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Synthesis and Structural Determination of 6-*O*-prop-2-ynyl-1,2:3,4-di-*O*-Isopropylidene-α-D-Galactose

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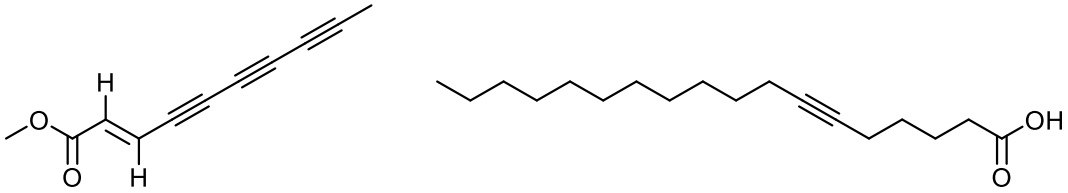
Abstract:

In this work, an important sugar alkynyl ether has been synthesized in two subsequent steps starting from commercially available D-galactose (**3**). This kind of compounds is highly significant in the synthesis of biologically active molecules such as 1,2,3-triazole and isoxazoles. In the first step, galactose (**3**) was reacted with acetone in the presence of anhydrous copper (II) sulfate to produce 1,2:3,4-di-O-isopropylidene-α-D-galactose (**4**) in good yield. The latter was reacted with excess of 3-bromoprop-1-yne in DMF in the presence of NaOH pellets to afford the target molecule **5** in a very good yield. The temperature of this step is crucial in determining the reaction yield. The exact structure of compound **5** is identified using NMR technique and DFT calculations.

Keywords: DFT calculation, Galactose, Propargyl ethers, Terminal alkynes

Introduction:

One of the significant categories of the organic compounds is alkynes.[1–3] Petroleum is the main source of naturally occurring alkynes as it contains acetylene which is the simplest member of the triple bond family.[4] However, the availability of alkyne in nature is rare such as dehydromatricaria ester (**1**)[5] which was extracted from plant source and tariric acid (**2**)[6] (Fig. 1) that found in the tallow-wood tree or *Eucalyptus microcorys*.



1 **2**

Figure 1. Naturally occurring acetylenes isolated from plant source; dehydromatricaria ester (1) and tariric acid (2)

Various alkynes possess remarkable biological activity and they have been utilised as drugs,[7,8] for example, the birth control medicine norethynodrel.[9] In addition, it was reported that some of the natural acetylenes i.e. falcarinol has been used as a pesticide.[10] Furthermore, both terminal and internal alkynes have essential role in the synthesis of many organic compounds like; aldehydes,[11] ketones,[12] carboxylic acids,[13] alkenes,[14] triazoles,[15–19] isoxazoles[20,22] and polymer.[23,24] Their conjugated polymers have great conductivity, and they have many applications in organic photonics.[25] The simplest way to prepare with variable alkyne chain is the alkylation of acetylene.[26] Alternatively, they can be synthesized by the elimination of X_2 or HX from alkenes[27] or propargylation of phenols and alcohols.[28] However, the latter requires harsher conditions due to their low acidity.[29] Alkynyl

monosaccharides can be synthesized through the glycosylation reaction of propargyl alcohol with sugar peracetates.[30] Herein, we prepare alkyne-sugar ether by the reaction of propargyl bromide and galactose diacetonide using mild conditions and determine the 3D shape of the synthesized molecule.

Materials and Methods:

General

Chemicals, reagents, and solvents were purchased from commercial providers; Ajax, Alfa Aesar and Sigma-Aldrich Chemical. Flash column chromatography was performed with silica gel (40-60 mesh). Aluminium-supported coated with silica (0.2 mm, 60 F_{254}) TLC plates were used. The progression of reactions was observed by TLC using freshly prepared alkaline $KMnO_4$ stain to develop spots on TLC plates. Melting points were determined on an Electrothermal Stuart SMP 30 capillary melting point apparatus. Specific rotation was detected using Automatic digital polarimeter KRUSS P3001 RS. Infrared spectra were recorded using prestige 21, SHIMADZU 2001, FT-IR. Proton, carbon and 2D NMR spectra were collected on Avance III 300, FT-NMR spectrometer, Bruker 2010 spectrometer at 300 MHz and 75 MHz respectively with TMS as an internal standard. The NMR spectra were recorded at the University of New South Wales, Australia.

Synthesis

Synthesis of 1,2:3,4-diacetonide-α-D-galactose (4)[31]

Zinc chloride (10.0 g, 0.029 mol) was portions-wise added to acetone (50 mL) and concentrated sulfuric acid (0.1 mL) was added at r.t. to give a clear solution. Galactose (3.5 g, 0.018 mol) was then added, and the resulting white suspension stirred for 5 h at r.t. Afterward, a suspension of Na_2CO_3 (6.5 g, 0.063 mol) in H_2O (10 mL) was added to the yellow reaction mixture at 0 °C. The suspension was allowed to stir for 30 min then filtered and the solid discarded. The volatile solvent was removed in *vacuo* below 30 °C to give a residue. The resulting yellow oil and aqueous layer were separated, and aqueous layer further extracted with Et_2O (3 × 10 mL). The combined organic layers were dried over $MgSO_4$, and the solvent removed under reduced pressure to yield 1,2:3,4-diacetonide-α-D-galactose (**4**) as a pale-yellow oil (3.9 g, 81%) R_f = 0.45 (1:1 EtOAc / Hexane). FTIR (KBr) cm^{-1}: 3483, 2987, 2935, 1382, 1255, 1212, 1167, 1069, 1001, 899. ^{1}H NMR (300 MHz, $CDCl_3$) δ ppm: 5.56 (d, J = 5.0 Hz,1H, H1), 4.60 (dd, J = 8.0, 2.4 Hz, 1H, H3), 4.32 (dd, J = 5.0, 2.4 Hz, 1H, H2), 4.26 (dd, J = 7.9, 1.6 Hz, 1H, H4), 3.86 (ddd, J = 7.3, 4.7, 2.0 Hz, H5), 3.83 (dd, J = 10.7, 4.7 Hz, 1H, H6a), 3.74 (dd, J = 10.7, 7.3 Hz, 1H, H6b), 2.37 (br s, 1H, OH), 1.52 (s, 3H, CH_3), 1.44 (s, 3H, CH_3), 1.32 (s, 6H, $C(CH_3)_2$). ^{13}C {^{1}H} NMR (75 MHz, $CDCl_3$) δ ppm: 109.4 and 108.6 (2 × $C(CH_3)_2$), 96.3 (C1), 71.5 (C4), 70.7 (C3), 70.5 (C2), 68.6 (C5), 62.3 (C6), 24.3 (CH_3), 24.9 (CH_3), 25.9 (CH_3), 26.0 (CH_3).

