*molbank*

MDPI

*Communication*

# Synthesis and Spectroscopic Study of New 1*H*-1-Alkyl-6-methyl-7-nitroso-3-phenylpyrazolo[5,1-c][1,2,4]triazoles

**Ion Burcă, Valentin Badea *, Vasile-Nicolae Bercean and Francisc Péter**

Department of Applied Chemistry and Organic and Natural Compounds Engineering, Politehnica University Timisoara, Vasile Pârvan 6 Blvd., 300223 Timisoara, Romania
* Correspondence: valentin.badea@upt.ro; Tel.: +40-742-044969

**Abstract:** The nitrosation of 1*H*-1-alkyl-6-methyl-3-phenylpyrazolo[5,1-c][1,2,4]triazoles leads to new 1*H*-1-alkyl-6-methyl-7-nitroso-3-phenylpyrazolo[5,1-c][1,2,4] triazoles that react in acidic media, giving rise to 1*H*-1-alkyl-7-hydroxyimino-6-methyl-3-phenylpyrazolo[5,1-c][1,2,4]triazolium salts. These compounds were characterized by FT-IR, UV-Vis, $^{1}$H-NMR, $^{13}$C-NMR, and $^{15}$N-NMR spectroscopic techniques.

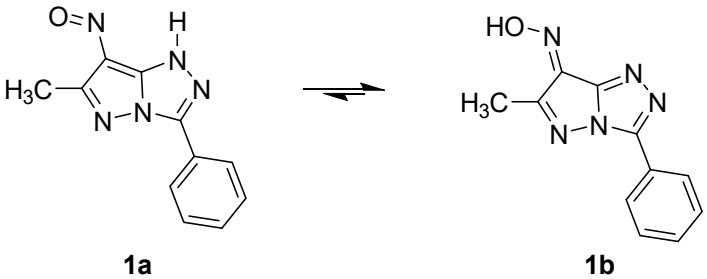
**Keywords:** nitrosation; 7-nitrosopyrazolo[5,1-c][1,2,4]triazole; 1*H*-1-alkyl-7-hydroxyimino-6-methyl-3-phenylpyrazolo[5,1-c][1,2,4]triazolium salts

## 1. Introduction

Compounds derived from pyrazolo[5,1-c][1,2,4]triazoles are used in photosensitive color materials, inks, and toners [1–4], as well as in other areas of interest [5–8]. To the best of our knowledge, there is limited available literature, excluding patent literature, on the synthesis and properties of these compounds [9,10].

Given the above, our aim is to increase knowledge on the synthesis and physicochemical properties of the pyrazolo[5,1-c][1,2,4]triazole heterocyclic pyrazolo[5,1-c][1,2,4] triazole system [11,12].

Previously, we have shown [12] that the nitrosation of 1*H*-6-methyl-3-phenylpyrazolo [5,1-c][1,2,4]triazole leads to the nitroso derivative (**1a**), which is as stable as its tautomer 1*H*-7-hydroxyimino-6-methyl-3-phenylpyrazolo[5,1-c][1,2,4]triazole (**1b),** as seen below in Scheme 1.




**Scheme 1.** Nitroso-hydroxyimino tautomerism of 1*H*-6-methyl-3-phenylpyrazolo[5,1-c][1,2,4]triazole derivative.

The scope of the current work is to extend the study on the nitrosation reaction of 1-alkylated (**2a–c**) derivatives of the 1*H*-6-methyl-3-phenylpyrazolo[5,1-*c*][1,2,4]triazole synthesized previously by our research group [13].

