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A Bioinformatics Research of Active Compounds Curcuma xanthorriza in Arthritis Disease

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ABSTRACT

Curcuma xanthorriza roxb. or commonly known as ginger is a plant that grows in the tropics which is known as a million benefits plant, one of which is for the treatment of Arthritis. The main active compounds that act as anti-inflammatory which refer to arthritis are curcumin and demethoxycurcumin. The purpose of this study was to analyze the active compounds contained in ginger which play an important role in the treatment of arthritis. Bioinformatics analysis was carried out using the ChemOffice 2016 software using the molecular mechanics method. The 2-dimensional structure analysis uses the ChemDraw program, while the 3-dimensional structure analysis uses the Chem3D program. From the data optimization results using the molecular mechanics method, the following results are obtained: The total energy produced in the compounds curcumin, d-camphor, demethoxycurcumin, p-tolymethilcarbinol, starch, respectively 17.4573 kcal / mol; 29,2006 kcal / mol; 13.8948 kcal / mol; -0.6574 kcal / mol; and 29,6089 kcal / mol. Based on the research data obtained, it can be concluded that the active compounds curcumin and demethoxycurcumin are compounds that act as anti-inflammatory triggers for arthritis. It is proven that the results of the MM2 method are in accordance with the related theory.
Keyword: curcuma, anti-inflammatory, molecular mechanics, curcumin, demethoxycurcumin..

Keywords: Anti-inflammatory; Curcuma; Curcumin, Demethoxycurcumin; Molecular mechanics

1. INTRODUCTION

Temulawak is a type of medicinal plant that is very well known in Indonesia or other tropical areas which is usually used as a spice in the kitchen. In biology, ginger is a family Zingiberaceae and one of its genera is Curcuma [1] [2]. Curcuma xanthorrizha (temulawak) is a medicinal plant that is thought to be able to prevent joint pain, known as arthritis [3-5]. There are 3 main ingredients in ginger including starch, curcuminoids and essential oils [6]. Chemical content that is directly related to joint pain is curcuminoids in which there are 3 active compounds, namely curcumin, demethoxycurcumin and bisdemethoxycurcumin [7-9].

Inflammation is a body's protective response to reduce and eliminate triggers for an injury or infection that usually harms the body [23]. Not only as anti-inflammatory alone, other functions of curcuma are also used as antioxidants [10-13], anticancer [14-16], and others. Testing the content of

ginger can be seen through some empirical evidence. Based on the research of Farida Y. et al (2018), ginger extraction using the protein denaturation method shows that the content in ginger has an anti-inflammatory function [24][25]. Not only that, research by Liang et al. (1985) in the writings of Srijanto (2004) also showed that curcumin is useful for relieving joint pain. Another evidence for content that plays a proven role in the research of Sidik, et al (2016), that the content in curcuminoids that act as anti-inflammatory is curcumin (58-71%) and demethoxycurcumin (29-42%) [17].

This study aims to analyze the potential of the active compounds contained in ginger as an anti-inflammatory. The analytical method used is molecular mechanics which will be analyzed using the ChemDraw and Chem3D applications, to get the results before and after optimization so that it can be seen how the changes in the position of each atom in the active compound of temualwak. Molecular mechanics is an empirical method that is useful for expressing the potential energy produced by a molecule as a geometric variable [26-30].

2. LITERATURE REVIEW

2.1 Arthritis Disease

Arthritis is the combined name for more than 100 diseases that all of which are characterized by pain, swelling, and muscle stiffness with impaired function of locomotion (joints and muscles). The most found is atrose (Arthritis deformans), generally without inflammation, then rheumatism (Arthritis rheumatica) with inflammation, spondylosis with inflammation of the spine, Reiter's syndrome (with inflammation of the kidneys and eye membranes), and gout. Other diseases found include acute rheumatism (arthritis) and rheumatism of the soft parts, which rest on the cartilage in other parts body. Arthritis pain can come from different sources. This includes inflammation of the synovial membrane (tissue in the form of joints), tendons, or joint bonding, muscle tension, and fatigue. A combination of these factors contribute to the intensity of pain [18].

