



Dedicated to Prof. Ion Grosu
on the occasion of his 70th anniversary

STRUCTURAL DIVERSIFICATION OF *N*-ACYLHYDRAZONES BY CLICK CHEMISTRY**

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We describe the synthesis of a novel *N*-acylhydrazone via Copper(I)-catalyzed Azide-Alkyne Cycloaddition (CuAAC) as key step for constructing triazole-functionalized systems. The synthetic approach involved preparation of a protected-phenol azide through a copper(I)-induced coupling of an aryl bromide with sodium azide, followed by aldehyde functionalization to yield the key precursor for *N*-acylhydrazone formation. The optical properties of the target *N*-acylhydrazone were investigated, revealing blue fluorescence both in solid-state and aqueous solutions.



INTRODUCTION

N-acylhydrazones are robust building blocks with a wide range of applications, from simple molecules able to form small heterocycles, like 2,5-disubstituted-1,3,4-oxadiazoles¹ to ligands able to coordinate metal ions for the formation of complexes with discrete structure or coordination polymers². *N*-acylhydrazones have also been used as building blocks for formation of macrocyclic molecules³ or polymeric structures under the form

of dynamers⁴ or COFs (Covalent Organic Frameworks)⁵ as well as switchable molecules through conformational and configurational changes, using light, metal-ions or solvent as triggers.⁶ A particular attention has been paid to the structural changes that occur under the influence of surrounding media leading to the emission of light. We^{6b} and others⁷ have previously reported bis-*N*-acylhydrazones able to emit light in organic solvents or aqueous environment (*i.e.* compounds I in Fig. 1), as well as the ability to form organic gels

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and find applications in sensing (*i.e.* compound **II** in Fig. 1).⁸

The formation of *N*-acylhydrazones is included among the reactions classified as 'click reactions' according to the criteria established by Sharpless and co-workers.⁹ Therefore, it is straightforward from a synthetic point of view, by simply mixing the aldehyde and the hydrazide in equimolar ratio, under a catalytic amount of acid, in an organic solvent.^{6b} Thus, to achieve structural diversity and enhance the properties of such compounds in terms of emitting light, solubility, behavior under organic and aqueous media, a very simple and convenient modification of the building blocks should be approached. To this end, Copper(I)-Azide Alkyne Cycloaddition reaction¹⁰ is the

methodology of choice, considering the simplicity of the reaction conditions and, most importantly, the high orthogonality and tolerance towards various functional groups. In this context, multifunctional organic azides or alkynes, able to act as precursors for *N*-acylhydrazones should be achieved.

Herein, we report a synthetic methodology for the preparation of structurally diverse *N*-acylhydrazones (Scheme 1). We exemplify our approach by synthesis of a key azide intermediate able to provide various substituted 1,2,3-triazoles and their further conversion into *N*-acylhydrazone **6** (Scheme 1). We also report preliminary investigation of the optical properties of the target compound by UV-Vis and fluorescence spectroscopy.