Synthesis of 6-*O*-prop-2-ynyl-1,2:3,4-diacetonide-α-D-galactose (5)[32,33]

Protected sugar **4** (0.52 g, 2 mmol) was dissolved in DMF (10 mL) in a dry flask and sodium hydroxide pellets (0.32 g, 8 mmol) were added. The flask was cooled in an NaBr 60 g-ice 100 g bath at –20 °C and the contents stirred for 10 min before 3-bromoprop-1-yne (2.2 mmol) was added dropwise. The reaction mixture was then allowed to stir for 24 h, gradually warming to r.t. The reaction mixture was partitioned between EtOAc (50 mL) and water (100 mL), the layers separated, and the aqueous layer extracted with more EtOAc (3 × 50 mL). The combined extracts were dried over Na_2SO_4 and evaporated to dryness under reduced pressure. The residue was flash chromatographed (silica gel, Et_2O / *n*-hexane 1:9) to give 6-*O*-prop-2-ynyl-1,2:3,4-diacetonide-α-D-galactose (**5**) as a white needles precipitate (1.10 g, 88%), m.p.= 51–52 °C (lit. 50–51 °C)[34], R_f = 0.41 (1:1 hexane/ Et_2O). FTIR (KBr) cm^{-1}: 3253, 2922, 2853, 2109, 1459, 1377, 1258, 1213, 1101, 1066, 1004, 890. ^{1}H NMR (300 MHz, $CDCl_3$) δ ppm: 5.54 (d, J = 5.0 Hz, 1H, H1'), 4.60 (dd, J 7.9, 2.4 Hz, 1H, H3'), 4.31 (dd, J = 5.0, 2.4 Hz, 1H, H2'), 4.26 (dd, J = 7.9, 2.0 Hz, 1H, H4'), 4.24 (dd, J = 15.9, 2.4 Hz, 1H, H3a), 4.19 (dd, J = 15.9, 2.4 Hz, 1H, H3b), 3.99 (ddd, J = 7.1, 6.2, 2.0 Hz, 1H, H5'), 3.77 (dd, J = 10.1, 6.2 Hz, 1H, H6'a), 3.66 (dd, J = 10.1, 7.1 Hz , H, H6'b), 2.42 (t, J = 2.4 Hz, 1H, H1), 1.32 (s, 3H, CH_3), 1.34 (s, 3H, CH_3), 1.45 (s, 3H, CH_3), 1.54 (s, 3H, CH_3). ^{13}C {^{1}H} NMR (75 MHz, $CDCl_3$) δ ppm: 109.3 and 108.6 (2 × $C(CH_3)_2$), 96.3(C1'), 79.6 (C2), 74.6 (C1), 71.2 (C4'), 70.6 (C3'), 70.4 (C2'), 68.7 (C6'), 66.7 (C5'), 58.4 (C3), 24.4 (CH_3), 24.9 (CH_3), 25.9 (CH_3), 26.0 (CH_3).

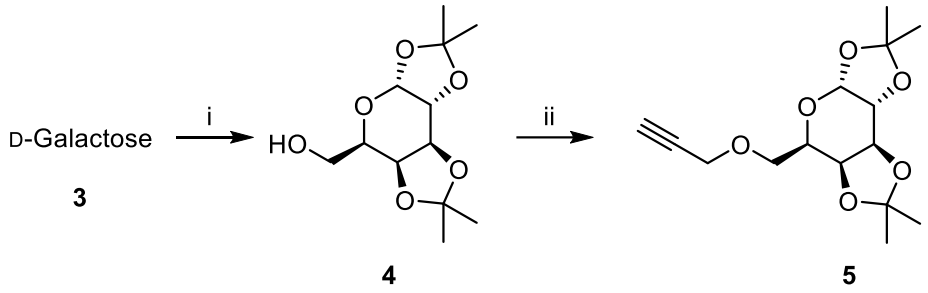
Computational method

The *in-silico* study was performed employing the ORCA 4.2.1 software[35,36]. The initial structures of 6-*O*-prop-2-ynyl-1,2:3,4-di-*O*-isopropylidene-α-D-galactose (**5**) were drawn through Avogadro program and were energy minimized at the B3LYP/def2-TZVP level of theory. The optimized geometries were verified by performing frequency calculation at B3LYP/def2-TZVP level (zero imaginary frequencies). Subsequently, single point energy calculations at the MO6-2X/def2-TZVP level were perfumed with

solvation method using the conductor-like polarizable continuum model (CPCM) in chloroform ($CHCl_3$).

Results and Discussion:

The target compound **5** has been synthesized from D-galactose in two subsequent steps (Scheme 1):



Reagents and conditions: i] Acetone, $ZnCl_2$, H_2SO_4, 0 °C–r.t, 5 h, 81%; ii] propargyl bromide, DMF, –20 °C–r.t., 24 h, 88%

Scheme 1. Synthesis of alkyne 5 from D-galactose (3)

Acetone is widely utilized in carbohydrate chemistry as a protecting group particularly for the *syn* vicinal diols.[37] The reaction of the hexose **3** with excess of acetone in the assistance of zinc chloride and sulfuric acid at room temperature for five hours afforded 1,2:3,4-di-O-isopropylidene-α-D-galactose (**4**) in a very good yield 81%. FTIR spectrum (Fig. 2) of compound **4** shows; a broad band at 3483 cm^{-1} belongs to the (O–H) stretching, medium bands at 2987 and 2935 cm^{-1} attributed to the (C–H) stretching, a sharp band at 1382 cm^{-1} corresponding to the (C–H) bending, and the sharp bands between 1225 cm^{-1} and 1069 cm^{-1} due to the (C–O) and (C–O–C) stretching.

