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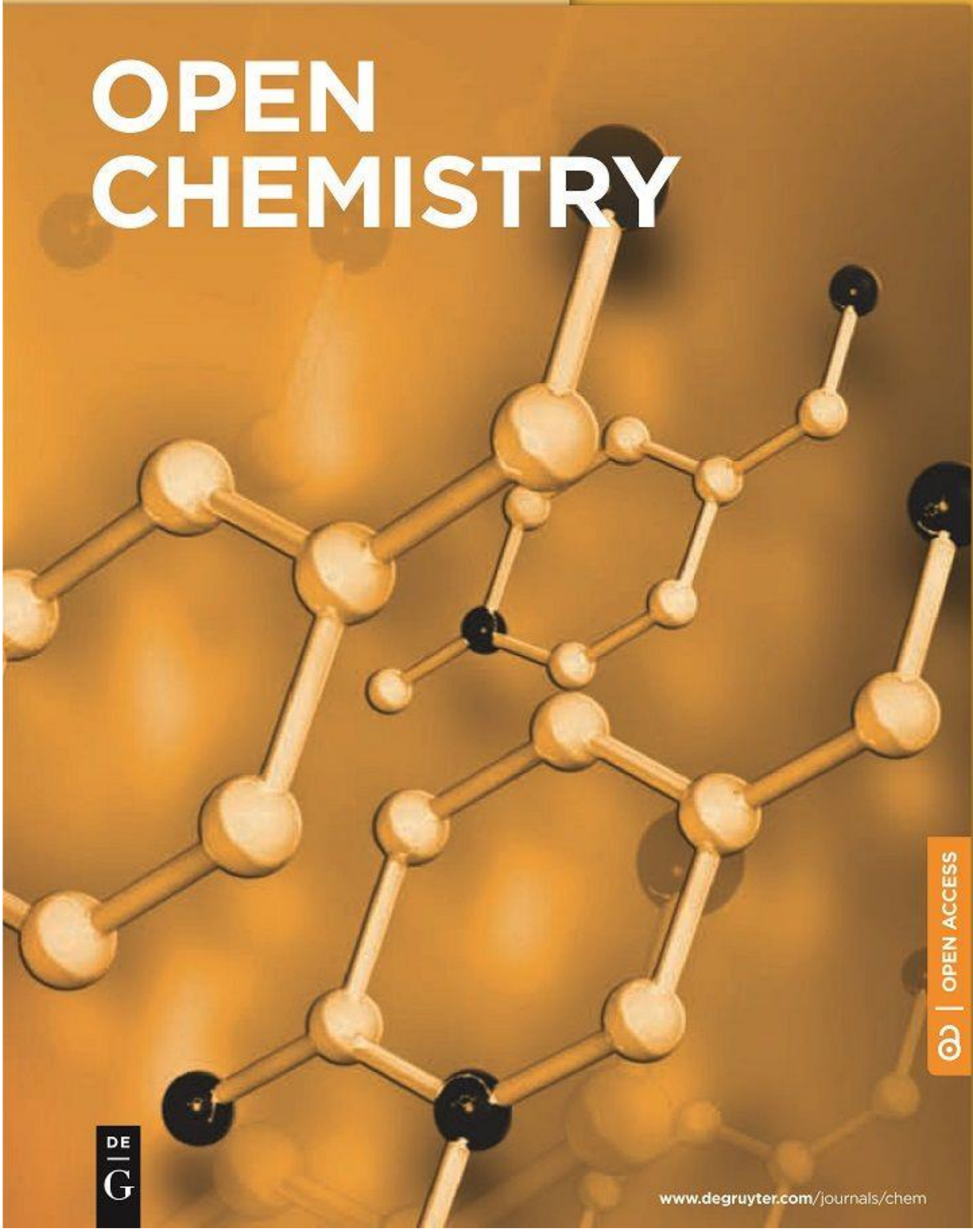

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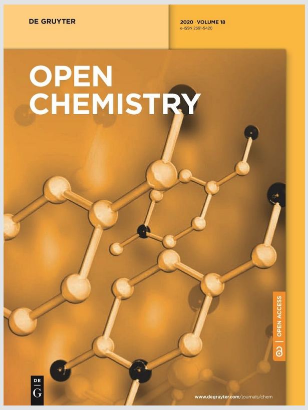

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- Supramolecular Chemistry and Nanochemistry
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Editorial Contact
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Volume 18 (2020): Issue 1 (Jan 2020)

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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

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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

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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

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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

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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

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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

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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

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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.,

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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)

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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

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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

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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

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***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)

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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*

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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

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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

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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

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Molecular Properties of Carbon Crystal Cubic Structures

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

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ABSTRACT

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

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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

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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

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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

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ABSTRACT

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

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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

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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

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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

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***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

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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

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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

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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

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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

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$LaCoO_3$ 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

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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

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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

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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

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ABSTRACT

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Shenghao Jiang, Macheng Shen and Fatima Rashid Sheykhahmad

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

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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

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

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

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Guoying Zhang and Xiaofeng Chi

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Jian Zhang, Pengcheng Wang and Qingqing Xiao

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

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Hasan Basri Karayel

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Hanshi Zhang and Guancheng Jiang

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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

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

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New derivatives of a natural nordentatin

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

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ABSTRACT

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

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

ABSTRACT

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

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ABSTRACT

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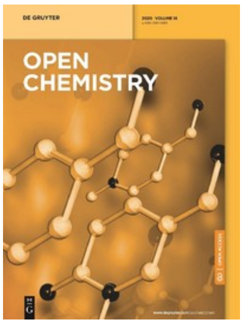

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Research Article

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

New derivatives of a natural nordentatin

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Abstract: New derivatives were obtained from natural nordentatin (**1**) previously isolated from the methanol fraction of *Clausena excavata* by an acylation method. Herein, we report ten new pyranocoumarin derivatives **1a–1j**. Their structures were elucidated based on UV-vis, FT-IR, NMR, and DART-MS data. The α-glucosidase inhibition and anticancer activities of nordentatin (**1**) and its derivatives were also evaluated. The α-glucosidase inhibition assay exhibited that the derivatives **1b**, **1d**, **1e**, **1f**, **1h**, **1i**, and **1j** possess higher inhibitory activity for α-glucosidase with IC_{50} values of 1.54, 9.05, 4.87, 20.25, 12.34, 5.67, and 2.43 mM, whereas acarbose was used as the positive control, IC_{50} = 7.57 mM. All derivatives exhibited a weak cytotoxicity against a cervical cancer (HeLa) cell line with the IC_{50} between 0.25 and 1.25 mM. They also showed moderate to low growth inhibition of a breast cancer (T47D) cell line with IC_{50} values between 0.043 and 1.5 mM, but their activity was lower than that of the parent compound, nordentatin (**1**) (IC_{50} = 0.041 mM).

