effici

... Show More

PDF

Cadmium (Cd) chloride affects the nutrient uptake and Cd-resistant bacterium reduces the adsorption of Cd in muskmelon plants

Jian Zhang, Pengcheng Wang and Qingqing Xiao

Article Category: Research Article | Pages: 711–719 | Published online: 30 Jun 2020

ABSTRACT

This study investigated the effect of cadmium (Cd) chloride on the uptake of N, P, and K and evaluate the effect of Cd-resistant bacterium “N3” on

... Show More

PDF

Removal of H_2S by vermicompost biofilter and analysis on bacterial community

Weiping Tian, Xuemin Chen, Peng Zhou, Xiaoyong Fu and Honghua Zhao

Article Category: Research Article | Pages: 720–731 | Published online: 02 Jul 2020

ABSTRACT

The vermicompost collected from dewatered domestic sludge as packing material in biofilter was investigated for hydrogen sulfide (H_2S) removal. No

... Show More

PDF

Effect of natural boron mineral use on the essential oil ratio and components of Musk Sage (*Salvia sclarea* L.)

Hasan Basri Karayel

Article Category: Research Article | Pages: 732–739 | Published online: 02 Jul 2020

ABSTRACT

This study was aimed to determine the effect of different boron doses (boron free, pure boron with 8 liters per decare and in 1/8 ratio diluted

... Show More

PDF

Structural cytotoxicity relationship of 2-phenoxy(thiomethyl)pyridotriazolopyrimidines: Quantum chemical calculations and statistical analysis

Hatem A. Abuelizz, El Hassane Anouar, Nasser S. Al-Shakliah, Mohamed Marzouk and Rashad Al-Salahi

Article Category: Research Article | Pages: 740–751 | Published online: 30 Jun 2020

ABSTRACT

Previously, a series of pyridotriazolopyrimidines (**1–6**) were synthesized and fully described. The target compounds (**1–6**) were evaluated

... Show More

PDF

A self-breaking supramolecular plugging system as lost circulation material in oilfield

Hanshi Zhang and Guancheng Jiang

Article Category: Research Article | Pages: 757–763 | Published online: 29 Jun 2020

ABSTRACT

Lost circulation is a frequently encountered problem during workover operations of a low-pressure reservoir. Many lost circulation materials (LCM)

... Show More

PDF

Synthesis, characterization, and pharmacological evaluation of thiourea derivatives

Sumaira Naz, Muhammad Zahoor, Muhammad Naveed Umar, Saad Alghamdi, Muhammad Umar Khayam Sahibzada and Wasim UlBari

Article Category: Research Article | Pages: 764–777 | Published online: 29 Jun 2020

ABSTRACT

Thioureas and their derivatives are organosulfur compounds having applications in numerous fields such as organic synthesis and pharmaceutical i

... Show More

PDF

Application of drug-metal ion interaction principle in conductometric determination of imatinib, sorafenib, gefitinib and bosutinib

Hassan A. Alhazmi, AbdulRhman Ali Bokar Nasib, Yasser Ali Musleh, Khaled Qassim Hijri, Zia ur Rehman, Gulrana Khuwaja, Mohammed Al-Bratty, Sadique A. Javed and Ismail A. Arbab

Article Category: Research Article | Pages: 798–807 | Published online: 02 Jul 2020

ABSTRACT

An analytical method for the quantification of anticancer agents such as imatinib, sorafenib, gefitinib and bosutinib using conductometry was d

... Show More

PDF

Advancing biodiesel production from microalgae *Spirulina* sp. by a simultaneous extraction-transesterification process using palm oil as a co-solvent of methanol

Yano Surya Pradana, Resti Nurmala Dewi, Kanadya Di Livia, Farida Arisa, Rochmadi, Rochim Bakti Cahyono and Arief Budiman

Article Category: Research Article | Pages: 833–842 | Published online: 28 Jul 2020

ABSTRACT

Microalgae have been considered as a potential candidate for biodiesel feedstock. Single-stage simultaneous extraction–transesterification process

... Show More

PDF

Synthesis and characterization of a novel chitosan-grafted-polyorthoethylaniline biocomposite and utilization for dye removal from water

Mirza Nadeem Ahmad, Arif Hussain, Muhammad Naveed Anjum, Tajamal Hussain, Adnan Mujahid, Muhammad Hammad Khan and Toheed Ahmed

Article Category: Research Article | Pages: 843–849 | Published online: 03 Aug 2020

ABSTRACT

Chitosan was grafted with polyorthoethylaniline through oxidative polymerization using ammonium persulfate as oxidant, resulting in the format

... Show More

PDF

Exergy analysis of conventional and hydrothermal liquefaction-esterification processes of microalgae for biodiesel production

Laras Prasakti, Sangga Hadi Pratama, Ardian Fauzi, Yano Surya Pradana, Rochmadi and Arief Budiman

Article Category: Research Article | Pages: 874–881 | Published online: 03 Aug 2020

ABSTRACT

As fossil fuels were depleting at an alarming rate, the development of renewable energy has become necessary. One of the promising renewable

... Show More

PDF

Treatment of Parkinson's disease using focused ultrasound with GDNF retrovirus-loaded microbubbles to open the blood-brain barrier

Feng Wang, Nana Li, Ruanling Hou, Lu Wang, Libin Zhang, Chenzhang Li, Yu Zhang, Yaling Yin, Liansheng Chang, Yuan Cheng, Yongling Wang and Jianping Lu

Article Category: Research Article | Pages: 882–889 | Published online: 03 Aug 2020

ABSTRACT

This study aims to prepare ultrasound-targeted glial cell-derived neurotrophic factor (GDNF) retrovirus-loaded microbubbles (M pLXSN-GDNF)

... Show More

PDF

New derivatives of a natural nordentatin

Tin Myo Thant, Nanik Siti Aminah, Alfinda Novi Kristanti, Rico Ramadhan, Hnin Thanda Aung and Yoshiaki Takaya

Article Category: Research Article | Pages: 890–897 | Published online: 03 Aug 2020

ABSTRACT

New derivatives were obtained from natural nordentatin (**1**) previously isolated from the methanol fraction of *Clausena excavata* by an acylatio

... Show More

PDF

Study of the remediation effects of passivation materials on Pb-contaminated soil

Shu-Xuan Liang, Xiao-Can Xi and Yu-Ru Li

Article Category: Research Article | Pages: 911–917 | Published online: 03 Aug 2020

ABSTRACT

The passivation effects of blast furnace slag, fly ash, corncob biochar, and phosphate fertilizer in Pb-contaminated soil was evaluated agains

... Show More

PDF

Saliva proteomic analysis reveals possible biomarkers of renal cell carcinoma

Xiao Li Zhang, Zheng Zhi Wu, Yun Xu, Ji Guo Wang, Yong Qiang Wang, Mei Qun Cao and Chang Hao Wang

Article Category: Research Article | Pages: 918–926 | Published online: 03 Aug 2020

ABSTRACT

Early diagnosis is a key to improve the prognosis of renal cell carcinoma (RCC); however, reliable RCC biomarkers are lacking in clinical practi

... Show More

PDF

REVIEW ARTICLES

Sinoporphyrin sodium, a novel sensitizer for photodynamic and sonodynamic therapy

Han-Qing Liu, Ya-Wen An, Zhi-Wen Li, Wei-Xin Li, Bo Yuan, Jian-Chun Wang, Hong-Tao Jin and Cheng Wang

Article Category: Review Article | Pages: 691–701 | Published online: 23 Jun 2020

ABSTRACT

Sinoporphyrin sodium (DVDMS) is a novel sensitizer discovered by Professor Fang Qi-Cheng and widely used in photodynamic (PDT) and sonodynamic ther

... Show More

PDF

Natural products isolated from *Casimiroa*

Khun Nay Win Tun, Nanik Siti Aminah, Alfinda Novi Kristanti, Hnin Thanda Aung and Yoshiaki Takaya

Article Category: Review Article | Pages: 778–797 | Published online: 02 Jul 2020

ABSTRACT

About 140 genera and more than 1,600 species belong to the Rutaceae family. They grow in temperate and tropical zones on both hemispheres, as tr

... Show More

PDF

SPECIAL ISSUE ON APPLIED BIOCHEMISTRY AND BIOTECHNOLOGY 2019

SPECIAL ISSUE ON MONITORING, RISK ASSESSMENT AND SUSTAINABLE MANAGEMENT FOR THE EXPOSURE TO ENVIRONMENTAL TOXINS

SPECIAL ISSUE ON 13TH JCC 2018

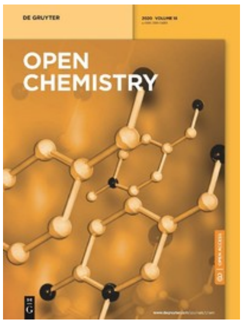
TOPICAL ISSUE ON AGRICULTURE

SPECIAL ISSUE ON THE 4TH GREEN CHEMISTRY 2018

SPECIAL ISSUE ON THE INTERNATIONAL CONFERENCE COSCI 2018

SPECIAL ISSUE ON THE INTERNATIONAL CONF ON SCIENCE, APPLIED SCIENCE, TEACHING AND EDUCATION 2019

JOURNAL + ISSUES



Open Chemistry

Volume 18: Issue 1

DETAILS

Open Chemistry is a peer-reviewed, open access journal that publishes original research, reviews and short communications in the fields of chemistry in an ongoing way. Our central goal is to provide a hub for researchers working across all subjects to present their discoveries, and to be a forum for the discussion of the important issues in the field.

Online ISSN: 2391-5420

First published: 01 Mar 2003

Language: English

Publisher: De Gruyter

SEARCH

Search within Journal...

◯ Issue ◯ Journal

Volume Issue Page

IMPRINTS

Birkhäuser

De Gruyter Mouton

De Gruyter Oldenbourg

De Gruyter Saur

Deutscher Kunstverlag

Edition Klaus Schwarz

Jovis

CONTACT & SERVICE

Help Center

Contact

Career

Our Locations

Imprint

STAY IN TOUCH

Blogs

Newsletter

Privacy Policy Terms and Conditions Disclaimer

© Walter de Gruyter GmbH 2020

Powered by PubFactory

Review Article

Khun Nay Win Tun, Nanik Siti Aminah*, Alfinda Novi Kristanti, Hnin Thanda Aung, Yoshiaki Takaya

Natural products isolated from *Casimiroa*

https://doi.org/10.1515/chem-2020-0128
received January 30, 2020; accepted May 20, 2020

Abstract: About 140 genera and more than 1,600 species belong to the Rutaceae family. They grow in temperate and tropical zones on both hemispheres, as trees, shrubs, and herbs. *Casimiroa* is one of the genera constituting 13 species, most of which are found in tropical and subtropical regions. Many chemical constituents have been derived from this genus, including quinoline alkaloids, flavonoids, coumarins, and *N*-benzoyltyramide derivatives. This article reviews different studies carried out on aromatic compounds of genus *Casimiroa*; their biological activities; the different skeletons of coumarins, alkaloids, flavonoids, and others; and their characteristic NMR spectral data.

Keywords: aromatic compounds, *Casimiroa*, NMR spectral data, Rutaceae

1 Introduction

Natural products, including plants, animals, microorganisms, and marine organisms, have been used by humans as medicines to prevent and treat diseases since ancient times. According to historical records, the use of plants as medicines is an traditional practice and started with human interaction with the environment [1–5]. Both in the developing and developed countries, people rely on herbal medicine because of fewer side effects [6,7]. There are many plants used in folk medicine. Many plant-based bioactive substances have been isolated, characterized, and used in pure form or as suitable derivatives for the therapeutic purpose [8,9]. The World Health Organization estimates that 80% of the world's population rely on traditional medicines for their primary health care needs [10]. The therapeutic potential of plants lies in chemical substances that produce a definite physiological action on man and animals. The key bioactive compounds in plants are produced as secondary metabolites [11,12].

Plants of *Casimiroa* belong to the Rutaceae family, which grows as tree in the tropical and subtropical areas of Central America and Mexico, the Caribbean, the Mediterranean region, India, Southeast Asia, South Africa, Australia, and New Zealand. This genus constitutes 13 species, and most of them, both wild and cultivated, are found in Mexico. The best-known species is *Casimiroa edulis* La Llave, also called "sapote blanco," "Mexican apple," "white sapote," "*Casimiroa*," and "sapote blance" by native people. Its fruit are edible [13,14]. Traditionally, the fruit and leaves of *Casimiroa* species are used to treat anxiety, as sedatives, and to treat dermatological conditions [15]. The pharmacological studies of an aqueous extract and alcohol extracts of the seeds and leaves of *C. edulis* exhibited the cardiovascular, anticonvulsant, sedative activities, anti-inflammatory, antimutagenic, diuretic activities, hypnotic, antihypertension, diuretic, anti-inflammatory muscle relaxant, and contractile properties. The pharmacological activities of the bioactive compounds from *Casimiroa* were also reported. Several species of this genus have been reported to possess interesting secondary metabolites. Among the major constituents of *Casimiroa* species are alkaloids, flavonoids, coumarins, limonoids, and *N*-benzoyltyramide derivatives [16–38]. The structures of the isolated compounds were elucidated based on the spectroscopic data, including NMR spectroscopy. This article also includes a review of characteristic NMR data of various classes of compounds from this genus.

*** Corresponding author: Nanik Siti Aminah,** Department of Chemistry, Faculty of Science and Technology, Universitas Airlangga, Komplek Kampus C UNAIR, Jl. Mulyorejo, Surabaya, Indonesia, e-mail: nanik-s-a@fst.unair.ac.id, tel: +62-31-5936501, fax: +62-31-5936502
Khun Nay Win Tun: Department of Chemistry, Faculty of Science and Technology, Universitas Airlangga, Komplek Kampus C UNAIR, Jl. Mulyorejo, Surabaya, Indonesia; Department of Chemistry, Taunggyi University, Taunggyi, Myanmar
Alfinda Novi Kristanti: Department of Chemistry, Faculty of Science and Technology, Universitas Airlangga, Komplek Kampus C UNAIR, Jl. Mulyorejo, Surabaya, Indonesia
Hnin Thanda Aung: Department of Chemistry, Mandalay University, Mandalay, Myanmar
Yoshiaki Takaya: Faculty of Pharmacy, Meijo University, 150 Yagotoyama, Tempaku, Nagoya, 468-8503, Japan

Open Access. © 2020 Khun Nay Win Tun *et al*., published by De Gruyter. This work is licensed under the Creative Commons Attribution 4.0 Public License.