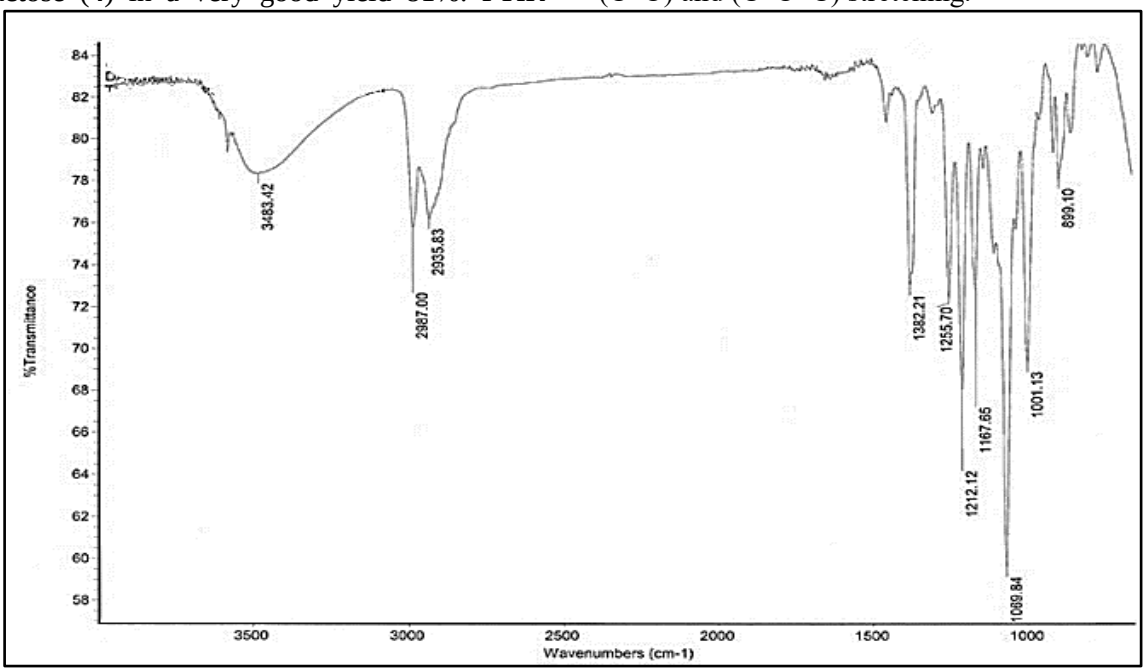


Figure 2. FTIR spectrum of compound 4

The formation of compounds **4** has also been evidenced by ^1H NMR (300 MHz, $CDCl_3$) spectrum (Fig. 3) that displays a doublet at 5.56 ppm with the coupling constant (J = 5.0 Hz) attributed to the anomeric proton; a doublet of doublet centred at 4.60 ppm (J = 8.0, 2.4 Hz) due to H-3 of the pyran ring, another doublet of doublet centred at 4.32 (J = 5.0, 2.4 Hz) belongs to the H-2, a doublet of doublet of H-4 centred at 4.26 (J = 7.9, 1.6 Hz), a doublet of doublet of doublet centred at 3.86 (J = 7.3, 4.7 Hz) attributed to H-5, and two doublets of doublets at 3.83 ppm (J = 10.7, 4.7 Hz) and 3.74 ppm (J = 10.7, 7.3 Hz) due to methylene protons H-6 in addition to the singlets at 2.37 ppm, 1.52 ppm, 1.44 ppm, and 1.32 ppm that attributed to the hydroxyl proton and the isopropylidene protons respectively.

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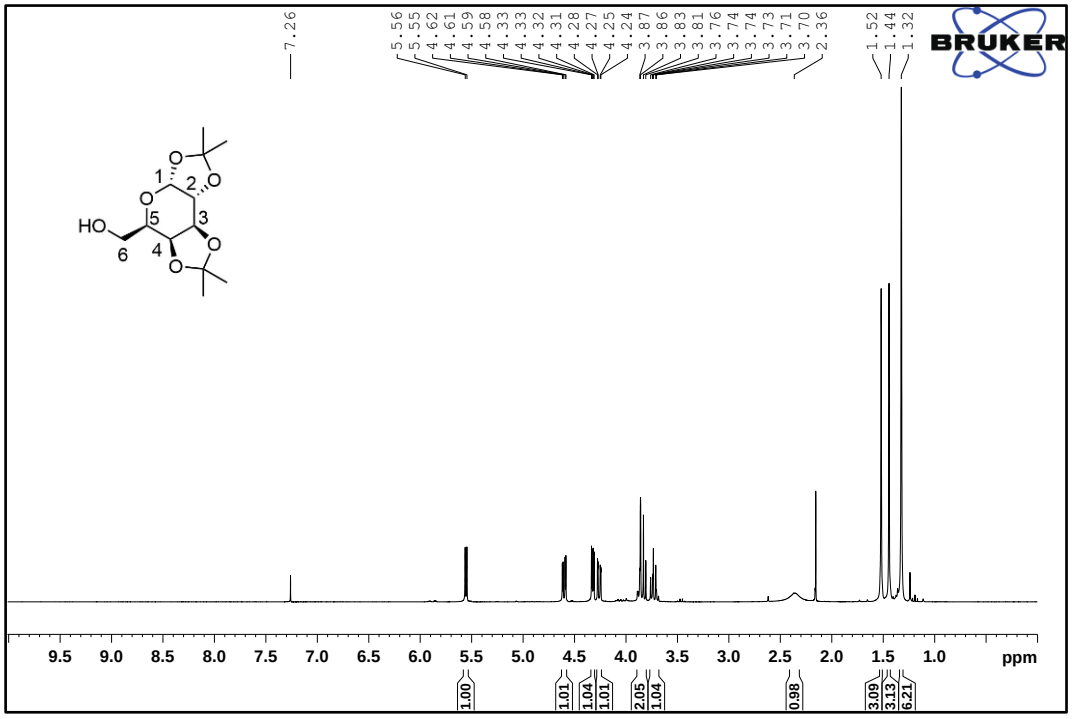


Figure 3. ^{1}H NMR (300 MHz, $CDCl_3$) spectrum of compound 4

Moreover, the structure of alcohol **4** is assigned by ^{13}C {^{1}H} NMR (75 MHz, $CDCl_3$) spectrum (Fig. 4) that exhibits two signals at 109.4 ppm and 108.6 ppm attributed to the quaternary carbons of the isopropylidene protecting groups. The carbon signals at 96.3 ppm, 71.5 ppm, 70.7 ppm, 70.5 ppm, 68.6 ppm, and 62.3 ppm are confirmed to C1, C4, C3, C2, C5, and C6 respectively. Finally, the signals belong to methyl group appear at 24.3, 24.9, 25.9, and 26.0 ppm.