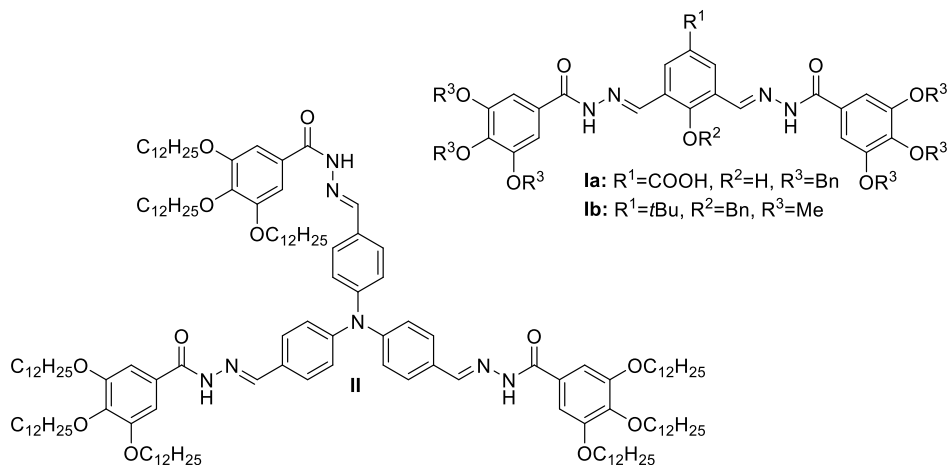
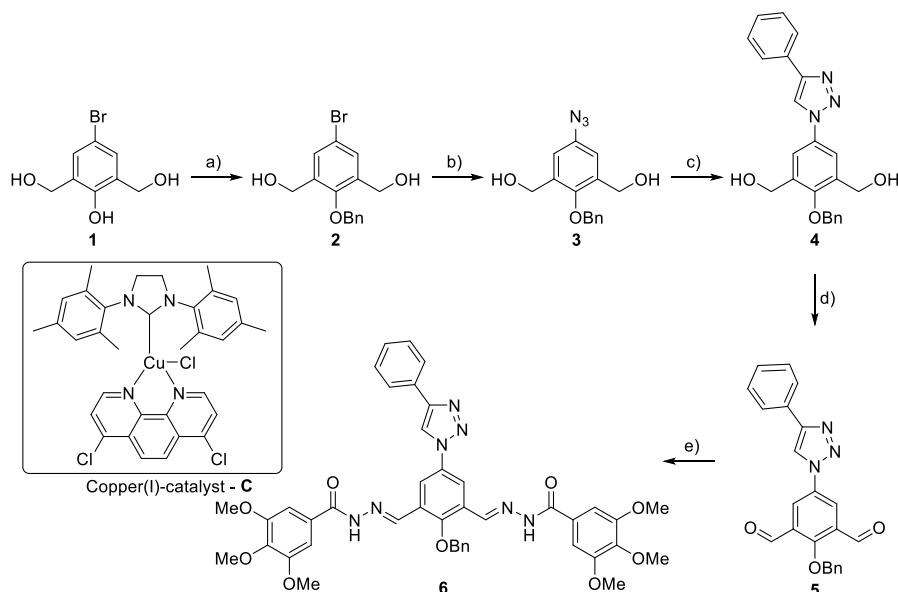


Fig. 1 – Examples of *N*-acylhydrazones that were found to emit light in various organic and aqueous environments (in solution or as gels).



Scheme 1 – Synthesis of compound **6**: a) BnBr, KI, K₂CO₃, acetone, 80%; b) NaN₃, CuI, ascorbic acid, NaOH, *N,N'*-dimethyl ethylenediamine, 80%; c) phenylacetylene, Copper(I)-catalyst **C**, MeOH 64%; d) MnO₂, CHCl₃, reflux, 3,5h, 71%; e) 3,4,5-trimethoxybenzhydrazide, TFA, DMSO, 78%.

RESULTS AND DISCUSSION

Target compound **6** was obtained starting from *p*-bromophenol. Compound **1** was synthesized as previously described¹¹ and further benzyl-protected to yield compound **2**, in 80% yield. The protection of the phenol was mandatory for the azidation reaction, which did not proceed otherwise, no matter of the reaction conditions. The synthesis of organic azides has significantly advanced over the past decades, as they have proven to be highly valuable intermediates in organic synthesis.¹² Preparation of aryl azides has known a very important development¹³ once the metal-catalyzed coupling of aryl-halides was reported, especially in the presence of proline¹⁴ or other amines such as DMEDA (*N,N'*-dimethylethylenediamine) or TMEDA (*N,N,N',N'*-tetramethylethylenediamine). For the formation of compound **3** from the electron

