

SYNTHESIS OF NEW BIS-1,2,3-TRIAZOLE DERIVATIVES BASED ON
DIPROPARGYL ADIPATEN.G. Nurillaeva¹I.S. Ortikov²I.A. Abdugafurov¹¹Mirzo-Ulugbek National University of Uzbekistan,²Alfraganus University in Uzbekistan.E-mail: ortikovilxomjon@gmail.com<https://doi.org/10.5281/zenodo.23140664>

Abstract. This study presents the synthesis of new bis-1H-1,2,3-triazole derivatives based on dipropargyl adipate. The target compounds were synthesized according to the principles of click chemistry via a copper(I)-catalyzed azide–alkyne cycloaddition (CuAAC) between aromatic azides and terminal alkyne fragments. *p*-Azidotoluene and *p*-azidoanisole were employed as the azide components. The selected synthetic approach is characterized by high product yields, relatively simple reaction conditions, and the high regioselectivity typical of CuAAC processes.

As a result, new bis-triazole derivatives containing two 1,2,3-triazole fragments linked through an adipate residue were obtained. The structures of the synthesized compounds were investigated by FTIR, ¹H NMR, and ¹³C NMR spectroscopy and were found to be consistent with the proposed structures. The results indicate that dipropargyl adipate can serve as a promising synthetic platform for the preparation of new bis-1,2,3-triazole derivatives.

Keywords: propargyl alcohol, adipic acid, dipropargyl adipate, *p*-azidoanisole, *p*-azidotoluene, CuAAC, click chemistry, bis-1,2,3-triazole.

Introduction. One of the important tasks of synthetic organic chemistry is the development of efficient and selective methods for obtaining new organic compounds that may have practical significance in medicine, pharmacy, agriculture, and various branches of industry.

In particular, the synthesis of heterocyclic systems that are widely represented in biologically active compounds and the preparation of their new derivatives are among the topical areas of modern organic and medicinal chemistry.

Among nitrogen-containing heterocyclic compounds, 1,2,3-triazoles occupy a special place. These compounds have attracted considerable attention because of their chemical stability, ease of modification with various functional groups, and broad spectrum of biological activities.

According to the literature, compounds containing a 1,2,3-triazole fragment include substances exhibiting antibacterial, antifungal, anti-inflammatory, antiallergic, and antitumor activities [1–5].

Therefore, incorporation of a 1,2,3-triazole ring into biologically active molecules is regarded as a promising strategy for the development of compounds with new pharmacological properties. Among the methods used to synthesize 1,2,3-triazole derivatives, the cycloaddition of azides and terminal alkynes catalyzed by copper(I), i.e., the copper(I)-catalyzed azide–alkyne cycloaddition (CuAAC), is of particular importance. This reaction is one of the key transformations of the click-chemistry

concept and is characterized by relatively mild conditions, tolerance toward a wide range of functional groups, high yields of the target products, and the predominant formation of 1,4-disubstituted 1,2,3-triazole derivatives. Accordingly, CuAAC is widely used in the synthesis of new heterocyclic compounds, biologically active molecules, ligands, and functional materials.

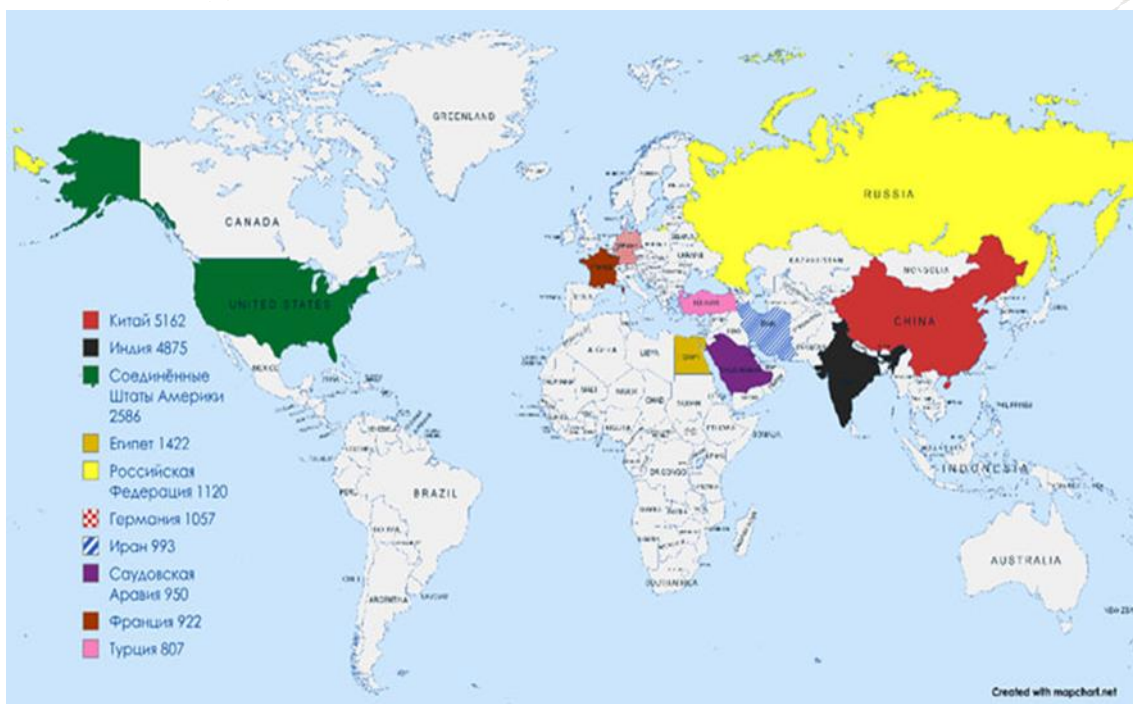


Figure 1. Top 10 countries by number of scientific publications on triazole synthesis during 2000–2025

In recent years, scientific interest in triazole compounds has continued to increase.

