



# CHEMISTRY & BIOLOGY INTERFACE

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## Sensing and quantification of Hg<sup>2+</sup> ions based on aggregation of carbamate-linked-triazole stabilized silver nanoparticles

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**Abstract:** A (1-(4-bromobenzyl)-1H-1,2,3-triazole-4-yl)methyl(4-bromophenyl)carbamate and (1-(4-methylbenzyl)-1H-1,2,3-triazole-4-yl)methyl(4-bromophenyl)carbamates (**4a-4b**) have been successfully synthesized by reacting prop-2-yn-1-yl(4-bromophenyl)carbamate (**2**) with 4-bromo benzyl bromide (**3a**) and 4-methyl benzyl bromide (**3b**) using cellulose supported cuprous iodide nanoparticles and water as solvent. These synthesized triazoles were utilized for the stabilization of silver nanoparticles. The triazole stabilized silver nanoparticles were further examined for their ion sensing ability towards various cations like, Hg<sup>2+</sup>, Cd<sup>2+</sup>, Cu<sup>2+</sup>, Zn<sup>2+</sup>, Pb<sup>2+</sup>, Cr<sup>2+</sup>, Co<sup>2+</sup>, Fe<sup>2+</sup>, Ni<sup>2+</sup>, Ca<sup>2+</sup>, Mg<sup>2+</sup> and Mn<sup>2+</sup> ions. The colorimetric and UV-visible studies revealed that stabilized AgNPs selectively sense Hg<sup>2+</sup> ion in preferences to other cations. Transmission electron microscopy (TEM) images clearly indicated that addition of Hg<sup>2+</sup> to a solution of stabilized AgNPs triggered the aggregation of silver nanoparticles due to which there occurs change in color from dark orange to colorless. The detection limits of AgNPs stabilized by **4a** and **4b** for Hg<sup>2+</sup> ions was found to be  $4.1 \times 10^{-6}$  M and  $3.67 \times 10^{-7}$  M, respectively. The present paper provides an easy and selective colorimetric approach for detection of mercury ion.

**Keywords:** Carbamates, 1,2,3-triazoles, silver nanoparticles, chemosensors, Hg<sup>2+</sup> sensors

### Introduction

The design and development of simple and sensitive analytical methods for sensing of toxic metal ions have received significant consideration in recent times because of the

toxicological effects of these metals on human and animal health, plant metabolism and on soil biological activity.<sup>1-3</sup> Mercury is known as extremely toxic metal ion which causes adverse effects on human health, environment and ecological safety<sup>4-6</sup> due to its highly reactive

nature towards sulfhydryl group of enzymes and protein which enhances its bio-accumulative properties.<sup>7-8</sup> Therefore, World health Organization and Environmental Protection Agency offers the maximum permissible limits of mercury ion in drinking water up to 5 ppb and 2 ppb, respectively.<sup>9-10</sup> Considering the hazardous effects of mercury ion, the design and development of highly sensitive and selective analytical tool for detection of mercury ion at low level concentration are an exciting area of research.<sup>11-12</sup>

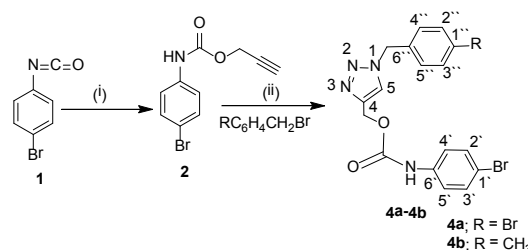
There are various methods for the detection of mercury ions at low concentration including atomic absorption spectroscopy,<sup>13</sup> cold vapour atomic fluorescence spectrometry,<sup>14</sup> X-ray absorption spectroscopy<sup>15</sup> and inductively coupled plasma mass spectroscopy.<sup>16</sup> However, these methods require expensive sophisticated instruments, trained operator and are difficult for on-site assay. Further, several fluorescent, chromomeric, luminescent based molecules have also been reported for efficient sensing of mercury ions at low concentration.<sup>17-20</sup> Colorimetric detection of mercury and other toxic ions in aqueous solution is an efficient approach as it involves least instruments and fast response via ion induced color change of solution.<sup>21-25</sup> In this context, silver nanoparticles-based sensors have drawn significant attention due to their high extinction coefficient, low toxicity, good stability and unique surface plasmon resonance absorption properties.<sup>26-31</sup>