## 2. Results and Discussion

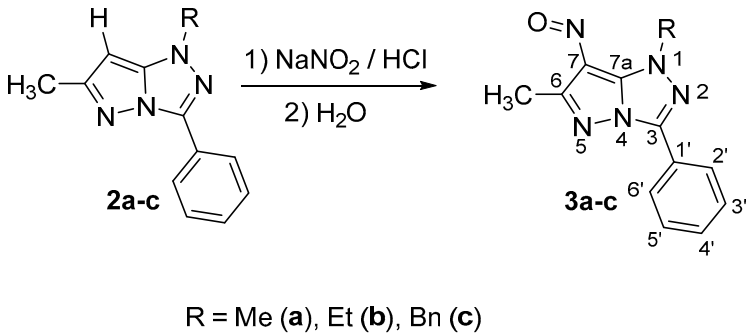
The nitrosation of 1*H*-1-alkyl-3-phenyl-6-methylpyrazolo[5,1-c][1,2,4]triazoles (**2a–c**) was performed in a similar way to the nitrosation of 1*H*-6-methyl-3-phenylpyrazolo[5,1-c][1,2,4] triazole [12], using sodium nitrite in aqueous hydrochloric acid, as seen below in Scheme 2.

check for updates

**Citation:** Burcă, I.; Badea, V.; Bercean, V.-N.; Péter, F. Synthesis and Spectroscopic Study of New 1*H*-1-Alkyl-6-methyl-7-nitroso-3-phenylpyrazolo[5,1-c][1,2,4]triazoles. *Molbank* **2024**, *2024*, M1815. https://doi.org/10.3390/M1815

Academic Editor: Fawaz Aldabbagh

Received: 9 March 2024
Revised: 18 April 2024
Accepted: 19 April 2024
Published: 24 April 2024




**Scheme 2.** The nitrosation of 1*H*-1-alkyl-6-methyl-3-phenylpyrazolo[5,1-*c*][1,2,4]triazoles (**2a–c**).

In the first step, a pale yellow hydrochloride of the 1*H*-1-alkyl-6-methyl-7-nitroso-3-phenylpyrazolo[5,1-c][1,2,4]triazole is formed, which forms blue-colored nitroso derivatives (**3a–c**) after precipitation in water. The conclusion is that at high dilution, water is a stronger base than that of **3a–c** triazoles in their oxime tautomer form.

The presence of the nitroso chromophore was confirmed by UV-Vis spectra, in which the compounds **3a–c** had the maximum absorption wavelength, as follows: $\lambda_{max}$ = 562 nm (**3a**), 558 nm (**3b**), and 563nm (**3c**). These values are specific to aromatic nitroso compounds.

For all compounds in the $^{1}$H-NMR spectrum, the absence of a signal at 5.6 ppm can be observed, which corresponds to the proton bound to the carbon atom at the 7-C position of 1*H*-1-alkyl-6-methyl-3-phenylpyrazolo[5,1-c][1,2,4]triazole [12].

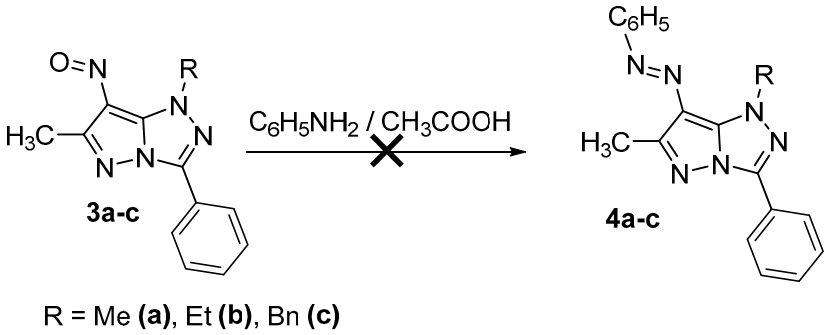
In the 2D NMR $^{1}$H-$^{13}$C HMBC and, respectively, $^{1}$H-$^{15}$N HMBC spectra of compounds **3a–c,** we can observe long-range correlations between protons and carbon atoms and respective correlations between protons and nitrogen atoms over two or three bonds. These long-range correlations observed through the corresponding cross peaks in the 2D NMR HMBC spectra (Table 1) confirm the structures of the synthesized compounds.