Studies devoted to the synthesis of triazoles, their chemical transformations, and biological properties are actively being conducted in China, India, the United States, Egypt, the Russian Federation, Germany, and many other countries [6–8]. In Uzbekistan, a number of studies have also been carried out in recent years on the synthesis of 1,2,3- and 1,2,4-triazole derivatives and on the investigation of their chemical properties and biological activities [9–10].

Dipropargyl esters of dicarboxylic acids are of particular interest because they contain two terminal alkyne reaction centers within a single molecule. Such compounds can undergo CuAAC reactions with aromatic azides, enabling the introduction of two 1,2,3-triazole fragments into the molecule. This affords symmetrical bis-triazole derivatives whose molecular architectures may be promising for subsequent chemical modification and biological studies.

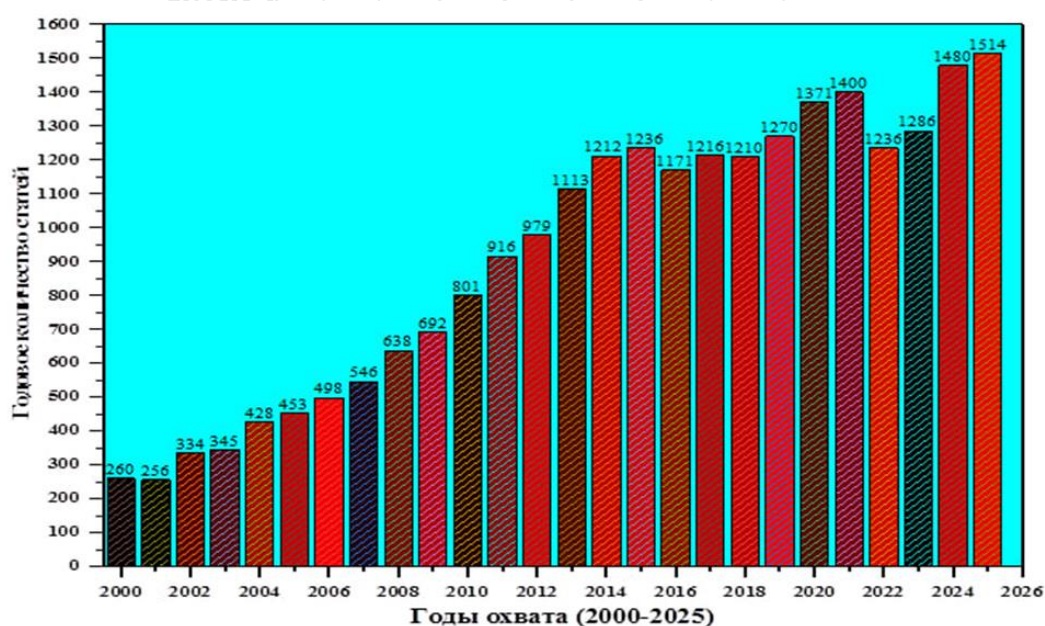


Figure 2. Growth in the number of scientific publications on triazole compounds during 2000–2025

A preliminary survey of the literature and open chemical databases revealed no specific information on the two compounds synthesized in this study, namely bis((1-(p-tolyl)-1H-1,2,3-triazol-4-yl)methyl) adipate and bis((1-(4-methoxyphenyl)-1H-1,2,3-triazol-4-yl)methyl) adipate.

In particular, these compounds were not found in the open PubChem chemical database.

However, the absence of a compound from PubChem does not by itself prove absolute novelty; rather, it can be regarded as additional evidence that information on these structures is limited or unavailable in open literature and public databases.

Thus, the practical and biological significance of 1,2,3-triazole derivatives, the broad synthetic potential of the CuAAC reaction, and the presence of two functional reaction centers in dipropargyl esters determine the relevance of this research direction. Accordingly, the aim of this study was to synthesize new bis-1,2,3-triazole derivatives from dipropargyl adipate and para-substituted aromatic azides, namely p-azidotoluene and p-azidoanisole, to isolate the products, and to characterize their structures using modern spectroscopic methods.

Materials and Methods: Chloroform, hexane, cyclohexane, ethyl acetate, benzene, toluene, ethanol, and methanol used in this study were dried and purified in advance according to standard procedures described in the literature [11]. Modern physicochemical methods were used to characterize the structures of the synthesized compounds. Infrared (FTIR) spectra were recorded on a PerkinElmer FTIR System 2000 spectrometer (USA) using KBr pellets. ^1H and ^{13}C NMR spectra were recorded on JNM-ECZ400R and JNM-ECZ600R spectrometers (JEOL, Japan) operating at 400 and 600 MHz, respectively. Chemical shifts are reported on the δ scale using tetramethylsilane (TMS, $\delta = 0$ ppm) as an internal standard. Deuterated chloroform (CDCl_3), dimethyl sulfoxide ($\text{DMSO}-d_6$), and pyridine- d_5 ($\text{C}_5\text{D}_5\text{N}$) were used as solvents. The progress of the reactions and the chromatographic homogeneity of the synthesized products were monitored by thin-layer chromatography (TLC) on Sorbfil (Russia) and Whatman® UV-254 (Germany) plates. Hexane/ethyl acetate mixtures of 4:1 and 1:1 were used as mobile phases. Melting points of the synthesized solid compounds were determined using Boetius (Germany) and MEL-TEMP (USA) apparatus.