Table 1: Pharmacological properties of compounds obtained from *Casimiroa* species

Compound (Cp)	Biological activities	Plant	Part used	Ref.
Umbelliferone (**1**)	Anticoagulant	*C. edulis*	Leaves	[25]
Esculetin (**2**)	Anticoagulant	*C. edulis*	Leaves	[25]
Herniarin (**3**)	Vasodilation and radical scavenging	*C. edulis* and *C. pubescens*	Seeds	[31]
3-(1′,1′-Dimethyl-allyl)-herniarine (**4**)	—	*C. pubescens*	Roots	[36]
Auraptene (**5**)	—	*C. pubescens*	Roots	[36]

2 Plant description

Plant descriptions of the best known species from *Casimiroa* are presented as follows:

Kingdom	Plantae
Order	Sapindales
Family	Rutaceae
Genus	*Casimiroa*
Species	*C. edulis*
Botanical name	*Casimiroa edulis* La Llave
English name	White sapote
Myanmar name	Tha-kyar-tee

C. edulis is 4.6–18.3 m high. Flowers are small, odorless, and pale green to cream color with five sepals, petals, and stamens. Fruits are round, ovary, or ovoid and golden-yellow when ripe. The leaflets are ovate and 4.5–12 cm long and 1–5 cm wide, with cuneate base, subserrate margins, bright green, glabrous or with scattered pubescence on the veins, pinnate vennation, and anastomising at the margins. The apex is acuminate.

2.1 *Casimiroa tetrameria*

C. tetrameria is about 50 ft height with dense, white, furry underside leaves. The small flowers grow in big groups and blossom many times a year, with fruit ripening after 6–8 months. This plant is originally from Southern Mexico, and it is not grown commercially.

Table 2: ^{13}C and ^{1}H NMR (δ, ppm) chemical shift data of simple coumarins isolated from genus *Casimiroa*

Carbon no.	Cp 1 [62]		Cp 2 [64]		Cp 3 [63]		Cp 4 [36]		Cp 5 [65]	
	δ_C	δ_H	δ_C	δ_H	δ_C	δ_H	δ_C (predicted)	δ_H	δ_C	δ_H
2	162.9	—	162.9	—	161.1	—	159.7	—	161.4	—
3	113.7	6.16	111.0	6.16	112.5	6.25	131.1	—	113.0	6.23
4	145.0	7.77	144.7	7.77	143.3	7.62	138.0	7.54	143.6	7.61
4a	112.2	—	111.3	—	112.5	—	112.5	—	112.5	—
5	129.6	7.39	111.5	6.74	128.7	7.37	129.8	7.36	128.8	7.34
6	113.7	6.77	143.2	—	113.0	6.85	111.0	6.83	113.3	6.83
7	162.0	—	150.8	—	162.8	—	160.2	—	162.2	—
8	102.8	6.71	102.2	6.93	100.8	6.82	100.6	6.83	101.7	6.80
8a	156.2	—	149.1	—	155.8	—	156.9	—	155.9	—
7 O-Me	—	—	—	—	55.7	3.86	55.8	3.88	—	—
1′	—	—	—	—	—	—	40.3	—	65.6	4.58
2′	—	—	—	—	—	—	145.6	6.19	118.5	5.45
3′	—	—	—	—	—	—	112.6	5.09, 5.13	142.5	—
4′	—	—	—	—	—	—	—	—	39.6	2.10
5′	—	—	—	—	—	—	—	—	26.3	2.12
6′	—	—	—	—	—	—	—	—	123.7	5.06
7′	—	—	—	—	—	—	—	—	132.1	—
8′	—	—	—	—	—	—	—	—	25.8	1.65
9′	—	—	—	—	—	—	—	—	17.8	1.59
10′	—	—	—	—	—	—	—	—	16.9	1.75
1′-Me-a	—	—	—	—	—	—	26.2	1.50	—	—
1′-Me-b	—	—	—	—	—	—	26.2	1.50	—	—

Table 3: Pharmacological properties of compounds isolated from various *Casimiroa* species

Compound (Cp)	Biological activities	Plant	Part used	Ref.
Xanthotoxol (**6**)	Anticoagulant	*C. edulis*	Leaves	[25]
Bergapten (**7**)	Antidiabetic	*C. edulis*	Stem bark	[38]
5-Methoxy-8-hydroxypsoralen (**8**)	—	*C. edulis*	Seeds	[66]
Isopimpinellin (**9**)	Antidiabetic and Antimutagenic	*C. edulis* and *C. pubescens*	Seeds	[24,33,38]
Imperatorin (**10**)	Anticoagulant, vasodilation, and radical scavenging	*C. edulis* and *C. pubescens*	Seeds	[25,31]
(*R*,*S*)-8-[(6,7-Dihydroxy-3,7-dimethyl-2-octenyl)oxy]psoralen (**11**)	Antimutagenic	*C.edulis*	Seeds	[24]
8-Geranyloxypsoralen (**12**)	Vasodilation and radical scavenging	*C. edulis* and *C. pubescens*	Seeds & leaves	[31]
8-(3′-Hydroxymethyl-but-2-enyloxy)-psoralen acetate (**13**)	Adipogenesis	*C. edulis* & *C. pringlei*	Leaves	[29]
Phellopterin (**14**)	Antimutagenic	*C. edulis*	Seeds	[24]
(*R*,*S*)-5-Methoxy-8-[(6,7-dihydroxy-3,7-dimethyl-2-octenyl)oxy] psoralen (**15**)	Antimutagenic	*C. edulis*	Seeds	[24]
5-Methoxy-8-geranyloxypsoralen (**16**)	—	*C. edulis*	Seeds	[66]
8-(3′-Hydroxymethyl-but-2-enyloxy)-5-methoxypsoralen acetate (**17**)	Adipogenesis	*C. edulis*	Leaves	[29]
5-Methoxy-8-(3″-hydroxymethyl-but-2″-enyloxy)-psoralen (**18**)	—	*C. tetrameria*	Leaves	[30]
5-Methoxy-8-(4′-acetoxy-3′-methyl-but-2-enyloxy) psoralen (**19**)	Solid tumor selective cytotoxicity	*C. tetrameria*	Seeds & leaves	[33]

Table 4: ^{13}C and ^{1}H NMR chemical shift data (δ, ppm) of furanocoumarins isolated from genus *Casimiroa*

Carbon no.	Cp 6 [67]		Cp 7 [38]		Cp 8 [68]		Cp 9 [69]		Cp 10 [70]		Cp 11 [24]		Cp 12 [70]	
	δ_C	δ_H	δ_C	δ_H	δ_C	δ_H	δ_C	δ_H	δ_C	δ_H	δ_C	δ_H	δ_C	δ_H
2	159.6	—	161.2	—	160.91	—	160.4	—	160.6	—	160.7	—	160.5	—
3	114.7	6.3	112.6	6.28	113.54	6.23	112.8	6.26	114.7	6.30	114.7	6.37	114.7	6.34
4	145.41	8.0	139.2	8.16	140.15	8.10	139.3	8.10	144.4	7.70	144.5	7.78	144.3	7.74
4a	116.4	—	106.5	—	108.11	—	107.6	—	116.5	—	116.5	—	116.4	—
5	110.3	no data	149.6	—	150.34	—	144.3	—	113.2	7.29	113.4	7.38	113.2	7.34
5-OMe	—	—	60.1	4.27	62.31	4.25	61.6	4.16	—	—	—	—	—	—
6	125.7	—	112.7	—	115.20	—	114.8	—	125.9	—	125.9	—	125.8	—
7	147.21	—	158.4	—	158.61	—	150.0	—	148.6	—	148.7	—	148.7	—
8	130.2	—	93.9	7.14	143.12	—	128.2	—	131.7	—	131.6	—	131.5	—
8-OMe			—	—	—	—	60.8	4.14	—	—	—	—	—	—
8a	139.81	—	152.7	—	152.80	—	143.7	—	143.8	—	143.9	—	143.9	—
2′	145.03	7.4	144.8	7.60	145.18	7.59	145.1	7.61	146.7	7.62	146.7	7.70	146.6	7.66
3′	106.87	6.95	105.0	7.02	105.62	6.99	105.1	6.99	106.7	6.75	106.7	6.82	106.7	6.79
1″	—	—	—	—	—	—	—	—	70.2	4.94	70.1	5.03	70.1	5.01
2″	—	—	—	—	—	—	—	—	119.8	5.54	120.1	5.67	119.4	5.57
3″	—	—	—	—	—	—	—	—	139.8	—	142.8	—	143.2	—
4″	—	—	—	—	—	—	—	—	18.2	1.65	36.4	2.27, 2.13	39.5	1.98
5″	—	—	—	—	—	—	—	—	25.9	1.67	29.2	1.55, 1.42	26.3	1.99
6″	—	—	—	—	—	—	—	—	—	—	77.7	3.27	123.7	4.98
7″	—	—	—	—	—	—	—	—	—	—	73.0	—	131.7	—
8′	—	—	—	—	—	—	—	—	—	—	26.4	1.17	25.6	1.61
9″	—	—	—	—	—	—	—	—	—	—	23.0	1.13	17.6	1.54
10″	—	—	—	—	—	—	—	—	—	—	16.5	1.71	16.5	1.67
Acetyl-Me	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Acetyl(C=O)	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Table 5: ^{13}C and ^{1}H NMR chemical shift data (δ, ppm) of furanocoumarins isolated from genus *Casimiroa*

Carbon no.	Cp 13 [29]		Cp 14 [71]		Cp 15 [24]		Cp 16 [72]		Cp 17 [29]		Cp 18 [30]		Cp 19 [33]	
	δ_C	δ_H	δ_C	δ_H	δ_C	δ_H	δ_C	δ_H	δ_C	δ_H	δ_C	δ_H	δ_C	δ_H
2	160.43	—	160.5	—	160.7		160.84	—	160.42		160.7	—	160.4	—
3	114.83	7.77	112.8	6.27	112.7	6.28	113.04	6.27	112.91	6.28	112.82	6.27	112.9	6.27
4	144.27	6.38	139.4	8.12	139.5	8.13	139.71	8.11	139.55	8.12	139.7	8.11	139.3	8.10
4a	116.54	—	107.5	—	107.5	—	107.78		107.61	—	107.7	—	107.6	—
5	113.81	7.37	144.3	—	144.5	—	144.67	—	144.26	—	150.7	—	144.5	—
5-OMe	—	—	60.7	4.17	60.7	4.18	61.02	4.16	60.79	4.18	60.8	4.16	60.8	4.16
6	125.95	—	114.5	—	114.5	—	114.73	—	114.61	—	114.6	—	114.6	—
7	148.32	—	150.8	—	150.9	—	151.18	—	150.57	—	Abs	—	150.5	—
8	131.39	—	126.8	—	126.7	—	126.99	—	136.51	—	Abs	—	126.6	—
8-OMe	—	—	—	—	—	—	—	—	—	—	—	—	—	—
8a	143.67	—	144.3	—	144.4	—	144.70		125.63	—	143.1	—	144.2	
2′	146.76	7.69	145.1	7.62	145.1	7.63	145.34	7.61	145.16	7.64	145.3	7.61	145.1	7.60
3′	106.76	6.82	105.0	6.98	105.1	7.00	105.36	6.98	105.12	6.99	105.3	6.98	105.1	6.97
1″	69.12	5.09	70.4	4.83	70.3	4.88	70.53	4.87	69.36	4.91	69.3	4.86	69.3	4.90
2″	125.13	5.86	119.8	5.59	120.2	5.66	119.70	5.58	125.27	5.86	122.2	5.71	125.2	5.84
3″	136.57	—	139.7	—	142.6	—	143.41	—	136.51		Abs	—	136.5	
4″	62.79	4.66	25.8	1.73	36.4	2.26, 2.12	39.85	1.99	62.78	4.66	21.5	1.85	21.4	1.79
5″	21.42	1.81	18.0	1.69	29.2	1.55, 1.38	26.63	1.99	21.41	1.80	61.8	δ 4.24	62.8	4.62
6″	—	—	—	—	77.6	3.24	124.07	5.01	—	—	—	—	—	—
7″	—	—	—	—	73.0	—	131.98	—	—	—	—	—	—	—
8′	—	—	—	—	26.4	1.17	17.92	1.56	—	—	—	—	—	—
9″	—	—	—	—	23.0	1.13	25.93	1.64	—	—	—	—	—	—
10″	—	—	—	—	16.3	1.68	16.77	1.66	—	—	—	—	—	—
Acetyl-Me	20.83	2.04	—	—	—	—	—	—	20.84	2.03	—	—	20.9	2.02
Acetyl(C=O)	170.85	—	—	—	—	—	—		170.84	—	—		170.8	—

Table 6: Pharmacological properties of compounds isolated from *Casimiroa* species

Compound (Cp)	Biological activities	Plant	Part used	Ref.
Proline (**20**)	Cardiovascular	*C. edulis*	Seeds	[35]
N-Methylproline (**21**)	Cardiovascular	*C. edulis*	Seeds	[35]
N-Monomethylhistamine (**22**)	Cardiovascular	*C. edulis*	Seeds	[35]
N,*N*-Dimethylhistamine (**23**)	Cardiovascular	*C. edulis*	Seeds	[35]
Synephrine acetonide (**24**)	Cardiovascular	*C. edulis*	Seeds	[35]
γ-Amino-butyric acid (**25**)	Cardiovascular	*C. edulis*	Seeds	[35]
Casimiroedine (**26**)	Cardiovascular	*C. edulis*	Seeds	[35]

Table 7: Pharmacological properties of compounds obtained from *Casimiroa* species

Compound (Cp)	Biological activities	Plant	Part used	Ref.
4-Methoxy-1-methyl-2(1*H*)-quinolinone (**27**)	Antimutagenic	*C. edulis*	Seeds	[24]
Edulitine (**28**)	—	*C. edulis*	Trunk & root bark	[23]
Casimiroin (**29**)	Antimutagenic	*C. edulis*	Seeds	[24]
Dictamnine (**30**)	—	*C. edulis*	Bark	[23]
γ-Fagarine (**31**)	Antimutagenic	*C. edulis*	Seeds & bark	[23,24]
Skirnmianine (**32**)	—	*C. edulis*	Bark	[23]

Table 8: ^{13}C and ^{1}H NMR chemical shift data (δ, ppm) of alkaloid isolated from genus *Casimiroa*

Carbon no.	Cp 27 [81]	
	δ_C	δ_H
1-NMe	29.03	3.70
2	163.82	—
3	96.49	6.06
4	162.64	—
4-OMe	55.79	3.97
4a	116.50	—
5	131.18	7.35
6	121.61	7.60
7	123.34	7.24
8	114.01	7.99
8a	139.75	—

2.2 *Casimiroa pringlei*

C. pringlei is a small tree found in central Mexico, which is about 4 m tall. There were no other literature references found. There were no reports about plant descriptions for other species.