Keywords: *Clausena excavata*, pyranocoumarin derivatives, nordentatin, yeast α-glucosidase inhibition, cytotoxicity, cervical cancer, breast cancer

*** Corresponding author: Nanik Siti Aminah,** Department of Chemistry, Faculty of Science and Technology, Airlangga University, Komplek Kampus C UNAIR, Jl. Mulyorejo, Surabaya, Indonesia, e-mail: nanik-s-a@fst.unair.ac.id, tel: +62-31-593-6501, fax: +62-31-593-6502
Tin Myo Thant: Department of Chemistry, Faculty of Science and Technology, Airlangga University, Komplek Kampus C UNAIR, Jl. Mulyorejo, Surabaya, Indonesia; Department of Chemistry, Mandalar Degree College, Mandalay, Myanmar
Alfinda Novi Kristanti, Rico Ramadhan: Department of Chemistry, Faculty of Science and Technology, Airlangga University, Komplek Kampus C UNAIR, Jl. Mulyorejo, Surabaya, Indonesia
Hnin Thanda Aung: Department of Chemistry, Mandalay University, Mandalay, Myanmar
Yoshiaki Takaya: Department of Pharmacy, Faculty of Pharmacy, Meijo University, 150 Yagotoyama, Tempaku, Nagoya, 468-8503, Japan

1 Introduction

Clausena excavata Burm f. belongs to the Rutaceae family and grows mainly in south and southeast Asia [1]. The plant is a wild shrub; its leaves, twigs, and root barks are used as traditional medicine for the treatment of cold, malaria, abdominal pain, snake-bite, viral infections (e.g., HIV), and dermatopathy. The plant is reported to contain bioactive constituents with antibacterial, antifungal, antimycobacterial, antinociceptive, *in vivo* immunomodulating, and insecticidal properties. Phytochemical studies have revealed that *C. excavata* is a rich source of coumarins [2,3], carbazole alkaloids [4], and limonoid [5]. Coumarins are plant-derived compounds with a benzopyrone moiety. They possess a wide variety of biological activities. Coumarins and their derivatives are being extensively studied for their biological activities, low toxicity, and low drug resistance properties [6,7].

It has been reported that nordentatin exhibits hypoglycemic activity [8]. The conversion reaction of this compound into its ester derivative is desired, as the derivative is expected to possess more potent biological activities, especially as an antidiabetic medicine in the future. Diabetes mellitus is a chronic disease caused by the dysfunction of carbohydrate metabolism. It has been recognized as one of the most serious public health problems globally. The International Diabetes Federation has estimated that 425 million people worldwide have diabetes. The number will increase to 642 million by 2040 [9–11]. Recently, there has been immense interest in the study of enzymes as drug targets. Especially, the inhibition of α-glucosidase can help in controlling postprandial glucose levels in diabetic patients. α-Glucosidases (α-D-glucoside glucohydrolase EC. 3.2.1.20) are membrane-bound enzymes, located in the epithelium of the small intestine, and the key enzymes of carbohydrate digestion. The inhibitors of α-glucosidase can delay the digestion of starch and other dietary sugars, and thus they prevent the onset of hyperglycemia and maintain the normal blood sugar level [9–11]. Clinical trials have already shown that α-glucosidase inhibitors can improve long-term glycemic control and decrease hemoglobin A1c (HbA1c) levels in patients with type II diabetes. They can also delay the development of type II diabetes in patients with impaired glucose tolerance [12]. Inhibitors of α-glucosidase such as voglibose, miglitol, and acarbose are currently used clinically, but their use is limited due to their adverse effects, such as diarrhea, abdominal cramping, flatulence, and vomiting. Therefore, much effort has been focused to develop effective α-glucosidase inhibitors from natural sources [13–15].

Cancer, in its various forms, is one of the major causes of death of the human population. Among them, cervical and breast cancers are the most common causes of cancer-related deaths in women globally [15,17]. Several natural products of plant origin could potentially be used as cancer chemotherapeutic agents. Some of the currently used plant-derived anticancer agents include podophyllotoxin, taxol, vincristine, and camptothecin [17]. The conversion reaction of marchantin to its ester derivatives increases the anticancer activity [18]. In the present work, we semi-synthesized pyranocoumarin benzoate derivatives from nordentatin (**1**) by using different benzoyl chlorides. Subsequently, the inhibitory effects of the resulting derivatives and of the parent compound against α-glucosidase enzymes and two cancer cell lines (HeLa and T47D) were evaluated and compared.

2 Materials and methods

2.1 Materials

2.1.1 Materials for synthesis

NMR experiments were performed on Bruker 600 MHz (^{1}H) and 151 MHz (^{13}C) instruments in $CDCl_3$ solvent. MS data were recorded on a DART-MS instrument. Melting points were determined on a Stuart (SMP30) instrument. Infrared spectra were recorded on an IR Tracer-100, ν in cm^{-1}. The UV-vis spectra were obtained on a Shimadzu (UV-1800) UV-vis spectrometer. The target compounds (**1a–1j**) were semi-synthesized by an acylation method with slight modification [19,20]. The starting material, nordentatin (**1**), was collected from our previous research [2]. Reagents such as 4-bromobenzoyl chloride, 3-chlorobenzoyl chloride, 2-chloro-4-nitrobenzoyl chloride, 3-chloro-4-fluoro benzoyl chloride, 3-bromo-benzoyl chloride, 4-butylbenzoyl chloride, 2,4,6-trichlorobenzoyl chloride, 3-trifluoromethylbenzoyl chloride, 3,5-bis (trifluoromethyl)benzoyl chloride, and 4-iodobenzoyl chloride (Wako, Japan) were used for the modification of compound **1** (nordentatin). Pyridine and 4-dimethylamino pyridine were used as catalysts. The reaction products were isolated by column chromatography on silica gel 60 (0.063–0.200 mm; Merck, Germany), by eluting with *n*-hexane and dichloromethane (20–100%). The reaction progress and the purity of the obtained compounds were monitored by p-TLC (preparative thin layer chromatography) on UV-254 plates (*n*-hex:CH_2Cl_2, 9:1; detection under UV light and by spraying anis aldehyde, followed by heating). The solvents (CH_2Cl_2, *n*-hex, and EtOAc) were purified by standard methods and distilled just before use.

2.1.2 Materials for antidiabetic and cytotoxic testing

The α-glucosidase from *Saccharomyces cerevisiae* (EC 3.2.1.20), and 4-nitrophenyl α-D-glucopyranoside (*p*-NPG) were obtained from Sigma-Aldrich. Spectrophotometric measurements for the yeast α-glucosidase inhibition were recorded on an i-Mark microplate reader.

The materials used in the cytotoxicity test with the 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium-bromide (MTT) cell viability assay performed on cervical (HeLa) and breast (T47D) cancer cell lines are as follows: Dulbecco's Modified Eagle's Medium, fetal bovine serum (FBS) 10% (w/v), dimethyl sulfoxide, phosphate buffer solution, MTT, phenazine methosulfate, sodium dodecyl sulfate 10% (w/v), and HCl 0.1 N.