EXPERIMENTAL SECTION

Synthesis of Dipropargyl Adipate (3) (General Procedure)

Adipic acid (21.9 g, 0.15 mol), propargyl alcohol (17.8 mL, $\rho = 0.9485$ g/mL), p-toluenesulfonic acid (p-TsOH, 5.0 g) as catalyst, and benzene (60 mL) as solvent were placed in a 250 mL round-bottom flask. The reaction mixture was heated at approximately 80 °C in a flask equipped with a reflux condenser and a Dean–Stark trap until the evolution of water formed during the reaction ceased. After heating for 5 h, the reaction mixture was cooled and the product was isolated by extraction. The product was then purified by vacuum distillation. Dipropargyl adipate was distilled at 162–163 °C under 8 mmHg and isolated in 86% yield. Chromatographic homogeneity was monitored by TLC: $R_f = 0.47$ (hexane/ethyl acetate = 4:1).

Synthesis of 4-Azidotoluene (6) (General Procedure)

Water (50 mL) was placed in a 500 mL beaker immersed in an ice bath, and sulfuric acid (50 mL) was added dropwise with continuous stirring. In a separate 1 L beaker, p-methylaniline (32.1 g) was mixed with water (50 mL), after which the previously prepared sulfuric acid solution was added. The reaction mixture was stirred magnetically in an ice bath for 20 min.

A solution of sodium nitrite (NaNO_2 , 24.84 g) in water (50 mL) was then added dropwise to the cooled reaction mixture, and stirring was continued at low temperature for a further 30 min. The resulting mixture was filtered, and a solution of sodium azide (NaN_3 , 19.5 g) in water (50 mL) was added dropwise to the filtrate. After stirring for 50 min, a reddish-brown oily product was formed. The product was extracted with chloroform. The organic phase was washed with water, treated with 100 mL of 3% NaHCO_3 solution, and then washed again with water until a neutral medium was obtained. Neutrality was checked using indicator paper. 4-Azidotoluene was isolated in 91% yield.

Synthesis of 4-Azidoanisole (7)

4-Azidoanisole was prepared by the diazotization–azidation procedure described above for 4-azidotoluene. p-Anisidine (47 g), sulfuric acid (50 mL), sodium nitrite (27.0 g), and sodium azide (24.0 g) were used. The reaction product was isolated and purified by the corresponding procedure to afford 4-azidoanisole (p-methoxyphenyl azide) in 87% yield.

Synthesis of Bis-Triazole Compound (8) from Dipropargyl Adipate and p-Azidotoluene

Dipropargyl adipate (0.555 g, 0.0025 mol), p-azidotoluene (0.665 g, 0.005 mol), copper(I) iodide (0.1 g) as catalyst, and toluene (25 mL) were placed in a 250 mL round-bottom flask. The reaction mixture was heated under reflux for 8 h. After completion of the reaction, the mixture was cooled and the solvent was evaporated, affording a dark-brown solid. The crude product was purified by recrystallization from ethanol. The hot solution was filtered under vacuum and allowed to cool slowly to room temperature, during which a light-brown crystalline precipitate formed. The precipitate was filtered and dried. The chromatographic homogeneity of the product was monitored by TLC. The sample was dissolved in chloroform and developed in hexane/ethyl acetate = 1:1; R_f = 0.38. The melting point was 118–119 °C, and the product yield was 85%. The structure of the synthesized compound was characterized by FTIR, ^1H NMR, and ^{13}C NMR spectroscopy, and the spectral data were consistent with the proposed bis-1,2,3-triazole structure.

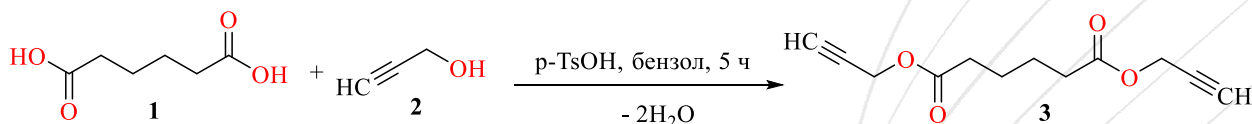
Synthesis of Bis-Triazole Compound (9) from Dipropargyl Adipate and p-Azidoanisole

Bis((1-(4-methoxyphenyl)-1H-1,2,3-triazol-4-yl)methyl) adipate was synthesized according to the general CuAAC procedure described above. Dipropargyl adipate (0.555 g, 0.0025 mol), p-azidoanisole (0.745 g, 0.005 mol), copper(I) iodide (0.1 g), and toluene (25 mL) were used. The reaction mixture was heated under reflux for 8 h, cooled, isolated by the corresponding procedure, and purified by recrystallization. Bis((1-(4-methoxyphenyl)-1H-1,2,3-triazol-4-yl)methyl) adipate (9) was isolated in 87% yield. The product had R_f = 0.46 (hexane/ethyl acetate = 1:1) and a melting point of 101–102 °C. Its structure was characterized by FTIR, ^1H NMR, and ^{13}C NMR spectroscopy.

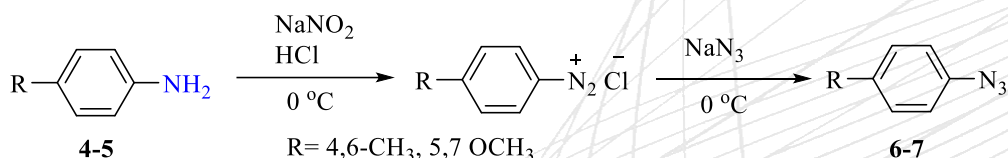
RESULTS AND DISCUSSION

In the first stage of the study, dipropargyl adipate (3), the dipropargyl ester of adipic acid, was prepared as the alkyne component for the synthesis of 1,2,3-triazole derivatives. The presence of two terminal alkyne groups in this molecule enables its use as a bifunctional starting material in azide–alkyne cycloaddition reactions. Dipropargyl adipate was synthesized by esterification of adipic acid with propargyl alcohol in a 1:2 molar ratio in the presence of p-toluenesulfonic acid (p-TsOH) as catalyst.