3 Chemical constituents

Recently, many chemical constituents have been derived from *Casimiroa*. These compounds can be classified into four groups: coumarins, alkaloids, flavonoids, and four *N*-benzoyltyramide derivatives. Name of the compounds and the corresponding plant sources are presented in Tables 1, 3, 6, 7, 11, 14, and 18.

Table 9: ^{13}C and ^{1}H NMR chemical shift data (δ, ppm) of alkaloid isolated from genus *Casimiroa*

Carbon no.	Cp 29 [24]	
	δ_C	δ_H
1-NMe	29.1	3.84
2	164.1	—
3	94.6	5.89
4	162.7	—
4-OMe	55.8	3.91
5	118.0	7.53
6	104.3	6.78
7	149.9	—
8	133.5	—
9	101.0	6.04
4a	113.0	—
8a	126.5	—

Table 10: ^{13}C and ^{1}H NMR chemical shift data (δ, ppm) of furoquinoline alkaloids isolated from genus *Casimiroa*

Carbon no.	Cp 30 [82]		Cp 31 [83]		Cp 32 [84]	
	δ_C	δ_H	δ_C	δ_H	δ_C	δ_H
2	168.9	—	163.2	—	164.4	—
3	103.7	—	103.9	—	102.0	—
4	157.0	—	156.9	—	157.2	—
4a	119.0	—	119.7	—	114.9	—
4-OMe	59.1	4.45	59.0	4.42	58.9	4.42
5	122.4	8.27	114.1	7.82	118.2	8.01
6	123.8	7.45	123.4	7.34	112.1	7.23
7	129.6	7.68	107.5	7.04	152.2	—
7-OMe	—	—	—	—	56.8	4.03
8	128.0	8.01	154.6	—	142.0	—
8a	145.9	—	137.5	—	141.5	—
8-OMe	—	—	56.0	4.06	61.7	4.12
2′	143.7	7.08	143.9	7.62	143.0	7.58
3′	104.8	7.69	104.5	7.05	104.6	7.03

4 Coumarins

Coumarin, being one of the members of the benzopyrone family, comprises a large group of compounds. More than 1,300 naturally occurring coumarins have been isolated from plants, bacteria, and fungi. It was first isolated from tonka bean and is reported in about 150 different species, distributed over nearly 30 different families, of which a few important ones are Rutaceae, Umbelliferae, Orchidaceae, Leguminosae, Labiatae, Clusiaceae, Guttiferae, Caprifoliaceae, Oleaceae, Nyctaginaceae, and Apiaceae. Coumarin is also found in fruits, green tea, and other foods such as chicory. Natural coumarins are mainly classified into six types based on their chemical structures. They are simple coumarins, furano coumarins, dihydrofurano coumarins, pyrano coumarins (linear and angular types), phenyl coumarins, and bicoumarins [39–41]. Coumarin is a plant-derived natural product known for its pharmacological properties such as anti-inflammatory [42,43], antibacterial [42], anticoagulant [44], antifungal [45,46], antiviral [47,48], anticancer [49–51], antidiabetic [52,53], antihypertensive [54], anticonvulsant [55], antioxidant [56–59], antimicrobial [60], and neuroprotective properties [61]. *Casimiroa* is the abundant source of coumarins. Simple coumarins, umbelliferone (**1**), esculetin (**2**), herniarin (**3**), 3-(1′,1′-dimethyl-allyl)-herniarine (**4**), and auraptene (**5**) were isolated from various parts (leaves,

Table 11: Pharmacological properties of quinolinone alkaloids obtained from *Casimiroa* species

Compound (Cp)	Biological activities	Plant	Part used	Ref.
1-Methyl-2-phenyl-4-quinolone (**33**)	Solid tumor selective cytotoxicity	*C. tetrameria*	Seeds	[33]
Edulein (**34**)	–	*C. edulis*	Trunk & root bark	[23]
5-Hydroxy-1-methyl-2-phenyl-4-quinolone (**35**)	Antimutagenic	*C. edulis*	Seeds	[24]
5,6-Dimethoxy-2-(3′-methoxyphenyl)-1*H*-quinolin-4-one (**36**)	–	*C. edulis*	Leaves	[28]
5,6-Dimethoxy-2-(3′,4′-dimethoxyphenyl)-1*H*-quinolin-4-one (**37**)	–	*C. edulis*	Leaves	[28]
5,6-Dimethoxy-2-(2′,5′,6′-tri-methoxyphenyl)-1*H*-quinolin-4-one (**38**)	Antihypertensive	*C.edulis*	Leaves & Fruits	[27,28]
5,8-Dimethoxy-2-(3′-methoxy-phenyl)-3-propyl-1*H*-quinolin-4-one (**39**)	Antihypertensive	*C. edulis*	Fruits	[27]
5,8-Dimethoxy-2-(3′,4′-di-methoxyphenyl)-3-propyl-1*H*-quinolin-4-one (**40**)	Antihypertensive	*C. edulis*	Fruits	[27]
2-(2′-Hydroxy-4′-methoxy-phenyl)-5,8-dimethoxy-3-propyl-1*H*-quinolin-4-one (**41**)	Antihypertensive	*C. edulis*	Fruits	[27]

seeds, and roots) of *C. edulis* and *Casimiroa pubescens* [25,31,36]. Fourteen furocoumarins, xanthotoxol (**6**), bergapten (**7**), 5-methoxy-8-hydroxypsoralen (**8**), isopimpinellin (**9**), imperatorin (**10**), (*R*,*S*)-8-[(6,7-dihydroxy-3,7-dimethyl-2-octenyl)oxy]psoralen (**11**), 8-geranyloxypsoralen (**12**), 8-(3′-hydroxymethyl-but-2-enyloxy)-psoralen acetate (**13**), phellopterin (**14**), (*R*,*S*)-5-methoxy-8-[(6,7-dihydroxy-3,7-dimethyl-2-octenyl)oxy]psoralen (**15**), 5-methoxy-8-geranyloxypsoralen (**16**), 8-(3′-hydroxymethyl-but-2-enyloxy)-5-methoxypsoralen acetate (**17**), 5-methoxy-8-(3″-hydroxymethyl-but-2‴-enyloxy)-psoralen (**18**), and 5-methoxy-8-(4′-acetoxy-3′-methyl-but-2-enyloxy) psoralen (**19**) were also identified from various parts (leaves, stem bark, and seeds) of *C. edulis*, *C. pubescens*, and *C. tetrameria* [24,25,29–31,33,38,66]. The structures of various coumarin compounds are shown in Figure 1 and 2, and their NMR (^{1}H NMR and ^{13}C NMR) data are listed in Tables 2, 4, and 5.

5 Alkaloids

More than 12,000 alkaloids have been isolated from the plant kingdom, and this number is increasing exponentially. Based on their structure, alkaloids may be classified as indole, tropane, piperidine, purine, imidazole, pyrrolizidine, pyrrolidine, quinolizidine, and isoquinoline alkaloids [73–75]. They are well known for their pharmacological activities such as antioxidant [76,77] antidiabetic [76], antimicrobial [77], anti-inflammatory [78], anticancer [79], and amoebicidal properties [80]. The structures of various alkaloids isolated from *Casimiroa* and their biological activities are described in the following section. Genus *Casimiroa* are famous for different alkaloids like furoquinoline, quinolinone, and quinolone. In 1999, seven active alkaloids, proline (**20**), *N*-methylproline (**21**), *N*-monomethylhistamine (**22**), *N*,*N*-dimethylhistamine (**23**), synephrine acetonide (**24**), γ-amino-butyric acid (**25**), and synephrine acetonide, (**26**) have been derived from the seeds of *C. edulis* (data not reported) [35]. Iriarte et al. and Ito et al. found the presence of 4-methoxy-1-methyl-2(1*H*)-quinolinone (**27**), edulitine (**28**) (no NMR data), casimiroin (**29**), dictamnine (**30**), γ-Fagarine (**31**), and skirnmianine (**32**) from various parts (seeds, bark, trunk, and root bark) of *C. edulis* [23,24]. A quinolone alkaloid, 1-methyl-2-phenyl-4-quinolone (**33**) was identified from the seeds of *C. tetrameria* [33]. Other researchers reported the presence of quinolone alkaloids: edulein (no NMR data) (**34**), seven quinolinone alkaloids: 5-hydroxy-1-methyl-2-phenyl-4-quinolone (**35**), 5,6-dimethoxy-2-(3-methoxyphenyl)-1*H*-quinolin-4-one (**36**), 5,6-dimethoxy-2-(3,4-dimethoxyphenyl)-1*H*-quinolin-4-one

Table 12: ^{13}C and ^{1}H NMR chemical shift data (δ, ppm) of quinolinone and quinolone alkaloids isolated from genus *Casimiroa*

Carbon no.	Cp 33 [85]		Cp 35 [24,86]		Cp 36 [28]		Cp 37 [28]		Cp 38 [28]		Cp 39 [27]	
	δ_C	δ_H	δ_C	δ_H	δ_C	δ_H	δ_C	δ_H	δ_C	δ_H	δ_C	δ_H
2	154.8	—	155.5	—	164.0	—	163.0	—	161.6	—	164.21	—
3	112.7	6.31	104.6	6.22	112.7	6.74	112.6	6.65	107.7	6.20	113.41	—
3-Propyl	—	—	—	—	—	—	—	—			24.63, 21.92, 13.94	0.96, 1.58, 2.45
4	177.6	—	181.7	—	180.1	—	182.0	—	180.2	—	179.10	—
4a	126.8	—	113.9	—	no data	—	119.0	—	118.0	—	117.31	—
5	126.8	8.51	162.8	—	151.8	—	151.8	—	151.4	—	152.32	—
6	123.8	7.45	110.9	7.48	No data	—	No data	—	149.0	—	152.92	7.81
5-OMe	—	—			62.0	3.88	62.0	3.93	62.0	3.92	61.10	3.83
6-OMe	—	—			57.3	3.88	61.4	3.91	61.8	3.88	—	—
7	132.3	7.73	134.3	7.56	120.9	7.49	121.0	7.37	120.9	7.39	120.94	7.95
8	115.9	7.57	109.8	7.56	115.0	7.56	115.0	7.47	115.0	7.54	115.14	—
8-OMe											59.73	3.79
8a	141.9	—	142.7	—	No data	—	No data	—	No data	—	116.81	—
1′	135.9	—	135.3	—	133.0	—	129.9	—	119.0	—	130.41	—
2′	128.5	7.42	128.9	6.81	118.4	7.57–7.44	116.9	7.18	153.0	—	119.25	7.15
3′	128.8	7.52	128.4	7.69	161.8	—	153.0	—	115.1	6.81	152.92	—
4′	129.6	7.52	129.9	—	131.2	7.13	155.0	—	117.0	7.14	131.12	7.14
5′	128.8	7.52	128.4	—	108.2	7.57–7.44	121.6	7.20	148.3	—	122.4	7.25
6′	128.5	7.42	128.9	7.19	119.6	7.57–7.44	125.6	7.33	153.4	—	126.14	7.31
2′-OMe	—	—	—	—	—	—	—	—	57.4	3.85	—	—
3′-OMe	—	—	—	—	55.9	3.93	57.4	3.85	—	—	56.11	3.71
4′-OMe	—	—	—	—	—	—	56.6	3.85	—	—	—	—
5′-OMe	—	—	—	—	—	—	—	—	57.0	3.81	—	—
6′-OMe	—	—	—	—	—	—	—	—	56.7	3.75	—	—
N-Me	37.3	3.62	37.9	3.60	—	—	—	—	—	—	—	—

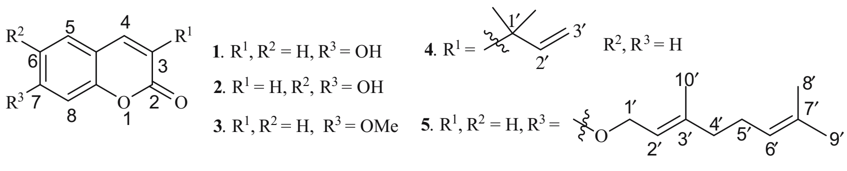


Figure 1: Structures of simple coumarins of *Casimiroa*.