In 1999, arthritis in the United States topped the rankings the most suffered by its citizens, namely 17.5%. This figure is way above a dangerous disease that is considered the number 1 killer in the world, namely heart disease which is ranked 3rd with a percentage of 7.8% (Anonymous, 2005a). The prevalence of arthritis or Chronic Joint Symptoms (CJS) among adults by gender in 2001, which was 37.3% suffered by women and 28.4% suffered by men (Anonymous, 2005a). on the other hand the prevalence of arthritis or CJS by age, i.e. 65 years and over, is 58.8%, 45-65 years at 42.1%, and 18-44 years at 19.0% [19].

Common symptoms of arthritis usually begin between the ages of 25 and 50 years, although it can occur at any age, even children (rheumatoid juvenile arthritis). The early signs of rheumatoid arthritis are: an inflammatory reaction in the synovial membrane and an increase in the number of synovial cells. Center for Disease Control and Prevention (CDC) an arthritis

foundation and Association of State and Territorial Health Officials, with input from more than 90 organizations, recommends actions in 3 areas for individuals and groups that deal with reducing the effects of arthritis, namely: (1) Research on surveillance, epidemiology, and prevention, (2) Communication and education, (3) Programs, policies and systems. The National Arthritis Action Plan (NAAP), a Public Health Strategy emphasizes broad efforts to reach that population group. This complementary approach to traditional medicine models emphasizes treatment of individuals suffering from arthritis [20]

2.2 Curcuma

Temulawak (Curcuma xanthorrhiza) is a native medicinal plant Indonesia, also known as Curcuma javanica. Curcuma is a plant native to Indonesia which later spread to Malaysia,Thailand, Vietnam, Burma, India and the Philippines. Spread of ginger closely related to the movement or mobility of the population, especially ethnic groups Java. The temulawak development area in Indonesia covers 13 provinces, namely: North Sumatra, Riau, Jambi, Jakarta, West Java, Central Java, Yogyakarta, East Java, Bali, West Kalimantan, East Kalimantan, North Sulawesi and South Sulawesi.

Temulawak has been used in the medicinal industry as herbs, herbs standardized and phytopharmaca drugs, in Indonesia and abroad. Needs Temulawak for the traditional medicine industry ranks first in Java East and ranks second in Central Java after ginger.18 Therefore in In 2004, the government through the Food and Drug Administration (POM) launched the National Movement to Drink Temulawak as a drink health [21][22].

3. EXPERIMENTAL

3.1 Preparation

This analysis uses a Lenovo 80JH x64-based PC Intel (R) Core (TM) i7-5500U CPU @ 2.40GHz 2.39GHz 4.00GB RAM, Microsoft Windows 10 Pro 64-bit with internet connection equipped with ChemDraw and Chem3D software.

ChemDraw Professional 16.0 program for creating 2-dimensional structures and determining the physical chemistry of active compounds in curcuma, Chem3D 16.0 program for creating 3-dimensional structures and optimization of structures using molecular mechanics force fields (MM2). The web server used is http://catalytic.ppj.unp.ac.id/index.php/jurnal,https://phytochem.nal.usda.gov/phytochem, https: //pubchem.ncbi.nlm.nih. gov /, http://swisstargetprediction.ch/.

The compounds to be analyzed in this study are curcumin, demethoxycurcumin, d-camphor, p-tolymethilcarbinol and starch.