The reaction was carried out for 5 h using a Dean–Stark apparatus, with continuous removal of the water formed during esterification. Removal of water from the reaction medium shifted the esterification equilibrium toward formation of the desired product. After completion of the reaction, the product was purified by vacuum distillation and dipropargyl adipate (3) was isolated in 86% yield. The product showed $R_f = 0.47$ (hexane/ethyl acetate = 4:1) and a boiling point of 162–163 °C at 8 mmHg. These physicochemical parameters were regarded as preliminary evidence for formation of dipropargyl adipate. The reaction scheme is shown below.



In the next stage of the study, para-substituted aromatic azides were selected as the second components required for construction of the 1,2,3-triazole ring. The aromatic azides were prepared from the corresponding aromatic amines, p-toluidine (4) and p-anisidine (5). First, the aromatic amines were diazotized at low temperature with sodium nitrite to form the corresponding diazonium salts. In the subsequent step, treatment of the diazonium salts with sodium azide afforded 4-azidotoluene (6) and 4-azidoanisole (7), respectively. This approach represents a convenient method for preparing aryl azides from aromatic amines and enabled the target products to be isolated in high yields.



As a result, 4-azidotoluene (6) and 4-azidoanisole (7) were obtained in 91% and 87% yields, respectively. The physical constants of the synthesized aromatic azides were compared with literature data and were found to be in agreement. Selected physicochemical parameters of dipropargyl adipate and the aromatic azides are summarized in Table 1.

Table 1. Selected physicochemical parameters of the synthesized dipropargyl adipate and aromatic azides

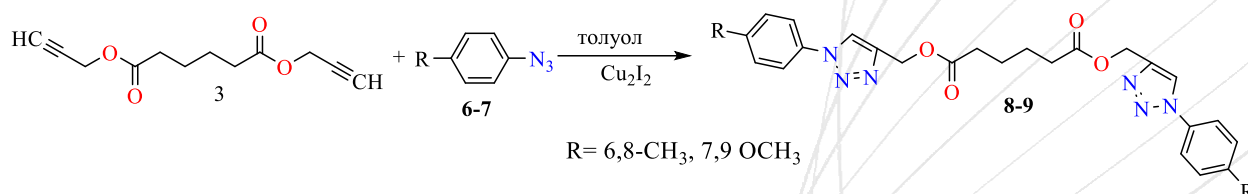
Nº	Compound / formula	Boiling point, °C (8 mmHg)	* R_f	Yield, %
3	$C_{12}H_{14}O_4$	162-163	0,47	86
6		82-83	0,70	91
7		97-98	0,76	87

*Eluent: hexane/ethyl acetate = 4:1

The results showed that under the selected conditions both the alkyne component, dipropargyl adipate, and the azide components, 4-azidotoluene and 4-azidoanisole, were obtained in high yields. The presence of terminal alkyne and azide functional groups required for the subsequent CuAAC reaction made these compounds suitable starting materials for the synthesis of bis-1,2,3-triazole derivatives.

In the next stage, Cu(I)-catalyzed azide–alkyne cycloaddition reactions of dipropargyl adipate with the aromatic azides p-azidotoluene and p-azidoanisole were carried out. Copper(I) iodide was used as the catalyst and toluene as the solvent.

The reagents were used in a 1:2 molar ratio, i.e., two moles of aromatic azide per mole of dipropargyl adipate. The reaction progress was monitored regularly by thin-layer chromatography (TLC). At the early stages of the reaction, an additional spot was observed together with the major product. This observation may be explained by stepwise reaction of the two terminal alkyne groups of dipropargyl adipate with the azide component, with formation of a mono-triazole intermediate. As the reaction proceeded, the intensity of this additional spot gradually decreased, whereas the intensity of the spot corresponding to the target bis-triazole product increased. After heating the reaction mixture for 8 h in the presence of the copper(I) catalyst, the spots corresponding to the starting materials were no longer observed on the TLC plate and essentially a single final product remained. These observations indicate that both terminal alkyne groups of dipropargyl adipate underwent azide–alkyne cycloaddition to form the corresponding bis-1,2,3-triazole derivatives.



The synthesis afforded bis((1-(p-tolyl)-1H-1,2,3-triazol-4-yl)methyl) adipate (8) in 85% yield and bis((1-(4-methoxyphenyl)-1H-1,2,3-triazol-4-yl)methyl) adipate (9) in 87% yield. Selected physicochemical properties of the obtained compounds are presented in Table 2.

Table 2. Selected physicochemical properties of the synthesized bis-1,2,3-triazole derivatives

№	Product name	Melting point, °C	*R _f	Yield, %
8	bis((1-(p-tolyl)-1H-1,2,3-triazol-4-yl)methyl) adipate	118-119	0,38	85
9	bis((1-(4-methoxyphenyl)-1H-1,2,3-triazol-4-yl)methyl) adipate	101-102	0,46	/87