rich bromide **2** we chose to use DMEDA, CuI, ascorbic acid, in basic medium (NaOH). This reaction occurred smoothly, under inert atmosphere, in approximately 35 minutes, with a very good yield in isolated product (80%). Interestingly, retention factor of compound **3** is very similar to the bromide precursor **2** and monitoring through TLC of the reaction progress was only possible by visualization with a solution of PPh₃ and followed by ninhydrin. Structural assignment was initially performed by FTIR, which displayed an intense band at 2100 cm⁻¹ (See Supporting Information for full spectrum), characteristic for the asymmetric vibration of the azide group.¹⁵ Further, the NMR spectrum of compound **2** displayed the signal assigned to the aromatic protons near bromine at $\delta = 7.48$ ppm and we noticed a significant shielding of the signal ($\delta = 7.07$ ppm) assigned to the proton closest to the azide group in compound **3**.

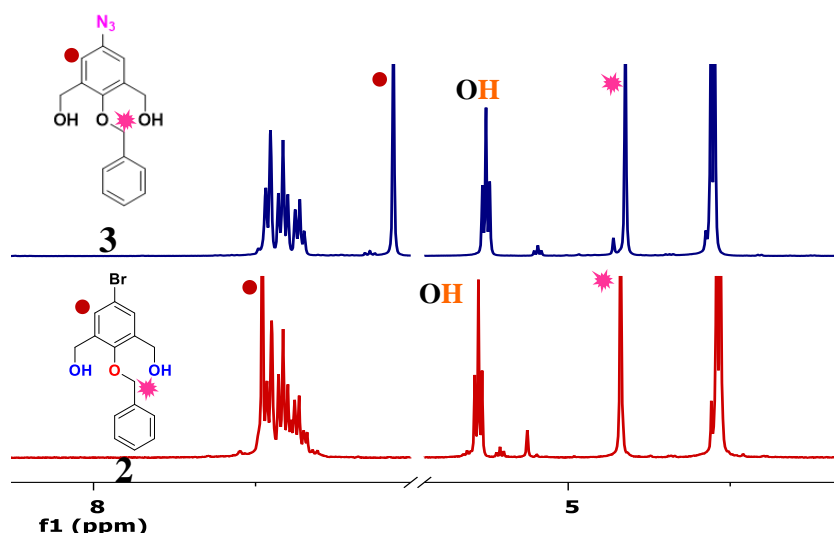


Fig. 2 – Overlay of ¹H NMR spectra (fragments, 500 MHz, DMSO-*d*₆), of compounds **2** and **3**.

Compound **3** was further used as starting material for CuAAC in presence of a copper(I)-*N*-heterocyclic carbene catalyst **C** to synthesize compound **4**. Among the plethora of available copper catalysts, we chose a well-defined copper(I)-*N*-heterocyclic carbene complex, as complexes from this family have been reported to be highly stable in the presence of air and as they do not require reducing agents.¹⁶ In the presence of 4,7-dichloro-1,10-phenanthroline, SiMesCuCl (1,3-Bis(2,4,6-trimethylphenyl)-4,5-dihydroimidazol-2-ylidene copper(I) chloride) forms the catalyst **C** a reddish complex that can be stored for years under bench conditions. The introduction of the *N*-donor heterocycle not only enhances the solubility of the catalyst in hydroalcoholic solvents but also

increases its reactivity by significantly weakening the Cu(I)-Cl bond. Indeed, catalyst **C** proved to be highly efficient in promoting the reaction under ambient conditions—without the need for an inert atmosphere, in methanol, at room temperature, and in the complete absence of a reducing agent.¹⁷

Triazole **4** was further converted into dialdehyde **5**, using manganese(IV) dioxide in chloroform, at reflux temperature.¹⁸ An interesting feature of these reactions was the increased yield of the product in short times, above 70% after 3.5 h.