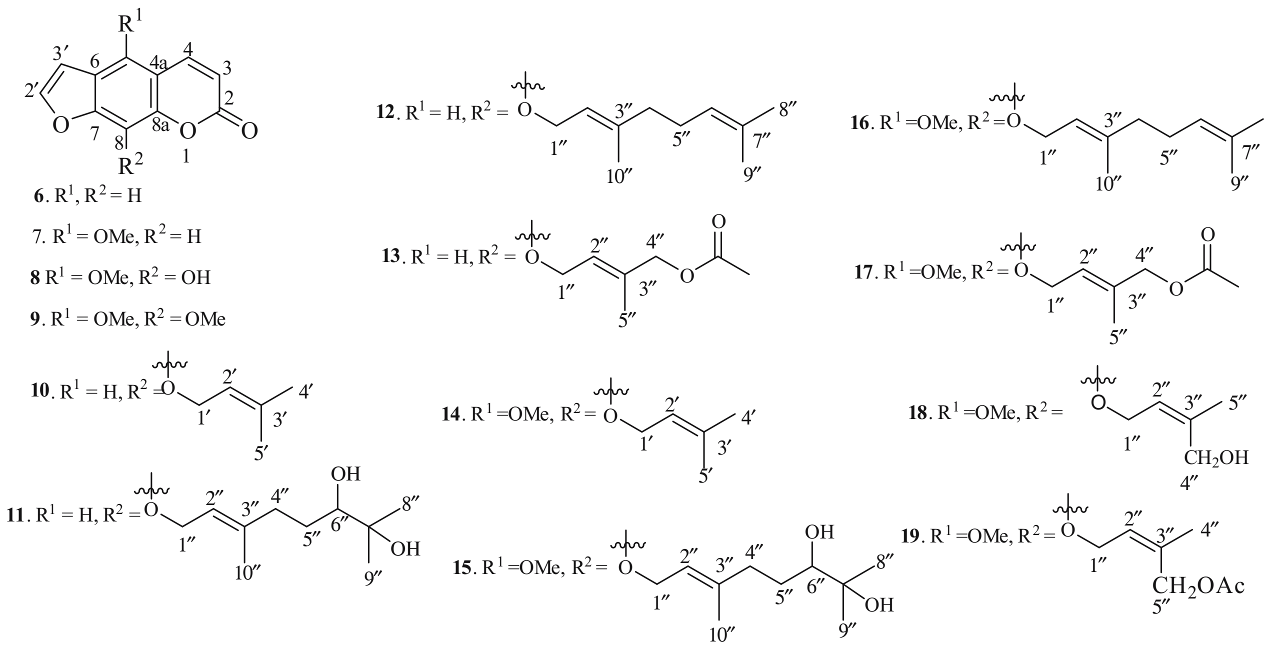


Figure 2: Structures of furanocoumarins from *Casimiroa*.

(**37**), 5,6-dimethoxy-2-(2,5,6-tri-methoxyphenyl)-1*H*-quinolin-4-one (**38**), 5,8-dimethoxy-2-(3′-methoxy-phenyl)-3-propyl-1*H*-quinolin-4-one (**39**), 5,8-dimethoxy-2-(3′,4′-di-methoxy-phenyl)-3-propyl-1*H*-quinolin-4-one (**40**), and 2-(2′-hydroxy-4′-methoxy-phenyl)-5,8-dimethoxy-3-propyl-1*H*-quinolin-4-one (**41**) from the various parts (leaves, fruits, seeds, trunk, and root bark) of *C. edulis* [23,24,27,28]. The chemical structures of various alkaloids are shown in Figures 3–5, and their NMR (^{1}H NMR and ^{13}C NMR) data are presented in Tables 8, 9, 10, 12, and 13.

6 Flavonoids

Flavonoids are a large group of plant metabolites. They are divided into several subgroups. Among them, flavones, flavonols, flavanones, flavanonols, flavanols or catechins, antocyanins, and chalcones are almost always in the plant kingdom. They have been isolated from fruits, nuts seeds, stem, flowers, wine, and other vegetal tissues of large number of plants [87]. Flavonoids are known for their pharmacological properties such as antioxidants [88–90], antibacterial [90], antiviral [91], anti-inflammatory [92,93], antiallergic [93], antidiabetic [94], and anticancer activities [95]. Twenty flavonoids, namely, 6,7-dimethoxyflavone (**42**), 6-hydroxy-5-methoxyflavone (**43**), zapotinin (**44**), 5,6,2′-trimethoxyflavone (**45**), 5,6,3′-trimethoxyflavone (**46**), 5,6,2′,3′-trimethoxy-flavone (**47**), 5,7,3′,5′-tetramethoxy-flavone (**48**), 5,6,3′,5′-tetramethoxy-flavone (**49**), zapotin (**50**), zapotinin acetate (**51**), 5,6,2′,3′,4′-pentamethoxyflavone (**52**), 5,6,2′,3′,6′-pentamethoxy-flavone (**53**), 5,6,2′,3′,4′,6′-hexamethoxy-flavone (**54**), 5,6,2′,3′,5′,6′-hexamethoxy-flavone (**55**), 5-methoxyflavone 6-*O*-β-D-glucoside (**56**), quercetin (**57**), quercetin 3-*O*-rutinoside (**58**), kaempferol 3-*O*-rutinoside (**59**), quercetin 3-*O*-glucoside (**60**), and kaempferol 3-O-*glu*coside (**61**) were isolated from various parts (stem bark, leaves, and seeds) of *C. edulis*, *C. pubescens*, Casimiroa *sapota*, and *C. tetrameria*. The structures of flavonoids are shown in Figure 6, and their

Table 13: ^{13}C and ^{1}H NMR chemical shift data (δ, ppm) of quinolinone and quinolone alkaloids isolated from genus *Casimiroa*

Carbon no.	Cp 40 [27]		Cp 41 [27]	
	δ_C	δ_H	δ_C	δ_H
2	158.79	—	163.9	—
3	113.31	—	113.31	—
3-Propyl	24.63, 21.92, 13.94	0.96, 1.58, 2.45	24.63, 21.92, 13.94	0.96, 1.58, 2.45
4	178.56	—	178.3	—
4a	117.83	—	117.31	—
5	149.77	—	152.32	—
6	145.29	6.88	No data	6.81
5-OMe	61.90	3.98	61.90	3.92
7	147.12	7.95	121.34	7.97
8	114.94	—	114.94	—
8-OMe	56.77	3.97	57.13	3.85
8a	116.51	—	116.81	—
1′	147.79	—	133.4	—
2′	119.61	7.56	119.21	—
3′	No data	—	162.1	7.49
4′	151.781	—	131.12	—
5′	108.14	7.39	108.14	7.29
6′	120.14	7.49	120.14	7.26
2′-OMe	—	—	—	—
3′-OMe	No data	3.93	—	—
4′-OMe	56.77	3.93	56.11	3.85
5′-OMe	—	—	—	—
6′-OMe	—	—	—	—
N-Me	—	—	—	—

NMR (^{1}H NMR and ^{13}C NMR) data are presented in Tables 15–17.

7 *N*-Benzoyltyramide derivatives

Four ***N***-benzoyltyramide derivatives **62–65** (Table 18), were reported from the genus *Casimiroa*. Compounds **62** and **63** contain isopropylidene moiety in their *O*-alkyl side chains. Likewise, compound **62** contains monoterpenic moiety in *O*-alkyl side chain. The structures of *N*-benzoyltyramide derivatives are shown in Figure 7, and their NMR (^{1}H NMR and ^{13}C NMR) data are presented in Table 19.

8 Pharmacological activities

Several pharmacological reports have confirmed the wide variety of biological activities of the genus *Casimiroa*. For example, Mora et al. [16] reported the effect on central nervous system by the extract of hydroalcoholic leaves of *C. edulis*, using different behavioral tests and animal models of depression and anxiety. The extract exhibited sedative and antidepressant properties in rodents. The leaves and seeds extracts of *C. edulis* also showed the anticonvulsant activity *in vivo* [15,17]. Esposito et al. [20] studied the HIV-1 reverse transcriptase-associated activities of the hydroalcoholic extract of *C. edulis* seeds, using HIV-1 RT RDDP assay and HIV-1 RT RNase H assay. The extract exhibited the ability to inhibit both RDDP (IC_{50} 0.27 µg mL^{-1}) and RNase H (IC_{50} 2.0 µg mL^{-1}) activities in a dose-dependent manner. The extract was also displayed dose-dependent cytotoxicity on K562 (CC_{50} 3.1 mg mL^{-1}) cell line. The antimutagenic activity of several compounds (**9**, **11**, **14**, **15**, **27**, **29**, **31**, **35**, **45**, and **48**) were evaluated against *Salmonella typhimurium* strain TM677, using the antimutagenicity assay. Compounds **15** and **29** were found to have the most significant antimutagenic activity against *S. typhimurium* strain TM677. Compounds **29** and **45** were also inhibited the formation of DMBA-induced preneoplastic lesions in the mouse mammary gland [24]. Awaad et al. [25] reported not only the antimicrobial activity of ethyl acetate, butanol, ether, and chloroform fractions but also anticoagulant activity of ethanol extract and

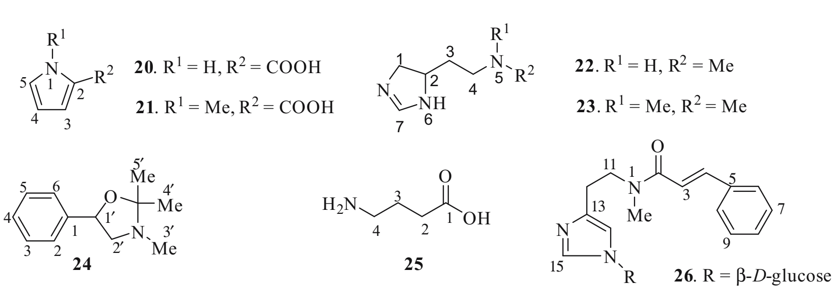


Figure 3: Structures of alkaloids from *Casimiroa*.

Table 14: Pharmacological properties of flavonoids obtained from *Casimiroa* species

Compound (Cp)	**Biological activities**	**Plant**	**Part used**	**Ref.**
6,7-Dimethoxyflavone (**42**)	Antioxidant & antidiabetic	*C. edulis*	Stem bark	[37]
6-Hydroxy-5-methoxyflavone (**43**)	Antioxidant	*C. edulis*	Seeds	[26]
Zapotinin (**44**)	—	*C. edulis*	Seeds	[66,96]
5,6,2′-Trimethoxyflavone (**45**)	Antimutagenic & solid tumor selective cytotoxicity	*C. edulis* & *C. tetrameria*	Seeds	[24,29,37]
5,6,3′-Trimethoxyflavone (**46**)	—	*C. sapota*	Leaves	[97]
5,6,2′,3′-Trimethoxyflavone (**47**)	—	*C. sapota*	Leaves	[97]
5,7,3’,5’-Tetramethoxy-flavone (**48**)	Solid tumor selective cytotoxicity	*C. edulis* & *C. tetrameria*	Seeds	[33]
5,6,3′,5′-Tetramethoxy-flavone (**49**)	—	*C. tetrameria*	Seeds	[98]
Zapotin (**50**)	Antimutagenic & solid tumor selective cytotoxicity	*C. edulis* & *C. pubescens*	Seeds	[24,33]
Zapotinin acetate (**51**)	—	*C. edulis*	Seeds	[66,96]
5,6,2′,3′,4′-Pentamethoxyflavone (**52**)	Vasodilation & radical scavenging	*C. pubescens*, C. edulis & *C. sapota*	Seeds	[32]
5,6,2′,3′,6′-Pentamethoxy-flavone (**53**)	—	*C. tetrameria*	Leaves	[30]
5,6,2′,3′,4′,6′-Hexamethoxy-flavone (**54**)	—	*C. tetrameria*	Leaves	[98]
5,6,2′,3′,5′,6′-Hexamethoxy-flavone (**55**)	—	*C. tetrameria* & *C. edulis*	Leaves	[29,30]
5-Methoxyflavone 6-*O*-β-D-glucoside (**56**)	Antioxidant	*C. edulis*	Leaves	[26]
Quercetin (**57**)	Antioxidant	*C. edulis*	Leaves	[26]
Quercetin 3-*O*-rutinoside (**58**)	Antioxidant	*C. edulis*	Leaves	[26]
Kaempferol 3-*O*-rutinoside (**59**)	—	*C. tetrameria*	Leaves	[98]
Quercetin 3-*O*-glucoside (**60**)	—	*C. tetrameria*	Leaves	[98]
Kaempferol 3-*O*-glucoside (**61**)	—	*C. tetrameria*	Leaves	[98]

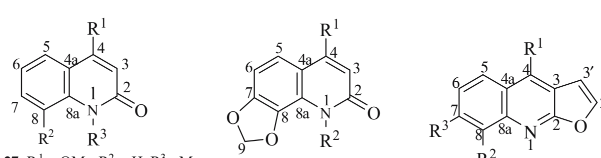
Table 15: ^{13}C and ^{1}H NMR chemical shift data (δ, ppm) of flavonoids isolated from genus *Casimiroa*

Carbon no.	Cp 42 [37]		Cp 43 [26]		Cp 45[38]		Cp 46 [66]		Cp 47 [97]	
	δ_C	δ_H	δ_C	δ_H	δ_C	δ_H	δ_C	δ_H	δ_C	δ_H
2	161.6	—	164.18	—	159.1	—	ND	—	ND	—
3		6.69	108.19	6.75	113.1	6.98	ND	6.63	11.25	6.82
4	178.0	—	180. 29	—	178.4	—	ND	—	ND	—
4a	119.3	—	119.48	—	119.1	—	ND	—	ND	—
5	113.4	7.32	149.10	—	158.0	—	ND	—	ND	—
6	148.0	—	148.57	—	149.7	—	ND	—	147.29	—
7	150.0	—	125.63	7.72	113.4	7.30	ND	7.30	7.58	119.53
8	119.1	7.32	115.28	7.45	119.2	7.27	ND	7.30	113.65	7.45
8a	151.6	—	154.19	—	151.9	—	ND	—	150.11	—
5-OMe	—	—	62.46	3.90	57.3	3.93	ND	3.99	60.00	3.94
6-OMe	57.2	3.94	—	—	55.7	3.93	ND	3.92	55.97	3.96
7-OMe	61.9	3.98	—	—	—	—	ND	—	—	
1′	131.7	—	132.49	—	120.8	—	ND		ND	—
2′	126.1	7.89	127.39	7.98	147.9	—	ND	7.42	ND	—
3′	129.0	7.51	130.26	7.54	111.7	7.03	ND	—	ND	—
4′	131.4	7.51	133.1	7.54	132.2	7.46	ND	7.03	115.46	7.25
5′	129.0	7.51	130.26	7.54	120.7	7.09	ND	7.42	124.28	7.24
6′	126.1	7.89	127.39	7.98	129.1	7.85	ND	7.42	120.23	7.39
2′-OMe	—	—	—	—	61.9	3.98	ND	—	60.66	3.92
3′-OMe	—	—	—	—	—	—		3.87	55.2	3.91
4′-OMe	—	—	—	—	—	—	—	—	—	—
5′-OMe	—	—	—	—	—	—	—	—	—	—
6′-OMe	—	—	—	—	—	—	—	—	—	—
Acetyl(C=O)	—	—	—	—	—	—	—	—	—	—
Acetyl-Me	—	—	—	—	—	—	—	—	—	—

ND = no data reported.