2.2 Methods

2.2.1 General procedure for the modification of nordentatin (1) with benzoyl chloride derivatives by an acylation method

Esterification of nordentatin (**1**) was carried out by an acylation method [6,15] (Figure 1). First, around 100 mg of sample (**1**) was put in each flask. It was dissolved by adding 2 mL of pyridine and 10 mg of 4-(dimethylamino)-pyridine (DMAP) to the mixture. Subsequently, the mixture was stirred on a magnetic stirrer, and different kinds of benzoyl chlorides were added slowly. Then, the reaction was allowed to proceed at room temperature for 1 h. The mixture was checked with TLC at 30 min intervals until the reaction was completed. A

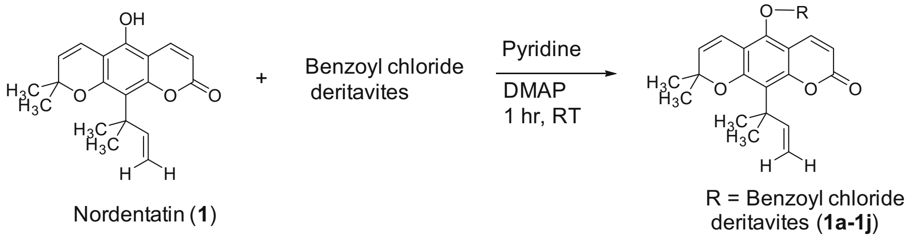

Figure 1: Scheme for the semi-synthesis of pyranocoumarin benzoate derivatives.

volume of 30 mL of EtOAc and 30 mL of distilled water were added to the product mixture. Pyridine was neutralized with 1 M concentrated HCl. The mixture was shaken vigorously three times by using a separating funnel and the organic layer was collected. The aqueous layer was exacted three times with 30 mL of EtOAc. The EtOAc portion was combined and dehydrated with brine water and anhydrous magnesium sulfate. The solvent was removed using a rotary evaporator. Finally, the product mixtures were chromatographed and the pure compounds **1a** to **1j** were obtained.

2.2.2 α-Glucosidase inhibition assay

The inhibition activity of all isolated compounds against yeast was determined by the method disclosed by Ramadhan et al. [21] with slight modifications. A sample (10 µL) was mixed with yeast (0.4 U/mL) in 1 mM phosphate buffer (pH 6.9), followed by shaking with a microplate shaker for 2 min and pre-incubation at 37°C for 10 min. The reaction mixture was added to 50 µL of *p*-nitrophenyl-α-D-glucopyranoside (*p*-NPG). Subsequently, the mixture was placed in an incubator at 37°C for 20 min. After the incubation, the reaction was quenched by adding Na_2CO_3 (100 µL). The release of *p*-nitrophenoxide from *p*-NPG was detected with a microplate reader at 415 nm (i-Mark ELISA [enzyme-linked immunosorbent assay] reader). Inhibition of the reaction was calculated using $[(A_0 - A_1)/A_0] \times 100$, where A_0 is the absorbance without the sample and A_1 is the absorbance with the sample. The IC_{50} value was determined from a plot of percentage inhibition versus sample concentration. Acarbose was used as the standard control, and the experiment was performed in triplicate.

2.2.3 MTT assay

The cytotoxicity of parent compound (**1**) and modified compounds (**1a–1j**) was measured by using the MTT assay method following the protocol of Suwito et al [22]. The cancer cells were seeded in a 96-well plate at a density of 1×10^4 cells/well with a phenol red-free RPMI (Roswell Park Memorial Institute) 1640 medium (containing 10% FBS) and kept for 24 h. Subsequently, the tested compound (various concentrations) was applied for 24 h. After addition of 0.5% MTT solution, the incubation was continued for a further 4 h at 37°C/5% CO_2. The stop solution (0.04 N HCl in isopropanol) was added to the culture medium in each well. The spectroscopic measurements were carried out at 570 nm (peak) and 630 nm (bottom) using an ELISA reader. The experiment was conducted in triplicate. Doxorubicin was used as a positive control.

Ethical approval: The conducted research is not related to either human or animal use.

3 Results and discussion

3.1 Semi-synthesis

In this study, derivatization of nordentatin (**1**) was carried out by using various benzoyl chlorides (Figure 1). The reaction was simple, quick, and has resulted in ten new pyranocoumarin benzoates (**1a–1j**) (Figure 2). Their structures were not only elucidated based on spectroscopic data but also compared with the structure of nordentatin (**1**) (Figures S1–S46). The FT-IR spectral data supported the presence of the –OH stretching group broad band in compound **1**, and the absence of –OH stretching in compounds **1a–1j**. In addition, the ^{13}C-NMR spectral data revealed the presence of one more carbonyl carbon from the benzoyl group at $\delta_c \sim 161$ ppm. The presence of fluoro-containing compounds was inferred from splitting patterns and coupling constants in ^{13}C-NMR.

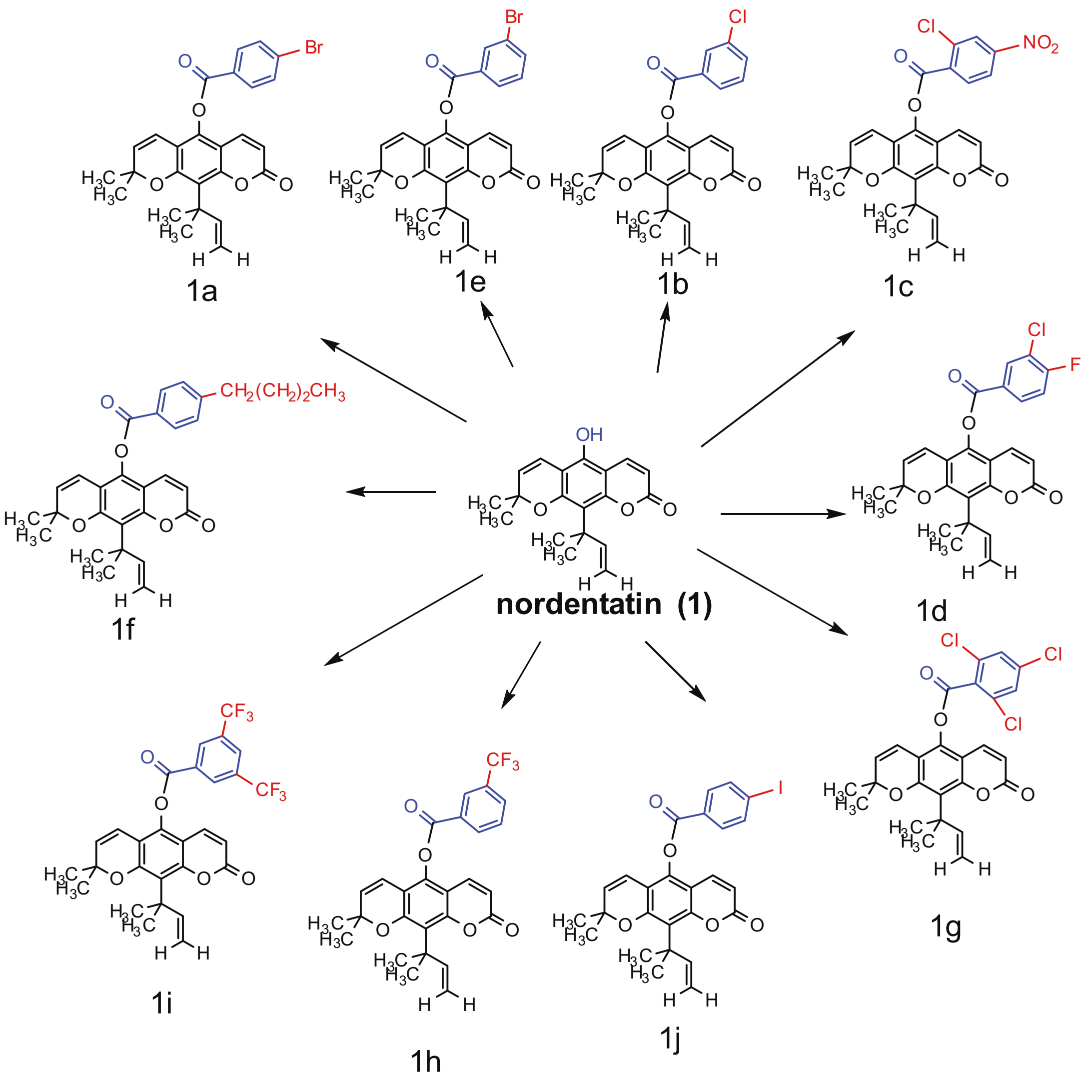

Figure 2: Structures of derivatives **1a–1j** from nordentatin (**1**).

