



Silver and copper-Supramolecular coordination polymers catalyzed alkyne–azide “Click” cycloadditions

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Abstract: Two 3D-supramolecular coordination polymers (SCP); $\{[\text{SnMe}_3(\text{bpe})][\text{Ag}(\text{CN})_2] \cdot 2\text{H}_2\text{O}\}$, **1** and $\{[\text{Cu}^{\text{I}}(\text{CN}_2(\text{phen})\text{Cu}^{\text{II}}(\text{CN})_2(\text{phen})) \cdot 5\text{H}_2\text{O}\}$, **2** have been synthesized and characterized by physicochemical and spectroscopic methods. The structure of **1** consists of cationic $\{-\text{Sn}(\text{Me}_3)\text{-bpe-}\}$ chains that are neutralized by $[\text{Ag}(\text{CN})_2]^-$ anions. The dicyanoargentate anions present discrete uncoordinated fragments between the cationic chains. The water molecules bind the cationic chains and the anions forming 3D-supramolecular structure through hydrogen bonds. The most intriguing feature in the structure of **2** is the unusual supramolecular interactions, including hydrogen bonds which involve the terminal cyanide and the phenanthroline (phen) ligands and $\pi\text{-}\pi$ stacking which generate a unique 3D-supramolecular architecture in the solid state. The SCP **1** and **2** exhibit good catalytic activity for the formation of substituted triazoles. In this case, the SCP **1** and **2**-catalyzed alkyne–azide cycloaddition provide 1,4-disubstituted 1,2,3-triazoles with such efficiency and scope that the transformation has been described as “click” chemistry.

Key words: click reaction, Copper, Silver, supramolecular polymers, Catalysis.

Introduction:

The supramolecular coordination polymers are undergoing a renaissance due to their unique structural and electronic properties and potential use in creating new therapeutics and electronically tunable materials [1-6]. The design and crystal engineering of the supramolecular coordination polymers continue to be a quite active research field because of their intriguing structural motifs and their potential applications as functional materials in areas such as magnetism, molecular sieves, ion exchange, gas storage, sensors, luminescence, non-linear optics, corrosion inhibition, biological activity, chirality, electronics, catalysis and conductivity [1-6]. Phenanthroline (phen) and 1,2-bis(4-pyridyl)ethane (bpe) have been extensively used as chemically versatile modules exhibiting a fortunate combination of structural and chemical properties [7-9]. Rigidity and planar structure of phen makes it an entropically better chelating molecule while bpe acts as

angular bipodal spacer ligand creating diverse topologies. Thus, supramolecular self-assembly was used to design silver or copper cyanide SCP containing bpe or phen, which have been carried out at room temperature between $[\text{M}(\text{CN})_4]^{3-}$ ($\text{M}=\text{Ag}$ or Cu) building blocks and bpe or phen in presence of Me_3SnCl to test their catalytic activity in click reactions. The concept of “click” chemical reactions was described by Sharpless, the copper(I)-catalyzed azide–alkyne cycloaddition (Cu-AAC: i.e., the copper-catalyzed Huisgen cycloaddition) reaction has emerged as the most extensively investigated and applied [10]. This reaction permits the chemoselective, regiocontrolled conjugation of a functionalized alkyne to a functionalized azide yielding 1,4- or 1,4,5-substituted 1,2,3-triazole and occasionally 1,5-regioisomer [11,13]. Applications in many areas ranging from functional materials, drug discovery, biological, and hybrid

bioconjugate areas have increased exponentially over the last decade [14-16]. The silver and copper complexes have been shown to act as mild π acids, thus effectively promoting the cycloaddition of azides onto terminal alkynes [17-19].