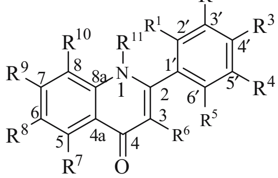
Table 16: ^{13}C and ^{1}H NMR chemical shift data (δ, ppm) of flavonoids isolated from genus *Casimiroa*

Carbon no.	Cp 50 [99]		Cp 52 [32]		Cp 53 [30]		Cp 55 [30]		Cp 56 [26]	
	δ_C	δ_H	δ_C	δ_H	δ_C	δ_H	δ_C	δ_H	δ_C	δ_H
2	158.9		160.6	—	158.5	—	158.6	—	164.18	—
3	115.2	6.26	110.9	6.84	115.2	6.27	114.5	6.29	108.19	6.75
4	178.2	—	178.4	—	178.0	—	177.8	—	180.29	—
4a	119.4	—	118.9	—	119.5	—	119.5	—	119.48	—
5	148.0	—	147.8	—	148.6	—	148.1	—	149.10	—
6	149.6	—	149.9	—	149.8	—	149.9	—	149.28	—
7	119.1	7.28	119.3	7.30	113.7	7.26	113.6	7.26	125.63	7.72
8	113.7	7.20	113.3	7.25	119.1	7.18	119.2	7.17	115.28	7.45
8a	152.7	—	151.7	—	152.6	—	152.4	—	154.19	—
5-OMe	61.8	3.98	56.2	3.98	62.0	3.97	62.0	3.98	62.5	3.9
6-OMe	57.3	3.92	61.3	3.93	57.4	3.91	57.3	3.91	—	—
1′	111.4	—	118.5	—	—	—	101.7	—	132.49	—
2′	158.6	—	153.3	—	147.15	—	140.9	—	127.46	δ 7.98
3′	104.0	6.63	142.7	—	132.1	—	149.2	—	130.28	7.54
4′	132.0	7.39	156.5	—	115.0	6.98	114.5	6.67	133.04	δ 7.54
5′	104.0	6.63	107.4	6.79	106.3	6.65	149.2	—	130.28	7.54
6′	158.6	—	124.2	7.5	151.8		140.9	—	127.46	7.98
2′-OMe	56.0	3.79	57.2	3.95	61.6	3.83	61.8	3.75	—	—
3′-OMe	—	—	62.0	3.91	56.7	3.85	56.7	3.88	—	—
4′-OMe	—	—	61.0	3.94	—	—	—	—	—	—
5′-OMe	—	—	—	—	—	—	56.7	3.88	—	—
6′-OMe	56.0	3.79	61.3	3.93	57.4	3.91	57.3	3.91	—	—
Acetyl(C=O)	—	—	—	—	—	—	—	—	—	—
Acetyl-Me	—	—	—	—	—	—	—	—	—	—
1″	—	—	—	—	—	—	—	—	103.38	4.96
2″	—	—	—	—	—	—	—	—	75.05	—
3″	—	—	—	—	—	—	—	—	78.11	—
4″	—	—	—	—	—	—	—	—	71.34	3–3.9
5″	—	—	—	—	—	—	—	—	78.4	—
6″	—	—	—	—	—	—	—	—	62.74	—



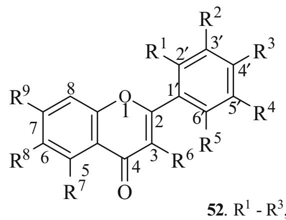
27. R^1 = OMe, R^2 = H, R^3= Me
28. R^1, R^2 = OMe, R^3 = H
29. R^1 = OMe, R^2 = Me
30. R^1 = OMe, R^2, R^3 = H
31. R^1, R^2 = OMe, R^3 = H
32. R^1-R^3 = OMe

Figure 4: Structures of quinolone alkaloids from *Casimiroa*.



33. R^1 - R^{10}= H, R^{11} = Me
34. R^1-R^8 = H, R^9 = OMe, R^{10} = H, R^{11} = Me
35. R^1 - R^6, R^8-R^{10}= H, R^7 = OH, R^{11}= Me
36. R^1, R^3 - R^6, R^9 - R^{11}= H, R^2, R^7, R^8 = OMe
37. R^1, R^4, R^5, R^9- R^{11}= H, R^2, R^3, R^7, R^8 = OMe
38. R^1, R^4, R^5, R^7, R^8 = OMe, R^2, R^3, R^6, R^9 - R^{11} = H
39. R^1, R^3 - R^5, R^8, R^9, R^{11} = H, R^2, R^7, R^{10}= OMe, R^6 = -C_3H_7
40. R^1, R^4, R^5, R^8, R^9, R^{11} = H, R^2, R^3, R^7, R^{10}= OMe, R^6 = -C_3H_7
41. R^1 = OH, R^2, R^4, R^5, R^8, R^9, R^{11} = H, R^3, R^7, R^{10}= OMe, R^6 = -C_3H_7

Figure 5: Structures of quinolinone and quinolone alkaloids from *Casimiroa*.



42. R^1 - R^7 = H, R^8, R^9 = OMe
43. R^1 - R^6, R^9 = H, R^7 = OMe, R^8 = OH
44. R^1, R^5, R^8 = OMe, R^2 - R^4, R^6, R^9 = H, R^7 = OH
45. R^1 - R^4, R^6, R^9 = H, R^5, R^7, R^8 = OMe
46. R^1, R^3, R^5, R^6, R^8 = H, R^2, R^4, R^7, R^9 = OMe
47. R^7, R^8, R^2 = OMe, R^1, R^3-R^6, R^9 = H
48. R^1, R^2, R^7, R^8 = OMe, R^3-R^6, R^9 = H
49. R^1, R^3. R^5. R^6. R^9 = H, R^2, R^4, R^7, R^8 = OMe
50. R^1, R^5, R^7, R^8 = OMe, R^2, R^3, R^4, R^6, R^9 = H
51. R^1, R^5, R^8 = OMe, R^2 - R^4, R^6, R^9 = H, R^7 = OAcO
52. R^1 - R^3, R^7, R^8 = OMe, R^4 - R^6, R^9 = H
53. R^1, R^2, R^5, R^7, R^8 = OMe, R^3, R^4, R^6, R^9 = H
54. R^1 - R^3, R^5, R^7, R^8 = OMe, R^4, R^6, R^9 = H
55. R^1, R^2, R^4, R^5, R^7, R^8 = OMe, R^3, R^6, R^9 = H
56. R^1 - R^6, R^9 = H, R^7 = OMe
57. R^1, R^4, R^5, R^8 = H, R^2, R^3, R^6, R^7, R^9 = OH
58. R^1, R^4, R^5, R^8 = H, R^2, R^3, R^7, R^9 = OH, R^6 = *O*-rhamnose glucose
59. R^1, R^2, R^4, R^5, R^8 = H, R^3, R^7, R^9 = OH, R^6 = *O*-rhamnose glucose
60. R^1, R^4, R^5, R^8 = H, R^2, R^3, R^7, R^9 = OH, R^6 = *O*-glucoside
61. R^1, R^2, R^4, R^5, R^8 = H, R^3, R^7, R^9 = OH, R^6 = O-glucoside

Figure 6: Structures of flavonoids from genus *Casimiroa*.

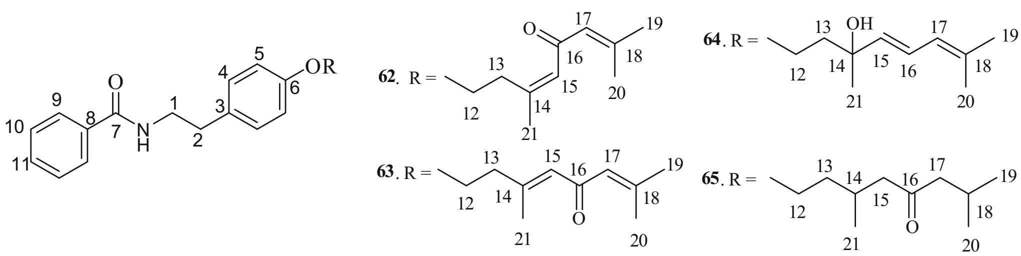


Figure 7: Structures of *N*-benzoyltyramide derivatives from *Casimiroa*.

compounds **1**, **2**, **6**, and **10** from the leaves of *C. edulis*. Another important study was performed on the antioxidant activity of fractions and isolated compounds (**43**, **54**, **55**, and **56**) from leaves of *C. edulis*. Ethanol fraction was exhibited the more potent antioxidant activity (842 µM Trolox equivalents/g dry weight) [26]. According to the study by Awaad et al. [27], compounds **38**–**39** and fruit extracts of *C. edulis* were tested for the antihypertensive activity using male dogs. All compounds showed the antihypertensive activity at doses of 50, 100, 200, and 300 mg/kg, and the ethanolic and total alkaloids (in chloroform) extracts were found to possess important antihypertensive properties at doses of 500 and 200 mg/kg, respectively. Nagai et al. [29] reported the functions of glucose and lipid metabolism activities with 3T3-L1 adipocytes on two furocoumarins (**13** and **17**) and two polymethoxyflavones (**45** and **53**) from leaves of *C. edulis*. It was clear that the addition of furanocoumarin increased the glucose uptake and lipid accumulation in 3T3-L1 adipocyte. Bertin et al. [31] reported vasodilation and radical-scavenging activity of imperatorin and selected coumarinic and flavonoid compounds (**3**, **10**, **12**, and **50**) from seeds of *C. edulis* and *C. pubescens*. Ya-ming et al. [33] evaluated solid tumor selective cytotoxicity of extract, fractions, and compounds (**19**, **33**, **45**, **46**, **48**, **61**, and **62**) from *C. tetrameria*. Compounds **48**, **61**, and **62** were active against solid tumor cell line C38 and a leukemia cell line L1210. Cardiovascular activities for compounds **20**–**27** were also reported [35]. Ubaldo-suarez et al. [36] evaluated antidepressant-like effect of hexane, ethyl acetate, and methanol roots extracts of *C. pubescens*, using the forced swim test. The result showed antidepressant-like activity on hexane extract. Further studies reported antidiabetic and antioxidant activities of compounds **7**, **9**, **42**, and **45**, isolated from *C. edulis* using the DPPH radical scavenging assay and the yeast α-glucosidase assay [37,38]. Moreover, the leaves, seeds, and nonedible fruit's parts extracts of *C. edulis* have been studied for their biological effects, including antihypertensive, vasorelaxant, antioxidant, anti-inflammatory, antitumor, relaxant, and contractile effect *in vitro* [18,103,104]. Landaverde et al. [105] noted

Table 17: ^{13}C and ^{1}H NMR chemical shift data (δ, ppm) of flavonoids isolated from genus *Casimiroa*

Carbon no.	Cp 57 [100]		Cp 58 [101]		Cp 59 [101]		Cp 60 [102]		Cp 61 [102]	
	δ_C	δ_H	δ_C	δ_H	δ_C	δ_H	δ_C	δ_H	δ_C	δ_H
2	147.8	—	158.22	—	155.98	—	158.4	—	156.4	—
3	136.8	9.44	134.52	—	134.58	—	135.6	—	133.3	—
4	176.9	—	178.39	—	177.23	—	179.1	—	177.4	—
4a	103.9	—	105.32	—	104.79	—	105.7	—	104.1	—
5	161.9	12.54	162.48	—	162.04	—	163.0	—	161.3	—
6	98.8	6.22	99.72	6.10	98.88	6.22	98.0	6.16	99.1	6.30
7	165.0	10.85	166.58	—	163.31	—	168.4	—	164.2	—
8	94.0	6.44	94.90	6.28	93.98	6.33	95.6	6.38	93.8	6.50
8a	157.4	—	158.91	—	156.82	—	160.0	—	156.5	—
1′	123.1	—	122.77	—	121.39	—	121.2	—	121.0	—
2′	115.7	7.71	117.37	7.64	130.76	8.19	115.9	7.47	131.0	8.05
3′	146.2	—	144.32	—	113.40	6.92	146.5	—	115.2	6.95
4′	148.7	—	150.23	—	160.92	—	151.4	—	160.0	—
5′	116.2	6.92	115.46	6.85	114.87	6.92	116.9	6.79	115.2	6.95
6′	120.6	7.57	122.47	7.63	131.03	8.19	121.3	7.64	131.0	8.05
1″	—	—	103.63	4.96	102.11	5.02	104.4	ND	101.2	5.48
2″	—	—	74.64	—	74.83	—	75.7	ND	74.3	3.32
3″	—	—	77.81	—	75.48	—	78.1	ND	76.5	3.55
4″	—	—	71.12	3.20–3.90	69.23	3.15–3.90	71.2	ND	69.9	3.20
5″	—	—	78.09	—	77.65	—	78.4	ND	77.6	3.21
6″	—	—	68.37	—	67.08	—	62.6	ND	60.9	3.58, 3.72
1‴	—	—	101.92	4.50	100.10	4.45	—	—	—	—
2‴	—	—	71.32	—	70.89	—	—	—	—	—
3‴	—	—	72.13	—	72.23	—	—	—	—	—
4″	—	—	73.73	3.20–3.90	73.46	3.20–3.90	—	—	—	—
5‴	—	—	68.91	—	67.88	—	—	—	—	—
6‴	—	—	18.84	1.12	18.12	1.09	—	—	—	—
3-OH	—	—	—	—	—	—	—	—	—	—
5-OH	—	—	—	—	—	—	—	—	—	—
7-OH	—	—	—	—	—	—	—	—	—	—
3′-OH	—	—	—	—	—	—	—	—	—	—
4′-OH	—	—	—	—	—	—	—	—	—	—

ND = no data reported.