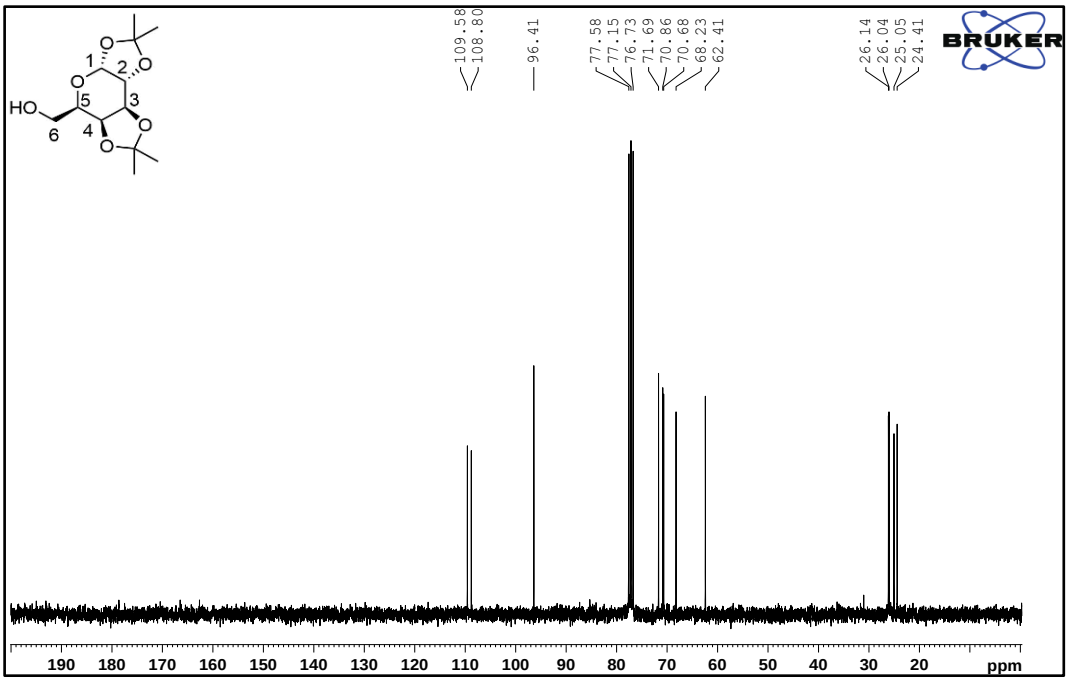


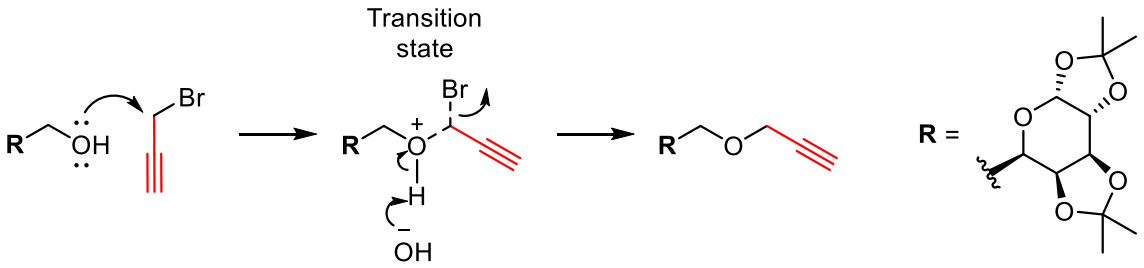
Figure 4. ^{1}H {^{1}H} NMR (75 MHz, $CDCl_3$) spectrum of compound 4

Treatment of galactose diacetonide **4** with 3-bromoprop-1-yne in the presence of sodium hydroxide in DMF at –20 °C to room temperature for 24 h gave 6-*O*-prop-2-ynyl-1,2:3,4-di-*O*-isopropylidene-α-D-galactose (**5**) in 88% yield. First, the addition of 3-bromoprop-1-yne to the reaction mixture is crucial in the determination of the yield of reaction. The effect of temperature, at the addition of the propargyl bromide, on the reaction outcome is illustrated in Table 1.

Table 1. The effect of the initial reaction temperature on the alkyne yield

Entry	Temperature °C	Yield
1	r.t.	57%
2	0	62%
3	–5	70%
4	–10	82%
5	–20	88%

The lower the temperature at the addition of propargyl bromide to an alcohol, the higher the reaction yield. This could be attributed to the formation of allenes during the reaction.[38]It is suggested that the formation of compound 5 follows the S_N2 mechanism in its initial step. Then, proton is subtracted due the base effect (Scheme 2).



Scheme 2. Suggested mechanism of the formation of compound 5

The disappearance of the (O–H) stretching band at 3483 cm^{-1} and the appearance of the bands at 3253 cm^{-1} and 2109 cm^{-1} due to the stretching of (≡C–H) and (C≡C) respectively in the FTIR spectrum (Fig. 5) are excellent evidence of the formation of alkyne **5**.