The supramolecular catalysts are stable, well-defined non-solvated materials, and soluble in most organic-aqueous solvents, thus making them attractive homogeneous alternatives to copper and silver salts for potentially promoting the formation of 1,2,3-triazole. To test this hypothesis, $\{[\text{SnMe}_3(\text{bpe})][\text{Ag}(\text{CN})_2] \cdot 2\text{H}_2\text{O}\}$ **1**, and $\{[\text{Cu}^{\text{I}}(\text{CN})_4(\text{phen})_2][\text{Cu}^{\text{II}}(\text{CN})_2(\text{phen})] \cdot 5\text{H}_2\text{O}\}$ **2**, were prepared and characterized, and their reactivity toward azide-alkyne cycloaddition reactions was evaluated, where, for the first time, supermolecular catalysts were used for 1,2,3-triazoles formation at room temperature

2. Experimental

2.1. Materials and instrumentation

All chemicals and solvents used in this study were of analytical grade supplied by Aldrich or Merck and used as received. Microanalyses (C, H, N) were carried out with a Perkin Elmer 2400 automatic elemental analyzer. The IR spectra were recorded on Perkin Elmer 1430 Ratio Recording Infrared Spectrophotometer as KBr discs. The magnetic susceptibility was determined with Johnson-Matthey susceptometer.

2.2 Synthesis of

$\{[\text{SnMe}_3(\text{bpe})][\text{Ag}(\text{CN})_2] \cdot 2\text{H}_2\text{O}\}$, **1**

A solution of 82 mg (0.25 mmol) of $\text{K}_3[\text{Ag}(\text{CN})_4]$ in 5 mL H_2O was added, with gentle stirring, to a mixture of solutions containing 150 mg (0.75 mmol) of Me_3SnCl in 5 mL MeCN and of 46 mg (0.25 mmol) of bpe in 5 mL MeCN. After about 2-3 weeks, colorless prismatic crystals of **1** started growing from initially clear solution. After filtration, washing with small, quantities of cold H_2O and MeCN and overnight drying, 107 mg of **1** were obtained. Anal. Calc. for **1** ($\text{C}_{17}\text{H}_{25}\text{N}_4\text{O}_2\text{AgSn}$): C, 37.53; H, 4.63; N, 10.30%. Found: C, 37.65; H, 4.17; N, 10.07%.

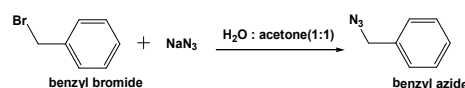
2.3 Synthesis of $\{[\text{Cu}^{\text{I}}(\text{CN})(\text{phen})_2][\text{Cu}^{\text{II}}(\text{CN})_2(\text{phen})] \cdot 5\text{H}_2\text{O}\}$, **2**

At room temperature, a solution of 99 mg (0.33 mmol) of $\text{K}_3[\text{Cu}(\text{CN})_4]$ in 30 mL H_2O was added, under gentle stirring to a solution of 60 mg (0.334 mmol) of 1,10-

phenanthroline (phen) in 20 mL acetonitrile. After 1 week green needle crystals were resulted from yellow solution, after filtration, subsequent washing with water and overnight drying, about 70 mg (51% referred to $\text{K}_3[\text{Cu}(\text{CN})_4]$ of green crystals were obtained. $\text{leff.} = 1.95$ BM, Anal. Calc. for **1** ($\text{C}_{39}\text{H}_{34}\text{N}_9\text{O}_5\text{Cu}_2$): C, 56.0; H, 2.8; N, 15.0%. Found: C, 55.96; H, 2.7; N, 14.9%.

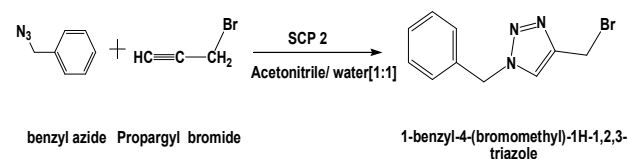
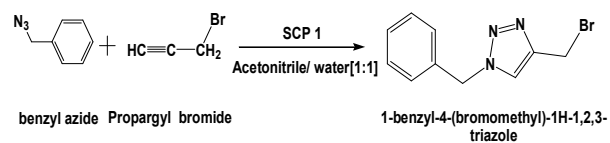
2.2.3 Synthesis of benzyl azide

Sodium azide (1.4gm, 2.5equiv.) and Benzyl bromide (1mL, 1.5equiv.) are dissolved in mixture of acetone and water (1:1, 20mL) by stirring in 100mL round-bottom flask under close system over night at room temperature, then leaving the mixture to evaporate acetone. The benzyl azide was extracted with water (1×10 mL) and diethyl ether (2×10 mL).