Once the dialdehyde in hand, we performed the reaction with 3,4,5-trimethoxybenzhydrazide, in DMSO, using TFA as acidic catalyst. The reaction proceeded well, furnishing the target *N*-acylhydrazone in 78% yield, by simple addition of

water and filtration of the resulted solid. We tested the solubility of compound **6** in various organic solvents. Although *N*-acylhydrazones are widely recognized for their poor solubility in organic solvents, this type of bis-*N*-acylhydrazone is highly soluble in DMF and DMSO but less soluble in MeOH and EtOH.^{6b}

We further investigated the optical properties of our synthesized compound **6**. We initially performed

UV-Vis absorption spectroscopy in DMSO (10^{-5} M) and the spectrum displayed a maximum at $\lambda = 305$ nm. We also determined the absorption coefficient by record of UV-Vis spectra on different dilutions in DMSO from stock solution of **6** in DMSO 10^{-3} M (see Supporting Information), and the extinction coefficients were calculated as an average of the individual values resulted for each sample, yielding a value of $3.94 \times 10^4 \text{ M}^{-1} \cdot \text{cm}^{-1}$.

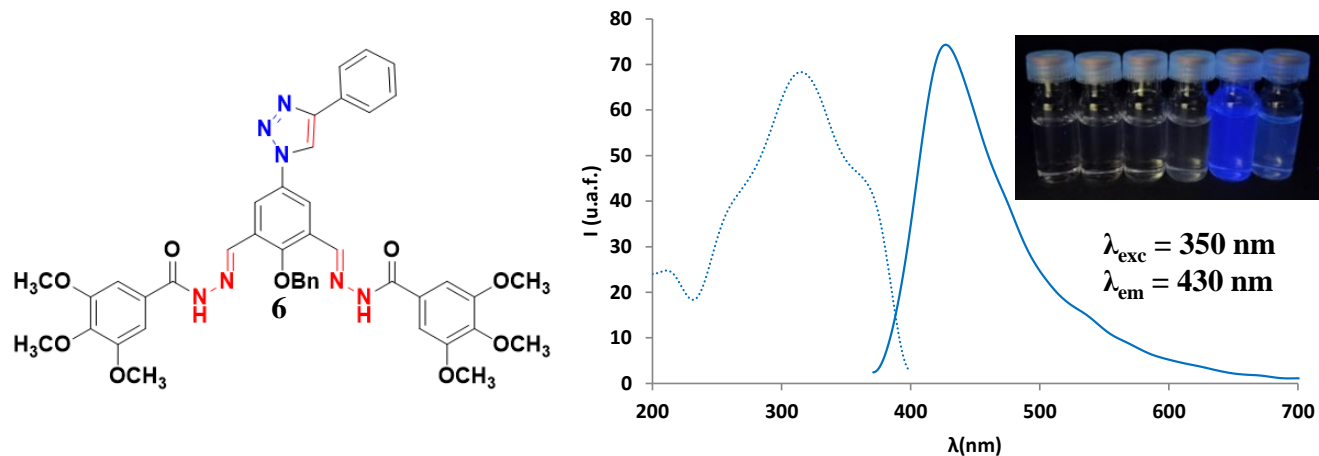


Fig. 3 – Excitation (dotted line) and emission (plain line) spectra of compound **6** (10^{-4} M) in DMSO/water (1/9).

As compound **6** showed blue light emission under the UV-lamp in solid state, we also checked the emitting ability in solution. While the spectra performed in DMSO showed no emission, addition of water to DMSO solutions of compound **6** at different concentrations ranging from millimolar to micromolar displayed blue fluorescence. For example, stock solutions of compound prepared in DMSO (10^{-2} mol/L), diluted to 10^{-4} mol/L using DMSO and DMSO/water (10%, 25%, 50%, 75%, 90% v/v) are shown in Fig. 3 to emit above 75% of water. The emitting color was found to change from light blue to intense blue with gradual increase of water percentage into its DMSO solution. The fluorescence spectra displayed an emission band, with maximum at $\lambda_{em} = 450$ nm, when excited at $\lambda_{exc} = 350$ nm. We suppose that the emission is due to conformational processes that may occur under aqueous environment, as previously observed,^{6b} enabling light emission through Aggregation-Induced Emission (AIE).¹⁹

EXPERIMENTAL

General Information. All commercial reactants and reagents were used without further purification.