3.1.1 Spectral data of compound 1a, 2,2-dimethyl-10-(2-methylbut-3-en-2-yl)-8-oxo-2*H*,8*H*-pyrano[3,2-*g*]chromen-5-yl 4-bromobenzoate

Nordentatin (108.2 mg, 0.3467 mmol), 4-bromobenzoyl chloride (121.6 mg, 0.5500 mmol), yield 43.2%. UV (MeOH), λ_{max} (log ε) 349 (0.79), 257 (2.87), 231 (1.0). M.p. 203–206°C. FT-IR 3,080, 2,972, 2,929, 2,873, 1,747, 1,730, 1,641, 1,618, 1,552 cm^{-1}. ^1H NMR (chloroform-*d*, 600 MHz) δ 2 × 8.11 (1H, d, J = 8.7 Hz), 2 × 7.72 (1H, d, J = 8.7 Hz), 7.53 (1H, d, J = 9.7 Hz), 6.33 (1H, dd, J = 17.4, 10.6 Hz), 6.26 (1H, d, J = 10.0 Hz), 6.19 (1H, d, J = 9.7 Hz), 5.69 (1H, d, J = 10.0 Hz), 4.98 (1H, dd, J = 17.4, 1.0 Hz), 4.92 (1H, dd, J = 10.6, 1.0 Hz), 2 × 1.70 (3H, s), 2 × 1.47 (3H, s). ^{13}C NMR (151 MHz, chloroform-*d*), δ 163.7, 160.1, 155.6, 2 × 153.8, 149.5, 141.2, 137.8, 132.4, 131.8, 131.8, 129.9, 126.8, 121.3, 115.6, 112.8, 112.0, 108.5, 2 × 107.2, 77.9, 41.4, 2 × 29.4, 2 × 27.7. DART-MS, $C_{26}H_{24}BrO_5$ [M + H]$^+$, *m/z*: 495.0805 (calcd mass for $C_{26}H_{24}BrO_5$, *m/z*: 495.0807), $C_{26}H_{24}{}^{81}BrO_5$ [M + H]$^+$, *m/z*: 497.0784.

3.1.2 Spectral data of compound 1b, 2,2-dimethyl-10-(2-methylbut-3-en-2-yl)-8-oxo-2*H*,8*H*-pyrano[3,2-*g*]chromen-5-yl 3-chlorobenzoate

Nordentatin (107.4 mg, 0.3442 mmol), 3-chlorobenzoyl chloride (90.3 mg, 0.5163 mmol), yield 74.9%, λ_{max} (log ε) 340 (0.772), 268 (1.703), 233 (1.952), 233 (1.952). M.p. 173–174°C. FT-IR 3,080, 2,964, 2,922, 2,852, 1,743, 1,724, 1,620, 1,602, 1,554 cm^{-1}. ^1H NMR (chloroform-*d*, 600 MHz) δ 8.33 (1H, dd, J = 6.9, 2.1 Hz), 8.16 (1H, ddd, J = 8.5, 4.5, 2.2 Hz), 2 × 7.52 (1H, d, J = 9.7 Hz), 7.34 (1H, t, J = 8.5 Hz), 6.33 (1H, dd, J = 17.4, 10.6 Hz), 6.24 (1H, d, J = 10.0 Hz), 6.20 (1H, d, J = 9.7 Hz), 5.71 (1H, d, J = 10.0 Hz), 4.98 (1H, d, J = 17.4 Hz), 4.92 (1H, m), 1.70 (6H, s), 1.48 (6H, s). ^{13}C NMR data (see the supplementary material). DART-MS, $C_{26}H_{24}ClO_5$, m/z: 451.1313 [M + H]$^+$ (calcd mass for $C_{26}H_{24}ClO_5$, m/z: 451.1312), $C_{26}H_{24}{}^{37}ClO_5$ [M + H]$^+$, m/z: 453.1286.

3.1.3 Spectral data of compound 1c, 2,2-dimethyl-10-(2-methylbut-3-en-2-yl)-8-oxo-2*H*,8*H*-pyrano[3,2-*g*]chromen-5-yl 2-chloro-4-nitrobenzoate

Nordentatin (115.6 mg, 0.3686 mmol), 2-chloro,4-nitrobenzoyl chloride (121.6 mg, 0.5500 mmol), yield 43.6%. UV (MeOH), λ_{max} (log ε) 340 (0.509), 267 (1.468). M.p. 197–198°C. FT-IR 3,105, 3,088, 2,995, 2,968, 2,933, 1,762, 1,720, 1,618, 1,535 cm^{-1}. ^{1}H NMR (chloroform-d, 600 MHz) δ 8.45 (1H, m), 8.29 (2H, d, J = 1.0 Hz), 7.60 (1H, d, J = 9.7 Hz), 6.32 (2H, m), 6.24 (1H, d, J = 9.7 Hz), 5.76 (1H, d J = 9.7 Hz), 4.98 (1H, dd, J = 17.4, 0.9 Hz), 4.92 (1H, dd, J = 10.6, 0.9 Hz), 1.70 (6H, s), 1.49 (6H, s). ^{13}C NMR data (see the supplementary material). DART-MS, $C_{26}H_{23}ClNO_7$, m/z: 496.1162 [M + H]$^+$ (calcd mass for $C_{26}H_{23}ClNO_7$, m/z: 496.1163), $C_{26}H_{23}{}^{37}ClNO_7$ [M + H]$^+$, m/z: 498.1129.

3.1.4 Spectral data of compound 1d, 2,2-dimethyl-10-(2-methylbut-3-en-2-yl)-8-oxo-2*H*,8*H*-pyrano[3,2-*g*]chromen-5-yl 3-chloro-4-fluorobenzoate

Nordentatin (108.2 mg, 0.3467 mmol), 3-chloro-4-fluorobenzoyl chloride (100.3 mg, 0.5201 mmol), yield 54.5%. UV (MeOH), λ_{max} (log ε) 340 (0.772), 268 (1.703), 233 (1.952), 233 (1.952). M.p. 173–174°C. FT-IR 3,086, 3,049, 2,970, 2,935, 2,922, 1,747, 1,720, 1,618, 1,598, 1,548 cm^{-1}. ^{1}H NMR (chloroform-d, 600 MHz) δ 8.33 (1H, dd, J = 6.9, 2.1 Hz), 8.16 (1H, ddd, J = 8.5, 4.5, 2.2 Hz), 7.52 (1H, d, J = 9.7 Hz), 7.34 (1H, t, J = 8.5 Hz), 6.33 (1H, dd, J = 17.4, 10.6 Hz), 6.24 (1H, d, J = 10.0 Hz), 6.20 (1H, d, J = 9.7 Hz), 5.71 (1H, d, J = 10.0 Hz), 4.98 (1H, d, J = 17.4 Hz), 4.94–4.90 (1H, m), 1.70 (6H, s), 1.48 (6H, s). ^{13}C NMR data (see the supplementary material). DART-MS, $C_{26}H_{23}ClFO_5$, m/z: 469.1221 [M + H]$^+$ (calcd mass for $C_{26}H_{23}ClFO_5$, m/z: 469.1218), $C_{26}H_{23}{}^{37}ClFO_5$ [M + H]$^+$, m/z: 471.1191.