2.2.4 Synthesis of 1-benzyl-4-bromomethyl triazole

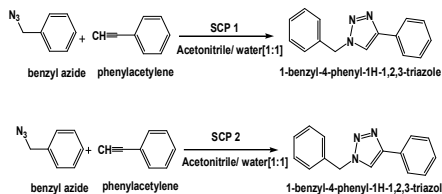
Propargyl bromide (1equiv, 0.09gm) and (2equiv, 0.19gm), benzyl azide ((1equiv. 0.12mL) and (2equiv. 0.25mL)) and the catalyst (0.025, 0.05, 0.1, 0.15equiv.) were mixed in presence of acetonitrile and water mixture (1:1, 20mL). The mixture was stirred at room temperature or with heating to deliver exclusively the corresponding 1,4-triazole.



2.2.5 Synthesis of 1-benzyl-4-phenyl triazole

Phenyl acetylene (1equiv. 0.1 mL) and (2 equiv. 0.22 mL), benzyl azide (1equiv. 0.12 mL) and (2 equiv. 0.25 mL) and catalyst (0.025, 0.05, 0.1, 0.15equiv.) in

presence of acetonitrile and water mixture (1:1, 20 mL) and stirring the mixture at room temperature or with heating to deliver exclusively the corresponding 1,4-triazole.



3. Results and Discussion

3.1 Crystal structure of

$\{[\text{SnMe}_3(\text{bpe})][\text{Ag}(\text{CN})_2] \cdot 2\text{H}_2\text{O}\}_n$, **1**

The asymmetric unit of **1** contains one 1,2-bis(4-pyridyl)ethane (bpe) molecule, one Me_3Sn cation, one Ag atom, two cyanide ligands and two water molecules, Fig. 1. The structure of **1** constructed of repeating asymmetric units with one distinct type of both silver and tin. The tin atom is penta-coordinated and has trigonal bipyramidal configuration (TBPY-5) with two nitrogen atoms of bpe ligands axially anchored to it forming cationic chain; $\text{N}3\text{-Sn}1\text{-N}4$ angle is 175.5° . The silver (I) ion is coordinated to two cyanide groups to form the discrete linear $[\text{Ag}(\text{CN})_2]^-$ anion; $\text{C-Ag-C} = 177.6^\circ$. The structure of **1** consists of cationic $\{-(\text{Me}_3\text{Sn}-\text{bpe})^+\}$ chains that are neutralized by $[\text{Ag}(\text{CN})_2]^-$ anions. The dicyanoargentate(I) anions present discrete uncoordinated fragments between the cationic chains. The cationic chains form parallel sets of layers which contain infinite chains with separation distances excluding any packing interaction, Fig. 2. The dicyanoargentate anions and the water molecules thread in the space between the cationic layers. The water molecules exist as pairs that are mutually interacted by hydrogen bonds; $\text{O}10\text{-H}7 = 1.92 \text{ \AA}$, $\text{O}7\text{-H}10 = 1.943 \text{ \AA}$ and oxygen-oxygen contacts, 2.879 . At the same time, the dimeric water molecules connect two $[\text{Ag}(\text{CN})_2]^-$ anions through hydrogen bonds; $\text{N}5\text{-H}10\text{i} = 2.077 \text{ \AA}$, $\text{N}24\text{-H}7 = 2.058 \text{ \AA}$, forming octagonal rings which are connected together by H-bonds at water molecules, 3.009 \AA , and short contacts; 2.786 \AA , forming ribbon-like structure. The anionic ribbons connect

the cationic layers by extensive hydrogen bonds; $2.715\text{-}2.958 \text{ \AA}$, and $\pi\text{-}\pi$ stacking and short contacts creating unique supramolecular 3D-network structure [20].