Thin layer chromatography was performed with silica gel plates deposited on aluminum Merck Silica 60 F254, with fluorescent indicator. TLC plates were visualized through UV irradiation at 254 and 365 nm. Chromatography columns used for the purification of the compounds were manually packed in the laboratory, using the same type of silica gel. Characterization of the compounds was realized by Nuclear Resonance Magnetic (NMR) spectrometry with Bruker Avance III (400 MHz and 500 MHz). Chemical shifts (δ) are reported in parts per million (ppm) using the peak values of the residual solvent as an internal reference. The multiplicities are abbreviates as following: s – singlet, d – doublet, t – triplet, dd – doublet of doublets. Characterization of the compounds was also performed by Fourier Transform Infrared (FTIR) spectroscopy. Absorption spectra were recorded on JASCO V-750 Spectrophotometer, using 10 mm Starna Scientific quartz cell. Stock solutions of compound were prepared in DMSO (10^{-3} mol/L), diluted to 10^{-4} mol/L and 10^{-5} mol/L using DMSO. Solution fluorescence spectra were recorded on a Thermo Scientific Varioskan Flash spectral scanning multimode reader. The spectra were recorded in suitable plates for all measurements. Stock solutions of compounds were

prepared in DMSO (10^{-3} mol/L), diluted to 10^{-4} mol/L and 10^{-5} mol/L using DMSO and DMSO/water (90% v/v).

5-bromo-benzyloxy-1,3-bis(hydroxymethyl)benzene

2. 4-Bromo-2,6-bis(hydroxymethyl)phenol **1** (12.87 mmol, 3 g, 1Eq) was dissolved into acetone (45 mL). Potassium iodide (14.15 mmol, 2.35 g, 1.1 eq), potassium carbonate (36.61 mmol, 5.32 g, 3 eq.) and benzyl bromide (1.60 mL, 1.05 g, 1Eq) were sequentially added to the solution and stirred at 60°C for 24 h. The mixture was left to cool to room temperature, then filtered. The pure compound was isolated in the form of a white solid. White solid, $R_f = 0.55$ (silica gel, ethyl acetate: petroleum ether = 1:2), m.p. 125–126.5 °C^{7e}, $\eta = 80\%$. ¹H NMR (500 MHz, DMSO-*d*₆) δ 7.47 (m, 7H, H_{Ar}), 5.28 (t, $J = 5.7$ Hz, 2H, OH), 4.84 (s, 2H, CH₂), 4.54 (d, $J = 5.7$ Hz, 4H, CH₂) ppm. ¹³C NMR (125 MHz, DMSO-*d*₆) δ 151.99, 138.11, 137.12, 129.12, 128.42, 128.08, 128.04, 116.28, 75.32, 57.46 ppm.

5-azido-2-benzyloxy-1,3-bis(hydroxymethyl)benzene

3. A mixture of ethanol and water (v:v=1:1) was deaerated under argon atmosphere through three successive cycles of cooling in liquid nitrogen, then returning to ambient temperature under inert argon atmosphere. In a special airtight flask, compound **2** (1.23 mmol, 0.4 g, 1 eq) was dissolved into the mixture ethanol-water (5 mL). Stirring was maintained till complete dissolution. Then, sodium azide (2.47 mmol, 0.160 g, 2 eq), ascorbic acid (0.24 mmol, 0.043 g, 0.2 eq.), *N,N'*-dimethyl ethylenediamine (0.37 mmol, 0.032 g, 0.3 eq), sodium hydroxide (0.24 mmol, 0.01 g, 0.2 eq) and at the end cooper(I) iodide (0.24 mmol, 0.047 g, 0.2 eq) were added to the solution, and stirred at 90°C for 25 min. The reaction was quenched by addition of water (50 mL) in order to dissolve the catalyst and stirring was maintained for 5 min. The compound was collected as a precipitate by filtration. Column chromatography on silica gel using ethyl acetate: cyclohexane = 1:9, led to isolation of the pure product. White solid, $R_f = 0.30$ (silica gel, ethyl acetate: cyclohexane = 1:2), $\eta = 80\%$. ¹H NMR (500 MHz, DMSO-*d*₆) δ 7.46 (d, $J = 7.3$ Hz, 2H, H_{Ar}), 7.42 (t, $J = 7.3$ Hz, 2H, H_{Ar}), 7.36 (t, $J = 7.3$ Hz, 1H, H_{Ar}), 7.07 (s, 2H, H_{Ar}), 5.25 (t, $J = 5.7$ Hz, 2H, OH), 4.82 (s, 2H, CH₂), 4.55 (d, $J = 5.7$ Hz, 4H, CH₂) ppm. ¹³C NMR (125 MHz, DMSO-*d*₆) δ 149.97, 137.38, 137.25, 134.67, 128.41, 128.05, 128.01, 116.80, 75.36, 57.63 ppm.