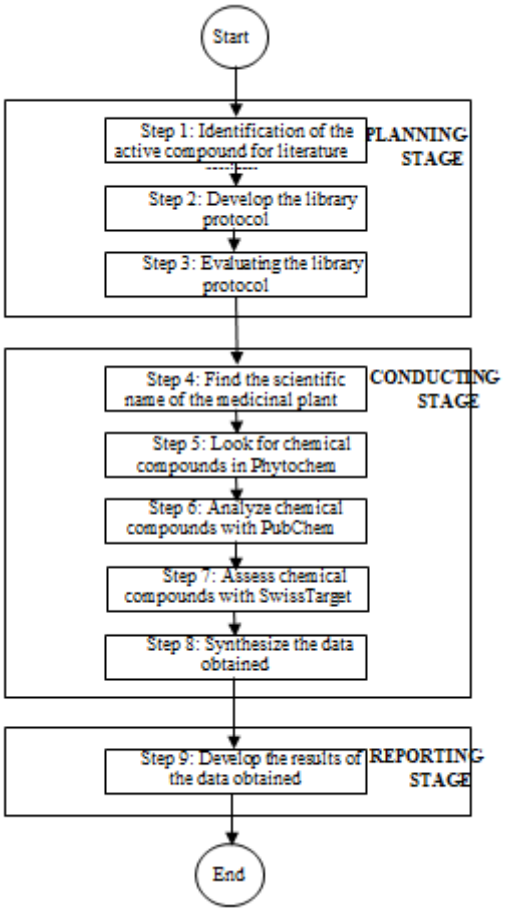

Figure 1. Systematic Review

((Source : Courtesy of Arinda Frissherlya, *et al)*

3.2 Implementation

The study in this research was carried out by computational methods using molecular mechanics as well as structural optimization analysis both before and after. Where the results of this study will be compared with existing theories, the research is included in applied research. The research was started by collecting various data on active compounds in ginger which had been isolated based on the database on Dr. website. Duke's Phytochemical and Ethnobotanical Databases at NAL (https://phytochem.nal.usda.gov/). Modeling the structure of active compounds is carried out in two ways, namely, downloading in the database on the PubChem website (https://pubchem.ncbi.nlm.nih.gov/) and also created manually in the 2016 ChemOffice program including 2-dimensional and 3-dimensional modeling. There are 5 active compounds selected, which are then performed geometry optimization in the 2016 ChemOffice software using the MM2 (Molecular Mechanics) method to find the most stable structure by knowing the value of Activation Energy after and before optimization, as well as seeing the bond interactions between atoms both before and after optimization. .

This research was conducted in several stages, namely: (1) Finding the ginger compound content with Phytochemicals, Pubchem and SwissTarget; (2) Two-dimensional analysis of Temulawak compounds using ChemDraw; (3) Analysis of Temulawak compounds through mechanical molecular dynamics; and (3) Analysis of atomic or molecular interactions on Temulawak compounds using Chem3D. In 3D analysis is done by converting 2D molecules into Chem3D. In the Chem3D program, each curcumin compound's structure into 3 dimensions and conditions can be analyzed prior to optimization. It's like measuring the distance between atoms and measuring the angle between the atoms. This Chem3D application is used for modeling 3D structures and data processing of molecular mechanics methods. Steps to use the Chem3D application: first, open the Chem3D program, then type the Chem / SMILES tab on the ChemDraw-LiveLink tab, type SMILES for each compound to be analyzed (Isomeric / Canonical), then the 2D and 3D structure of the compound will appear . Then click Minimize Energy and Computing Properties on the Calculations tab in the MM2 section. MM2 calculation results will be displayed on the Output tab. To see the value of A (length of each atom) can be viewed by clicking the Measurement tab; Generate All Bond Lengths on the Structure tab. The results can be seen in the eleven left tabs (adjacent to the 3D structure). Then all data from MM2 results can be transferred to the research data table that has been prepared previously.

4. RESULTS AND DISCUSSION

Predictions of the physical and chemical properties of 5 active compounds in ginger such as boiling point, melting point, critical temperature, critical pressure, Gibss energy, Log P, Molecular weight, Molar refractivity, Polar surface area, and pKa can be seen in table 3 below.

Table 1 Physical and Chemical Properties of Active Compounds

	Curcumin	D-Camphor	Demethoxy Curcumin	p-Tolymethil carbinol	Starch
Boiling point (K)	794,503	477,064	770.85	499,404	864,835
Melting point (K)	761.41	346.1	715.39	275.45	767.27
Critical Temperature (K)	982,702	695,083	963,116	688.49	1196,401
Critical Press (Bar)	22,504	30.83	25,508	36,029	43,112
Gibbs Energy (KJ / mol)	-285.14	1.44	-178.93	-11.58	-1334.42
Log P	2,561	2,457	2,688	1,789	-4,118
Molecular Weight (g / mol)	368,385	152,237	338,359	136,194	342,297

Molar Refractivity (cm3 / mol)	10,615	44,492	97,006	42,333	68,337
Polar Surface Area (PSA)	93.06	17.07	83.83	20.23	189.53
pKa	8.86	-	9.20	14,266	15,873