*TLC system: hexane/ethyl acetate = 1:1

FTIR Spectra of the Synthesized Compounds and Their Interpretation

Sintez qilingan birikmalarining funksional guruhlarini tavsiflash hamda azid-alkin FTIR spectra of the synthesized compounds were recorded and analyzed to characterize their functional groups and to assess the course of the azide–alkyne cycloaddition reaction. The dipropargyl adipate molecule contains terminal alkyne ($\equiv\text{C}-\text{H}$), carbon–carbon triple-bond ($\text{C}\equiv\text{C}$), ester carbonyl ($\text{C}=\text{O}$), C–O, and aliphatic methylene groups, each of which gives characteristic absorption bands in the IR spectrum. Intense absorption bands observed at 1723.88 and 1735.09 cm^{-1} were assigned to the $\text{C}=\text{O}$ stretching vibrations of the ester carbonyl group. Bands at 2125.61 and 2129.89 cm^{-1} corresponded to $\text{C}\equiv\text{C}$ stretching vibrations, whereas absorptions at 3223.32 and 3287.30 cm^{-1} were assigned to the $\equiv\text{C}-\text{H}$ stretching vibration of the terminal alkyne group. C–H stretching vibrations of the methylene groups in the aliphatic chain were observed in the 3000–2850 cm^{-1} region, while their deformation vibrations appeared at 1456–1420 cm^{-1} . Characteristic bands associated with C–O vibrations of the ester fragment were recorded in the 1228.72–1115.42 cm^{-1} region. These spectral data demonstrate the presence of ester and terminal alkyne functional groups in dipropargyl adipate.

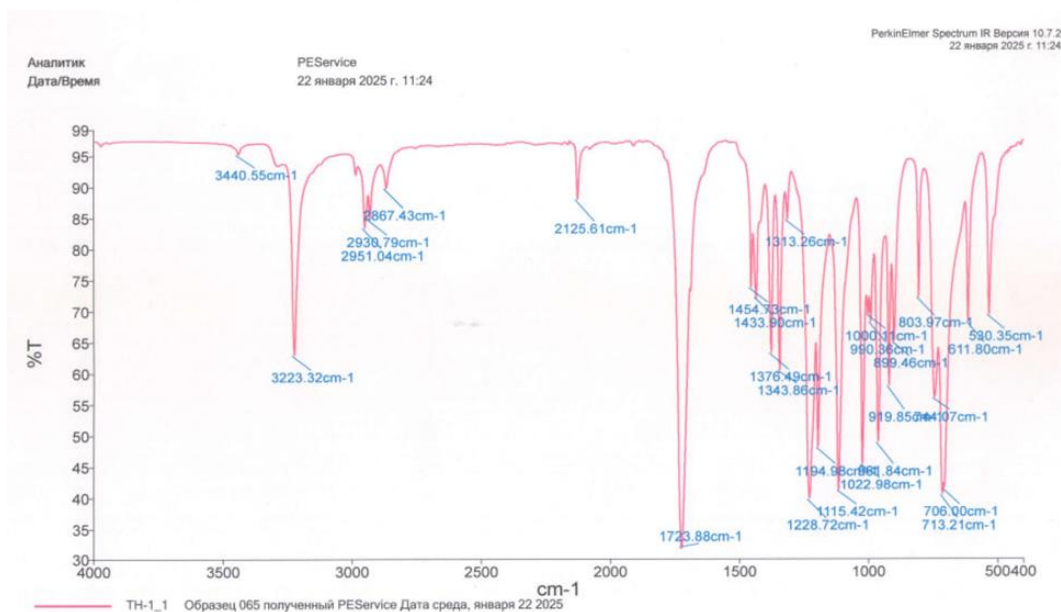


Figure 3. FTIR spectrum of dipropargyl adipate

The FTIR spectra of the bis-1,2,3-triazole derivatives obtained after the azide–alkyne cycloaddition were also analyzed.

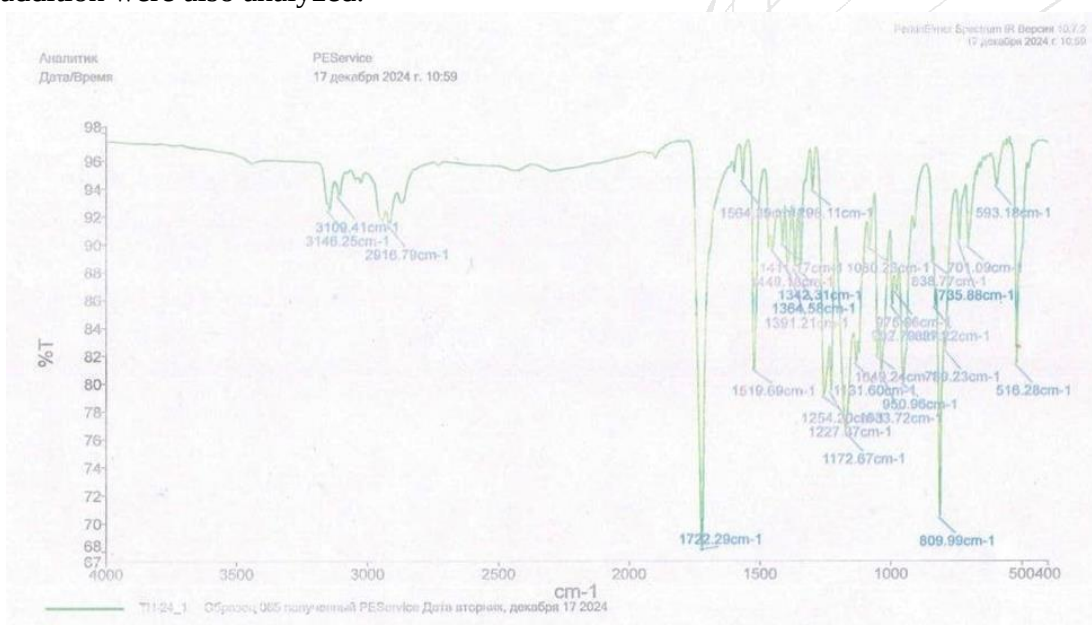


Figure 4. FTIR spectrum of bis((1-(p-tolyl)-1H-1,2,3-triazol-4-yl)methyl) adipate

Comparison of the FTIR spectra of the target bis-triazole derivatives with that of the starting dipropargyl adipate revealed substantial differences. In particular, the absorption bands characteristic of the $\text{C}\equiv\text{C}$ triple bond in the 2200–2100 cm^{-1} region and of the terminal alkyne $\equiv\text{C}-\text{H}$ group at approximately 3300 cm^{-1} were absent from the spectra of the target products. The disappearance of these bands is an important spectral indication that the terminal alkyne groups were consumed in the azide–alkyne cycloaddition reaction.