3.2 Spectral characteristics of **1**

The IR spectrum of the SCP **1** displays strong band at 2138 cm^{-1} corresponding to ν_{CN} . The presence of this band at lower wavenumber than those of the bridging cyanides and higher value than those of the terminal cyanides is a good evidence of the presence of the hydrogen bonds between the $[\text{Ag}(\text{CN})_2]^-$ anions and the water molecules. Also, the IR spectrum of **1** shows the band of $\nu_{(\text{Ag-C})}$ at about 468 cm^{-1} ; the presence of this band confirms the presence of Ag-CN moiety. Water molecules in **1** give rise to the appearance of a broad band at 3425 cm^{-1} . Methylene groups of the bpe ligand as well as the methyl groups of the Me_3Sn fragment are characterized in the IR spectrum of **1** by C-H stretching vibrations at 2925 and 2871 cm^{-1} and by C-H deformation band at 1461 cm^{-1} . ^1H NMR spectrum of the SCP **1**, displays three distinct bands for the bipodal ligand, bpe. The doublet at 8.42 and 8.43 ppm is assigned to $\text{H}_{2,6}$ & $\text{H}_{2,6}$, while the doublet at 7.24 and 7.25 ppm is assigned to $\text{H}_{3,5}$ & $\text{H}_{3,5}$. The ethylenic group gives rise to one singlet band at 2.93 ppm . The protons of the Me_3Sn group gave rise to band at 0.53 ppm with its characteristic satellite bands that result from spin-spin coupling with the tin atom. The singlet band at 3.38 ppm is due to the protons of the water molecules. On the other hand, there are four bands for bpe, in the ^{13}C -spectrum; at 123.4 ppm for β carbon nuclei, at 148.9 ppm for γ carbon nuclei, at 149.3 ppm for α carbon nuclei and at 33.4 ppm for the ethylenic carbons. The cyanide groups display singlet band in the ^{13}C -spectrum; at 142.5 ppm and the Me_3Sn units give rise to a triplet band at 0.21 ppm with its characteristic satellite bands. Thus, the NMR spectra confirm the presence of the cyanide ligand, the bipodal ligands, water molecules as well as the Me_3Sn units as bridging groups. The ratio between the peaks' areas of all types in the ^1H NMR spectrum of **1** support the composition elucidated by X-ray diffraction and elemental analysis.

3.3 Crystal Structure of the SCP $\{[\text{Cu}^{\text{I}}(\text{CN})(\text{phen})_2][\text{Cu}^{\text{II}}(\text{CN})_2(\text{phen})]\cdot 5\text{H}_2\text{O}\}_n$, **2**

The asymmetric unit of the SCP **2** contains two discrete molecular structures and consists of two crystallography different Cu(I/II) atoms, three ordered cyanide groups, three phen molecules and five clathrated water molecules, [Fig. 3](#). The structure of the SCP **2** contains $[\text{Cu}^{\text{I}}(\text{CN})_2(\text{phen})]$, $[\text{Cu}^{\text{II}}(\text{CN})_2(\text{phen})]$ fragments and five water molecules which are connected with each other by hydrogen bonds. In $[\text{Cu}^{\text{I}}(\text{CN})_2(\text{phen})]$ fragment, the copper center is coordinated by two phen ligands and one cyanide ligand in a distorted trigonal bipyramid (TBPY-5) geometry. On the other hand, the copper atom, in the $[\text{Cu}^{\text{II}}(\text{CN})_2(\text{phen})]$ fragment, is coordinated to one phen ligand and two cyanide groups, forming slightly distorted tetrahedral (T-4) geometry. There are five clathrated water molecules per $\{[\text{Cu}^{\text{I}}(\text{CN})_2(\text{phen})][\text{Cu}^{\text{II}}(\text{CN})_2(\text{phen})]\}_n$ fragments which form hydrogen bonds. The oxygen atoms of the water molecules are close packed by short contacts in the range of 2.75–2.87 Å, forming a unique 1D-tape. This 1D-tape consists of fused two four- and one six-oxygen member rings creating water cluster. The water molecules spread between the layers of the $[\text{Cu}^{\text{I}}(\text{CN})(\text{phen})_2]$ and $[\text{Cu}^{\text{II}}(\text{CN})_2(\text{phen})]$ fragments forming H-bonds with the terminal cyanide groups and the hydrogen atoms of the phen ligand to extend the structure of **2** to 3D-network [\[21\]](#). So, these water tapes play a complementary role via hydrogen bonds for stabilizing the network structure of the SCP **2** in addition to the π - π stacking, [Fig. 4](#).

