Oxidative Cyclization of N-Acylhydrazones. Development of Highly Selective Turn-on Fluorescent Chemodosimeters for Cu$^{2+}$

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1. Figures S1-S8

**Figure S1.** Absorption spectra of 2a (20 μM) in CH$_3$CN in the presence of given metal ion of increasing concentration. Concentrations of metal ions increased in the same manner from 0 to 250 μM.

**Figure S2.** Absorption spectra of 2b (20 μM) in CH$_3$CN in the presence of given metal ion of increasing concentration. Concentrations of metal ions increased in the same manner from 0 to 250 μM.
**Figure S3.** Absorption spectra of 2c (20 μM) in CH₃CN in the presence of given metal ion of increasing concentration. Concentrations of metal ions increased in the same manner from 0 to 250 μM.

**Figure S4.** Absorption spectra of 2d (20 μM) in CH₃CN in the presence of given metal ion of increasing concentration. Concentrations of metal ions increased in the same manner from 0 to 250 μM.
**Figure S5.** Absorption spectra of 3a (10 μM) in CH$_3$CN in the presence of given metal ion of increasing concentration. Concentrations of metal ions increased in the same manner from 0 to 250 μM.

**Figure S6.** Absorption spectra of 3b (10 μM) in CH$_3$CN in the presence of given metal ion of increasing concentration. Concentrations of metal ions increased in the same manner from 0 to 250 μM.
**Figure S7.** Absorption spectra of 3c (10 μM) in CH₃CN in the presence of given metal ion of increasing concentration. Concentrations of metal ions increased in the same manner from 0 to 250 μM.

**Figure S8.** Absorption spectra of 3d (10 μM) in CH₃CN in the presence of given metal ion of increasing concentration. Concentrations of metal ions increased in the same manner from 0 to 250 μM.
2. **Figure S9**

![Fluorescence spectra of 2 in CH$_3$CN in the presence of increasing concentration of Cu(ClO$_4$)$_2$. $[2] = 10 \mu$M.](image)

**Figure S9.** Fluorescence spectra of 2 in CH$_3$CN in the presence of increasing concentration of Cu(ClO$_4$)$_2$. $[2] = 10 \mu$M.

3. **Figure S10**

![Fluorescence spectra of 3 in CH$_3$CN in the presence of increasing concentration of Cu(ClO$_4$)$_2$. $[3] = 10 \mu$M.](image)

**Figure S10.** Fluorescence spectra of 3 in CH$_3$CN in the presence of increasing concentration of Cu(ClO$_4$)$_2$. $[3] = 10 \mu$M.
4. Table S1

Table S1. Absorption and fluorescence spectral parameters of 13

<table>
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<tr>
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<th>$\lambda_{\text{abs}}$, nm</th>
<th>$\varepsilon$, $10^4$ M$^{-1}$ cm$^{-1}$</th>
<th>$\lambda_{\text{fls}}$, nm</th>
<th>$\Phi^a$</th>
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<tr>
<td>13a</td>
<td>300</td>
<td>4.37</td>
<td>353/366</td>
<td>0.725</td>
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<tr>
<td>13b</td>
<td>294</td>
<td>3.98</td>
<td>347/361</td>
<td>0.719</td>
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<tr>
<td>13c</td>
<td>291</td>
<td>3.81</td>
<td>360</td>
<td>0.719</td>
</tr>
<tr>
<td>13d</td>
<td>295</td>
<td>3.76</td>
<td>368</td>
<td>0.720</td>
</tr>
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</table>

$^a$ Fluorescence quantum yield of 13 was measured using quinine sulfate as a standard (0.546 in 0.5 M H$_2$SO$_4$; Demas, J. N.; Crobys, G. A. *J. Phys. Chem.* **1971**, 75, 991-1024). The measurement error was up to 5%.

5. Figure S11

![Fluorescence spectra](image)

Figure S11. Fluorescence excitation and emission spectra of (a) the oxidation product 13a and (b) 3a in the presence of 1.0 equivalent Cu$^{2+}$ in CH$_3$CN
6. Figure S12

Figure S12. Absorption and fluorescence spectra of 13a (10 μM) in CH₃CN in the presence of increasing concentration of Cu²⁺. The excitation wavelength for acquiring fluorescence spectra was 283 nm.

7. Figure S13

Figure S13. Time scan of fluorescence intensity of 3a (0.5 μM) in CH₃CN in the presence of 0.5 equiv. of Cu²⁺. The excitation and emission wavelength were 283 nm and 360 nm, respectively.
8. Figure S14

Figure S14. (a) Fluorescence spectra of 3a (0.5 μM) in CH₃CN in the presence of increasing concentration of Cu(ClO₄)₂ and (b) linear response curve. Excitation wavelength was 283 nm.

9. Optimization of assay conditions in aqueous solution

Figure S15. Plots of the fluorescence intensity of 3a (10 μM) in the presence of 25 equiv. of Cu²⁺ as a function of pH of CH₃CN-H₂O (1:1, v/v) solution
Figure S16. Ionic strength effect (KCl) of the fluorescence of 3a in the presence of 25 equiv. of Cu$^{2+}$ in CH$_3$CN-H$_2$O (1:1, v/v). [KCl] = 0 - 0.2 M.