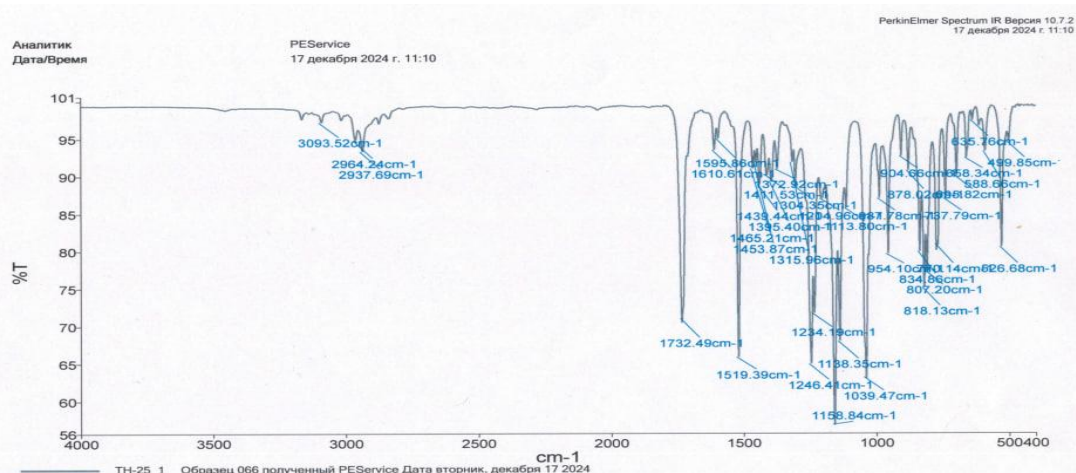


Figure 5. FTIR spectrum of bis((1-(4-methoxyphenyl)-1H-1,2,3-triazol-4-yl)methyl) adipate

At the same time, intense absorption bands characteristic of the ester carbonyl group remained in the 1750–1730 cm^{-1} region, together with bands in the 3000–2850 cm^{-1} region attributable to aliphatic methylene groups.

Because the target products contain aromatic fragments, absorption bands assigned to C=C vibrations of the aromatic ring were observed in the 1600–1500 cm^{-1} region. In addition, bands characteristic of C–H stretching vibrations at sp^2 -hybridized carbon atoms appeared in the 3100–3000 cm^{-1} region. For compound 9, which contains methoxy groups, relatively stronger absorptions were observed in the 1250–1000 cm^{-1} region; these can be attributed to overlap of C–O stretching vibrations from the ester and aromatic methoxy groups. In the spectrum of the p-tolyl-containing compound 8, an intense band near 800 cm^{-1} is consistent with out-of-plane C–H deformation vibrations of a para-disubstituted aromatic ring.

Thus, disappearance of the spectral features characteristic of the terminal alkyne groups of the starting dipropargyl adipate, together with the appearance of new absorptions associated with aromatic and triazole fragments in the target products, supports successful azide–alkyne cycloaddition and formation of the proposed bis-1,2,3-triazole structures.

NMR Spectra of the Synthesized Compounds and Their Interpretation

To characterize the structures of the synthesized bis-1,2,3-triazole derivatives more reliably, their ^1H and ^{13}C NMR spectra were analyzed.