**Table 1.** Experimental 2D NMR correlation data for compounds **3a–c**.

| Compound | HMBC Long-Range Correlations | |
|---|---|---|
| | **$^{1}$H-$^{13}$C (ppm)** | **$^{1}$H-$^{15}$N (ppm)** |
| **3a** | 6-C-C$\underline{H}_3$ (3.04) → 6-$\underline{C}$ (164.2) | 6-C-C$\underline{H}_3$ (3.04) → 5-$\underline{N}$ (263.5) |
| | 6-C-C$\underline{H}_3$ (3.04) → 7-$\underline{C}$ (145.0) | 1-N-C$\underline{H}_3$ (4.32) → 1-$\underline{N}$ (168.6) |
| | 1-N-C$\underline{H}_3$ (4.32) → 7a-$\underline{C}$ (133.9) | 1-N-C$\underline{H}_3$ (4.32) → 2-$\underline{N}$ (288.4) |
| **3b** | 1-N-CH$_2$C$\underline{H}_3$ (1.50) → 1-N-$\underline{C}$H$_2$CH$_3$ (49.2) | 1-N-CH$_2$C$\underline{H}_3$ (1.50) → 1-$\underline{N}$ (183.5) |
| | 6-C-C$\underline{H}_3$ (3.03) → 7-$\underline{C}$ (145.0) | 6-C-C$\underline{H}_3$ (3.03) → 5-$\underline{N}$ (263.5) |
| | 6-C-C$\underline{H}_3$ (3.03) → 6-$\underline{C}$ (164.2) | 1-N-C$\underline{H}_2$CH$_3$ (4.70) → 1-$\underline{N}$ (183.5) |
| | 1-N-C$\underline{H}_2$CH$_3$ (4.70) → 1-N-CH$_2$$\underline{C}$H$_3$ (16.3) | 1-N-C$\underline{H}_2$CH$_3$ (4.70) → 2-$\underline{N}$ (286.0) |
| | 1-N-C$\underline{H}_2$CH$_3$ (4.70) → 7a-$\underline{C}$ (133.9) | |
| **3c** | 6-C-C$\underline{H}_3$ (3.04) → 7-$\underline{C}$ (145.0) | 6-C-C$\underline{H}_3$ (3.04) → 5-$\underline{N}$ (264.4) |
| | 6-C-C$\underline{H}_3$ (3.04) → 6-$\underline{C}$ (164.2) | 1-N-C$\underline{H}_2$ (5.79) → 1-$\underline{N}$ (181.6) |
| | 1-N-C$\underline{H}_2$ (5.79) → 7a-$\underline{C}$ (133.9) | 1-N-C$\underline{H}_2$ (5.79) → 2-$\underline{N}$ (286.5) |
| | 1-N-C$\underline{H}_2$ (5.79) → 1″-$\underline{C}$ (134.8) | |
| | 1-N-$\underline{C}$H$_2$ (5.79) → 2″-$\underline{H}$, 6″-$\underline{H}$ (7.41–7.40) | |

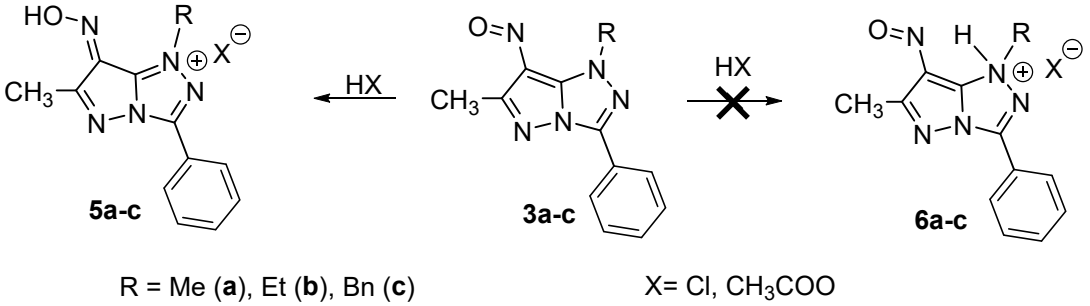
However, compounds **3a–c** do not exhibit one of the characteristic reactions of the N=O group grafted onto an aromatic heterocycle, namely condensation with aniline in

an acetic acid medium at reflux (Scheme 3), a reaction that is shown in the literature for nitrosopyrazoles [14].