5-(4-phenyl-1,2,3-triazole)-2-benzyloxy-1,3-

bis(hydroxymethyl) benzene 4. Azide **3** (0.9 mmol, 0.25 g, 1 eq) was dissolved in methanol (4 mL), then phenylacetylene (1.75 mmol, 0.18 g, 2 eq) and copper(I) catalyst **C** (0.09 mmol, 0.05 g, 10%Eq) were added to the solution mixture. Stirring was maintained at room temperature. After 2h, the solvent was evaporated, and the residue was extracted with ethyl acetate (3 x 30 mL). The organic layers were dried over anhydrous magnesium sulphate and evaporated. The residue was dried under vacuum. White brownish solid, $R_f = 0.15$ (silica gel, ethyl acetate: cyclohexane = 1:2), $\eta = 64\%$. ¹H NMR (400 MHz, DMSO-*d*₆) δ 9.35 (s, 1H, H_{triazole}), 8.00 (d, 2H, (d, $J = 7.7$ Hz, 2H, H_{Ar}), 7.95 (s, 2H, H_{Ar}), 7.53-7.40 (m, 8H, H_{Ar}), 4.94 (s, 2H, CH₂), 4.67 (s, 4H, CH₂) ppm.

5-(4-phenyl-1,2,3-triazole)-2-benzyloxy-1,3-

phthalaldehyde 5. The alcohol **4** (1.5503 mmol, 0.6 g, 1 eq) was suspended in chloroform (20 mL) and manganese dioxide (31 mmol, 2.7 g, 20 eq) was added to the solution. The mixture was stirred at 65°C for 3.5 h and left to cool to room temperature, then filtered through a mixture of celite (80%) and silica gel (20%), followed by the evaporation of the solvent. The residue was purified by column chromatography on silica gel using as mobile phase ethyl acetate: cyclohexane = 1:9, to isolate the pure product. White yellowish solid, $R_f = 0.20$ (silica gel, ethyl acetate: cyclohexane = 1:2), $\eta = 71\%$. ¹H NMR (400 MHz, CDCl₃) δ 10.26 (s, 2H, CHO), 8.52 (s, 2H, H_{Ar}), 8.28 (s, 1H, H_{triazole}), 7.92 (d, $J = 7.9$ Hz, 2H, H_{Ar}), 7.48 (t, $J = 7.4$ Hz, 2H, H_{Ar}), 7.42–7.40 (m, 4H, H_{Ar}), 7.35–7.33 (m, 2H, H_{Ar}), 5.27 (s, 2H, CH₂) ppm. ¹³C NMR (100 MHz, DMSO-*d*₆) δ 188.57, 162.11, 148.15, 135.47, 133.72, 132.16, 130.46, 129.84, 129.50, 129.47, 129.16, 128.87, 125.84, 125.10, 120.40, 81.16. ppm.

5-(4-phenyl-1,2,3-triazole)-2-benzyloxy-1,3-bis-N-3,4,5-trimethoxybenzohydrazone 6.