The copper(I)-catalyzed click reactions has received much attention because of its numerous applications in medicinal chemistry,<sup>32</sup> material chemistry<sup>33</sup> and bioconjugation.<sup>34</sup> 1,4-Disubstituted 1,2,3-triazoles have also found numerous applications in supramolecular<sup>35</sup> and coordination chemistry<sup>36</sup> because of their excellent capabilities to exhibit variety of noncovalent interactions with host analytes.<sup>37</sup> 1,2,3-Triazoles are versatile ligands offering various binding sites for metal coordination

*via* either N2, N3 or C5 atoms.<sup>38-40</sup> The role of 1,2,3-triazoles as a potential ligand with Hg<sup>2+</sup> ion chelating ability has been highlighted in literature. For instance, Anjul et al. reported some bile acid derived triazoles with high selectivity and sensitivity towards Hg<sup>2+</sup> ions.<sup>41</sup> Arasappan and co-workers studied some sugar-triazole based molecules with high affinity for Hg<sup>2+</sup> ions.<sup>42</sup> Keeping in view of the above, it was planned to synthesize some molecular architectures containing 1,2,3-triazole and carbamate moieties for stabilization of silver nanoparticles. Therefore, herein, we report the synthesis of carbamate-linked 1,2,3-triazoles and investigated their silver nanoparticles stabilizing ability and ion sensing properties. We found that carbamate-linked 1,2,3-triazole ligand stabilizes silver nanoparticles in presence of sun light and exhibited selective colorimetric sensing for the mercury ion *via* visual colour change from dark orange to colorless solution.

## Results and Discussion

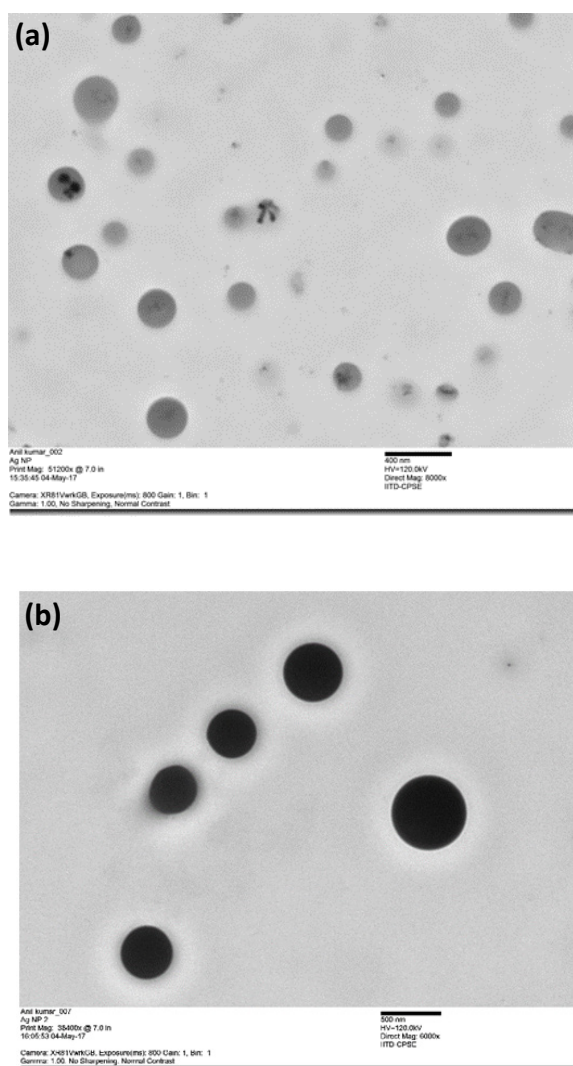
The synthesis of carbamate - linked 1,2,3-triazoles (**4a-4b**) is depicted in scheme 1. In the first step the prop-2-yn-1-yl (4-bromophenyl)carbamate (**2**) was synthesized from 4-bromo phenyl isocyanate (**1**) and propargyl alcohol using N,N-dimethyl amino pyridine in dichloromethane. Prop-2-yn-1-yl (4-bromophenyl)carbamate was then subjected to one-pot multicomponent reaction with 4-methyl or 4-bromo benzyl bromides (**3a-3b**), sodium azide and catalytic amounts of cellulose supported cuprous iodide nanoparticles in water<sup>43</sup> yielding the 1,2,3-triazoles (**4a-4b**) in good to high yield at 80°C.