3.4 Spectral characteristics of **2**

The IR spectrum of the SCP **2** exhibits a strong broad band at 3397 cm^{-1} corresponding to the stretching vibrations of the water molecules. The IR spectrum of the SCP **2** exhibits bands characteristic of the $(\text{CuCN})_n$ fragment and the phen ligand. The spectrum displays the bands of the phen ligand at 3059, 2926 cm^{-1} ($\nu_{\text{CH}(\text{arom})}$), (1421 cm^{-1} (δ_{CH}) and at 770, 724 cm^{-1} (γ_{CH}). These bands are shifted to lower wave numbers from the vibration frequencies of the free phen ligand due to

the formation of hydrogen bonds between the hydrogen atoms of the ligand and the donor sites of the $(\text{CuCN})_n$ fragment. In contrast, the band at 1617 cm^{-1} corresponds to $\nu_{\text{C}=\text{N}}$ while those at 1586, 1507 and 1459 cm^{-1} are attributed to $\nu_{\text{C}-\text{C}}$ of the phen ligand in the SCP **1**. These bands exhibit small shifts to lower wave numbers from those of the phen ligand supporting coordination of phen to Cu centers. The presence of two ν_{CN} IR absorption bands in the spectrum of the SCP **2** at 2129 and 2086 cm^{-1} supports the presence of two different cyanide groups. The first type of the cyanide groups is bonded to CuI while the other is coordinated to CuII center, supporting the presence of mixed valence copper cyanide coordination polymer. It is noteworthy that the ν_{CN} bands (2129, 2086 cm^{-1}) of the SCP **2** are different from that of $\text{K}_3[\text{Cu}(\text{CN})_4]$ (2081 cm^{-1}), which also supports the presence of two types of cyanide groups. In addition, the $\nu_{\text{Cu}-\text{C}}$ bands at 429 and 435 cm^{-1} confirm the presence of two $(\text{CuCN})_n$ fragments.

3.5 Click reactions

The advantageous properties of Huisgen cyclo-addition, together with the most useful modular nature of the click chemistry approach, make it well-suited for use in the synthesis of new molecules, especially conjugates composed of two quite different subunits. Examples are bioorganic-inorganic conjugates such as the organic azides and the boron clusters [\[22\]](#). A preliminary screening study using phenyl acetylene, benzyl azide and catalysts **1** and **2**, which differ in the nature ligands, geometry and metals, was undertaken (Figures 1 and 2). For initial studies, reactions were performed in acetonitrile and water (1:1). This ratio was found to be suitable solvent because of the high solubility of both alkyne and azides to give corresponding triazoles (1-benzyl-4-bromomethyl triazole and 1-benzyl-4-phenyl triazole) in 100% yield. The different factors affecting the yield of triazoles such as concentration of azide and alkyne, catalyst amount, time and temperature, have been investigated to apply the best conditions to obtain 98-100% yield triazoles. The results are shown in [Tables 1-8](#). It is observed that