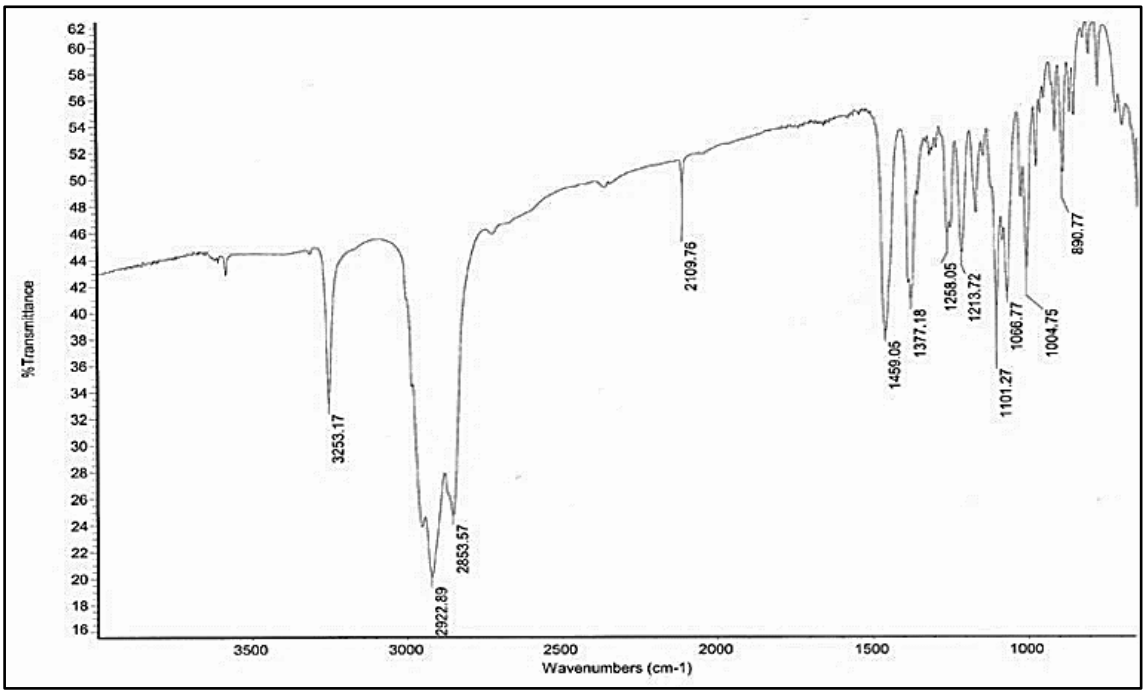


Figure 5. FTIR spectrum of compound 5

Further proof of the formation of compound **5** is introduced by ^{1}H NMR spectrum (Fig. 6) that displays two doublets of doublets centred at 4.23 ppm and 4.20 ppm corresponding to the methylene H-3 having coupling constants 15.9 Hz and 2.4 Hz. Moreover, the appearance of triplet at 2.42 ppm (J = 2.4 Hz) belongs to the acetylenic proton H-1 is another evidence of formation of the alkyne **5**.

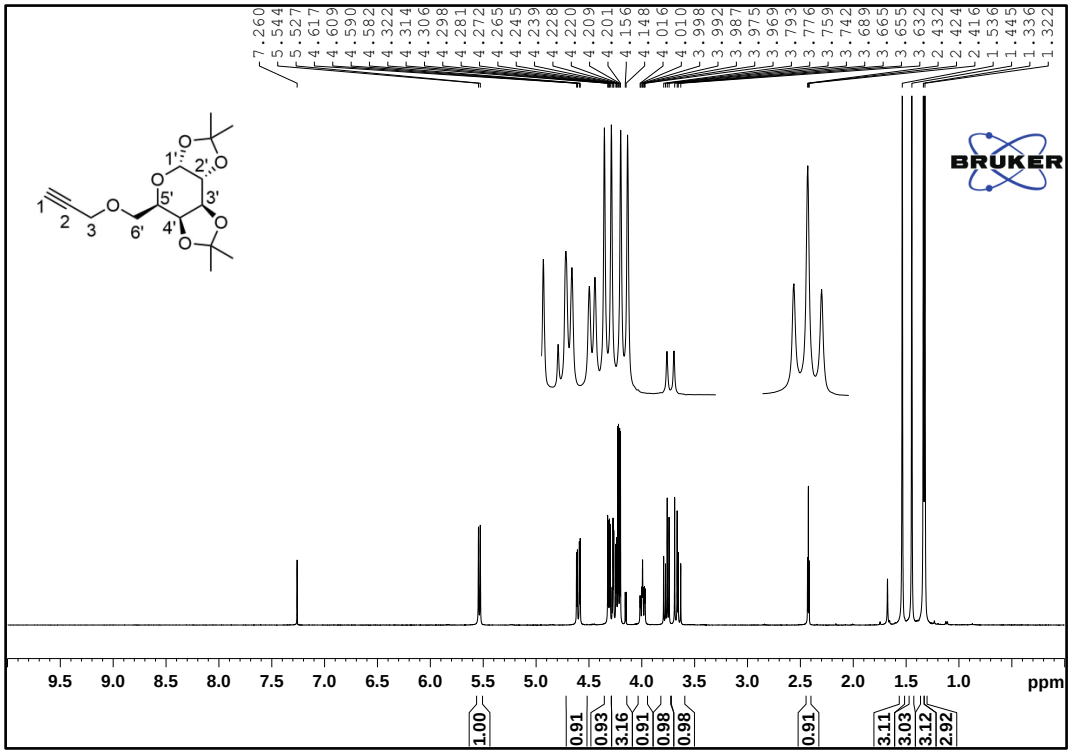


Figure 6. ^{1}H NMR (300 MHz, $CDCl_3$) spectrum of compound 5

A cross peak is shown in the COSY spectrum (Fig. 7) between the two doublets of doublets centred at 4.23 ppm and 4.20 ppm and the triplet at 2.42 ppm which means the presence of the long-range coupling.[39]

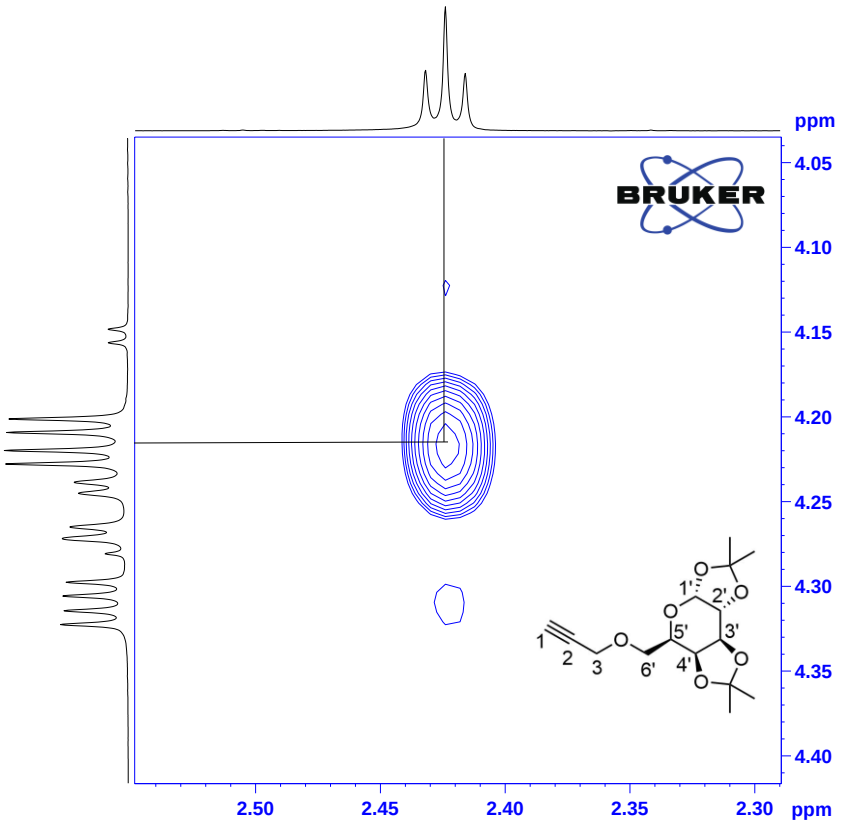


Figure 7. Zoomed in ^{1}H–^{1}H COSY (300 MHz, $CDCl_3$) spectrum of compound 5

The ^{13}C NMR spectrum of compound **5** (Fig. 8) shows three new signals at 79.8, 74.7 ppm and 58.7 ppm belonging to C2, C1 and C3 respectively.