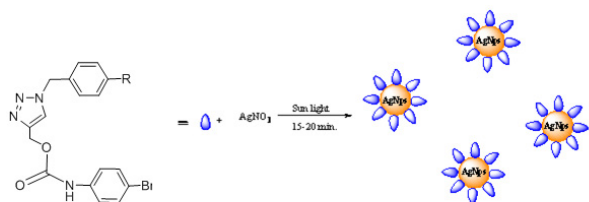
**Scheme 1** Synthesis of carbamate-linked 1,4-disubstituted 1,2,3-triazoles (**4a-4b**): Reagents and conditions: (i) Propargyl alcohol, N,N-dimethyl amino pyridine, DCM. (ii) Substituted benzyl bromide, sodium azide, cuprous iodide nanoparticles catalyst, and water (10 mL), 80 °C.

The structures of both the carbamate-linked 1,2,3-triazoles (**4a-4b**) were confirmed on the basis of their FTIR, <sup>1</sup>H NMR, <sup>13</sup>C NMR and HRMS spectral data. The FTIR spectrum of compound **4a**, showed a characteristic N-H stretching band at 3401 cm<sup>-1</sup>, whereas C=O stretching bands of ester and amide groups were observed at 1734 cm<sup>-1</sup> and 1593 cm<sup>-1</sup>, respectively. The <sup>1</sup>H NMR spectra of compound **4a** exhibited a characteristic singlet at δ 7.66 corresponding to triazolyl proton. The two sets of methylene protons were observed at δ 4.80 and δ 5.40. The <sup>13</sup>C NMR spectrum of compound **4a** exhibited characteristic peaks at δ 143.44 and δ 120.31 due to C-4 and C-5 carbon atoms of the triazole ring. While, two methylene carbons resonated at δ 58.13 and δ 53.57 ppm. The mass spectrum of **4a** showed a peak at m/z 466.9529 (M+H)<sup>+</sup> which is in good agreement with the molecular formula of the compound. These synthesized carbamate-linked 1,2,3-triazoles (**4a-4b**) were used for the synthesis of silver nanoparticles. The silver nanoparticles were synthesized by the reduction of silver nitrate by visible light in the presence of carbamate-linked 1,2,3-triazole as per literature procedure (scheme 2).<sup>41</sup> The solution of silver nitrate (2 μM) in a mixture of CHCl<sub>3</sub>/MeOH (7:3) was slowly added to the solution of the **4a** (2 μM) in CHCl<sub>3</sub>/MeOH (7:3) and the resultant solution was exposed to sun light for 20-30 minutes. It was interesting to observe that colourless solution turned to dark orange within 15 minutes, which clearly indicated the formation of carbamate-linked 1,2,3-triazole stabilized silver nanoparticles. Further, to verify the role of **4a-4b** in the formation of

silver nanoparticles, a reaction was carried out without addition of **4a-4b**. It was observed that colour of solution was not changed even after continuing exposure to the sunlight for 8 hours. The formation of 1,2,3-triazole stabilized silver nanoparticles was confirmed by TEM and FT-IR data. Transmission electron microscopy (TEM) image have shown particle size of the nanoparticles ranged from 8 nm to 45 nm and average size was found to be 27 nm (**Fig. 1** and **Fig. S18**). The FT-IR spectrum also confirmed carbamate-linked 1,2,3-triazole stabilized silver nanoparticles (**Fig. S15** and **S16**).



**Fig. 1** TEM images of (a) silver nanoparticles stabilized with ligand **4a** (b) silver nanoparticles stabilized with ligand **4b**