the azide/alkyne ratio as well as the amount of catalyst (0.05-0.15 mol%) affects the time required to obtain the best yield of triazole. Using 0.15 mol% of SCP **1** as a catalyst with the ratio 2:1 azide/ alkyne (propargyl bromide) affords the full conversion (yield 98%) of azide/alkyne to triazole after 25 min at room temperature, [Table 1](#), entry 7. On the other hand, full conversion [yield 100%] of azide/alkyne (propargyl bromide) [1:2] to triazole required the use of 0.15 mol% of the catalyst SCP **2** within 30 min at room temperature [Table 2](#), entry 4. Above reactions represent the best conditions for the formation of 100% yield triazole within shortest time. Also, in case of the alkyne phenyl acetylene, using 0.10 mol% of the SCP **1** as a catalyst with the ratio 1:1 azide/ alkyne affords the full conversion (yield 100%) of azide/alkyne to triazole after 30 min at room temperature, [Table 3](#), entry 7. In the case of the SCP **2**, full conversion [yield 100%] of azide/alkyne [1:1] to triazole required the use of 0.15 mol% of the catalyst **2** within 35 min at room temperature [Table 4](#), entry 4. Above reactions represent the best conditions for the formation of 100% yield triazole within shortest time. Varying the nature of the catalyst between the silver **1** and copper **2** metals had little impact on the yield. A key advantage of using **1** is that there was no evidence that the catalyst and alkyne reacted vigorously, including when reactions are done at a larger scale. For instance, when a 10-fold increase in reaction scale was run using phenyl acetylene and SCP **1**, the desired triazole was readily isolated in 100% yield after 30 minutes at room temperature. One additional advantage of using the homogeneous catalyst as opposed to AgNO₃ is that at the completion of a reaction there was no evidence of silver metal deposition, owing to the robust nature of the metal complex [\[17-19\]](#). The general utility of the catalyst under the most promising conditions was evaluated subsequently using SCP **1** and **2** and two of different alkynes in direct comparison to reactions performed in the presence of catalysts Cu(OAc)₂ and AgNO₃ as shown in [Tables 5-8](#). In all cases

isolated yields are reported.

Under identical conditions for the AgNO₃ or Cu(OAc)₂ and sodium ascorbate-catalyzed reaction, it was found that Propargyl bromide and phenyl acetylene were converted to the corresponding triazole in 100% yield in both cases after only 25-28 and 5-12 hours, respectively, at room temperature, [Tables 5-8](#). The reactions progress were monitored by TLC and the products were purified by preparative TLC using CH₂Cl₂ (1:1) as a mobile phase to generate the desired tris-triazoles in quantitative high yields. The SCP **2** was successful in producing 1,2,3-triazoles in 100% in 50 minutes without using sodium ascorbate. During the course of our studies, as previously reported by Sharpless [\[14\]](#), the use of the SCP **2** reduced by sodium ascorbate gave generally higher yields than a direct source of Cu owing to the high degree of efficiency, the reaction could be conducted with a stoichiometric amount (4.5 equiv.) of azides. Purification was greatly simplified by the absence of side products. When experiments are repeated at high temperatures (40-60 °C), the yields of the catalyzed reactions were below 80% for all the compounds tested after 20 minutes. However after 30 minutes two of the alkynes tested generated triazole in greater than 90% yield. When the control reactions were run in the absence of the catalyst, yields of the products at room temperature were negligible (< 1%).