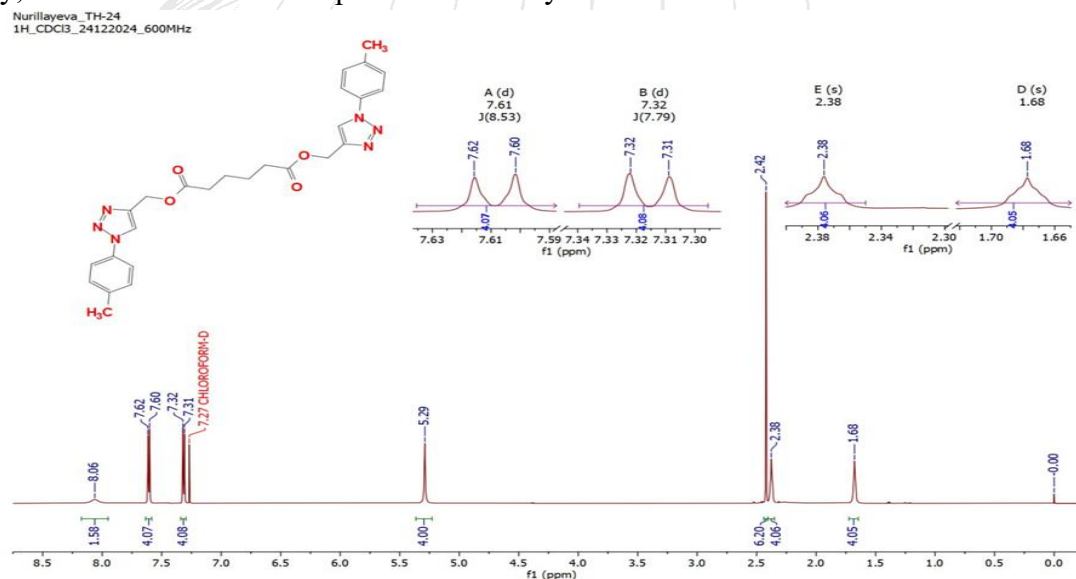
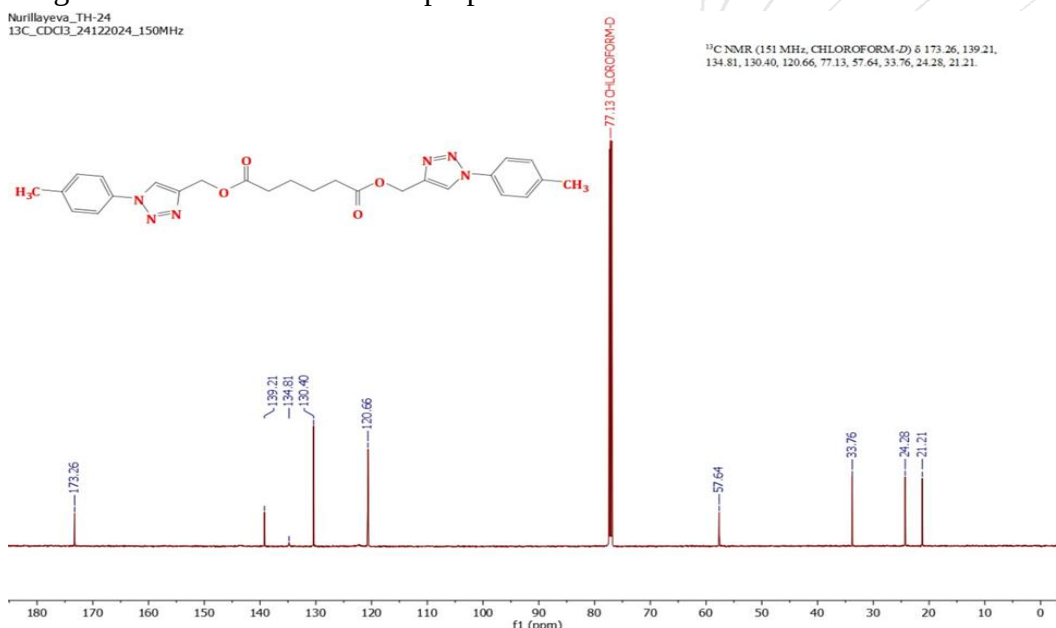


Figure 6. ^1H NMR spectrum of bis((1-(p-tolyl)-1H-1,2,3-triazol-4-yl)methyl) adipate

^1H NMR (600 MHz, CDCl_3 , δ , ppm): In the spectrum of bis((1-(p-tolyl)-1H-1,2,3-triazol-4-yl)methyl) adipate (**8**), the singlet observed at $\delta \approx 8.06$ ppm (s, 2H) was assigned to the triazole-ring protons and indicates formation of the 1,2,3-triazole fragments. In the aromatic region, two doublets were recorded at $\delta \approx 7.61$ ppm (d, 4H, Ar-H) and $\delta \approx 7.32$ ppm (d, 4H, Ar-H), corresponding to the aromatic protons of the para-substituted tolyl rings. The singlet at $\delta \approx 5.29$ ppm (s, 4H) was assigned to the $-\text{O}-\text{CH}_2-$ triazole methylene protons between the ester oxygen atoms and the triazole fragments. The singlet at $\delta \approx 2.42$ ppm (s, 6H) corresponds to the methyl protons of the p-tolyl groups (Ar- CH_3). The methylene protons α to the carbonyl groups in the adipate fragment appeared at $\delta \approx 2.38$ ppm as a triplet (t, 4H), whereas the internal β -methylene protons of the chain were observed at $\delta \approx 1.68$ ppm as a multiplet (m, 4H). The residual CDCl_3 signal was recorded at $\delta \approx 7.27$ ppm. The integration and chemical-shift values of these proton signals are consistent with the proposed bis-triazole structure.

Figure 7. ^{13}C NMR spectrum of bis((1-(p-tolyl)-1H-1,2,3-triazol-4-yl)methyl) adipate

^{13}C NMR (151 MHz, CDCl_3 , δ , ppm): A signal at $\delta \approx 173.26$ ppm was observed for the carbonyl carbon atoms of the ester groups. Signals in the $\delta \approx 139.21$ – 120.66 ppm region were assigned to the sp^2 -hybridized carbon atoms of the triazole rings and aromatic fragments. The signal at $\delta \approx 57.64$ ppm corresponds to the methylene carbon atoms of the $-\text{O}-\text{CH}_2-$ triazole fragments. Signals at $\delta \approx 33.76$ and 24.28 ppm were assigned to the methylene carbon atoms of the adipate chain, whereas the signal at $\delta \approx 21.21$ ppm corresponds to the methyl carbon atoms of the p-tolyl groups. The residual CDCl_3 signal was observed at $\delta \approx 77.13$ ppm. The absence of the terminal-alkyne carbon signals characteristic of the starting dipropargyl ester, normally found at approximately 70–80 ppm, provides additional evidence that the terminal alkyne groups were consumed in the cycloaddition reaction. Overall, the ^1H and ^{13}C NMR data, together with the FTIR results, are consistent with the proposed structure of bis((1-(p-tolyl)-1H-1,2,3-triazol-4-yl)methyl) adipate (**8**). The ^1H and ^{13}C NMR spectra of the second target product, bis((1-(4-methoxyphenyl)-1H-1,2,3-triazol-4-yl)methyl) adipate (**9**), were also examined in detail.

Characteristic signals attributable to the triazole protons, para-substituted aromatic-ring protons, the $-\text{O}-\text{CH}_2-$ triazole fragment, methylene groups of the adipate chain, and methoxy

groups were observed. These spectral data were found to be consistent with the proposed structure of compound **9**.