### Scheme 2 Synthesis of silver nanoparticles

The sensing behavior of silver nanoparticles stabilized by **4a** and **4b** towards different metal ions such as  $\text{Hg}^{2+}$ ,  $\text{Cd}^{2+}$ ,  $\text{Cu}^{2+}$ ,  $\text{Zn}^{2+}$ ,  $\text{Pb}^{2+}$ ,  $\text{Cr}^{3+}$ ,  $\text{Co}^{2+}$ ,  $\text{Fe}^{2+}$ ,  $\text{Ni}^{2+}$ ,  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$  and  $\text{Mn}^{2+}$  was investigated using colorimetric and UV-visible spectroscopic methods. Colorimetric sensing properties of triazole stabilized silver nanoparticles towards different metal ions were examined for visual colorimetric examination by addition 0.1 mL of perchlorate salts of metal ions (25  $\mu\text{M}$ ) to 2.5 mL of carbamate-linked 1,2,3-triazole-stabilized silver nanoparticles solution (2  $\mu\text{M}$ ). The addition of mercury ion to a solution of AgNPs led to the color changes from dark orange to colorless. However, no color change in solution of **4a** was observed upon addition of other metal ions such as  $\text{Cd}^{2+}$ ,  $\text{Cu}^{2+}$ ,  $\text{Zn}^{2+}$ ,  $\text{Pb}^{2+}$ ,  $\text{Cr}^{3+}$ ,  $\text{Co}^{2+}$ ,  $\text{Fe}^{2+}$ ,  $\text{Ni}^{2+}$ ,  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$  and  $\text{Mn}^{2+}$  ions as shown in Fig. 2. The observed colorimetric behavior of **4a**-AgNPs upon addition of  $\text{Hg}^{2+}$  ions can be explained by  $\text{Hg}^{2+}$  triggered aggregation of AgNPs. The observed aggregation behavior of AgNPs can be explained by the formation of Ag-Hg amalgam through the partial transfer of electron density from silver to  $\text{Hg}^{2+}$  ion. The addition of  $\text{Hg}^{2+}$  ions to the **4a** stabilized silver nanoparticles removed the carbamate-linked 1,2,3-triazole which has been used as a capping agent for the stabilization of silver nanoparticles which leads to a thermodynamically favorable redox reaction between  $\text{Hg}^{2+}$  and silver nanoparticles there by the color of solution changes from dark orange to colorless.<sup>44-47</sup> Further, the selectivity of carbamate-linked 1,2,3-triazole-stabilized silver

nanoparticles towards  $\text{Hg}^{2+}$  ion was explored by addition of mixture of all tested metal ions to a solution of stabilized AgNPs which exhibited similar color changes as observed with  $\text{Hg}^{2+}$  ion, showing that the sensing  $\text{Hg}^{2+}$  ion is not interfered in presence of other metal ions. The TEM data also confirmed the  $\text{Hg}^{2+}$  ion triggered aggregation of AgNPs as depicted in Fig. 3.

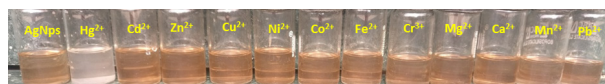


Fig. 2 A Photographic image of the solution of AgNPs stabilized with ligand **4a**

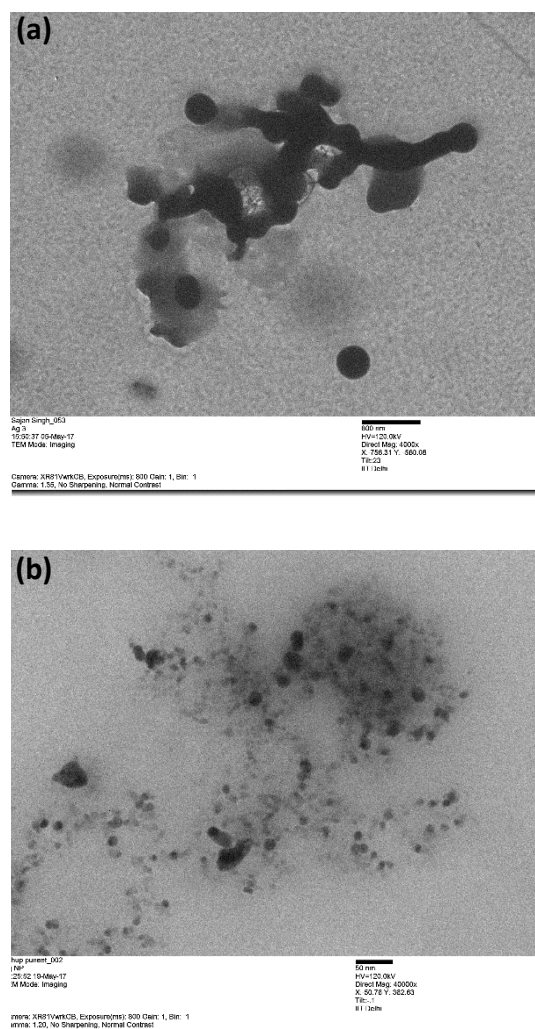
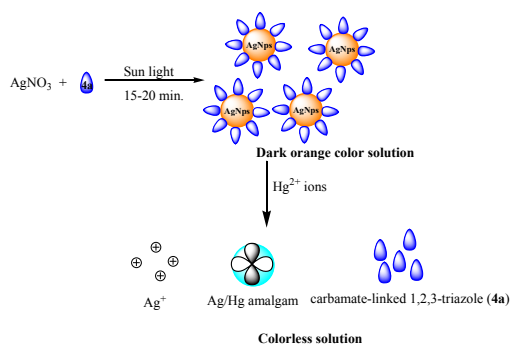