Dialdehyde **5** (0.13 mmol, 0.05 g, 1 eq) was dissolved in DMSO and 3,4,5-trimethoxybenzhydrazide (0.26 mmol, 0.06 g, 2 eq) and a few drops of TFA were added. The reaction was maintained at room temperature under stirring for 72h. Water (up to 90%) was then added and the compound of interest precipitated. A filtration under vacuum and dryness followed in order to isolate the pure product. White solid, $R_f = 0.1$ (silica gel, ethyl acetate: cyclohexane = 1:2), $\eta = 78\%$. ¹H NMR (500 MHz, DMSO-*d*₆) δ 11.98 (s, 2H, NH), 9.53 (s, 1H, H_{triazole}), 8.80 (s, 2H, H_{Ar}),

8.46 (s, 2H, CH=N), 8.05 (d, $J = 7.7$ Hz, 2H, H_{Ar}), 7.59 (d, $J = 7.4$ Hz, 2H, H_{Ar}), 7.54 (t, $J = 7.7$ Hz, 2H, H_{Ar}), 7.47–7.40 (m, 4H, H_{Ar}), 7.25 (s, 4H, H_{Ar}), 5.09 (s, 2H, CH₂), 3.89 (s, 12H, OCH₃), 3.75 (s, 6H, OCH₃) ppm. ¹³C NMR (125 MHz, DMSO-*d*₆) δ 162.94, 155.67, 152.76, 147.58, 141.59, 140.68, 135.48, 133.64, 130.42, 130.19, 128.98, 128.67, 128.61, 128.52, 128.51, 128.43, 128.28, 125.47, 118.46, 105.46, 78.64, 60.16, 56.20 ppm.

CONCLUSIONS

In conclusion, we described the synthesis of a novel *N*-acylhydrazone bearing a triazole moiety involving a CuAAC key step between a protected-phenol azide and phenyl acetylene. The azide was synthesized by a copper-mediated coupling reaction of aryl-bromide and sodium azide and further functionalized with aldehyde groups to provide the key building block for preparation of the *N*-acylhydrazone. The target compound was further investigated for optical properties, showing an absorption maximum at $\lambda = 305$ nm, as well as the ability to emit blue light at $\lambda = 450$ nm in solid state and aqueous solutions.