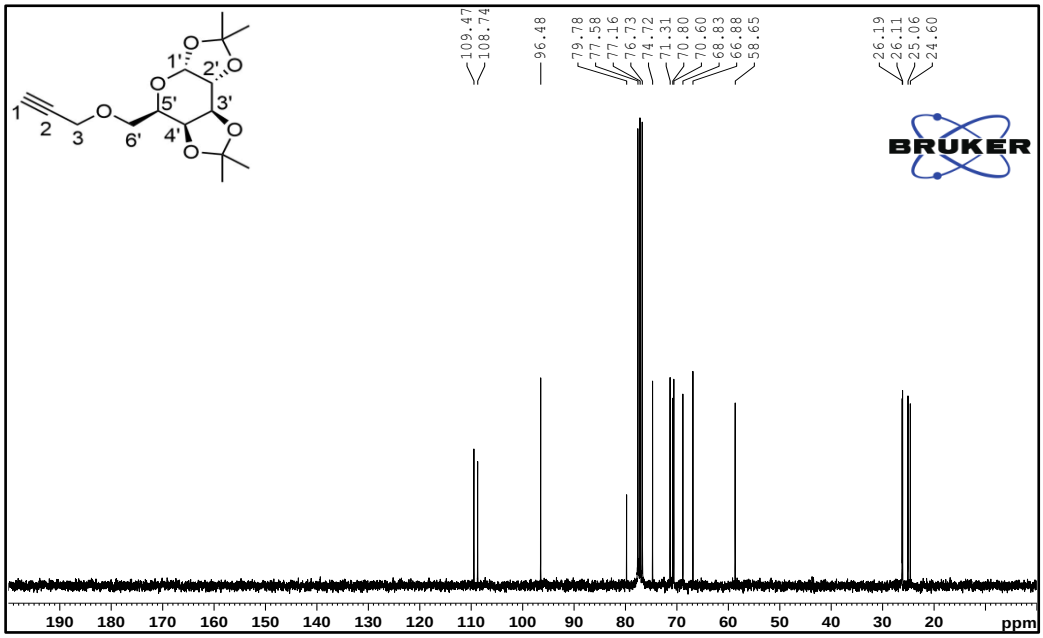


Figure 8. ^{1}H {^{1}H} NMR (75 MHz, $CDCl_3$) spectrum of compound 5

It is known that the preferred 3D shape of the pyranose six-membered ring in the saccharides is chair conformations $^{4}C_1$ and $_{4}C^{1}$ (Fig. 9).[40,41]

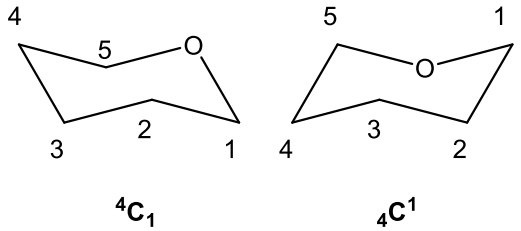


Figure 9. Chair conformations of pyranoses

The computational study of compound **5** demonstrated that the lowest energy galactopyranose ring adopted chair $^{3}C_O$ conformation (Fig. 10). According to Karplus equation, the magnitude of coupling constant decreases as the dihedral angle between the vicinal hydrogen atoms raises from 0° to 90° and then starts to increase with the raise of the angle.[42] In the suggested 3D shape of the six-membered ring, the dihedral angle between H2' and H3' is approximately 90° and this is confirmed by ^{1}H NMR as the coupling constant $^{3}J_{H,H}$ between H2' and H3' is 2.4 Hz.

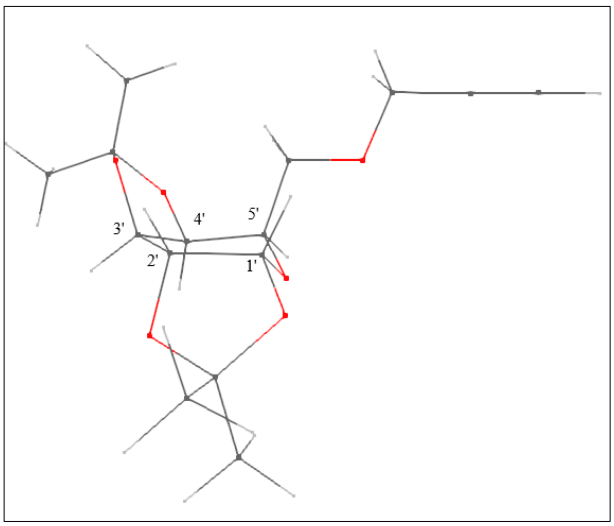


Figure 10. The suggested conformation of compound 5 based on computational study and NMR spectra

Conclusion:

Alkynyl sugar ether was produced by reacting protected sugar with propargyl bromide in the presence of a base. It is found that the reaction temperature is crucial in the determination of the final yield of the propargyl derivative. The 1D and 2D NMR spectra were consistent with the computational study, which revealed that the sugar pyran ring adopted chair conformation. However, the oxygen atom occupied the bottom edge of the chair not C-1 as expected.

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Authors' declaration:

- Conflicts of Interest: None.
- We hereby confirm that all the Figures and Tables in the manuscript are mine ours. Besides, the Figures and images, which are not mine ours, have been given the permission for re-publication attached with the manuscript.
- Ethical Clearance: The project was approved by the local ethical committee in University of Kerbala.

Authors' contributions statement:

H.H.A. A. synthesized and purified all compounds in this work. A.I. M. and B.A. J. contributed equally to the project through the suggestion of proposal, interpreting the analytical data and writing the manuscript.