Table 18: Pharmacological properties of benzoyltyramide derivatives isolated from *Casimiroa* species

Compound (Cp)	Biological activities	Plant	Part used	Ref.
Pubesamide A (**62**)	Solid tumor selective cytotoxicity	*C. tetrameria* & *C. pubescens*	Seeds	[33,34]
Pubesamide B (**63**)	Solid tumor selective cytotoxicity	*C. tetrameria* & *C. pubescens*	Seeds	[33,34]
Pubesamide C (**64**)	—	*C. pubescens*	Seeds	[34]
Tetrahydropubesamide A (**65**)	—	*C. pubescens*	Seeds	[34]

Table 19: ^{13}C and ^{1}H NMR chemical shift data (δ, ppm) of *N*-benzoyltyramide derivatives isolated from genus *Casimiroa*

Atom no.	Cp 61 [34]		Cp 62 [34]		Cp 63 [34]		Cp 64 [34]	
	δ_C	δ_H	δ_C	δ_H	δ_C	δ_H	δ_C	δ_H
1	41.3	3.69	41.3	3.69	41.3	3.67	41.2	3.69
2	34.8	2.87	34.8	2.86	34.8	2.86	34.8	2.87
3	131.2	—	130.7	—	131.3	—	130.8	—
4	129.8	7.14	129.7	7.13	129.8	7.14	129.7	7.15
5	114.9	6.85	114.8	6.86	114.9	6.85	114.7	6.85
6	157.5	—	157.7	—	157.2	—	157.7	—
7	167.4	—	167.4	—	167.4	—	167.4	—
8	134.7	—	134.7	—	134.6	—	134.7	—
9	126.8	7.69	126.1	7.68	126.8	7.68	126.8	7.69
10	128.5	7.45	128.5	7.45	128.5	7.41	128.5	7.38
11	131.4	7.38	131.4	7.41	131.4	7.47	131.6	7.45
12	65.9	4.09	67.2	4.16	65.4	4.12	66.0	3.97
13a	40.6	2.59	33.7	3.06	40.9	2.14	36.0	1.78
13b	—	—	—	—	40.9	1.97	36.0	1.67
14	154.9	—	155.0	—	72.7	—	26.4	2.26
15	126.2	6.08	127.4	6.08	136.6	5.63	50.6	2.41
16	191.4	—	190.8	—	124.5	6.52	210.4	—
17	127.4	6.13	126.0	6.13	124.3	5.82	52.3	2.26
18	153.0	—	153.0	—	135.5	—	24.5	2.15
19	27.8	1.88	27.8	1.89	18.3	1.73	22.6	0.90
20	20.6	2.17	20.6	2.15	26.0	1.76	22.6	0.91
21	19.3	2.22	26.8	2.01	29.0	1.37	19.9	0.97

that essential oils extracted from *C. pringlei* displayed significant sedative and anxiolytic properties in rats. However, there is still a lack of biological and other phytochemical research to prove medicinal uses of genus *Casimiroa* like *Casimiroa watsonii*, *Casimiroa tomentosa*, *C. sapota* Var. Villosa, *Casimiroa calderoniae*, *Casimiroa dura*, *Casimiroa emarginata*, *Casimiroa greggii*, and *Casimiroa microcarpa*.

9 Concluding remarks

Casimiroa genus is a rich of diverse plant metabolites, with important biological activities. Their potential as drug leads is yet to be explored. Several *Casimiroa* species have not yet been chemically studied. Therefore, it is necessary to carry out these studies to contribute to the taxonomic classification and medicinal chemistry. In this article, the emphasis has been on the NMR data of compounds obtained from the genus, and pharmaceutically most of these compounds were reported in 1968s, and during that time, the data were either incomplete or unavailable. In this review, we have presented the NMR data and its description of compounds isolated from the genus *Casimiroa*. In addition, the information concerning different skeletons of the compounds is also provided.

Acknowledgments: The authors are grateful to Airlangga Development Scholarship (ADS) and RISET MANDAT

GRANT of Universitas Airlangga, Surabaya, Indonesia. The appreciation is also conveyed to Prof. M. Iqbal Choudhary from H. E. J. Research Institute of Chemistry, International Center of Chemical and Biological Sciences, University of Karachi, Karachi-75270, Pakistan, for his help in improving this review article.

Conflict of interest: The authors have no conflict of interest.

References

[1] Cragg GM, Newman DJ. Natural product drug discovery in the next millennium. Pharm Biol. 2001;39(Suppl 1):8–17. doi: 10.1076/phbi.39. s1.8.0009.

[2] Yuan H, Ma Q, Ye L, Piao G. The traditional medicine and modern medicine from natural products. Molecules. 2016;21(5):559. doi: 10.3390/molecules21050559.

[3] Wohlleben W, Mast Y Stegmann E, Ziemert N. Antibiotic drug discovery. Microb Biotechnol. 2016;9(5):541–8. doi: 10.1111/1751-7915.12388.

[4] Pan SY, Litscher G, Gao SH, Zhou SF, Yu ZL, Chen HQ, et al. Historical perspective of traditional indigenous medical practices: the current renaissance and conservation of herbal resources. Evid Based Complementary Altern Med. 2014;2014:1–20. doi: 10.1155/2014/525340.

[5] Karunamoorthi K, Jegajeevanram K, Vijayalakshmi J, Mengistie E. Traditional medicinal plants: A source of phytotherapeutic modality in resource-constrained health care settings. J Evid Based Complementary Altern Med. 2012;18(1):67–74. doi: 10.1177/2156587212460241.

[6] Ekor M. The growing use of herbal medicines: issues relating to adverse reactions and challenges in monitoring safety. Front Pharmacol. 2014;4:177. doi: 10.3389/fphar.2013.00177.

[7] Van Andel T, Carvalheiro LG. Why urban citizens in developing countries use traditional medicines: the case of suriname. Evid Based Complementary Altern Med. 2013;201:1–13. doi: 10.1155/2013/687197.

[8] Dias DA, Urban S, Roessner U. A historical overview of natural products in drug discovery. Metabolites. 2012;2(2):303–36. doi: 10.3390/metabo2020303.

[9] Chikezie PC, Ibegbulem CO, Mbagwu FN. Bioactive principles from medicinal plants. Res J Phytochemistry. 2015;9(3):88–115. doi: 10.3923/rjphyto.2015.88.115.

[10] Duraipandiyan V, Ayyanar M, Ignacimuthu S. Antimicrobial activity of some ethnomedicinal plants used by Paliyar tribe from Tamil Nadu, India. BMC Complementary Altern Med. 2006;6:35–41. doi: 10.1186/1472-6882-6-35.

[11] Phua DH, Zosel A, Heard K. Dietary supplements and herbal medicine Toxicities when to anticipate them and how to manage them. Int J Emerg Med. 2009;2(2):69–76. doi: 10.1007/s12245-009-0105-z.

[12] Bernardini S,Tiezzi A, LaghezzaMasci V, Ovidi E. Natural products for human health: an historical overview of the drug discovery approaches. Nat Prod Res. 2018;32(16):1926–50. doi: 10.1080/14786419.2017.1356838.

[13] Satheesh N. Review on distribution, nutritional and medicinal values of *Casimiroa edulis*llave-an underutilized fruit in Ethiopia. American-Eurasian J Agric Env Sci. 2015;15(8):1574–83. doi: 10.5829/idosi.aejaes.2015.15.8.9585.

[14] Yamamoto M, Tomita T, Onjo M, Ishihata K, Kubo T, Tominaga S. Genetic diversity of white sapote (*Casimiroa edulis* La Llave & Lex.) demonstrated by intersimple sequence repeat analysis. HortScience. 2007;42(6):1329–31. doi: 10.21273/HORTSCI.42.6.1329.

[15] Garzon-De la Mora P, Garcia-lopez PM, Garcia-Estrada J, Navarro-Ruiz A, Villanueva-Michel T, Villarreal-de Puga LM, et al. *Casimiroa edulis* seed extracts show anticonvulsive properties in rats. J Ethnopharmacol. 1999;68(1–3):275–82. doi: 10.1016/s0378-8741(99)00125-7.

[16] Mora S, Diaz-Veliz G, Lungenstrass H, Garcia-Gonzalez M, Coto-Morales T, Poletti C, et al. Central nervous system activity of the hydroalcoholic extract of *Casimiroa edulis* in rats and mice. J Ethnopharmacol. 2005;97(2):191–7. doi: 10.1016/j.jep.2004.10.028.

[17] Navarro Ruiz A, Bastidas Ramirez BE, Garcia Estrada J, Garcia Lopez P, Garzon P. Anticonvulsant activity of *Casimiroa edulis* in comparison to phenytoin and Phenobarbital. JEthnopharmacol. 1995;45(3):199–206. doi: 10.1016/0378-8741(94)01216-m.

[18] Vázquez-Cruz B, Vázquez-Muñoz M, Navarrete-Bastida R, Trujillo-González ID, De Haro R, Segura D, et al. Antihypertensive and vasorelaxant effects of the aqueous extract of *Casimiroa edulis*. Pharmacologyonline. 2009;3:73–8.

[19] Romero ML, Escobar LI, Lozoya X, Enriquez RG. High performance liquid chromatographic study of *Casimiroa edulis*: I. Determination of imidazole derivatives and rutin in aqueous and organic extracts. J Chromatogr. 1983;281:245–51. doi: 10.1016/S0021-9673(01)87882-1.

[20] Esposito F, Zinzula L, Maxia A, Tramontano E, Sanna C. Inhibition of HIV-1 reverse transcriptase associated activities by the hydroalcoholic extract of *Casimiroa edulis* seeds. Nat Prod Res. 2011;25(11):1067–73. doi: 10.1080/14786419.2010.508896.

[21] Miller SL, Haber WA, Setzer WN. Chemical composition of the leaf essential oil of *Casimiroa edulis* La llave & lex. (Rutaceae) from Monteverde, Costa Rica. Nat Prod Commun. 2009;4(3):425–6. doi: 10.1177/1934578X0900400322.

[22] Kincl FA, Romo J, Rosenkranz G, Sondheimer F. The constituents of *Casimiroa edulis* Llave et lex. Part I. The seed. J Chem Soc. 1956;4136–69. doi: 10.1039/JR9560004163.

[23] Iriarte J, Kincl FA, Rosenkranz G, Sondheimer F. The constituent of *Casimiroa edulis*Llave et lex. Part II. The bark. J Chem Soc. 1956;4170–3. doi: 10.1039/JR9560004170.

[24] Ito A, Shamon LA, Yu B, Mata-Greenwood E, Lee SK, Breemen RBV, et al. Antimutagenic constituents of *Casimiroa edulis* with potential cancer chemopreventive activity. J Aric Food Chem. 1998;46:3509–16. doi: 10.1021/jf9802373.

[25] Awaad AS, Al-Jaber NA, Soliman GA, Al-Outhman MR, Zain ME, Moses JE, et al. New biological activities of