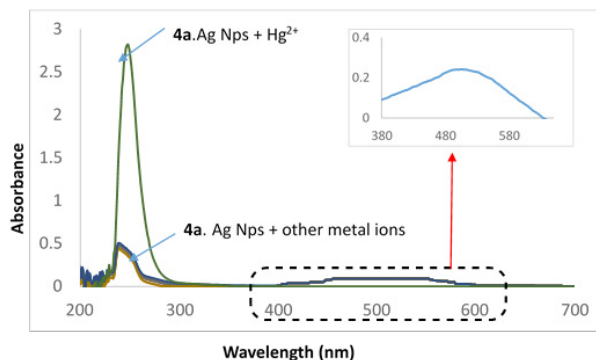
Fig. 3 TEM image of AgNPs stabilized with (a) ligand **4a** and (b) ligand **4b** after addition of  $\text{Hg}^{2+}$  ion



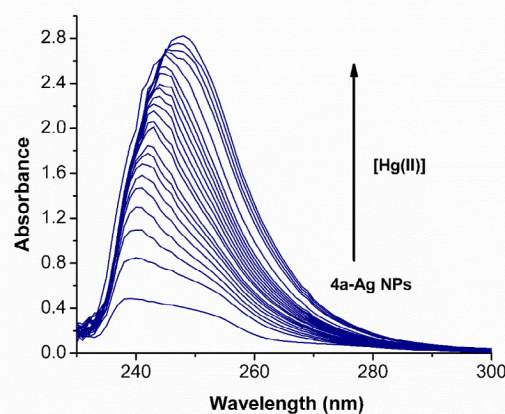
To explore more insight about the selectivity of **4a**-AgNPs towards various metal ions sensing, the UV-visible experiments were performed by the addition of various metal ions such as  $\text{Hg}^{2+}$ ,  $\text{Cd}^{2+}$ ,  $\text{Cu}^{2+}$ ,  $\text{Zn}^{2+}$ ,  $\text{Pb}^{2+}$ ,  $\text{Cr}^{3+}$ ,  $\text{Co}^{2+}$ ,  $\text{Fe}^{2+}$ ,  $\text{Ni}^{2+}$ ,  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$  and  $\text{Mn}^{2+}$  ions in form of their perchlorate salts. In UV-visible spectrum of carbamate-linked 1,2,3-triazole-stabilized silver nanoparticles (**4a**-AgNPs) exhibited absorption peak at 248 nm and 511 nm as shown in Fig. 4. The absorption peak in UV region at 248 nm was assigned for carbamate linked 1,2,3-triazole moiety (**4a**) whereas peak in visible region at 511 nm was assigned for silver-nanoparticles. It was observed that upon addition of 25  $\mu\text{M}$  solution of  $\text{Hg}^{2+}$  ions to a 2.0  $\mu\text{M}$  solution of AgNPs stabilized by **4a**, the intensity of absorption maxima at 248 nm was significantly increased whereas the peak at 511 nm was disappeared as shown in Fig. 4. On the other hand, other metal ions like  $\text{Cd}^{2+}$ ,  $\text{Cu}^{2+}$ ,  $\text{Zn}^{2+}$ ,  $\text{Pb}^{2+}$ ,  $\text{Cr}^{3+}$ ,  $\text{Co}^{2+}$ ,  $\text{Fe}^{2+}$ ,  $\text{Ni}^{2+}$ ,  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$  and  $\text{Mn}^{2+}$  ions fail to exhibit any noticeable change in absorption spectrum. The observed spectral behavior can be explained by the  $\text{Hg}^{2+}$ -induced aggregation of AgNPs. The AgNPs are oxidized by  $\text{Hg}^{2+}$ , resulting in the formation of soluble  $\text{Ag}(\text{I})$ . Afterward, the elemental Hg interacts with the surface of AgNPs, yielding the amalgam particles thereby removing **4a** from their surface as shown in scheme 3. The recovered carbamate-linked 1,2,3-triazole (**4a**) in the solution showed an intense peak at 248 nm in UV-visible spectrum.