References:

1. Heravi MM, Dehghani M, Zadsirjan V, Ghanbarian M. Alkynes as Privileged Synthons in Selected Organic Name Reactions. Curr Org Synth. 2019;16(2):205–243. DOI: 10.2174/1570179416666190126100744. PMID: 31975673.
2. Gabriele B, Mancuso R, Larock RC. Recent Advances in the Synthesis of Iodoheterocycles via Iodocyclization of Functionalized Alkynes. Curr Org Chem. 2014; 18(3) 341–358. DOI: 10.2174/1385272813179990034
3. Guo L, Song F, Zhu S, Li H, Chu L. *syn*-Selective alkylarylation of terminal alkynes via the combination of photoredox and nickel catalysis. Nat Commun. 2018; 9: 4543–4550. https://doi.org/10.1038/s41467-018-06904-9
4. Bowen B, Howlett J, Wood W. The removal of acetylene from hydrocarbon gases. J. Chem. Technol. Biotechnol. 1950; 69: 65–69. https://doi.org/10.1002/jctb.5000690301
5. Kimura Y, Mori M, Suzuki A, Kobayashi A. Isolation and Identification of Two Nematicidal Substances from Roots of Erigeron philadelphicus L. and Nematicidal Activities of Their Related Compounds. Agric Biol Chem. 2019; 45(12): 2915–2917. DOI: 10.1080/00021369.1981.10864986
6. Stuhlfauth T, Fock H, Huber H, Klug K. The distribution of fatty acids including petroselinic and tariric acids in the fruit and seed oils of the Pittosporaceae, Araliaceae, Umbelliferae, Simarubaceae and Rutaceae. Biochem Syst Ecol. 1985; 13(4): 447–453. DOI: 10.1016/0305-1978(85)90091-2
7. Iqbal N, Maiti D, Cho E. Access to Multifunctionalized Benzofurans by Aryl Nickelation of Alkynes: Efficient Synthesis of the Anti-Arrhythmic Drug Amiodarone, Angew Chem Int Ed. 2019; 58 (44): 15808–15812. DOI:10.1002/anie.201909015.
8. Carvalho N, Herrmann R, Wagner G. Synthesis of alkynyl-substituted camphor derivatives and their use in the preparation of paclitaxel-related compounds. Beilstein J Org Chem. 2017; 13: 1230–1238. DOI:10.3762/bjoc.13.122.
9. Jin Y, Duan L, Chen M, Penning TM, Kloosterboer HJ. Metabolism of the synthetic progestogen norethynodrel by human ketosteroid reductases of the aldo-keto reductase superfamily. J Steroid Biochem Mol Biol. 2012; 129(3-5): 139-44. DOI: 10.1016/j.jsbmb.2011.12.002.
10. Kobaek-Larsen M, Baatrup G, Notabi MK, El-Houri RB, Pipó-Ollé E, Christensen Arnspang E, et al. Dietary Polyacetylenic Oxylipins Falcarinol and Falcarindiol Prevent Inflammation and Colorectal Neoplastic Transformation: A Mechanistic and Dose-Response Study in A Rat Model. Nutrients. 2019; 11(9):2223. DOI: 10.3390/nu11092223
11. Alabugin IV, Gonzalez-Rodriguez E, Kawade RK, Stepanov AA, Vasilevsky SF. Alkynes as Synthetic Equivalents of Ketones and Aldehydes: A Hidden Entry into Carbonyl Chemistry. Molecules. 2019; 24: 1036. DOI: 10.3390/molecules24061036.
12. Miura T, Biyajima T, Fujii T, Murakami M. Synthesis of α-Amino Ketones from Terminal Alkynes via Rhodium-Catalyzed Denitrogenative Hydration of N-Sulfonyl-1,2,3-triazoles, J Am Chem Soc. 2012; 134 (1): 194–196. DOI:10.1021/ja2104203.
13. Zeng M, Herzon SB. Synthesis of 1,3-Amino Alcohols, 1,3-Diols, Amines, and Carboxylic Acids from Terminal Alkynes. J Org Chem. 2015; 80(17): 8604–8618. DOI: 10.1021/acs.joc.5b01220.
14. Wu X, Tamm M, Recent advances in the development of alkyne metathesis catalysts, Beilstein J Org Chem. 2011; 7: 82–93. DOI:10.3762/bjoc.7.12.
15. Mohammed AI, Abboud ZH, Alghanimi AHO. Synthesis of D-mannitol substituted ether-linked bis-1,2,3-triazoles as models of gemini surfactants. Tetrahedron Lett. 2012; 53 (38): 5081–5083. DOI: 10.1016/j.tetlet.2012.07.014.
16. Mohammed AI, Mansour NH, Mahdi LS. Synthesis and antibacterial activity of 1-N-(β-d-glucopyranosyl)-4-((1-substituted-1H-1,2,3-triazol-4-yl)ethoxymethyl)-1,2,3-triazoles. Arab J Chem. 2017; 10(Suppl 2): S3508–S3514. DOI: 10.1016/j.arabjc.2014.02.016.
17. Mohammed AI. Synthesis of Nonionic Surfactants. Sugar-Substituted Ether-Linked Bis-1, 2, 3-Triazoles. Asian J Chem. 2012; 24(12):5585–5588.
18. Francis DV, Miles DH, Mohammed AI, Read RW, Wang X. Towards functional fluorous surfactants. Synthesis of hydrophilic fluorous 1,2,3-

triazolylmethyl ethers and di(1,2,3-triazolylmethyl) ethers. J Fluorine Chem. 2011; 132 (11): 898–906. DOI: 10.1016/j.jfluchem.2011.07.002.