**Scheme 3.** Reaction of 1*H*-1-alkyl-6-methyl-7-nitroso-3-phenylpyrazolo[5,1-*c*][1,2,4]triazoles (**3a–c**) with aniline.

The lack of aniline reactivity, together with the fact that nitroso derivatives **3a–c** change color from blue to yellow when dissolving in acetic acid or a hydrochloric acid/methanol mixture, suggests that pyrazolotriazolium salts are formed. We propose as possible structures for these salts the structures **5a–c**, in which the nitroso chromophore no longer exists; see Scheme 4.




**Scheme 4.** 1*H*-1-alkyl-7-hydroxyimino-6-methyl-3-phenylpyrazolo[5,1-*c*][1,2,4]triazolium salt (**5a–c**) formation.

In support of the proposed structures, **5a–c,** are the $\lambda_{max}$ values from the UV-Vis spectra in acetic acid and methanolic HCl solution (Table 2), in which the characteristic absorption of the aromatic N=O chromophore around 560 nm is hypsochromically shifted to lower values of around 520 nm in acetic acid and around 340 nm in methanolic hydrochloric acid solution, respectively.

**Table 2.** UV-VIS absorption maxima of compounds **3a–c**.

| R | $\lambda_{max}$ [nm], ε [$M^{-1}$·$cm^{-1}$] ($CH_3OH$) | $\lambda_{max}$ [nm] ($CH_3COOH$) | $\lambda_{max}$ [nm] ($HCl/CH_3OH$) |
|---|---|---|---|
| -$CH_3$ | 561.5, 63.6 | 519 | 339.5 |
| -$C_2H_5$ | 558.0, 65.1 | 518.5 | 340.5 |
| -$CH_2C_6H_5$ | 563.0, 56.4 | 522 | 343 |

## 3. Materials and Methods

The chemical reagents were purchased from commercial sources (Merck, Darmstadt, Germany, and Fluka, Buchs, Switzerland) and used in the syntheses as received. The 1*H*-6-methyl-3-phenylpyrazolo[5,1-c][1,2,4]triazole, the 1*H*-1-alkyl-6-methyl-3-phenylpyrazolo[5,1-c][1,2,4]triazoles (**2a–c**), and the 1*H*-6-methyl-7-nitroso-3-phenylpyrazolo[5,1-c][1,2,4]triazole (**1a**) were prepared according to methods in the literature [1,11,12,14].

Melting points were measured on a Böetius PHMK apparatus (Veb Analytik, Dresden, Germany) and were uncorrected. A TLC analysis was performed on 60 F254 silica gel plates from Merck using benzene-ethyl acetate = 1:1 (*v*/*v*) as eluent. IR spectra were recorded on a Jasco FT/IR-410 spectrophotometer (Jasco Corporation, Tokyo, Japan) in KBr pellets. The $^{1}$H-NMR and $^{13}$C-NMR spectra were recorded on a Bruker Avance III 500 MHz spectrometer (Billerica, USA). Chemical shifts (δ) were measured in ppm and coupling constants (*J*) in Hz. TMS was used as an internal standard. The elemental analysis was performed at the "Iuliu Haţieganu" University of Medicine and Pharmacy in Cluj-Napoca.

## 4. Experimental Section

### *4.1. General Synthesis Procedure*

To a cooled solution (0 °C) of the 1*H*-1-alkyl-6-methyl-3-phenylpyrazolo[5,1-c][1,2,4]triazole (0.5 g, 2.5 mmol) in 30 mL of concentrated HCl and 100 mL of distilled water, a 30% sodium nitrite solution (2.75 mmol) was added dropwise under stirring. After 30 min of stirring at 0 °C and then 5 h at room temperature, a viscous suspension was formed. Then, the suspension was poured over 200 mL of water, and the obtained precipitate was separated by vacuum distillation. The compound was recrystallized from 96% ethanol [13].