3.1.5 Spectral data of compound 1e, 2,2-dimethyl-10-(2-methylbut-3-en-2-yl)-8-oxo-2*H*,8*H*-pyrano[3,2-*g*]chromen-5-yl 3-bromobenzoate

Nordentatin (104.8 mg, 0.3358 mmol), 3-bromo-benzoyl chloride (110.5 mg, 0.5037 mmol), yield 93.5%. UV (MeOH), λ_{max} (log ε) 340 (0.782), 268 (1.811), 209 (4.0). M.p. 127–128°C. FT-IR, 3,080, 2,964, 2,935, 2,883, 1,741, 1,724, 1,620, 1,602, 1,554 cm^{-1}. ^{1}H NMR (chloroform-d, 600 MHz) δ 8.32 (1H, dd, J = 1.7 Hz), 8.12 (1H, dt, J = 7.8, 1.3 Hz), 7.90 (1H, ddd, J = 8.0, 2.0, 1.0 Hz), 7.54 (1H, d, J = 9.7 Hz), 7.41 (1H, dt, J = 7.9 Hz), 6.33 (1H, dd, J = 17.4, 10.6 Hz), 6.26 (1H, d, J = 10.0 Hz), 6.21 (1H, d, J = 9.7 Hz), 5.70 (1H, d, J = 10.0 Hz), 4.98 (1H, dd, J = 17.4, 1.0 Hz), 4.92 (1H, dd, J = 10.6, 1.0 Hz), 1.70 (6H, s), 1.48 (6H, s). ^{13}C NMR data (see the supplementary material). DART-MS, $C_{26}H_{24}BrO_5$, m/z: 495.0802 [M + H]$^+$ (calcd mass for $C_{26}H_{24}BrO_5$, m/z: 495.0807), $C_{26}H_{24}{}^{81}BrO_5$ [M + H]$^+$, m/z: 497.0779.

3.1.6 Spectral data of compound 1f, 2,2-dimethyl-10-(2-methylbut-3-en-2-yl)-8-oxo-2*H*,8*H*-pyrano[3,2-*g*]chromen-5-yl 4-butylbenzoate

Nordentatin (113.6 mg, 0.3467 mmol), 4-butylbenzoyl chloride (107.4 mg, 0.5461 mmol), yield 37%. UV (MeOH), λ_{max} (log ε) 349 (0.79), 257 (2.87), 231 (1.0). M.p. 77–78°C. ^{1}H NMR (chloroform-d, 600 MHz), δ 2 × 8.16 (1H, d, J = 8.3 Hz), 7.57 (1H, d, J = 9.7 Hz), 2 × 7.37 (1H, d, J = 8.3 Hz), 6.34 (1H, dd, J = 17.4, 10.6 Hz), 6.17 (1H, d, J = 9.7 Hz), 5.67 (1H, d, J = 10.0 Hz), 4.98 (1H, dd, J = 17.4, 1.0 Hz), 4.91 (1H, dd, J = 10.6, 1.0 Hz), 2.79–2.67 (2H, m), 1.70 (6H, s), 1.67 (4H, tt, J = 8.9, 7.6 Hz), 1.47 (6H, s), 1.40 (2H, dq, J = 14.7, 7.4 Hz), 0.96 (3H, t, J = 7.4 Hz). ^{13}C NMR data (see the supplementary material). DART-MS, $C_{30}H_{33}O_5$, m/z 473.2328 [M + H]$^+$ (calcd mass for $C_{30}H_{33}O_5$, m/z: 473.2328).

3.1.7 Spectral data of compound 1g, 2,2-dimethyl-10-(2-methylbut-3-en-2-yl)-8-oxo-2*H*,8*H*-pyrano[3,2-*g*]chromen-5-yl 2,4,6-trichlorobenzoate

Nordentatin (107.6 mg, 0.3448 mmol), 2,4,6-trichlorobenzoyl chloride (126.1 mg, 0.5172 mmol) yield 90%. UV (MeOH), λ_{max} (log ε, MeOH), 349 (0.396), 267 (0.949), 259 (0.868). M.p. 149–150°C. FT-IR 3,093, 3,078, 2,999, 2,980, 2,929, 1,762, 1,728, 1,614, 1,600, 1,579, 1,550 cm^{-1}. ^{1}H NMR (chloroform-d, 600 MHz), δ 7.93 (1H, d, J = 9.7 Hz), 7.50 (2H, s), 6.65 (1H, d, J = 10.0 Hz), 6.32 (1H, dd, J = 17.4, 10.6 Hz), 6.24 (1H, d, J = 9.7 Hz), 5.77 (1H, d, J = 10.0 Hz), 4.97 (1H, dd, J = 17.4, 0.9 Hz), 4.91 (1H, dd, J = 10.6, 1.0 Hz), 1.70 (6H, s), 1.49 (6H, s). ^{13}C NMR data (see the supplementary material). DART-MS, $C_{26}H_{22}Cl_3O_5$, m/z: 519.0536 [M + H]$^+$ (calcd mass for $C_{26}H_{22}Cl_3O_5$, m/z: 519.0533), $C_{26}H_{22}{}^{37}ClCl_2O_5$ [M + H]$^+$, *m/z*: 521.0505, $C_{26}H_{22}{}^{37}Cl_2ClO_5$ [M + H]$^+$, *m/z:* 523.0471, $C_{26}H_{22}{}^{37}Cl_3O_5$ [M + H]$^+$, *m/z*: 525.0438.

3.1.8 Spectral data of compound 1h, 2,2-dimethyl-10-(2-methylbut-3-en-2-yl)-8-oxo-2*H*,8*H*-pyrano[3,2-*g*]chromen-5-yl 3-(trifluoromethyl)benzoate

Nordentatin (110.7 mg, 0.3548 mmol), 3-(trifluoromethyl)benzoyl chloride (110.9 mg, 0.5322 mmol), yield 65.4%. UV (MeOH), λ_{max} ($\log \varepsilon$) 352 (1.078), 272 (3.769), 228 (4.0), 209 (2.085). M.p. 77–78°C. FT-IR 3,095, 3,080, 2,966, 2,937, 2,924, 2,883, 1,747, 1,728, 1,620, 1,602, 1,552 cm^{-1}. ^{1}H NMR (chloroform-*d*, 600 MHz) δ 8.51 (1H, s), 8.45 (1H, d, *J* = 7.8 Hz), 7.98 (1H, d, *J* = 7.9 Hz), 7.74 (1H, t, *J* = 7.8 Hz), 7.54 (1H, d, *J* = 9.7 Hz), 6.34 (1H, dd, *J* = 17.4, 10.6 Hz), 6.26 (1H, d, *J* = 10.0 Hz), 6.20 (1H, d, *J* = 9.7 Hz), 5.71 (1H, d, *J* = 10.0 Hz), 5.02–4.96 (1H, m), 4.95–4.89 (1H, m), 1.71 (6H, s), 1.48 (6H, s). ^{13}C NMR data (see the supplementary material). DART-MS, $C_{27}H_{24}F_3O_5$, *m/z*: 485.1571 [M + H]$^+$ (calcd mass for $C_{27}H_{24}F_3O_5$, *m/z*: 485.1576).