**Scheme 3:** Detection of  $\text{Hg}^{2+}$  ions using **4a**-AgNPs



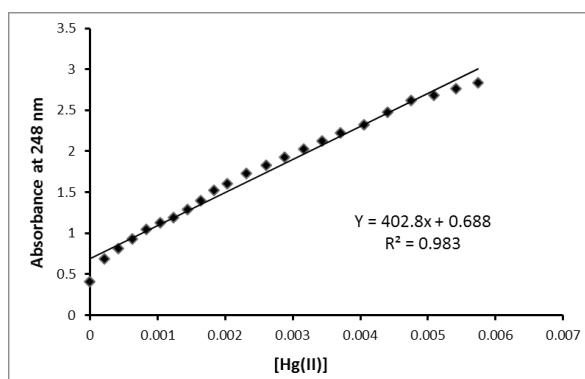
**Fig. 4:** UV-visible spectra for the AgNPs stabilized with ligand **4a** solution (2  $\mu\text{M}$ , optical path length = 1 cm) after the addition of different equivalent of various metal ions



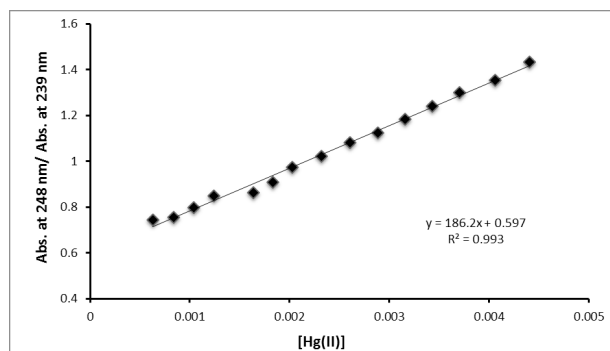
**Fig. 5** UV-visible spectra for the triazole-**4a**-AgNPs ( $1.26 \times 10^{-4} \text{M}$ ) solution after the addition of different concentrations of  $\text{Hg}^{2+}$  ( $2.1 \times 10^{-4} \text{M}$  to  $5.7 \times 10^{-3} \text{M}$ ) over the interval of 5 minutes.

Furthermore, for the determination of detection limit of carbamate-linked 1,2,3-triazole stabilized silver nanoparticles for  $\text{Hg}^{2+}$  ion, the UV-visible absorption spectrum of blank test were measured. The standard deviation ( $\alpha$ ) of absorbance intensity for **4a**-AgNPs and **4b**-AgNPs at 248 nm were found to be  $5.51 \times 10^{-4}$  for **4a**-AgNPs and  $1.1 \times 10^{-4}$  for **4b**-AgNPs, respectively. The linear fitting were performed according to titration curves and slope was determined (Fig. 6, Fig. 7, Fig. S20 and S21;

see supporting information). The limits of detection (LOD) of AgNPs stabilized by **4a** and **4b** were determined from the equation  $LOD = 3\alpha/S$ , where,  $\alpha$  is the standard deviation of the absorbance intensity of carbamate-linked 1,2,3-triazole stabilized silver nanoparticles of blank measurements, S is the slope of linear equation.<sup>48-49</sup> The detection limits of the UV-visible spectrum for  $Hg^{2+}$  ion by **4a**-AgNPs and **4b**-AgNPs were found to  $4.1 \times 10^{-6}$  M and  $3.67 \times 10^{-7}$  M, respectively.



**Fig. 6** Determination of detection limit for  $Hg^{2+}$  ion for **4a**-AgNPs. Absorbance Vs.  $Hg^{2+}$  concentration plot in **4a**-AgNPs. The standard deviation ( $\alpha$ ) of blank (**4a**-AgNPs) measurements =  $5.51 \times 10^{-4}$  (at 248 nm)



**Fig. 7** Determination of detection limit for  $Hg^{2+}$  ion for **4a**-AgNPs from radiometric methods. Absorbance (248 nm/239 nm) Vs.  $Hg^{2+}$  concentration plot in **4a**-AgNPs. The standard deviation ( $\alpha$ ) of blank (**4a**-AgNPs) measurements =  $5.51 \times 10^{-4}$  (at 248 nm)

These data clearly indicated that synthesized **4a** and **4b** stabilized AgNPs can detect mercury ion at low level concentration which is better or comparable with earlier reported methods.<sup>50-53</sup>