(Source : Courtesy of Arinda Frissherly, *et al)*

Geometry optimization is a process to obtain the most stable conformation by calculating its energy until the minimum energy is reached. Optimization was carried out using the molecular mechanics method (MM2) with the ChemOffice 2016 program. In this study, the optimization method chosen was the MM2 method, although this method can be said to be less accurate, but because the data from the optimization results are quite easy to compare, this method can be used. Predictions of the physicochemical properties of the tested active compounds can be seen in Table 3 above. The active compound with the lowest boiling point is D-Camphor and the highest is Starch. The boiling point is the temperature at which the vapor pressure is equal to the overall pressure experienced by the liquid [25]. The compound with the highest melting point is starch, while the lowest is p-tolymethylcarbinol. The melting point is the temperature at which a solid turns into a liquid [26]. The melting point increases as the molecular weight increases. The critical point of temperature is the temperature at which the compound will not change even though it is under pressure. The lowest critical point is p-tolymethylcarbinol and the highest is starch. Gibbs energy is used to predict whether a compound will run spontaneously or not. If $G < 0$ means it is spontaneous, $G = 0$, it is in equilibrium and $G > 0$, it is not spontaneous [25]. Compounds other than d-camphor (curcumin, demethoxycurcumin, p-tolymethylcarbinol, starch) occur spontaneously while d-camphor is not spontaneous. The requirement for a compound to be classified as a good active compound is to have a molecular mass of <500 g/mol, log $P < 5$, which is Lipinski's rule [27]. All of these compounds meet Lipinski's rules which are classified as active compounds that are good for treating arthritis. From the Minimize Energy data, it can be concluded that curcumin and demethoxycurcumin are the most stable compounds because they have the lowest steric energy compared to d-camphor, p-tolymethylcarbinol and starch compounds. Detection device system are useful for the driver can regain consciousness and focus on the traffic. detection device system using image processing that is used to detect the eyes of the car driver, if the driver detects the data from the image processing will communicate and to a tool called a nozzle, then the nozzle will issue The air sprays into the driver's face slowly and in the driver's seat is also installed a dc motor that can cause a low level of shock to the driver, so that the driver can regain consciousness and focus on the traffic.

5. CONCLUSION

From the results of research conducted using the ChemOffice 2016 program with the molecular mechanics method (MM2), it can be concluded that the active compounds that play a major role in Arthritis disease and anti-inflammatory triggers are curcumin and demethoxycurcumin. This is because the lower the energy (steric and potential energy) produced, the higher the reaction to inflammation, causing these compounds

to trigger arthritis. It can be concluded that this research can be said to be successful and in accordance with the previous theory.

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REFERENCES

[1] Sholihah, PK, Nihayati, E, & ... (2021). Optimization of curcumin temulawak (Curcuma xanthorrizha Roxb.) on calcareous marginal land under teak. IOP Conference Series …, iopscience.iop.org, <https://iopscience.iop.org/article/10.1088/1755-1315/913/1/012004/meta>

[2] KRISTANTO, KA EFEK PROTEKTIF EKSTRAK TEMULAWAK (Curcuma xanthorrizha Roxb.) TERHADAP GINJAL MENCIT YANG DIINDUKSI GENTAMISIN. katalog.ukdw.ac.id, <https://katalog.ukdw.ac.id/4803/>

[3] Hijriani, N, Yusetyani, L, & Hasmono, D (2019). The effect of curcuma (Curcuma xanthorrizha roxb.) extract as an adjuvant of captopril therapy on cardiac histopathology of male mice (Mus musculus) with …. Journal of Basic and Clinical …, degruyter.com, <https://doi.org/10.1515/jbcpp-2019-0280>

[4] Arsya, MR, Utami, PD, & Dikman, I (2019). Pengaruh Pemberian Ekstrak Temulawak (Curcuma Xanthorrizha Roxb.) Terhadap Level Nekrosis pada Jaringan Lien Mencit Putih (Mus Musculus L.) Jantan Galur …. Hang Tuah …, journal-medical.hangtuah.ac.id, <https://journal-medical.hangtuah.ac.id/index.php/jurnal/article/view/57>

[5] Genta, Y (2019). SUPLEMENTASI TEPUNG TEMULAWAK (CURCUMA XANTHORRIZHA ROXB) DAN MINERAL ZINKDALAM RANSUM TERHADAP PERFORMA ITIK SIKUMBANG …., scholar.unand.ac.id, <http://scholar.unand.ac.id/46757/>

[6] Syafitri, F (2018). PENGARUH PENAMBAHAN Spirulina fusiformis DAN KURKUMINOID TEMULAWAK (Curcuma xanthorrizha Roxb) DALAM RANSUM TERHADAP ….