Figure S17. Influence of reaction duration on the fluorescence of 3a in the presence of 25 equivalents of Cu$^{2+}$ in a mixture of CH$_3$CN and Tris-HCl (5 mM, pH 7.2, KCl 0.1 M) aqueous buffer solution (20/80, v/v) at 50°C.
Figure S18. Fluorescent response of 3a toward Cu$^{2+}$ with varied counter anion in a mixture of CH$_3$CN and Tris-HCl (5 mM, pH 7.2, 0.1 M KCl) aqueous buffer solution (20/80, v/v)
11. $^1$H NMR and $^{13}$C NMR spectra of compounds 2-13

$N'$(2-Methoxybenzylidene)-4-ethoxybenzohydrazide (2a):

$^1$H NMR (500MHz, DMSO-$d_6$)

$^{13}$C NMR (125MHz, DMSO-$d_6$)
$N'$(2-Methoxybenzylidene)-4-methylbenzohydrazide (2b):  
$^1$H NMR (500MHz, DMSO-$d_6$)

$^{13}$C NMR (125MHz, DMSO-$d_6$)
$N^\prime$-(2-Methoxybenzylidene)benzohydrazide (2c):

$^1$H NMR (500MHz, DMSO-$d_6$)

$^{13}$C NMR (125MHz, DMSO-$d_6$)
$N^\prime$-(2-Methoxybenzylidene)-4-chlorobenzohydrazide (2d):

$^1$H NMR (500MHz, DMSO-$d_6$)

$^{13}$C NMR (125MHz, DMSO-$d_6$)
4-Ethoxy-N'-(furan-2-ylmethylene)benzohydrazide (3a):

$^1$H NMR (400MHz, DMSO-$d_6$)

[Chemical structure image]

$^{13}$C NMR (100MHz, DMSO-$d_6$)

[Chemical structure image]
$N'-(\text{Furan-2-ylmethylene})-4$-methylbenzohydrazide (3b):

$^1$H NMR (400MHz, DMSO-$d_6$)

$^{13}$C NMR (100MHz, DMSO-$d_6$)
N\textsuperscript{\textprime}-(Furan-2-ylmethylene)benzohydrazide (3c):

\textsuperscript{1}H NMR (400MHz, DMSO-\textit{d}\textsubscript{6})

\textsuperscript{13}C NMR (100MHz, DMSO-\textit{d}\textsubscript{6})
4-Chloro-N'-(furan-2-ylmethylene)benzohydrazide (3d):

$^1$H NMR (400MHz, DMSO-$d_6$)

$^{13}$C NMR (100MHz, DMSO-$d_6$)
4-Ethoxy-\(N'-(1-\text{furan-2-yl})\text{ethylidene}\)benzohydrazide (4):

\[^1\text{H NMR (400MHz, DMSO-d}_6\text{)}\]

\[^{13}\text{C NMR (100MHz, DMSO-d}_6\text{)}\]

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$N^{\prime}-(2$-Ethoxybenzylidene)-4-ethoxybenzohydrazide (5):

$^1$H NMR (400MHz, DMSO-$d_6$)

$^{13}$C NMR (100MHz, DMSO-$d_6$)
\(N^\prime-(2\text{-Propoxybenzylidene})-4\text{-ethoxybenzohydrazide (6):}\)

\(^1\text{H NMR (400MHz, DMSO-\textit{d}_6)}\)

\(^{13}\text{C NMR (100MHz, DMSO-\textit{d}_6)}\)
$N'$-(2-Isopropoxybenzylidene)-4-ethoxybenzohydrazide (7):  
$^1$H NMR (400MHz, DMSO-$d_6$)

$^{13}$C NMR (100MHz, DMSO-$d_6$)
4-Ethoxy-N'-(thiophen-2-ylmethylene)benzohydrazide (8):

$^{1}$H NMR (400MHz, DMSO-$d_6$)

$^{13}$C NMR (100MHz, DMSO-$d_6$)
\(N'\)-Benzylidene-4-ethoxybenzohydrazide (9):

\(^1\)H NMR (400MHz, DMSO-\(d_6\))

\(^{13}\)C NMR (100MHz, DMSO-\(d_6\))
4-Ethoxy-N′-(2-methylpropylidene)benzohydrazide (10):

$^1$H NMR (400MHz, CD$_3$CN)

$^{13}$C NMR (400MHz, DMSO-$d_6$)
4-Penyl-N’-(2-methoxybenzylidene)benzohydrazide (11):
$^1$H NMR (400MHz, DMSO-$d_6$)

$^{13}$C NMR (100MHz, DMSO-$d_6$)
N'-{(2-Methoxybenzylidene)-2-naphthohydrazide (12):

$^1$H NMR (400MHz, DMSO-$d_6$)

$^{13}$C NMR (100MHz, DMSO-$d_6$)
2-(4-Ethoxyphenyl)-5-furan-2-yl-1,3,4-oxadiazole (13a):

$^1$H NMR (400MHz, DMSO-$d_6$)

$^{13}$C NMR (100MHz, DMSO-$d_6$)
2-Furan-2-yl-5-\(p\)-tolyl-1,3,4-oxadiazole (13b):

\(^1\)H NMR (400MHz, CDCl\(_3\))

\(^{13}\)C NMR (100MHz, CDCl\(_3\))
2-Furan-2-yl-5-phenyl-1,3,4-oxadiazole (13c):

$^1$H NMR (400MHz, CDCl$_3$)

$^{13}$C NMR (100MHz, CDCl$_3$)
2-(4-Chlorophenyl)-5-furan-2-yl-1,3,4-oxadiazole (13d):

$^1$H NMR (400MHz, CDCl$_3$)

$^{13}$C NMR (100MHz, CDCl$_3$)