Casimiroa edulis leaf extract and isolated compounds. Phyther Res. 2012;26(3):452–7. doi: 10.1002/ptr.3690.
[26] Awaad AW, El-Sayed NH, Maitland DJ, Mabry TJ. Phenolic antioxidants from *Casimiroa edulis* leaves. Pharm Biol. 2006;44(4):258–62. doi: 10.1080/13880200600713899.
[27] Awaad AS, Maitland DJ, Moneir SM. New alkaloids from *Casimiroa edulis* fruit and their pharmacological activity. Chem Nat Compd. 2007;43(5):576–80. doi: 10.1007/s10600-007-0196-9.
[28] Khaleel AEM. 2-Phenyl-4-quinolinone alkaloids from *Casimiroa edulis* Llave et Lex (Rutaceae). Monatshefte fur Chem. 2012;133:183–7. doi: 10.1007/s706-002-8248-4.
[29] Nagai H ,Tanaka T, Goto T, Kusudo T, Takahashi N, Kawada T. Phenolic compounds from leaves of *Casimiroa edulis* showed adipogenesis activity. Biosci Biotechnol Biochem. 2014;78(2):296–300. doi: 10.1080/09168451.2014.877821.
[30] Heneka B, Rimpler H, Ankli A, Sticher O, Gibbons S, Heinrich M. A furanocoumarin and polymethoxylated flavonoids from the Yucatec Mayan plant *Casimiroa tetrameria*. Phytochemistry. 2005;66:649–52. doi: 10.1016/j.phytochem.2004.12.005.
[31] Bertin R, Chen Z, Martínez-vázquez M, García-argaéz A, Froldi G. Vasodilation and radical-scavenging activity of imperatorin and selected coumarinic and flavonoid compounds from genus *Casimiroa*. Phytomedicine. 2014;21(5):586–94. doi: 10.1016/j.phymed.2013.10.030.
[32] García-Argáez AN, González-Lugo NM, Parra-Delgado H, Martínez-Vázquez M. Casimiroin, zapoterin, zapotin and 5,6,2′,3′,4′-pentamethoxyflavone from *Casimiroa pubescens*. Biochem Syst Ecol. 2005;33(4):441–3. doi: 10.1016/j.bse.2004.11.004.
[33] Ya-ming XU, Ramirez-ahumada MDC, Valeriote FA, Gunatilaka AAL. Solid tumor inhibitory and other constituents of *Casimiroatetrameria*. Chin J Nat Med. 2011;9(5):334–7. doi: 10.3724/SP.J.1009.2011.00334.
[34] Garcia-Argaez AN, Gonzalez-Lugo NM, Parra-Delgado H, Martınez-Vazquez M. Pubesamides A, B, and C, three new *N*-benzoyltyramide derivatives isolated from *Casimiroa pubescens*. Z Naturforsch. 2004;59(b):245–8. doi: 10.1515/znb-2004-0219.
[35] Magos GA, Vidrio H, Reynolds WF, Enríquez RG. Pharmacology of *Casimiroa edulis* IV. Hypotensive effects of compounds isolated from methanolic extracts in rats and guinea pigs. J Ethnopharmacol. 1998;64(1):35–44. doi: 10.1016/s0378-8741(98)00101-9.
[36] Ubaldo-suarez D, Reyes RE, Rosa-sierra RDL, Martinez-Vazquez M. Antidepressant-like effect of *Casimiroa pubescences* root extracts. Nat Prod Res. 2019;33(17):2526–30. doi: 10.1080/14786419.2018.1448808.
[37] Tun KNWT, Aminah NS, Kristanti AN, Ramadhan R, Takaya Y. Two flavonoids from stem bark of Casimiroa edulis and their antidiabetic and antioxidant activities. IOP conference secrecies: Earth and Environmental Science; 2018 Oct 8-12; Universitas Airlangga, Indonesia, 2019. doi: 10.1088/1755-1315/217/1/012006.
[38] Tun KNW, Aminah NS, Kristanti AN, Ramadhan R, Takaya Y, Aung HT. Coumarins from Myanmar edible fruit tree (*Casimiroa edulis*). J Indian Chem Soc. 2019;96(6):737–40.
[39] Venugopala KN, Rashmi V, Odhav B. Review on natural coumarin lead compounds for their pharmacological activity. Biomed Res Int. 2013;2013:963248. doi: 10.1155/2013/963248.
[40] Borges F, Roleira F, Milhazes N, Santana L, Uriarte E. Simple Coumarins and Analogues in Medicinal Chemistry: Occurrence, Synthesis and Biological Activity. Curr Med Chem. 2005;12(8):887–916. doi: 10.2174/0929867053507315.
[41] Srikrishna D, Goduqu C, Dubey PK. A review on pharmacological properties of coumarins. Mini Rev Med Chem. 2018;18(2):113–41. doi: 10.2174/1389557516666160801094919.
[42] Chavan RR, Hosamani KM. Microwave-assisted synthesis, computational studies and antibacterial anti-inflammatory activities of compounds based on coumarin-pyrazole hybrid. R Soc Open Sci. 2018;5(5):172435. doi: 10.1098/rsos.172435.
[43] Hadjipavlou-Litina D, Kontogiorgis C, Pontiki E, Dakanali M, Akoumiabaki A, Katerinopoulos HE. Anti-inflammatory and antioxidant activity of coumarins designed as potential fluorescent zinc sensors. J Enzyme Inhib Med Chem. 2007;22(3):287–92. doi: 10.1080/14756360601073914.
[44] Lei L, Xue Y, Liu Z, Peng S, He Y, Zhang Y, et al. Coumarin derivatives from *Ainsliaea fragrans* and their anticoagulant activity. Sci Rep. 2015;5:13544. doi: 10.1038/srep13544.
[45] Ramírez-Pelayo C, Martínez-Quiñones J, Gil J, Durango D. Coumarins from the peel of citrus grow in Colombia:composition, elicitation and antifungal activity. Heliyon. 2019;15(6):e01937. doi: 10.1016/j.heliyon.2019.e01937.
[46] Montagner C, Souza SM, Groposoa C, Monache FD, Smânia EF, Smânia A. Antifungal activity of coumarins. Z Naturforsch C J Biosci. 2008;63c(1–2):21–28. doi: 10.1515/znc-2008-1-205.
[47] Shokoohinia Y, Sajjadi SE, Gholamzadeh S, Fattahi A, Behbahani M. Antiviral and cytotoxic evaluation of coumarins from *Prangos ferulacea*. Pharm Biol. 2014;52(12):1543–9. doi: 10.3109/13880209.2014.907322.
[48] Hassan MZ, Osman H, Ali MA, Ahsan MJ. Therapeutic potential of coumarins as antiviral agents. Eur J Med Chem. 2016;123:236–55. doi: 10.1016/j.ejmech.2016.07.056.
[49] Ding C, Zhang W, Li J, Lei J, Yu J. Cytotoxic constituents of ethyl acetate fraction from *Dianthus superbus*. Nat Prod Res. 2013;27(18):1691–4. doi: 10.1080/14786419.2012.763127.
[50] Susidarti RA, Rahmani M, Ismail HBM, Sukari MA, Hin TYY, Lian GEC, et al. Cytotoxic activity of coumarins from *Micromelum minutum*. Pharm Biol. 2009;47(2):182–5. doi: 10.1080/13880200802436513.
[51] Mojarrab M, Emami SA, Delazar A, Tayarani-Najaran Z. Cytotoxic Properties of Three Isolated coumarin-hemiterpene ether derivatives from Artemisia armeniaca Lam. Iran J Pharm Res. 2017;16(1):221–9.
[52] Dehghan H, Sarrafi Y, Salehi P, Ebrahim SN. α-Glucosidase inhibitory and antioxidant activity of furanocoumarins from *Heracleum persicum*. Med Chem Res. 2017;26:849–55. doi: 10.1007/s00044-017-1796-y.
[53] Karakaya S, Gözcü S, Güvenalp Z, Özbek H, Yuca H, Dursunoğlu B, et al. The α-amylase and α-glucosidase inhibitory activities of the dichloromethane extracts and constituents of Ferulagobracteata roots. Pharm Biol. 2018;56(1):18–24. doi: 10.1080/13880209.2017.1414857.
[54] Razavi BM, Arasteh E, Imenshahidi M, Iranshahi M. Antihypertensive effect of auraptene, a monoterpene

coumarin from the genus Citrus, upon chronic administration. Iran J Basic Med Sci. 2015;18(2):153–8.
[55] Mukes S, Kaikini A, Peshattiwar V, Bagle S, Dighe V, Sathaye S. Neuroprotective effect of coumarin nasal formulation: kindling model assessment of epilepsy. Front Pharmacol. 2018;9:992. doi: 10.3389/fphar.2018.00992.
[56] Kassim NK, Rahmani M, Ismail A, Sukari MA, Ee GC, Nasir NM, et al. Antioxidant activity-guided separation of coumarins and lignin from *Melicope glabra* (Rutaceae). Food Chem. 2013;139(1–4):87–92. doi: 10.1016/j.foodchem.2013.01.108.
[57] Esterhuizen LL, Meyer R, Dubery IA. Antioxidant activity of metabolites from *Coleonema album* (Rutaceae). Nat Prod Commun. 2006;1(5):367–75. doi: 10.1177/1934578X0600100505.
[58] Vera N, Zampini C, María Inés Isla MI, Bardón A. Antioxidant and XOD inhibitory coumarins from *Pterocaulon polystachyum* DC. Nat Prod Commun. 2007;2(5):551–6. doi: 10.1177/1934578X0700200508.
[59] Thuong PT, Hung TM, Ngoc TM, Ha DT, Min BS, Kwack SJ, et al. Antioxidant activities of coumarins from Korean medicinal plants and their structure–activity relationships. Phytotherapy Res. 2010;24(1):101–6. doi: 10.1002/ptr.2890.
[60] Widelski J, Luca SV, Skiba A, Chinou L, Marcourt L, Wolfender JL, et al. Isolation and antimicrobial activity of coumarins derivatives from fruit of *Peucedanum luxurians* Tamamsch. Molecules. 2018;23(5):1222. doi: 10.3390/molecules23051222.
[61] Wang C, Pei A, Chen J, Yu H, Sun ML, Liu CF, et al. A natural coumarins derivative esculetin offers neuroprotection on cerebral ischemia/reperfusion injury in mice. J Neurochem. 2012;121(6):1007–13. doi: 10.1111/j.1471-4159.2012.07744.x.
[62] Kim JS, Kim JC, Shim SH, Lee EJ, Jin WY, Bae K, et al. Chemical constituents of the root of *Dystaenia takeshimana* and their anti-inflammatory activity. Arch Pharm Res. 2006;29(8):617–23. doi: 10.1007/bf02968244.
[63] Askari M, Sahebkar A, Iranshahi M. Synthesis and purification of 7-prenyloxycoumarins and herniarin as bioactive natural coumarins. Iran J Basic Med Sci. 2009;12(2):63–69.
[64] Dudek-Makuch M, Matlawska I. Coumarins in horse cheatnut flowers: isolation and quantification by UPLC method. Acta Pol Pharm. 2013;70(3):517–22.
[65] Tjahjandarie TS. Coumarins from the stem bark of *Feronia limonia*. J Chem Pharm Res. 2014;6(12):499–504.
[66] Dreyer DL. Citrus bitter principles. IX. Extractives of *Casimiroa edulis* Llave*et* Lex. The structure of Zapoterin. J Org Chem. 1968;3(9):3577–82. doi: 10.1021/jo01273a049.
[67] Attia GIEA, Abou-El-seoud KA, Ibrahim ARS. Biotransformation of furanocoumarins by *Cunninghamella elegans*. Bull Fac Pharm Cairo Univ. 2015;53(1):1–4. doi: 10.1016/j.bfopcu.2014.09.001.
[68] Shults EE, Petrova TN, Shakirov MM, Chernyak EI, Pokrovskiy LM, Nekhoroshev SA, et al. Coumarin compounds from roots of *Peucedanum* (*Peucedanum morisonii* Bess). Chem Sustain Dev. 2003;4:649–65.
[69] O'Neill T, Johnson JA, Webster D, Gray CA. The Canadian medicinal plant *Heracleum maximum* contains antimycobacterial diynes and furanocoumarins. J Ethnopharmacol. 2013;147(1):232–7. doi: 10.1016/j.jep.2013.03.009.
[70] Nam VD,Teruhisa F, Hirofumi T, Hiroshi K, Khoi NM, Dung LV, et al. Chemical composition of *Clausena lansium* (Lour.) skeels leaves and antifungal activity. Nat prod Sci. 2016;22(1):35–40. doi: 10.20307/nps.2016.22.1.35.
[71] Bergendorff O, Dekermendjian K, Nielsen M, Shan R, Witt R, Ai J, et al. Furanocoumarins with affinity to brain benzodiazepine receptor *in vitro*. Phytochemistry. 1997;44(6):1121–214. doi: 10.1016/s0031-9422(96)00703-0.
[72] Chung LY, Yap KF, Goh SH, Mustafa MR, Imiyabir Z. Muscarinic receptor binding activity of polyoxygenated flavones from *Melicope subunifoliolata*. Phytochemistry. 2008;69(7):1548–54. doi: 10.1016/j.phytochem.2008.01.024.
[73] Facchini PJ. Alkaloid biosynthesis in plants: biochemistry, cell biology, molecular regulation, and metabolic engineering applications. Annu Rev Plant Physiol Plant Mol Biol. 2001;52(1):29–66. doi: 10.1146/annurev.arplant.52.1.29.
[74] Khan F, Qidwai T, Shukla RK, Gupta V. Alkaloids derived from tyrosine: modified benzyltetrahydroisoquinoline alkaloids. In: Ramawat K, Mérillon JM, editors. Natural Products. Berlin, Heidelberg: Springer; 2013. p. 405–60. doi: 10.1007/978-3-642-22144-6_15.
[75] Kaur R, Arora S. Alkaloids-important therapeutic secondary metabolites of plant origin review article. J Crit Rev. 2015;2(3):1–8.
[76] Tiong SH, Looi CY, Hazni H, Arya A, Paydar M, Wong WF, et al. Antidiabetic and antioxidant properties of alkaloids from *Catharanthus roseu*s (L.) G. Don, Molecules. 2013;18(8):9770–84. doi: 10.3390/molecules18089770.
[77] Costa EV, da Cruz PEO, de Lourenço CC, de Souza Moraes VR, de Lima Nogueira PC, Salvador MJ. Antioxidant and antimicrobial activities of aporphinoids and other alkaloids from the bark of *Annona salzmannii* A. DC. (Annonaceae). Nat Prod Res. 2013;27(11):1002–6. doi: 10.1080/14786419.2012.688044.
[78] Souto AL, Tavares JF, da Silva MS, de Fátima M, Diniz FFM, de Athayde-Filho PF, et al. Anti-Inflammatory activity of alkaloids: An update from 2000 to 2010. Molecules. 2011;16(10):8515–34. doi: 10.3390/molecules16108515.
[79] Lu JJ, Bao J, Chen XP, Huang M, Wang YT. Alkaloids isolated from natural herbs as the anticancer agents. Evid Based Complement Altern Med. 2012;2012:1–12. doi: 10.1155/2012/485042.
[80] Vaid RM, Bhutani KK. Comparison of anti-amoebic activity of stereoisomeric diamino and monoaminopregnene alkaloids and their *N*-methylated analogs. J Chem Sci. 2013;25(1):183–5.
[81] Min YD, Kwon HC, Yang MC, Lee KH, Choi SU, Lee KR. Isolation of limonoids and alkaloids from *Phellodendron amurense* and their multidrug resistance (MDR) reversal activity. Arch Pharm Res. 2007;30(1):58–63. doi: 10.1007/bf02977779.
[82] Pusset J, Lopez J, Pais M, Neirabeyeh M, Veillon JM. Isolation and 2D NMR studies of alkaloids from *Comptonella sessilifoliola*1. Planta Med. 1991;57(2):153–5. doi: 10.1055/s-2006-960053.
[83] Haque MM, Begum S, Sohrab MH, Ahsan M, Hasan CM, Ahmed N, et al. Secondary metabolites from the stem of Ravenia spectabilisLindl. Pharmacogn Mag. 2013;9(33):76. doi: 10.4103/0973-1296.108147.