3.1.9 Spectral data of compound 1i, 2,2-dimethyl-10-(2-methylbut-3-en-2-yl)-8-oxo-2*H*,8*H*-pyrano[3,2-*g*]chromen-5-yl 3,5-bis(trifluoromethyl)benzoate

Nordentatin (103.6 mg, 0.33205 mmol), 3,5-bis(trifluoromethyl)benzoyl chloride (121.6 mg, 0.5500 mmol), yield 41%. UV (MeOH), λ_{max} ($\log \varepsilon$) 349 (0.79), 257 (2.87), 231 (1.0). M.p. 186–187°C. FT-IR 3,089, 3,066, 2,999, 2,981, 2,937, 1,759, 1,737, 1,620, 1,604, 1,552 cm^{-1}. ^{1}H NMR (chloroform-*d*, 600 MHz) δ 8.69 (2H, s), 8.22 (1H, s), 7.51 (1H, d, *J* = 9.7 Hz), 6.33 (1H, dd, *J* = 17.4, 10.6 Hz), 6.23 (1H, d, *J* = 10.0 Hz), 6.21 (1H, d, *J* = 9.7 Hz), 5.73 (1H, d, *J* = 10.0 Hz), 4.99 (1H, dd, *J* = 17.4, 0.8 Hz), 4.93 (1H, dd, *J* = 10.6, 0.9 Hz), 1.71 (6H, s), 1.49 (6H, s). ^{13}C NMR data (see the supplementary material). DART-MS $C_{28}H_{23}F_6O_5$, *m/z*: 553.1440 [M + H]$^+$ (calcd mass for $C_{28}H_{23}F_6O_5$, *m/z*: 553.1450).

3.1.10 Spectral data of compound 1j, 2,2-dimethyl-10-(2-methylbut-3-en-2-yl)-8-oxo-2*H*,8*H*-pyrano[3,2-*g*]chromen-5-yl 4-iodobenzoate

Nordentatin (103.0 mg, 0.3301 mmol), 4-iodobenzoyl chloride (131.8 mg, 0.4952 mmol), yield 58%. UV (MeOH), λ_{max} ($\log \varepsilon$) 349 (0.79), 257 (2.87), 231 (1.0). M.p. 156–157°C. FT-IR 3,072, 2,972, 2,927, 2,870, 1,747, 1,730, 1,643, 1,614, 1,587 cm^{-1}. ^{1}H NMR (chloroform-*d*, 600 MHz) δ 7.95 (4H, s), 7.52 (1H, d, *J* = 9.7 Hz), 6.33 (1H, dd, *J* = 17.4, 10.6 Hz), 6.25 (1H, d, *J* = 10.0 Hz), 6.19 (1H, d, *J* = 9.7 Hz), 5.69 (1H, d, *J* = 10.0 Hz), 4.98 (1H, dd, *J* = 17.4, 0.9 Hz), 4.91 (1H, dd, *J* = 10.6, 1.0 Hz), 1.70 (6H, s), 1.47 (6H, s). ^{13}C NMR data (see the supplementary material). DART-MS, $C_{26}H_{24}IO_5$, *m/z*: 543.0667 [M + H]$^+$ (calcd mass for $C_{26}H_{24}IO_5$, *m/z*: 543.0668).

3.2 α-Glucosidase inhibition activity of nordentatin (1) and its derivatives (1a–1j)

All the compounds were evaluated for their inhibitory effect on yeast α-glucosidase (Table 1). Among the modified compounds, **1b**, **1d**, **1e**, **1f**, **1h**, **1i**, and **1j** exhibited a high inhibition of α-glucosidase with IC_{50} values of 1.54, 9.05, 4.87, 20.25, 12.34, 5.67, and 2.43 mM (acarbose 7.57 mM) (Table 1) [23]. The highest inhibition activity was shown when chloride was at the *meta*-position as in **1b**, followed by *para*-substituted iodide (**1j**) and the *meta*-position of bromide (**1e**). They are also comparable with the standard control acarbose. In addition, compounds containing bistrifluoromethane (**1i**), trifluoromethane (**1h**), 3-chloro, 5-fluoro (**1d**), and *para*-butyl groups (**1f**) showed higher activity than nordentatin (**1**) with an IC_{50} value of 36.7 mM. Based on this study, we can conclude that the activity of some compounds increased after modification, while that of some compounds decreased, e.g., **1a**, **1c**, and **1g** showed no inhibition.

Table 1: Results of α-glucosidase inhibition assay of derivatives **1a–1j**

Compound no.	IC_{50} (mM) Yeast α-glucosidase
1a	NI*
1b	1.54
1c	NI*
1d	9.05
1e	4.87
1f	20.25
1g	NI*
1h	12.34
1i	5.67
1j	2.43
1	36.7
Acarbose (std)	7.57

NI* = no inhibition at concentration ≤ 5 mg/mL

Table 2: Investigation of the cytotoxicity of the modified compounds (**1a–1j**) against HeLa and T47D cell lines

Compound name	IC_{50} (mM)	
	HeLa	T47D
1a	0.45	0.10
1b	0.39	0.04
1c	0.40	0.24
1d	0.28	0.11
1e	0.59	0.12
1f	1.25	1.57
1g	0.52	0.41
1h	0.34	0.38
1i	0.25	0.24
1j	0.35	0.23
1	0.61	0.04
Doxorubicin	$0.\ 4 \times 10^{-2}$	0.6×10^{-4}

3.3 Cytotoxic activity of nordentatin (1) and modified compounds (1a–1j) against HeLa and T47D cell lines

The cytotoxicity of all modified compounds was tested against a HeLa cell line, and their IC_{50} values were compared with those of nordentatin (**1**) and the standard control doxorubicin (Table 2). All tested compounds showed low activity with IC_{50} values ranging from 0.25 to 1.25 mM against HeLa cells.

However, the results indicated that the modified compounds that contain fluorobenzoyl groups (**1i**, **1d**, **1h**, and **1b**) have more cytotoxic activity than others and nordentatin (**1**). On the other hand, the activity of compounds **1j**, **1c**, **1a**, **1g**, **1e,** and **1f** was lower (Table 2). The investigation of cell proliferation of modified compounds was also performed on a T47D cell line (Table 2). The results revealed that the modified compounds have moderate to low inhibition against the cancer cell line with the IC_{50} values ranging from 0.043 to 1.57 mM, but their activity was lower than the activity of the parent compound, nordentatin (**1**) with an IC_{50} value of 0.041 mM (Table 2). The structure–activity relationship study showed that the modified compounds with chloro and bromo compounds at *meta* and *para* positions had stronger inhibition than others.

4 Conclusions

In the current work, we continue our previous research concerning bioactive secondary metabolites from natural medicinal plants and their derivatives. As a result, ten new pyranocoumarin benzoate derivatives were semi-synthesized in good to excellent yields from natural nordentatin (**1**) by an acylation method. Both parent and modified compounds were tested for their antidiabetic activity by an α-glucosidase assay and anticancer activity (HeLa and T47D cell lines) by an MTT assay. Among the tested compounds, modified compound **1b** showed the highest inhibition activity against yeast α-glucosidase enzymes, in particular 5 times higher than that of acarbose and 20 times higher than that of the parent compound, nordentatin (**1**). Among the tested compounds, modified compound **1i** showed the highest cytotoxic activity against the HeLa cell line. Compound **1b** showed a moderate cytotoxic activity against T47D but it was less effective than the parent compound, nordentatin (**1**). As a result of this study, we can conclude that some modified compounds are promising, since their activity is comparable with that of standard drugs. Especially, active compound **1b**, 2,2-dimethyl-10-(2-methylbut-3-en-2-yl)-8-oxo2*H*,8*H*-pyrano[3,2-*g*] chromen-5-yl-3-chlorobenzoate, should be studied as a potential alternative α-glucosidase inhibitor.