CONCLUSION

As a result of this study, two bis-1,2,3-triazole derivatives, bis((1-(p-tolyl)-1H-1,2,3-triazol-4-yl)methyl) adipate (**8**) and bis((1-(4-methoxyphenyl)-1H-1,2,3-triazol-4-yl)methyl) adipate (**9**), were synthesized from dipropargyl adipate, p-azidotoluene, and p-azidoanisole via copper(I)-catalyzed azide-alkyne cycloaddition (CuAAC) in 85% and 87% yields, respectively.

The reaction progress was monitored by thin-layer chromatography. The appearance of an additional spot at the early stages of the reaction, followed by a gradual decrease in its intensity and predominance of the spot corresponding to the main bis-triazole product, indicates stepwise reaction of the two terminal alkyne groups of dipropargyl adipate with the azide components. The structures of the synthesized compounds were investigated by FTIR, ^1H NMR, and ^{13}C NMR spectroscopy. In the FTIR spectra, disappearance of the $\text{C}\equiv\text{C}$ and $\equiv\text{C}-\text{H}$ absorption bands characteristic of the starting dipropargyl ester, together with the appearance of new bands associated with aromatic and triazole fragments, indicated that the azide-alkyne cycloaddition had occurred. The characteristic triazole proton signal at $\delta \approx 8.0$ ppm in the ^1H NMR spectra, as well as the corresponding aromatic, triazole, carbonyl, and aliphatic carbon signals in the ^{13}C NMR spectra, were consistent with the proposed bis-1,2,3-triazole structures.

Thus, the CuAAC click-chemistry approach employed in this study was shown to provide an efficient synthetic route for obtaining bis-1,2,3-triazole derivatives from dipropargyl adipate in high yields. The presence of two 1,2,3-triazole fragments, ester groups, and nitrogen and oxygen donor atoms in the molecules of the obtained compounds makes them interesting targets for further physicochemical and biological investigations.

Because the biological activity of these compounds was not investigated within the scope of the present study, future work should evaluate their antimicrobial, anti-inflammatory, and other pharmacological properties, as well as their ability to form complexes with metal ions. Mazkur birikmalarning biologik faolligi ushbu tadqiqot doirasida o'rganilmaganligi sababli, kelgusida ularning antimikrob, yallig'lanishga qarshi va boshqa farmakologik xususiyatlarini, shuningdek metall ionlari bilan kompleks hosil qilish qobiliyatini o'rganish maqsadga muvofiq hisoblanadi.

REFERENCES

1. Bakr F.A.-W., Ehab A.-L., Hanan A.M., Ghada E.A. Design and synthesis of new 4-pyrazolin-3-yl-1,2,3-triazoles and 1,2,3-triazol-4-yl-pyrazolin-1-ylthiazoles as potential antimicrobial agents. *European Journal of Medicinal Chemistry*, 2012, 52, 263-268.
2. Zhigan J., Julin G., Ghen W., Shengzheng W., Na L., Yan J., Guoqiang D. Design, synthesis and antifungal activity of novel triazole derivatives containing substituted 1,2,3-triazole-piperidine side chains. *European Journal of Medicinal Chemistry*, 2014, 82, 490-497.
3. Sirassu N., Sathesh K. N., T. Savitha, M. Ravinder, M. Srinivasa, N. Vasudeva. One-pot synthesis and biological evaluation of novel 4-[3-fluoro-4-(morpholin-4-yl)]phenyl-1H-1,2,3-triazole derivatives as potent antibacterial and anticancer agents. *Journal of heterocyclic chemistry*, 2020, 57(4), 1655-1665.

4. Livi O., Biagi G., Ferreti M., Lucacchini A., Baili P.L. Synthesis and in vitro anto anti-inflammatory activity of 4-phenyl-1,2,3-triazole derivatives. *Europ. J. Med.chem.*-1983, 18(5), 471-475.
5. Livi O., Ferrarini P. L., Tonetti., Smaldone F., Zefola G. Syntesiedosame farmacologica di deerivati 1,2,3-triazolici dellanaftalina, Chinoline e piridina. *Farmaco Ed.Se.*1979, 34(3), 217-228.
6. Cardona-Galeano W., Yepes A.F., Ramírez-Malule H. Triazole-based click chemistry as strategic for novel therapeutics treatments of cancer: A bibliometric analysis 2007–2024 // *Journal of Applied Pharmaceutical Science*. 2025., V. 15., №5., P. 064–074.
7. Caiana R.R.A., Santos C.S., de Oliveira R.N., Freitas J.C.R. Scientific and Technological Prospecting of 1H-1,2,3-Triazoles // *Current Organic Chemistry*. 2022., V. 26., №3., P. 275–286.
8. Sweileh W.M., Sawalha A.F., Al-Jabi S., Zyoud S.H. Bibliometric Analysis of Literature on Antifungal Triazole Resistance: 1980–2015 // *Germes*. 2017., V. 7., №1., P. 19–27
9. Khojimatova Sh. R., Ortikov I. S., Abdugafurov I. A., Elmuradov B. J. Catalytic cyclization of isomeric prop-2-yn-1-yl 2-(nitrophenoxy)acetates and p-bromophenyl azide. *Uzbek Chemical Journal*. 2022, No. 6, pp. 69–77.
10. Aytmuratova U.K., Azamatov A.A., Ortikov I.S., Tursunkhodzhaeva F.M.. Investigation of the analgesic and anti-inflammatory activity of a newly synthesized 1,2,3-triazole derivative. // *Frontiers in Health Informatics*. 2024. -13(6). -P.686-693
11. Gordon A., Ford R. *The Chemist's Companion: Physicochemical Properties and Methods*. Moscow: Mir, 1976, 541 p.