[84] Parhoodeh P, Rahmani M, Mohd N, Sukari HMA, Ee GCL. Alkaloid constituents of *Haplophyllumlaeviusculum* (Rutaceae) (Kandungan Alkaloid daripada*Haplophyllum laeviusculum*(Rutaceae). Sains Malays. 2012;41(1):47–52.
[85] Biavatti MW, Vieira PC, da Silva MFDGF, Fernandes JB, Victor SR, Pagnocca FC, et al. Zukerman-Schpector J. Biological activity of quinoline alkaloids from *Raulinoa echinata* and X-ray structure of flindersiamine. J Braz Chem Soc. 2002;13(1):66–70. doi: 10.1590/S0103-50532002000100010.
[86] Setzer WN, Vogler B, Bates RB, Schmidt JM, Dicus CW, Nakkiew P, et al. HPLC-NMR/HPLC-MS analysis of the bark extract of *Stauranthus perforates*. Phytochem Anal. 2003;14(1):54–59. doi: 10.1002/pca.687.
[87] Panche AN, Diwan AD, Chandra SR. Flavonoids: an overview. J Nutr Sci. 2016;5(e47):1–14. doi: 10.1017/jns.2016.41.
[88] Hasan A, Sadiq A, Abbas A, Mughal E, Khan KM, Ali M. Isolation and synthesis of flavonols and comparison of their antioxidant activity. Nat Prod Res. 2010;24(11):995–1003. doi: 10.1080/14786410902847302.
[89] Badmus JA, Ekpo OE, Ratenbach F, Marnewick JL, Hussein AA, Hiss DC. Isolation and antioxidant activity of flavonoids from *Holarrhena floribunda* (G.don) leaves. Acta Biochim Pol. 2016;63(2):353–8. doi: 10.18388/abp.2015_1178.
[90] Benmerache A, Benteldjoune M, AlabdulMagid A, Abedini A, Berrehal D, Kabouche A, et al. Chemical composition, antioxidant and antibacterial activities of *Tamarix balansae* J. Gay aerial parts. Nat Prod Res. 2017;31(24):2828–35. doi: 10.1080/14786419.2017.1299729.
[91] Kang SY, Kang JY, Oh MJ. Antiviral activities of flavonoids isolated from the bark of *Rhus verniciflua* stokes against fish pathogenic viruses *in vitro*. J Microbiol. 2012;50(2):293–300. doi: 10.1007/s12275-012-2068-7.
[92] Peng W, Wang L, Qiu XH, Jiang YP, Pan L, Jia XG, et al. Flavonoids from *Caragana pruinosa* roots. Fitoterapia. 2016;114:105–9. doi: 10.1016/j.fitote.2016.08.020.
[93] Chan SC, Chang YS, Wang JP, Chen SC, Kuo SC. Three new flavonoids and antiallergic, anti-inflammatory constituents from the heartwood of *Dalbergiaodorifera*. Planta Med. 1998;64(2):153–8. doi: 10.1055/s-2006-957394.
[94] Alhassan AM, Ahmed QU, Latip J, Shah SAA. A new sulphate flavone and other phytoconstituents from the leaves of *Tetraceraindica* Merr. And their alpha-glucosidase inhibitory activity. Nat Prod Res. 2019;33(1):1–8. doi: 10.1080/14786419.2018.1437427.
[95] Batra P, Sharma AK. Anti-cancer potential of flavonoids: recent trends and future perspectives. 3 Biotech. 2013;3(6):439–59. doi: 10.1007/s13205-013-0117-5.
[96] Garratt PJ, Scheinmann F, Sondheimer F. Constituents of *Casimiroa edulid* Llave et Lex. -VI:2′,5,6-trimethoxyflavone, 2′,5,6,7-tetramethoxyflavone (zapotin) and 5-hydroxy-2′,6,7-trimethoxyflavone (zapotinin). Tetrahedron. 1960;3(4):139–44. doi: 10.1016/0040-4020(60)80001-4.
[97] Mostafa NM, El-Ghffar, Hegazy HG, Eldahshan OA. New methoxyflavone from *Casimiroa sapota* and the biological activities of its leaves extract against lead acetate induced hepatotoxicity in rats. Chem Biodivers. 2018;(4):e1700525. doi: 10.1002/cbdv.201700528.
[98] Heinrich M, Heneka B, Ankli A, Rimpler H, Sticher O, Kostiza T. Spasmolytic and antidiarrhoeal properties of the Yucatec Mayan medicinal plant *Casimiroa tetrameria*. J Pharm Pharmacol. 2005;57(9):1081–5. doi: 10.1211/jpp.57.9.0002.
[99] Budzianowski J, Morozowska M, Wesolowska M. Lipophilic flavones of *Primula veris* L. from field cultivation and *in vitro* cultures. Phytochemistry. 2005;66(9):1033–9. doi: 10.1016/j.phytochem.2005.03.024.
[100] Kyriakou E, Primikyri A, Charisiadis P, Katsoura M, Gerothanassis IP, Stamatis H, et al. Unexpected enzyme-catalyzed regioselective acylation of flavonoid aglycones and rapid product screening. Org Biomol Chem. 2012;10(9):1739–42. doi: 10.1039/C2OB06784F.
[101] Akkola EK, Suntara I, Kelesb H, Sezika E, Gurlerc G. Bioassay-guided isolation and characterization of wound healer compounds from *Morus nigra* L. (Moraceae). Rec Nat Prod. 2015;9(4):484–95.
[102] Aisyah LS, Yun YF, Herlina T, Julaeha E, Zainuddin A, Nurfarida I, et al. Flavonoid compounds from the Leaves of *Kalanchoe prolifera* and their cytotoxic activity against P-388 Murine Leukimia Cells. Nat Prod Sci. 2017;23(2):139–45. doi: 10.20307/nps.2017.23.2.139.
[103] Elkady WM, Ibrahim EA, Gonaid MH, El Baz FK. Chemical profile and biological activity of *Casimiroa edulis* non-edible fruit's parts. Adv Pharm Bull. 2017;7(4):655–60. doi: 10.15171/apb.2017.079.
[104] Magos GA, Vidrio H, Enriquez R. Pharmacology of *Casimiroa edulis*; III. Relaxant and contractile effects in rat aortic rings. J Ethnopharmacol. 1995;47(1):1–8. doi: 10.1016/0378-8741(95)01247-b.
[105] Landaverde NA, Juarez-Flores B, Jimenez-Capdeville ME, Ortiz-Perez MD. Anxiolytic and sedative effects of essential oil from *Casimiroa pringlei* on wistar rats. J Med Plant Res. 2009;3(10):791–8.

Open Chemistry

Country	Germany - SIR Ranking of Germany
Subject Area and Category	Chemistry Chemistry (miscellaneous) Materials Science Materials Chemistry
Publisher	Walter de Gruyter GmbH
Publication type	Journals
ISSN	23915420
Coverage	2003, 2015-2020
Scope	Open Chemistry is a peer-reviewed, open access journal that publishes original research, reviews and short communications in the fields of chemistry in an ongoing way. Our central goal is to provide a hub for researchers working across all subjects to present their discoveries, and to be a forum for the discussion of the important issues in the field. Our journal is the premier source for cutting edge research in fundamental chemistry and it provides high quality peer review services for its authors across the world. Moreover, it allows for libraries everywhere to avoid subscribing to multiple local publications, and to receive instead all the necessary chemistry research from a single source available to the entire scientific community.

16

H Index

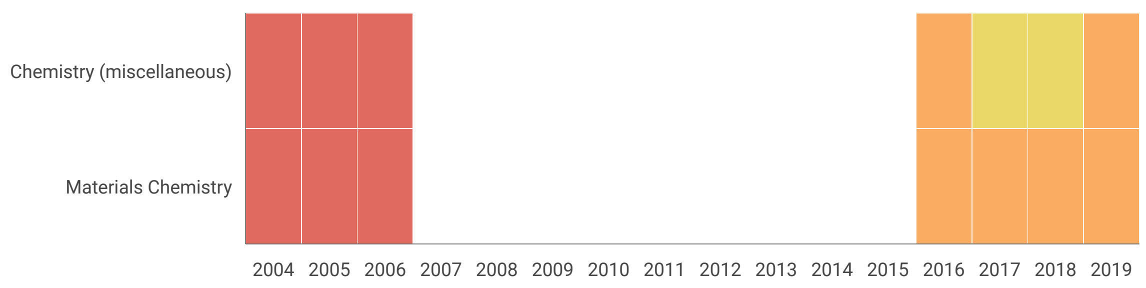
Homepage

How to publish in this journal

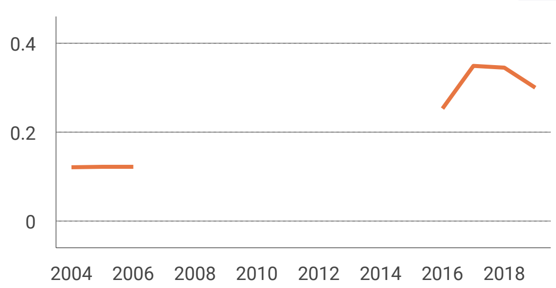
Contact

Join the conversation about this journal

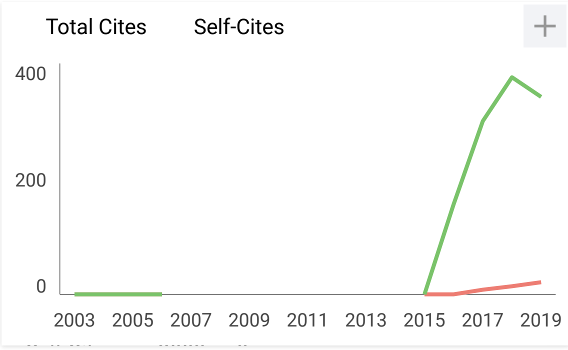
Quartiles

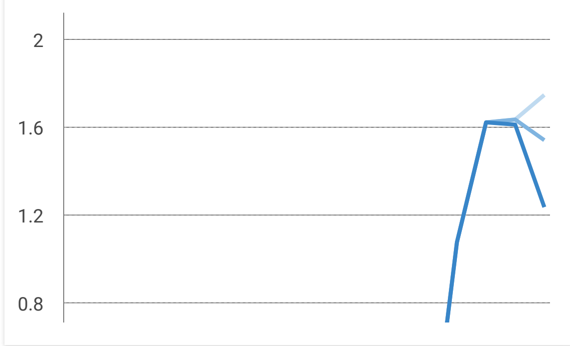


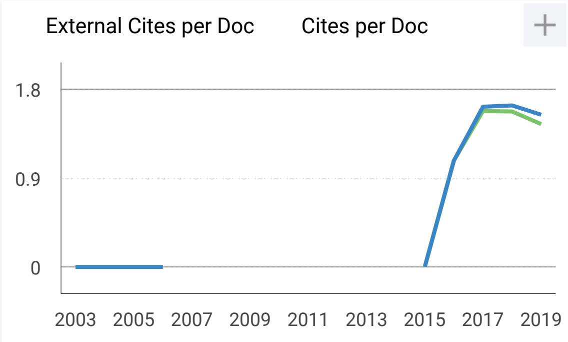
SJR

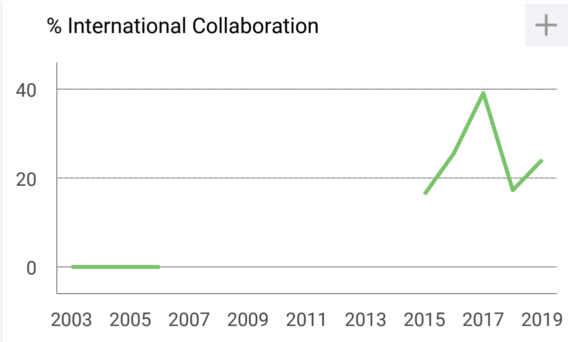


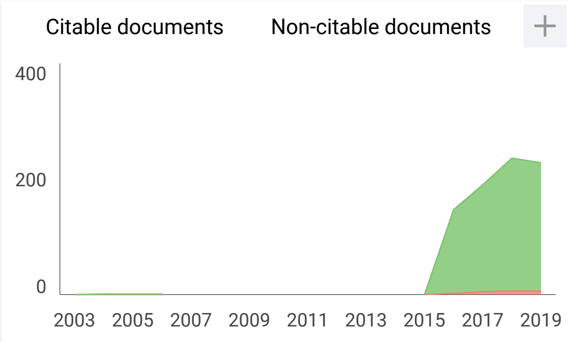
Citations per document

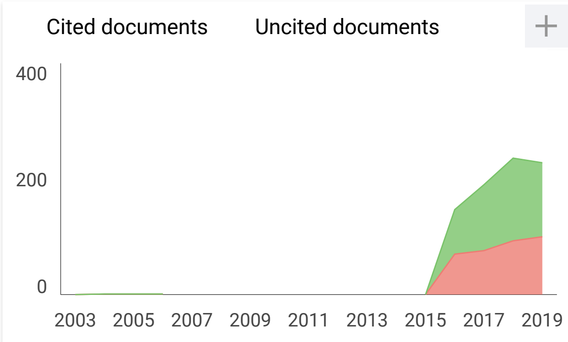


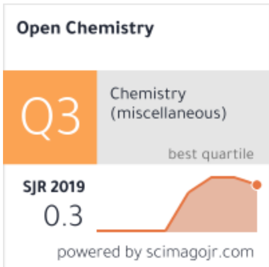












← Show this widget in your own website

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

<a href="https://www.scimag

Referred Academic Journal

Rapid index and hard copies printig and shipping to every corne world.

iiste.org

Leave a comment