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Table1 Optimization with silver polymer catalyst in the Ag-AAC reaction for entries 1- 9 propargyl bromide ,benzyl azide, entry 10 recovery reaction

Entry	Azide	Alkyne	Catalyst ratio	Time	Temperature	Yield
1	2	1	0.15	80	r.t	98%
2	2	1	0.1	30	r.t	98%
3	2	1	0.05	25	r.t	100%
4	1	2	0.15	90	r.t	97%
5	1	2	0.1	70	r.t	100%
6	1	2	0.05	95	r.t	98%
7	1	1	0.15	110	r.t	100%
8	1	1	0.1	130	r.t	100%
9	1	1	0.05	145	r.t	100%
10	2	1	0.15	50	r.t	100%
11	2	1	0.15	12	60c	98%
12	2	1	0.15	20	40c	100%

Table 2 Optimization with copper polymer catalyst in the Cu-AAC reaction for entries 1-9 propargylbromide ,benzylazide, entry 10 recovery reaction

Entry	Azide	Alkyne	Catalyst ratio	Time/min	Temperature	Yield
1	2	1	0.15	90	r.t	100%
2	2	1	0.1	105	r.t	100%
3	2	1	0.05	120	r.t	95%
4	1	2	0.15	30	r.t	100%
5	1	2	0.1	70	r.t	98%
6	1	2	0.05	60	r.t	98%
7	1	1	0.15	60	r.t	95%
8	1	1	0.1	80	r.t	100%
9	1	1	0.05	95	r.t	100%
10	1	2	0.15	50	r.t	100%

table 3 Optimization with silver polymer catalyst in the Ag-AAC reaction for entries 1-9 phenyl acetylene , benzyl bromide Entry 10 reaction recovery.

Entry	Azide	Alkyne	Catalyst ratio	Time	Temperature	Yield
1	2	1	0.15	90	r.t	100%
2	2	1	0.1	103	r.t	95%
3	2	1	0.05	105	r.t	98%
4	1	2	0.15	130	r.t	98%
5	1	2	0.1	135	r.t	100%
6	1	2	0.05	90	r.t	97%
7	1	1	0.15	100	r.t	98%
8	1	1	0.1	30	r.t	100%
9	1	1	0.05	90	r.t	97%
10	1	1	0.1	70	r.t	100%
11	1	1	0.1	20	40c	100%

12	1	1	0.1	10
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Table4 Optimization with copper polymer catalyst in the Cu-AAC reaction for entries 1-9 phenyl acetylene, benzyl bromide.
Entry 10 reaction recovery

Entry	Azide	Alkyne	Catalyst ratio/equiv	Time	Temperature	Yield
1	2	1	0.15	50	r.t	100%
2	2	1	0.1	80	r.t	98%
3	2	1	0.05	50	r.t	98%
4	1	2	0.15	60	r.t	95%
5	1	2	0.1	90	r.t	100%
6	1	2	0.05	75	r.t	98%
7	1	1	0.15	35	r.t	100%
8	1	1	0.1	50	r.t	98%
9	1	1	0.05	65	r.t	100%
10	1	1	0.15	55	r.t	100%
11	1	1	0.15	10	40	98%
12	1	1	0.15	7	60	100%

Table5 comparison between SCP1 and AgNO₃ as catalysis for Ag-AAC reaction in the case of propargyl bromide and benzyl azide

Compound	Catalyst ratio	Alkyne	Azide	yield	Time
SCP1	0.15	1	2	100%	30 min
AgNO ₃	0.15	1	2	100%	28 hour

Table 6 comparison between SCP2 and Cu(OAc)₂ as catalysis for Ag-AAC reaction in the case of propargyl bromide and benzyl azide

Compound	Catalyst ratio	Alkyne	Azide	Yield	Time
Scp2	0.15	1	2	100%	30 min
Cu(OAc) ₂	0.15	1	2	100%	12Hour

Table7 comparison between SCP1 and AgNO₃ as catalysis for Ag-AAC reaction in the case of phenyl acetylene and benzyl azide

Compound	Catalyst ratio	alkyne	azide	yield	Time
Scp1	0.15	1	1	100%	30 min
AgNO ₃	0.15	1	1	100%	25 hour

Table 8 comparison between SCP2 and Cu(OAc)₂ as catalysis for Ag-AAC reaction in the case of phenyl acetylene and benzyl azide

compound	Catalyst ratio	Alkyne	azide	yield	Time
Scp2	0.15	1	1	100%	35min
Cu(OAc) ₂	0.15	1	1	98%	12 hour