[7] Wulandari, T, & Aznam, N (2018). Uji Efek Analgetik Temulawak Instan (Curcuma Xanthorrizha Roxb) Pada Mencit Jantan Dengan Metode Geliat. Jurnal Kimia Dasar

[8] Cahyono, B, Ariani, J, Failasufa, H, Suzery, M, Susanti, S, & ... (2019). Extraction of homologous compounds of curcuminoid isolated from temulawak (Curcuma xanthorriza roxb.) plant., doc-pak.undip.ac.id, <http://doc-pak.undip.ac.id/1841/1/peer_RJC_12_1.pdf>

[9] Widyastuti, I, Luthfah, HZ, Hartono, YI, & ... (2021). Antioxidant activity of temulawak (Curcuma xanthorrhiza Roxb.) and its classification with chemometrics. Indonesian Journal …, pdfs.semanticscholar.org, <https://pdfs.semanticscholar.org/d441/256b18faf89e0f789698fa0b65447342330e.pdf>

[10] Septiana, AT, Handayani, I, & ... (2019). Aktivitas antioksidan dan sifat fisikokimia madu temulawak (curcuma zanthorrhiza roxb) yang ditambah ekstrak jahe (zingiber officinale rosc). Jurnal Aplikasi Teknologi …, ejournal2.undip.ac.id, <https://ejournal2.undip.ac.id/index.php/jatp/article/view/4849>

[11] Sari, KP EKSTRAKSI KURKUMIN DARI RIMPANG TEMULAWAK (Curcuma xanthorrhiza Roxb) SEBAGAI ANTIOKSIDAN MENGGUNAKAN PELARUT ETANOL. researchgate.net, <https://www.researchgate.net/profile/Kharisma-Sari/publication/325319520_EKSTRAKSI_KURKUMIN_DARI_RIMPANG_TEMULAWAK_Curcuma_xanthorrhiza_Roxb_SEBAGAI_ANTIOKSIDAN_MENGGUNAKAN_PELARUT_ETANOL/links/5b055e08a6fdcc8c252283e0/EKSTRAKSI-KURKUMIN-DARI-RIMPANG-TEMULAWAK-Curcuma-xanthorrhiza-Roxb-SEBAGAI-ANTIOKSIDAN-MENGGUNAKAN-PELARUT-ETANOL.pdf>

[12] LESTARI, MDWI (2018). PENAMBAHAN TEMULAWAK (Curcuma xanthorrhiza) DALAM PAKAN BUATAN SEBAGAI ANTIOKSIDAN TERHADAP JUMLAH TOTAL LEUKOSIT, DIFERENSIAL …., repository.unair.ac.id, <https://repository.unair.ac.id/72390/>

[13] Ayuningtyas, AC (2018). KARAKTERISASI ISOLAT KAPANG ENDOFIT DOMINAN PADA RIMPANG TEMULAWAK (Curcuma xanthorrhiza Roxb) SEBAGAI PENGHASIL ANTIOKSIDAN., e-journal.uajy.ac.id, <http://e-journal.uajy.ac.id/id/eprint/16105>

[14] ANDRIANI, FN (2021). POTENSI EKSTRAK KUNYIT DAN TEMULAWAK SEBAGAI ANTI-KANKER PADA HEWAN COBA DAN MANUSIA: SYSTEMATIC LITERATURE REVIEW., repository.unusa.ac.id, <http://repository.unusa.ac.id/id/eprint/6912>

[15] Sheikh, E, Bhatt, MLB, & Tripathi, M (2018). Bio-based synthesised and characterized monodispersed Curcuma longa silver nanoparticles induces targeted anticancer activity in breast cancer cells.