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REFERENCES

- a) C.C. Paraschivescu, N.D. Hädade, A.G. Coman, A. Gautier, F. Cisnetti and M. Matache, *Tetrahedron Lett.*, **2015**, *56*, 3961–3964; b) C.C. Paraschivescu, M. Matache, C. Dobrotă, A. Nicolescu, C. Maxim, C. Deleanu, I.C. Fărcășanu and N.D. Hädade, *J. Org. Chem.*, **2013**, *78*, 2670–2679; c) C.C. Anghel, A.G. Mirea, C.C. Popescu, A.M. Mădălan, A. Hanganu, A. Bende, N.D. Hädade, M. Matache and M. Andruh, *Dyes Pigm.*, **2023**, *210*, 111023.
- a) S. Anbu, S. Kamalraj, C. Jayabaskaran and P.S. Mukherjee, *Inorg. Chem.*, **2013**, *52*, 8294–8296. b) J.-C. Qin, B.-D. Wang, Z.-Y. Yang and K.-C. Yu, *Sens. Actuators B Chem.*, **2016**, *224*, 892–898. c) S. Joshi, S. Agarwal, A. Panjla, S. Valiyaveetil, S. Ganesh and S. Verma, *ChemBioChem*, **2022**, *23*, e202100654.
- a) F.B.L. Coughon, A.R. Stefankiewicz and S. Ulrich, *Chem. Sci.*, **2024**, *15*, 879–895; b) M. Matache, E. Bogdan and N.D. Hädade, *Chem. Eur. J.*, **2014**, *20*, 2106–2131; c) T. Jiao, G. Wu, Y. Zhang, L. Shen, Y. Lei, C.-Y. Wang, A.C. Fahrenbach, and H. Li, *Angew. Chem. Int. Ed. Engl.*, **2020**, *59*, 18350–18367.
- Y. Zhang and M. Barboiu, *Chem. Rev.*, **2016**, *116*, 809–834.
- a) F.J. Uribe-Romo, C.J. Doonan, H. Furukawa, K. Oisaki and O.M. Yaghi, *J. Am. Chem. Soc.*, **2011**, *133*, 11478–11481; b) Z. Zhuang, H. Shi, J. Kang and D. Liu, *Mater. Today Chem.*, **2021**, *22*, 100573.
- a) A.G. Coman, A. Paun, C.C. Popescu, N.D. Hädade, A. Hanganu, G. Chiritoiu, I.C. Farcasanu and M. Matache, *Bioorg. Chem.*, **2019**, *92*, 103295; b) A.G. Coman, A. Paun, C.C. Popescu, N.D. Hädade, C.C. Anghel, A.M. Mădălan, P. Ioniță, and M. Matache, *New J. Chem.*, **2018**, *42*, 14111–14119. c) D. J. van Dijken, P. Kovaříček, S. P. Ihrig and S. Hecht, *J. Am. Chem. Soc.*, **2015**, *137*, 14982. d) M. N. Chaur, D. Collado and J.-M. Lehn, *Chem. Eur. J.*, **2011**, *17*, 248. e) C.C. Paraschivescu, A.G. Coman, C.C. Anghel and M. Matache, *Rev. Roum. Chim.*, **2015**, *60*, 339–343.
- A. Maity, F. Ali, H. Agarawal, B. Anothumakkool and A. Das, *Chem. Commun.*, **2015**, *51*, 2130.
- a) S. Sharma, M. Kumaria and N. Singh, *Soft Matter*, **2020**, *16*, 6532–6538. b) S. Mondal, P. Bairi, S. Das and A. K. Nandi, *Chem. Eur. J.*, **2018**, *24*, 5591–5600.
- H.C. Kolb, M.G. Finn and K.B. Sharpless, *Angew. Chem. Int. Ed.*, **2001**, *40*, 2004–2021.
- a) M. Meldal and C.W. Tornøe, *Chem. Rev.*, **2008**, *108*, 2952–3015. b) E. Haldón, M.C. Nicasi and P.J. Pérez, *Org. Biomol. Chem.*, **2015**, *13*, 9528–9550.
- L. González-Bulnes, I. Ibáñez, L.M. Bedoya, M. Beltrán, S. Catalán, J. Alcamí, S. Fustero and J. Gallego, *Angew. Chem. Int. Ed.*, **2013**, *52*, 13405–13409.
- S. Brase, C. Gil, K. Knepper and V. Zimmermann, *Angew. Chem. Int. Ed.*, **2005**, *44*, 5188–5240.
- M. Goswami and B. de Bruin, *Eur. J. Org. Chem.*, **2017**, *2017*, 1152–1176.
- W. Zhu and D. Ma, *Chem. Commun.*, **2004**, *888*, 888–889.
- E. Lieber, C.N.R. Rao, T.S. Chao and C.W.W. Hoffman, *Anal. Chem.*, **1957**, *29*, 916–918.
- M.-L. Teyssot, L. Nauton, J.-L. Canet, F. Cisnetti, A. Chevy and A. Gautier, *Eur. J. Org. Chem.*, **2010**, *2010*, 1879–1890.
- M.-L. Teyssot, A. Chevy, M. Traïkia, M. El-Ghozzi, D. Avignant and A. Gautier, *Chem. Eur. J.*, **2009**, *15*, 6322–6326.
- R. Ziessel, P. Nguyen, L. Douce, M. Cesario and C. Estournès, *Org. Lett.*, **2004**, *6*, 2865–2868.
- J. Mei, N.L.C. Leung, R.T. K. Kwok, J.W.Y. Lam and B.Z. Tang, *Chem. Rev.*, **2015**, *115*, 11718–11940.