### *4.2. 1,6-Dimethyl-7-nitroso-3-phenylpyrazolo[5,1-c][1,2,4]triazole* (**3a**)

Blue-colored powder; isolation yield: 89%; melting point: 199–201 °C; FT-IR [cm$^{-1}$]: 2944, 2879, 1594, 1509, 1484, 1030, 1070; UV-Vis: $\lambda_{max}$ [nm]: 561.55, ε [M$^{-1}$·cm$^{-1}$]: 63.6; $^{1}$H NMR ($CDCl_3$, 500 MHz) δ (ppm): 8.34–8.32 (m, 2H, 2′-H, 6′-H), 7.56–7.54 (m, 3H, 3′-H, 4′-H, 5′-H), 4.32 (s, 3H, 1-N-C$\underline{H}_3$), 3.04 (6-C-C$\underline{H}_3$); $^{13}$C NMR ($CDCl_3$, 125 MHz) δ (ppm): 164.2 (6-C), 144.9 (7-C), 140.4 (3-C), 134.8 (7a–C), 131.4 (4′-C), 129.1 (3′-C, 5′-C), 127.1 (2′-C, 6′-C), 123,8 (1′-C), 40.6 (1-N-$\underline{C}H_3$), 13.4 (6-C-$\underline{C}H_3$)**;** $^{15}$N NMR ($CDCl_3$, 50 MHz) δ (ppm): 168.6 (1-N), 263.5 (5-N), 288.4 (2-N); Anal. Calcd for $C_{12}H_{11}N_5O$: C, 59.74; H, 4.60; N, 29.03. Found: C, 59.54; H, 4.37; N, 28.89. (Figures S1–S6)

### *4.3. 1-Ethyl-6-methyl-7-nitroso-3-phenylpyrazolo[5,1-c][1,2,4]triazole* (**3b**)

Blue-colored powder; isolation yield: 82%; melting point: 172–174 °C; FT-IR [cm$^{-1}$]: 2982, 2935, 1696, 1584, 1505, 1485, 1444, 1371, 772, 736, 691; UV-Vis: $\lambda_{max}$ [nm]: 558, ε [M$^{-1}$·cm$^{-1}$]: 65.1; $^{1}$H NMR ($CDCl_3$, 500 MHz) δ (ppm): 8.34–8.33 (m, 2H, 2′-H, 6′-H), 7.54–7.53 (m, 3H, 3′-H, 4′-H, 5′-H), 4.70 (q, 2H, *J* = 7.2 Hz, 1-N-C$\underline{H}_2$-$CH_3$), 3.03 (6-C-C$\underline{H}_3$), 1.50 (t, 3H, *J* = 7.2 Hz, 1-N-$CH_2$-C$\underline{H}_3$); $^{13}$C NMR ($CDCl_3$, 125 MHz) δ (ppm): 164.2 (6-C) 145.0 (7-C), 140.4 (3-C), 133.9 (7a–C), 131.3 (4′-C), 129.0 (3′-C, 5′-C), 127.1 (2′-C, 6′-C), 124.0 (1′-C), 49.2 (1-N-$\underline{C}H_2$-$CH_3$), 16.2 (1-N-$CH_2$-$\underline{C}H_3$), 13.4 (6-C-$\underline{C}H_3$)**;** $^{15}$N NMR ($CDCl_3$, 50 MHz) δ (ppm): 183.5 (1-N), 263.5 (5-N), 286.0 (2-N); Anal. Calcd for $C_{13}H_{13}N_5O$: C,61.17; H, 4.136; N, 26.56. Found: C, 61.09; H,5.11; N, 27.22. (Figures S7–S13).