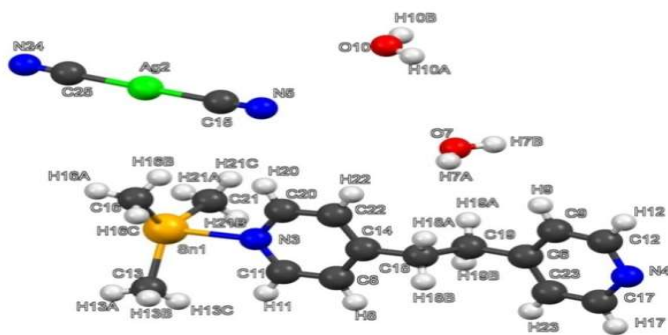


Figure 1 An ORTEP plot of the asymmetric unit of the SCP 1 with atom labeling scheme

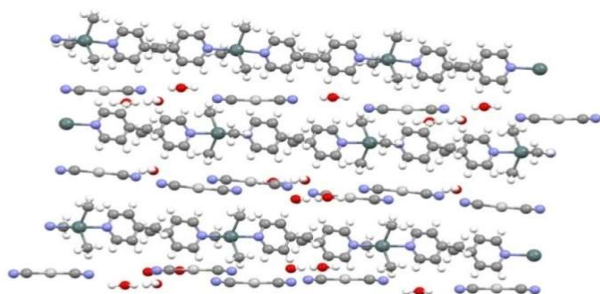


Figure 2 View of the overall 3D-structure of 1 showing the alternating cationic and anionic layers.

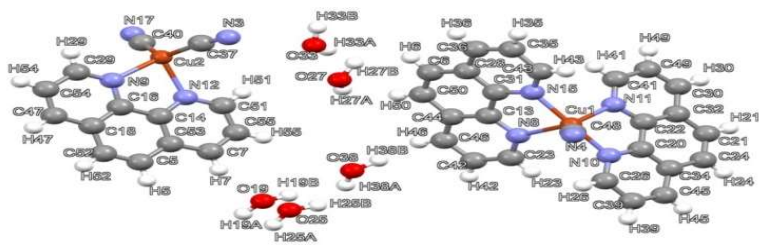


Figure 3 An ORTEP plot of the asymmetric unit of the SCP 2 with atom labeling scheme

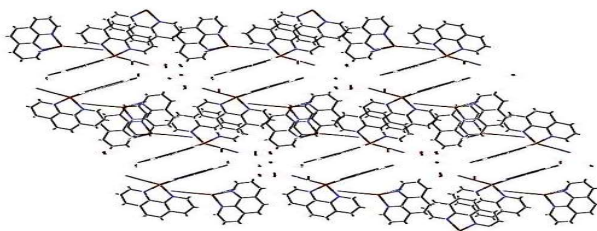


Figure 4 3D-network structure showing hydrogen bonds in the SCP 2 along the a-axis

الملخص العربي

إمكانية استخدام بعض البوليمرات التناسقية الجديدة فائقة الجزيئية متعددة الأبعاد المحتوية على النحاس أحادي التكافؤ والفضة أحادية التكافؤ كمحفزات لبعض التفاعلات الكيميائية. وهذا النوع من البوليمرات التناسقية فائقة الجزيئية قد تم تحضيره عن تفاعلات التجمع باستخدام التجمع الذاتي بين أملاح النحاس الأحادي والثنائي التكافؤ والمعطيات الأحادية لقواعد البيريدين أو عن طريق المعطيات الثنائية الحلقية غير المتجانسة. استخدام النحاس الأحادي والفضة الأحادية كعوامل حفازة في التفاعلات التقريبية للحصول على 1.4-ثنائي الاستبدال للتزاي زول ويتم دراسة هذا المركب عن طريق الأشعة تحت الحمراء وقياس الرنين المغناطيسي للهيدروجين.