## Experimental

### Instrumentation, Analysis and Starting Material

Isocyanates, propargyl alcohol, benzyl halides, DMAP, cuprous iodide, microcrystalline cellulose were procured from sigma Aldrich and used as received. All the melting points ( $^{\circ}C$ ) were recorded in an open capillary using LABCO melting point apparatus. IR spectra were recorded on SHIMAZDU IR AFFINITY-I FT-IR spectrophotometer. The  $^1H$  NMR (400 MHz) and  $^{13}C$  NMR (100 MHz) spectra were recorded using BrukerAvance-III 400 nano bay spectrometer. The high-resolution mass spectra (HRMS) were recorded using Micromass QTOF micro-mass spectrometer. HR-TEM images were obtained from JEOL JEM-3000F high-resolution transmission electron microscope. The thin-layer chromatography (TLC) was performed on readymade silica gel plates and visualized under ultraviolet lamp.

### Procedure for the synthesis of carbamate-linked terminal alkyne

To a stirred solution of propargyl alcohol (1.1 mmol) and DMAP (1.1 mmol) 30 mL of dichloromethane, phenyl isocyanate (1 mmol; dissolved in dichloromethane) was added drop wise at  $0^{\circ}C$ . The stirring of reaction mixture was continued till the completion of reaction as monitored by TLC. After completion of the reaction, the reaction mixture was diluted with dichloromethane and the organic layer was washed with 2N sulphuric acid ( $2 \times 10$  mL), water ( $2 \times 10$  mL) and brine (10 mL) and dried over anhydrous sodium sulphate. Dichloromethane was evaporated in vacuum to

obtain the product.

**Prop-2-yn-1-yl (4-bromophenyl)carbamate (2):** off white solid, 91% yield, Mp: 124-126°C. IR (KBr,  $\nu_{\max}/\text{cm}^{-1}$ ): 3298 (NH str.), 2137 (C≡C str), 1703 (C=O str, ester), 1638 (C=O str, amide), 1595, 1545, 1487, 1452, 1396, 1312, 1242 (C-O str, ester), 1111, 1070 (C-O str, ester), 1007, 980, 829, 764, 691, 646, 509.  $^1\text{H}$  NMR ( $\text{CDCl}_3$ , 400 MHz):  $\delta$  2.55 (s, 1H, alkyne CH), 4.80 (s, 2H,  $\text{CH}_2$ ), 6.72 (bs, 1H, NH), 7.28-7.32 (m, 2H, H3, H5), 7.43-7.46 (m, 2H, H2, H6).  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ , 100 MHz):  $\delta$  52.91 ( $\text{OCH}_2$ ), 75.19 (CH-acetylene), 77.61 (C-acetylene), 116.45 (C2, C4, C5), 120.31 (C1), 132.07 (C2, C2, C3), 136.50 (C6), 152.24 (C=O). HRMS:  $m/z$  ( $\text{M}+\text{H}$ )<sup>+</sup> Calcd. for  $\text{C}_{10}\text{H}_8\text{BrNO}_2$  253.9817, found: 253.9804.

**General Procedure for the synthesis of (1-(4-substitutedbenzyl)-1H-1,2,3-triazole-4-yl)methyl(4-bromophenyl)carbamates (4a-4b)**<sup>43</sup>:

A mixture of benzyl halide (1mmol), alkyne 2 (1mmol), sodium azide (1.2 mmol) and the catalyst (100 mg) in 10 mL of water was stirred at 80°C until TLC analysis shows that the reaction is complete. The reaction mixture was cooled to room temperature, filtered and residues thus obtained were washed with ethyl acetate. Solvent was evaporated under high vacuum to get corresponding 1,4-disubstituted 1,2,3-triazoles **4a-4b** in 71-88% yield.

**(1-(4-bromobenzyl)-1H-1,2,3-triazole-4-yl)methyl(4-bromophenyl)carbamate (4a):** Off white solid, 71% yield, Mp: 128-130°C. IR (KBr,  $\nu_{\max}/\text{cm}^{-1}$ ): 3401 (NH str.), 3136 (C-H str, triazole), 1734 (C=O str, ester), 1701, 1643 (C=O str, amide), 1593, 1528, 1489, 1456, 1398, 1308, 1211 (C-O str, ester), 1057 (C-O str, ester), 1013, 820, 783, 567, 498.  $^1\text{H}$  NMR ( $\text{CDCl}_3$ , 400 MHz):  $\delta$  4.80 (s, 2H,  $\text{OCH}_2$ ), 5.40 (s, 2H, N- $\text{CH}_2$ ), 7.04 (bs, 1H, NH), 7.31-7.33 (m, 2H, Ar-H, 4''H and 5''H), 7.43-7.45 (m, 2H, 2''H,