Pharmacognosy Magazine, phcog.com, <https://www.phcog.com/article.asp?issn=0973-1296;year=2018;volume=14;issue=57;spage=340;epage=345;aulast=Sheikh>
[16] Do, DM, Vo, TH, Nguyen, DH, Le, KM, Huynh, TT, & ... (2019). Identification of Curcuma aromatica growing in Vietnam and its potential anticancer components. …, researchgate.net, <https://www.researchgate.net/profile/Minh-Duc-3/publication/339045801_Identification_of_Curcuma_aromatica_growing_in_Vietnam_and_its_potential_anticancer_components/links/610f89da0c2bfa282a2f5637/Identification-of-Curcuma-aromatica-growing-in-Vietnam-and-its-potential-anticancer-components.pdf>
[17] Aiswariya, KS, & Jose, V (2021). Photo-mediated facile synthesis of silver nanoparticles using Curcuma zanthorrhiza rhizome extract and their in vitro antimicrobial and anticancer activity. Journal of Inorganic and Organometallic Polymers …, Springer, <https://doi.org/10.1007/s10904-021-01951-0>
[18] Weyand, CM, & Goronzy, JJ (2021). The immunology of rheumatoid arthritis. Nature immunology, nature.com, <https://www.nature.com/articles/s41590-020-00816-x>
[19] Bullock, J, Rizvi, SAA, Saleh, AM, Ahmed, SS, & ... (2018). Rheumatoid arthritis: a brief overview of the treatment. Medical Principles and …, karger.com, <https://www.karger.com/Article/Abstract/493390>
[20] Scherer, HU, Häupl, T, & Burmester, GR (2020). The etiology of rheumatoid arthritis. Journal of autoimmunity, Elsevier, <https://www.sciencedirect.com/science/article/pii/S0896841119308431>
[21] Kurniawati, D., & Zainul, R. (2015). Biosorption of Pb (II) from aqueous solutions using column method by lengkeng (Euphoria logan lour) seed and shell. Journal of Chemical and Pharmaceutical Research, 7(12), 872-877.
[22] Rais, N. S. M., Isa, I. M., Hashim, N., Saidin, M. I., Yazid, S. N. A. M., Ahmad, M. S., ... & Mukdasai, S. (2019). Simultaneously Determination of Bisphenol A and Uric Acid by Zinc/Aluminum-layered Double Hydroxide-2-(2, 4dichlorophenoxy) Propionate Paste Electrode. International Journal of ELECTROCHEMICAL SCIENCE, 14, 7911-7924.
[23] Anhar, A., Sumarmin, R., & Zainul, R. (2016). Measurement of glycemic index of West Sumatera local rice genotypes for healthy food selection. Journal of Chemical and Pharmaceutical Research, 8(8), 1035-1040.
[24] Fatimah, S., Syafrini, D., & Zainul, R. (2021). Rendang lokan: history, symbol of cultural identity, and food adaptation of Minangkabau tribe in West Sumatra, Indonesia. Journal of Ethnic Foods, 8(1), 1-10.
[25] Yulkifli, Y., Ardanus, A., & Fauzi, A. (2017). Validitas Alat Praktikum Muai Panjang Menggunakan Sensor Efek Hall yang Dilengkapi Lembar Kerja Peserta Didik.
[26] Kharisma, V. D., Ansori, A. N. M., Dian, F. A., Rizky, W. C., Dings, T. G. A., Zainul, R., & Nugraha, A. P. (2021). MOLECULAR DOCKING AND DYNAMIC SIMULATION OF ENTRY INHIBITOR FROM TAMARINDUS INDICA BIOACTIVE COMPOUNDS AGAINST SARS-COV-2 INFECTION VIA VIROINFORMATICS STUDY. Biochemical and Cellular Archives, 3323-3327.
[27] Zainul, R. (2016). Isolation and identification of freshwater microalgae potentially as antibacterial from Talago Biru, Koto Baru, West Sumatera. Der Pharmacia Lettre, 8(20), 157-165.
[28] Zainul, R., Effendi, J., & Mashuri, M. (2019). Phototransformation of Linear Alkylbenzene Sulphonate (LAS) Surfactant Using ZnO-CuO Composite Photocatalyst. KnE Engineering, 235-247.
[29] Sharif, S. N. M., Hashim, N., Isa, I. M., Bakar, S. A., Saidin, M. I., Ahmad, M. S., ... & Kamari, A. (2021). The effect of swellable carboxymethyl cellulose coating on the physicochemical stability and release profile of a zinc hydroxide nitrate–sodium dodecylsulphate–imidacloprid. Chemical Physics Impact, 2, 100017.
[30] Zainul, R., Hashim, N., Yazid, S. N. A. M., Sharif, S. N. M., Ahmad, M. S., Saidin, M. I., ... & Isa, I. M. (2021). Magnesium layered hydroxide-3-(4-methoxyphenyl) propionate modified single-walled carbon nanotubes as sensor for simultaneous determination of Bisphenol A and Uric Acid. International Journal of ELECTROCHEMICAL SCIENCE, 16, 1-11.