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References

[1] Kongkathip N, Kongkathip B. Constituents and bioactivities of *Clausena excavata*. Heterocycles. 2009;79(C):121–44.
[2] Thant TM, Aminah NS, Kristanti AN, Ramadhan R, Phuwapraisirisan P, Takaya Y. A new pyrano coumarin from *Clausena excavata* roots displaying dual inhibition against α-glucosidase and free radical. Nat Prod Res. 2019; 1–6.
[3] Takemura Y, Nakamura K, Hirusawa T, Ju-ichi M, Ito C, Furukawa H. Four new furanone-coumarins from Clausena excavata. Chem Pharm Bull (Tokyo). 2000;48(4):582–4.
[4] Taufiq-Yap YH, et al. A new cytotoxic carbazole alkaloid from *Clausena excavata*. Nat Prod Res. 2007;21(9):310–3.
[5] Kumar R, Saha A, Saha D. A new antifungal coumarin from *Clausena excavata*. Fitoterapia. 2012;83(1):230–3.

[6] Lipeeva AV, et al. Design, synthesis and antibacterial activity of coumarin-1,2,3-triazole hybrids obtained from natural furocoumarin peucedanin. 2019;24:1–23.
[7] Davorka Z, Muratovic S, Makuc D, Plavec J, Cetina M, Nagl A, et al. Benzylidene-bis-(4-hydroxycoumarin) and benzopyrano-coumarin derivatives: synthesis, 1H/13C-NMR conformational and X-ray crystal structure studies and *in vitro* antiviral activity evaluations. Molecules. 2011;16(7):6023–40.
[8] Noipha K, Thongthoom T, Songsiang U, Boonyarat C, Yenjai C. Carbazoles and coumarins from *Clausena harmandiana* stimulate glucose uptake in L6 myotubes. Diabetes Res Clin Pract. 2010;90(3):67–71.
[9] Flores-Bocanegra L, González-Andrade M, Bye R, Linares E, Mata R. α-Glucosidase inhibitors from *Salvia circinata*. J Nat Prod. 2017;80(5):1584–93.
[10] Gothai S, Ganesan P, Park SY, Fakurazi S, Choi DK, Arulselvan P. Natural phyto-bioactive compounds for the treatment of type 2 diabetes: Inflammation as a target. Nutrients. 2016;8(8):461–38.
[11] Bathula C, Mamidala R, Thulluri C, Agarwal R, Jha KK, Munshi P, et al. Substituted furopyridinediones as novel inhibitors of α-glucosidase. RSC Adv. 2015;5:90374–85.
[12] Du ZY, et al. α-Glucosidase inhibition of natural curcuminoids and curcumin analogs. Eur J Med Chem. 2006;41(2):213–8.
[13] Taha M, et al. Synthesis of novel triazinoindole-based thiourea hybrid: a study on α-glucosidase inhibitors and their molecular docking. Molecules. 2019;24:1–16.
[14] Zhao X, et al. Resveratroloside alleviates postprandial hyperglycemia in diabetic mice by competitively inhibiting α-glucosidase. J Agric Food Chem. 2019;67(10):2886–93.
[15] Santana FR, et al. Evaluation of the cytotoxicity on breast cancer cell of extracts and compounds isolated from *Hyptis pectinata* (L.) poit. Nat Prod Res. 2020;34(1):102–9.
[16] Potikanond S, et al. *Kaempferia parviflora* extract exhibits anti-cancer activity against HeLa cervical cancer cells. Front Pharmacol. 2017;8(Sep):1–12.
[17] Chattopadhyay S, Bisaria VS, Panda AK, Srivastava AK. Cytotoxicity of in vitro produced podophyllotoxin from *Podophyllum hexandrum* on human cancer cell line. Nat Prod Res. 2004;18(1):51–7.
[18] Novakovic M, Simic S, Koracak L, Zlatovic M, Ilic-Tomic T, Asakawa Y, et al. Chemo- and biocatalytic esterification of marchantin A and cytotoxic activity of ester derivatives. Fitoterapia. 2020;142:104520.
[19] Wu CZ, et al. Synthesis and evaluation of bakuchiol derivatives as potential anticancer agents. Molecules. 2018; 23(3):1–12.
[20] Pena MJ, Botubol-Ares JM, nJames Hanson R, Galan RH, Collado IG. Efficient o-acylation of alcohols and ohenol using Cp2TiCl as a reaction promoter. Eur J Org Chem. 2016;2016(21):3584–91.
[21] Ramadhan R, Worawalai W, Phuwapraisirisan P. New onocer-anoid xyloside from *Lansium parasiticum*. Nat Prod Res. 2019;33(20):2917–24.
[22] Suwito H, Hardiyanti HD, Ul Haq K, Kristanti AN, Khasanah M. (*E*)-3-[3-(4-Morpholinophenyl)acryloyl]-2*H*-chromen-2-one. Molbank. 2018;2018(4):1–5.
[23] Choi CW, et al. Yeast α-glucosidase inhibition by isoflavones from plants of leguminosae as an in vitro alternative to acarbose. J Agric Food Chem. 2010;58(18):9988–93.

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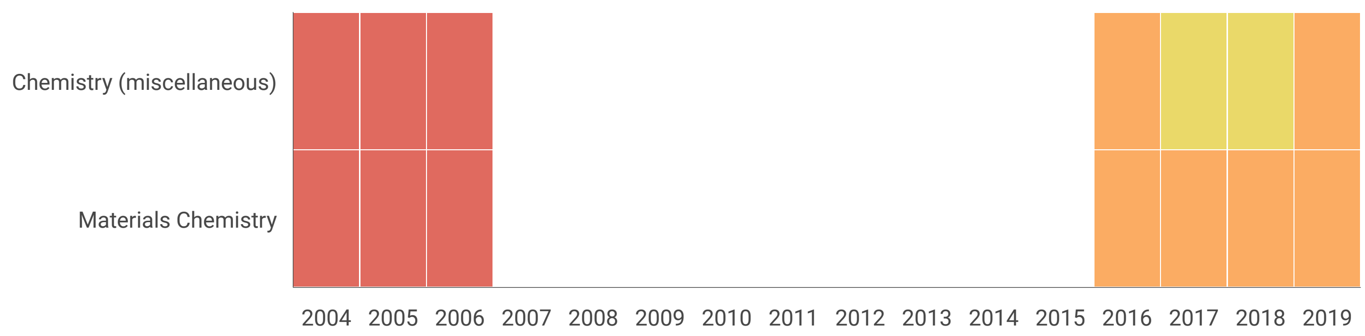