3''H), 7.66-7.67 (m, 3H, 4''H, 5''H, triazolyl-H), 8.14 (s, 2H, 2''H, 3''H).  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ , 100 MHz):  $\delta$  53.57 ( $\text{NCH}_2$ ), 58.13 ( $\text{OCH}_2$ ), 116.23 (1''C), 120.31 (C-5), 123.11 (4''C, 5''C), 123.86 (1''C), 129.74 (4''C, 5''C), 132.03 (2''C, 3''C), 132.37 (2''C, 3''C), 133.32 (6''C), 136.71 (6''C), 143.44 (C-4), 153.02 (C=O). HRMS:  $m/z$  ( $\text{M}+\text{H}$ )<sup>+</sup> Calcd. for  $\text{C}_{17}\text{H}_{14}\text{Br}_2\text{N}_4\text{O}_2$  467.1346, found: 466.9529

**(1-(4-methylbenzyl)-1H-1,2,3-triazole-4-yl)methyl(4-bromophenyl)carbamate (4b):** Off white solid, 88% yield, Mp: 139-141°C. IR (KBr,  $\nu_{\max}/\text{cm}^{-1}$ ): 3248 (NH str.), 3109 (C-H str, triazole), 1719 (C=O str, ester), 1667, 1591 (C=O str, amide), 1535, 1485, 1452, 1393, 1302, 1231 (C-O str, ester), 1119, 1072 (C-O str, ester), 1015, 814, 762, 691, 509.  $^1\text{H}$  NMR ( $\text{CDCl}_3$ , 400 MHz):  $\delta$  2.37 (s, 3H,  $\text{CH}_3$ ), 5.27 (s, 2H,  $\text{OCH}_2$ ), 5.49 (s, 2H, N- $\text{CH}_2$ ), 7.20 (s, 4H, 2''H, 3''H, 4''H, 5''H) 7.28-7.32 (m, 3H, 2''H, 3''H, NH), 7.41-7.45 (d, 2H, 4''H, 5''H), 7.59 (s, H, triazolyl-H).  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ , 100 MHz):  $\delta$  21.15 ( $\text{CH}_3$ ), 54.11 ( $\text{NCH}_2$ ), 58.10 ( $\text{OCH}_2$ ), 116.10 (4''C, 5''C), 120.33 (1''C), 123.75 (C-5), 128.23 (4''C, 5''C), 129.84 (2''C, 3''C), 131.25 (2''C, 3''C), 131.99 (6''C), 136.89 (1''C), 138.89 (6''C), 143.16 (C-4), 153.10 (C=O). HRMS:  $m/z$  ( $\text{M}+\text{H}$ )<sup>+</sup> Calcd. for  $\text{C}_{18}\text{H}_{17}\text{BrN}_4\text{O}_2$ : 401.0613, found: 401.0597.

**Synthesis of triazole stabilized silver nanoparticles**<sup>41</sup>:

For the synthesis of silver nanoparticles, 20 mL (2  $\mu\text{M}$ ) solution of silver nitrate in chloroform/methanol (7:3) was mixed with 20 mL (2  $\mu\text{M}$ ) solution of the triazole in chloroform/methanol (7:3) and the mixture was exposed to sun light. The color of the solution becomes dark orange within 15 minutes indicating the formation of triazole stabilized silver nanoparticles.

**Conclusion**

In summary, we have reported the synthesis

of carbamate-linked 1,4-disubstituted 1,2,3-triazoles (**4a-4b**) using cellulose supported cuprous iodide nanoparticles as a heterogeneous catalyst in good to excellent yield from carbamate-linked terminal alkyne via azide-alkyne cycloaddition reaction using water as solvent. These synthesized carbamate-linked 1,4-disubstituted 1,2,3-triazoles (**4a-4b**) have been used for stabilization of silver nanoparticles. These carbamate-linked 1,4-disubstituted 1,2,3-triazoles stabilized silver nanoparticles showed remarkable colorimetric sensitivity and selectivity for mercury ion with detection limit of  $4.1 \times 10^{-6}$  M for triazole-**4a**-AgNPs and  $3.67 \times 10^{-7}$  M for triazole-**4b**-AgNPs. The present study may have an impact on the development of novel and selective chemosensors for the detection of mercury.

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