19. Nief OA, Abdullah EK, Alzahawy HMG, Jasim MN. Synthesis, Characterization of Poly Heterocyclic Compounds, and Effect on Cancer Cell (Hep-2) *In vitro*. Baghdad Sci J. 2018; 15(4): 415–424. Available from: https://bsj.uobaghdad.edu.iq/index.php/BSJ/article/view/35
20. AL-Joubory AKJ, Abdullah LW, Mohammed AJ. Synthesis, Characterization and Biological Activity Evaluation of Some Pyrazoles, Thiazoles and Oxazoles Derived from 2-Mercaptoaniline. Baghdad Sci J. 2021; 18(1(Suppl.): 764–774. Available from: https://bsj.uobaghdad.edu.iq/index.php/BSJ/article/view/3955
21. Vaidya VV, Wankhede KS, Nara SJ, Salunkhe MM, Trivedi GK. Synthesis of Isoxazole Conjugates of 1,4-Benzodioxane Moiety via Intermolecular 1,3-Dipolar Cycloaddition, Synth Commun. 2009; 39(21): 3856–3866. DOI: 10.1080/00397910902838979.
22. Vaidya VV, Wankhede KS, Salunkhe MM, Trivedi GK. Synthesis of isoxazole conjugates of sugars via 1,3-dipolar cycloaddition. Canadian J Chem. 2011; 86(2): 138–141. DOI: 10.1139/v07-145
23. Roland C, Li H, Abboud K, Wagener KB, Veige AS. Cyclic polymers from alkynes. Nature Chem. 2016; 8: 791–796. DOI:10.1038/nchem.2516.
24. Yang LC, Han L, Ma HW, Liu P, Shen H, Li C, et al. Synthesis of Alkyne-functionalized Polymers via Living Anionic Polymerization and Investigation of Features during the Post-"thiol-yne" Click Reaction. Chin J Polym Sci. 2019; 37: 841–850. DOI:10.1007/s10118-019-2203-6.
25. Huizhi L, Xunlai L, Qingquan L. Conjugated Conductive Polymer Materials and its Applications: A Mini-Review. Front Chem. 2021; 9: 728–733. DOI: 10.3389/fchem.2021.732132.
26. Kazakov PV, Demina EI. Alkylation of acetylene by tert-butyl alcohol. Russ Chem Bull. 2002; 51: 2134–2135. DOI: 10.1023/A:1021640700304.
27. Shaw R, Elagamy A, Althagafi I, Pratap R. Synthesis of alkynes from non-alkyne sources. Org Biomol Chem. 2020; 18: 3797–3817. DOI: 10.1039/D0OB00325E.
28. Li Ren-Zhe, Liu Da-qi, Niu Dawen. Asymmetric O-propargylation of secondary aliphatic alcohols. Nat Catal. 2020; 3: 672–680. DOI: 10.1038/s41929-020-0462-9
29. Zhang X, Wei M, Chen J, Liu X. One-pot synthesis of novel ether-linked diisoxazole derivatives via sequential O-propargylation and 1,3-dipolar cycloaddition from 2-bromohomoallylic alcohols, Synth Commun. 2020; 50(1): 97–103. DOI: 10.1080/00397911.2019.1684522.
30. Mohammed AI, Jwad RS. Synthesis and NMR Study of Some Important Glucopyranosyl Derivatives. J Kerbala Univ. 2011; 9(1): 42–48.
31. Stick RV, Tilbrook DMG. The Synthesis of Some Octenoses as Potential Precursors to Lincosamine, a Derived Portion of the Antibiotic Lincomycin. Australian J Chem. 1990; 43: 1643–1655. DOI: 10.1071/CH9901643.
32. Jwad RS, Synthesis of 1-Nonyl-4-[(6-Deoxy-1,2:3,4-Di-*O*-Isopropylidene-α-D-Galactos-6-yl)oxymethyl]1*H*-1,2,3-Triazole *Via* Click Chemistry, ANJS. 2011; 14 (1): 58–67.
33. Mahdi LS, Mohammed AI, Mohammed MJ. Convenient synthesis of dipropargyl ether derivative of D-mannose, AIP Conf Proc 2020; 2290: 030024. DOI: 10.1063/5.0027403.
34. Hajlaoui K, El Guesmi A, Ben Hamadi N, Msaddek M. Synthesis of Novel Pyrazole–sucrose Derivatives by 1,3-dipolar Cycloaddition. J Heterocycl Chem. 2018; 55(9): 2069–2074. DOI: 10.1002/jhet.3246.
35. Neese F. The ORCA program system, Wiley Interdiscip Rev: Comput Mol Sci. 2012; 2(1): 73–78. DOI: 0.1002/wcms.81.
36. Neese F. Software update: the ORCA program system, version 4.0, Wiley Interdiscip Rev: Comput Mol Sci. 2017; 8: e1327. DOI: 10.1002/wcms.1327
37. Wanga T, Demchenko AV. Synthesis of carbohydrate building blocks via regioselective uniform protection/deprotection strategies. Org Biomol Chem. 2019; 17: 4934–4950. DOI: 10.1039/C9OB00573K.
38. Klaus B. Functionalized Allenes: Generation by Sigmatropic Rearrangement and Application in Heterocyclic Chemistry. Curr Org Chem. 2019; 23(27): 3040–3063. DOI: 10.2174/1385272823666191112102523.
39. Klukowski P, Schubert M. Chemical shift-based identification of monosaccharide spin-systems with NMR spectroscopy to complement untargeted glycomics, Bioinform. 2019; 35(2): 293–300. DOI: 10.1093/bioinformatics/bty465.
40. Marszalek PE, Pang Y, Li H, El Yazal J, Oberhauser AF, Fernandez JM. Atomic levers control pyranose ring conformations, Proc Natl Acad Sci. 1999; 96(14): 7894–7898. DOI: 10.1073/pnas.96.14.7894.
41. Inagaki M, Iwakuma R, Kawakami S, Otsuka H, Rakotondraibe HL. Detecting and Differentiating Monosaccharide Enantiomers by ^{1}H NMR Spectroscopy, J Nat Prod. 2021; 84(7): 1863–1869. DOI: 10.1021/acs.jnatprod.0c01120.
42. Coxon B. Chapter 3 Developments in the Karplus Equation as they Relate to the NMR Coupling Constants of Carbohydrates. Adv Carbohydr Chem Biochem. 2009; 62: 17–82. DOI: 10.1016/S0065-2318(09)00003-1.

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تحضير و تحديد التركيب للمركب 6-*O*-بروب-2-نايل- 1،2: 3،4-ثنائي- *O*- أيزوبروبليدين- د-ألفا- جالاكتوز

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الخلاصة:

في هذا العمل، تم تحضير إثير ألكينيل سكر مهم في خطوتين متتاليتين بدءًا من سكر د-جالاكتوز المتاح تجاريًا. إن هذا النوع من المركبات يعد ذات أهمية في تحضير مركبات ذات فعالية حيوية مثل الترايازولات و الآيسوكسازولات. في الخطوة الأولى، تم تفاعل الجالاكتوز (**3**) مع الأسيتون في وجود كبريتات النحاس اللامائي (II) لإنتاج 1،2: 3،4-ثنائي- *O*- أيزوبروبليدين- د-ألفا- جالاكتوز (**4**) بمنتوج جيد. ثم تفاعل المركب الأخير مع زيادة من بروميد البروبارجيل في مذيب ثنائي مثيل فورمأمايد بوجود حبيبات هيدروكسيد الصوديوم لتعطي الجزيء المستهدف **5** في بمنتوج جيد جدًا. إن درجة حرارة هذه الخطوة تعد حاسمة في تحديد منتوج التفاعل. تم تحديد الوضعية الفراغية للمركب **5** بإستخدام تقنية الرنين المغناطيسي النووي وحسابات نظرية الكثافة الوظيفية DFT.

الكلمات المفتاحية: حسابات نظرية الكثافة الوظيفية، الجالاكتوز، إثيرات البروبارجيل, الألكينات الطرفية.