### *4.4. 1-Benzyl-6-methyl-7-nitroso-3-phenylpyrazolo[5,1-c][1,2,4]triazole* (**3c**)

Blue-colored powder; isolation yield: 81%; melting point: 185–190 °C; FT-IR [cm$^{-1}$]: 2953, 2928, 1572, 1485, 1456, 767, 727, 692; UV-Vis: $\lambda_{max}$ [nm]: 563.1, ε [M$^{-1}$·cm$^{-1}$]: 56.4; $^{1}$H NMR ($CDCl_3$, 500 MHz) δ (ppm): 8.33–8.31 (m, 2H, 2′-H, 6′-H), 7.52–7.51 (m, 3H, 3′-H, 4′-H, 5′-H), 7.41–7.40 (m, 2H, 2″-H, 6″-H); 7.33–7.28 (m, 3H, 3″-H, 4″-H, 5″-H), 5.79 (s, 2H, 1-N-C$\underline{H}_2$-), 3.04 (6-C-C$\underline{H}_3$); $^{13}$C NMR ($CDCl_3$, 125 MHz) δ (ppm): 164.2 (6-C), 145.0 (7-C), 140.7 (3-C), 134.8 (1″-C), 133.9 (7a–C), 131.4 (4′-C), 129.0 (3′-C, 5′-C, 3″-C, 5″-C), 128.9 (2″-C, 6″-C), 128.6 (2′-C, 6′-C), 127.2 (4″-C), 123.9 (1′-C), 57.1 (1-N-$\underline{C}H_2$-), 13.4 (6-C-$\underline{C}H_3$); $^{15}$N NMR ($CDCl_3$, 50 MHz) δ (ppm): 181.6 (1-N), 264.4 (5-N), 286.5 (2-N); Anal. Calcd for $C_{18}H_{15}N_5O$: C, 68.13; H, 4.76; N, 22.07. Found: C,68.05; H, 4.69; N, 21.89. (Figures S14–S20).

## 5. Conclusions

The nitrosation of 1*H*-6-methyl-3-phenylpyrazolo[5,1-c][1,2,4]triazoles leads to 1*H*-7-hydroxyimino-6-methyl-3-phenylpyrazolo[5,1-c][1,2,4]triazoles, while the nitrosation of 1*H*-1-alkyl-6-methyl-3-phenylpyrazolo[5,1-c][1,2,4]triazoles gives rise to 1*H*-1-alkyl-6-

methyl-7-nitroso-3-phenylpyrazolo[5,1-c][1,2,4]triazoles. The tendency of these compounds to exist in the form of hydroxyimino is highlighted by the fact that even in a weakly acidic environment, the nitroso aromatic group no longer shows the characteristic properties of reactions or color. This is the reason that we proposed their existence in solution in the form of 1-{1*H*-1-alkyl-7-hydroxyimino-6-methyl-3-phenylpyrazolo[5,1-c][1,2,4]}triazolium salts.

**Supplementary Materials:** Figure S1 1H NMR spectrum of the compound (**3a**), Figure S2 13C NMR spectrum of the compound (**3a**), Figure S3 HSQC 1H-13C spectrum of the compound (**3a**), Figure S4 HMBC 1H-13C spectrum of the compound (**3a**), Figure S5 HMBC 1H-15N spectrum of the compound (**3a**), Figure S6 FT-IR spectrum of the compound (**3a**), Figure S7 1H NMR spectrum of the compound (**3b**), Figure S8 13C NMR spectrum of the compound (**3b**), Figure S9 COSY 1H-1H spectrum of the compound (**3b**), Figure S10 HMBC 1H-13C spectrum of the compound (**3b**), Figure S11 1H-13C spectrum of the compound (**3b**), Figure S12 HMBC 1H-15N spectrum of the compound (**3b**), Figure S13 FT-IR spectrum of the compound (**3b**), Figure S14 1H NMR spectrum of the compound (**3c**), Figure S15 13C NMR spectrum of the compound (**3c**), Figure S16 COSY 1H-1H spectrum of the compound (**3c**), Figure S17 HMBC 1H-13C spectrum of the compound (**3c**), Figure S18 1H-13C spectrum of the compound (**3c**), Figure S19 HMBC 1H-15N spectrum of the compound (**3c**), Figure S20 FT-IR spectrum of the compound (**3c**).

**Author Contributions:** Designed the experiments, V.B.; performed the experiments, I.B. and V.-N.B.; analyzed the spectral data, V.B. and F.P.; wrote the manuscript, I.B. and V.-N.B.; supervision, F.P. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research received no external funding.

**Data Availability Statement:** The data presented in this study are available within the article or Supplementary Materials.