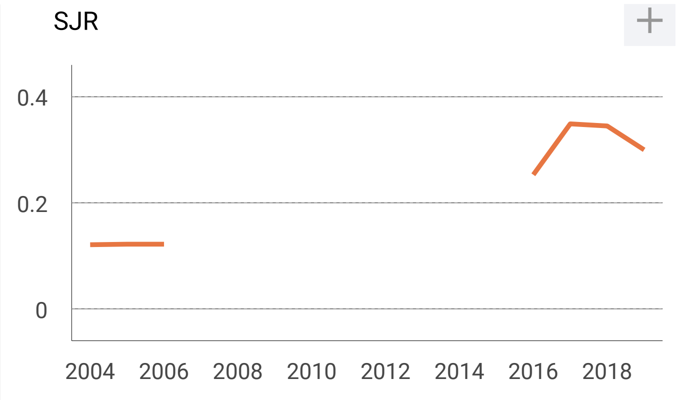

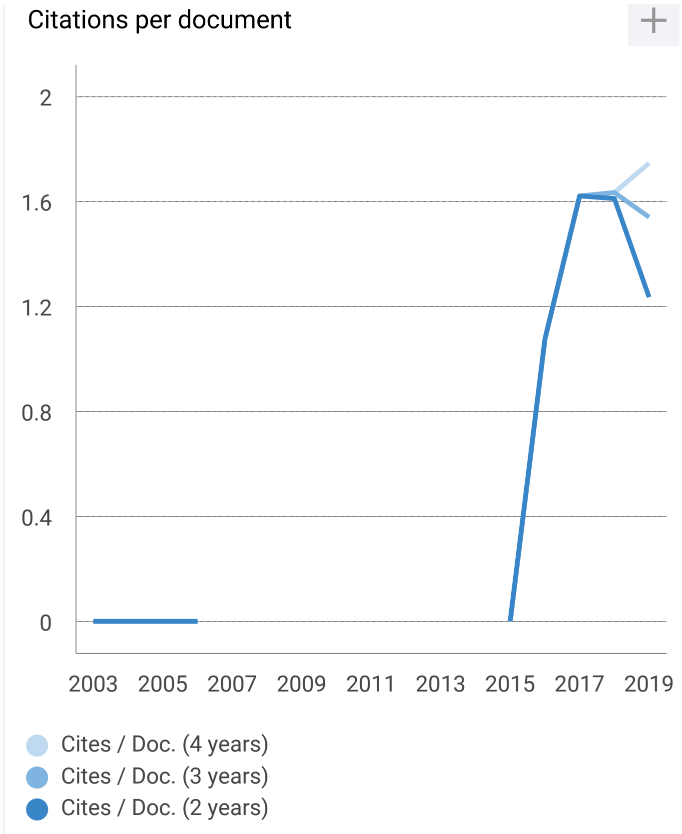

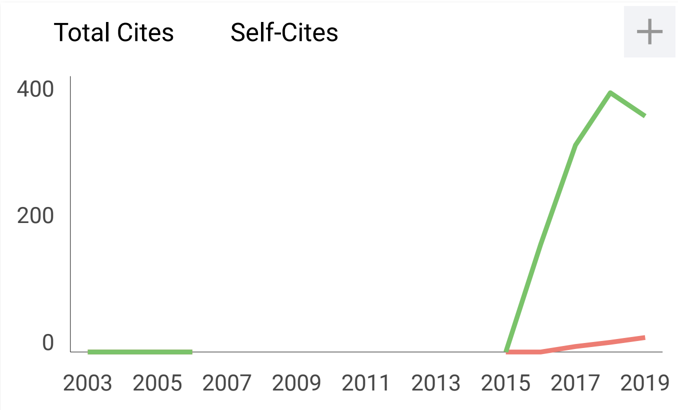

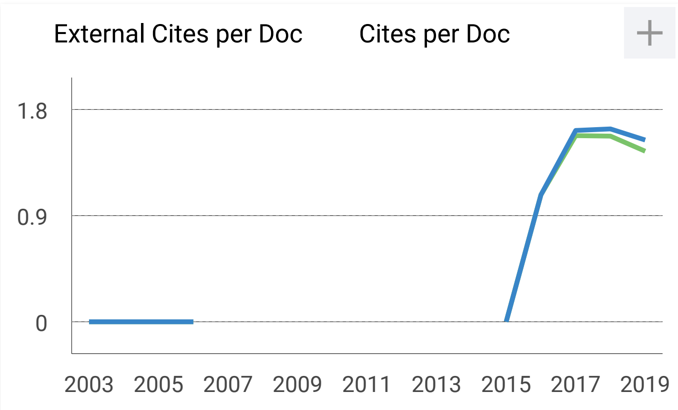

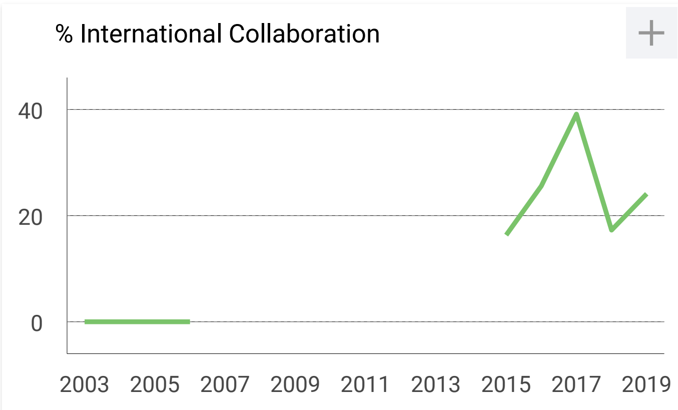

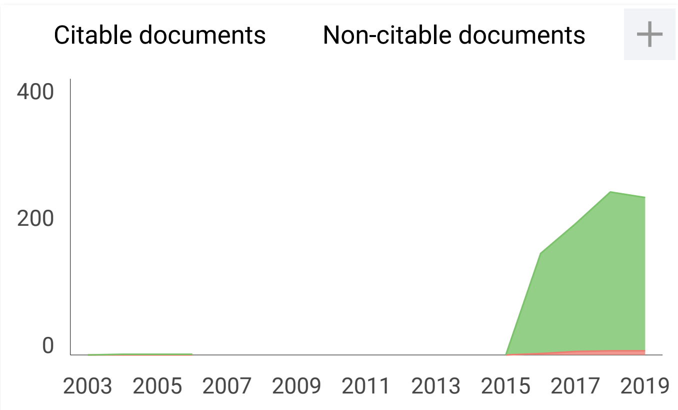

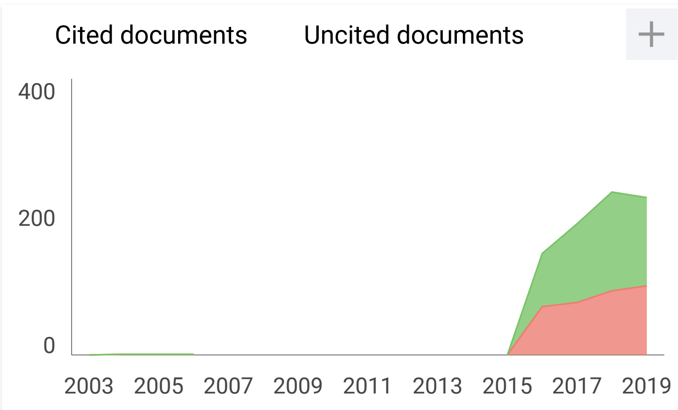

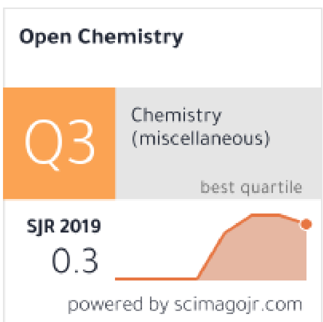

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