**Conflicts of Interest:** The authors declare no conflicts of interest.

## References

1. Bailey, J. Synthesis of 1*H*-Pyrazolo[3,2-c]-s-Triazoles and Derived Azamethine Dyes. *J. Chem. Soc. Perkin Trans. 1* **1977**, *18*, 2047–2052. [CrossRef]
2. Diehl, D.R.; Kapiamba, M.; Cowan, S.W. Photographic Element, Pyrazolazole Coupler, Method for It's Preparation and an Azomethine Dye. EP1014185A1, 28 June 2000.
3. Komamura, T.; Onishi, A.; Tanaka, T.; Nakayama, Y.; Honda, M.; Miura, N. Metal Complex Methin Dye. EP0763569A1, 19 March 1997.
4. Diehl, D.R.; Niger, R.J.; Dunlap, R.P.; Sonnefeld, W.J.; Schmitthenner, H.F. Imaging Materials Containing Peptoid Substituted Azole Couplers. US6514679B1, 4 February 2003.
5. Arisumi, K.; Feng, F.; Miyashita, T.; Ninomiya, H. Functionalization of Polymer Langmuir−Blodgett Films Using Active Ester Groups. *Langmuir* **1998**, *14*, 5555–5558. [CrossRef]
6. Plos, G.; Lagrange, A. Composition for Oxidative Dyeing of Keratinous Fibres and Dyeing Process Using the Same. EP1062937A1, 27 December 2000.
7. Kato, K.; Suzuki, T.; Ishihara, H. Bacteriaproof and Mildewproof Agent. JP2002167305A, 11 June 2002.
8. Abdallah, M.A.; Riyadh, S.M.; Abbas, I.M.; Gomha, S.M. Synthesis and Biological Activities of 7-Arylazo-7*H*-Pyrazolo[5,1-c][1,2,4] Triazol-6(5*H*)-Ones and 7-Arylhydrazono-7H-[1,2,4]Triazolo[3,4-b] [1,3,4]Thiadiazines. *J. Chin. Chem. Soc.* **2005**, *52*, 987–994. [CrossRef]
9. Ibrahim, Y.A.; Al-Awadi, N.A.; John, E. Pyrolytic Desulfurization Ring Contraction of Condensed Thiadiazines as a General Route towards Pyrazoloazines and Pyrazoloazoles with a Bridgehead (Ring Junction) Nitrogen Atom. *Tetrahedron* **2008**, *64*, 10365–10374. [CrossRef]
10. Dawood, K.M. Indolizines, Triazolo[4,3-a]Pyridines, Benzimidazo[1,2-d]Oxadiazoles, and Pyrazolo[1,5-c]Triazoles via Nitrogen and Sulfur Ylides. *Heteroat. Chem.* **2004**, *15*, 432–436. [CrossRef]
11. Badea, V.; Şofei, M.D.; Venter, M.M.; Bercean, V.N. Regioselective Alkylation of 1*H*-7-Ethoxycarbonyl-6-Methyl-3-Phenyl-Pyrazolo[5,1-c][1,2,4]Triazole and 1*H*-6-Methyl-3-Phenyl-Pyrazolo[5,1-c][1,2,4]Triazole. *Tetrahedron* **2007**, *63*, 1467–1473. [CrossRef]
12. Bercean, V.-N.; Badea, V.; Şofei, M.-D.; Mitroi, D.; Csunderlik, C. Nitrozarea pirazolo[5,1-c][1,2,4]triazolilor. *Rev. Chim.* **2006**, *57*, 326–328.

13. Hüttel, R.; Büchele, F.; Jochum, P. Über Nitro-, Nitroso- und Azopyrazole. *Chem. Ber.* **1955**, *88*, 1577–1585. [CrossRef]
14. Șofei, M.-D. Contributions to the Study of Functionalization Reactions of Heterocyclic Compounds with Nitrogen. Ph.D. Thesis, University Politehnica of Timișoara, Timișoara, Romania, 2007. Available online: https://dspace.upt.ro/jspui/handle/123456789/4134 (accessed on 23 August 2023).