Supplementary information

All extraction studies were executed with the utmost of care in a temperature-controlled laboratory at 25 (± 2) °C.

Table 3.5: Data for the percentage extraction of nickel(II) using varying concentrations of synergist (SDBS). [Complimentary to Figure 3.5 in thesis]

<table>
<thead>
<tr>
<th>Synergist concentration (M)</th>
<th>Run</th>
<th>[Ni^{2+}] after extraction (mg.L^{-1})</th>
<th>% Extraction</th>
<th>Average % extraction</th>
<th>Standard deviation (σ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.01</td>
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<td>24.8</td>
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</table>

* pH = 5.03
** Nickel stock concentration = 57.8 mg.L^{-1};
*** Nickel blank concentration = 0.00 mg.L^{-1}
Table 3.7: Data for the percentage extraction of nickel(II) using 2-(1-octyl-imidazol-2-yl)pyridine (4) and varying concentrations of synergist (SDBS). [Complimentary to Figure 3.7 in thesis]

<table>
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<th>[Ni²⁺] after extraction (mg.L⁻¹)</th>
<th>% Extraction</th>
<th>Average % extraction</th>
<th>Standard deviation (σ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No synergist</td>
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</table>

* pH = 5.03
** Nickel stock concentration = 57.8 mg.L⁻¹
*** Nickel blank concentration = 0.00 mg.L⁻¹
Table 3.8: Data for the percentage extraction of nickel(II) using 2-(1’-pyrazolyl)-methylpyridine (5) and varying concentrations of synergist (SDBS). [Complimentary to Figure 3.8 in thesis]

<table>
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<th>Synergist concentration (M)</th>
<th>Run</th>
<th>[Ni²⁺] after extraction (mg.L⁻¹)</th>
<th>% Extraction</th>
<th>Average % extraction</th>
<th>Standard deviation (σ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No synergist</td>
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<td>60.2</td>
<td>5.82</td>
<td>5.37</td>
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</table>

* pH = 5.03

** Nickel stock concentration = 63.9 mg.L⁻¹

*** Nickel blank concentration = 0.03 mg.L⁻¹
Table 3.9: Data for the percentage extraction of nickel(II) using 2-(3-butyl-pyrazol-5-yl)pyridine (8) and varying concentrations of synergist (SDBS). [Complimentary to Figure 3.9 in thesis]

<table>
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<th>Synergist concentration (M)</th>
<th>Run</th>
<th>[Ni²⁺] after extraction (mg.L⁻¹)</th>
<th>% Extraction</th>
<th>Average % extraction</th>
<th>Standard deviation (σ)</th>
</tr>
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<td>73.0</td>
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<td>44.5</td>
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</table>

* pH = 5.03
** Nickel stock concentration = 63.9 mg.L⁻¹
*** Nickel blank concentration = 0.03 mg.L⁻¹
Table 3.10: A comparison of the percentage extraction of nickel(II) using 2-(1H-imidazol-2-yl)pyridine (1), 2-(1-methyl-imidazol-2-yl)pyridine (2), 2-(1-butyl-imidazol-2-yl)pyridine (3) and 2-(1-octyl-imidazol-2-yl)pyridine (4). [Complimentary to Figure 3.10 in thesis]

<table>
<thead>
<tr>
<th>Ligand</th>
<th>Run</th>
<th>([\text{Ni}^{2+}]) after extraction (mg.L(^{-1}))</th>
<th>% Extraction</th>
<th>Average % extraction</th>
<th>Standard deviation ((\sigma))</th>
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</thead>
<tbody>
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<td>Ligand 1</td>
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<td>3</td>
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<td>72.4</td>
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<td>3</td>
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<td>15.0</td>
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<td>76.5</td>
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<td></td>
</tr>
</tbody>
</table>

* \(\text{pH} = 5.03\)

** Synergist concentration = 0.05 M.

*** Nickel stock concentration (1–3) = 63.9 mg.L\(^{-1}\)

**** Nickel stock concentration (4) = 57.8 mg.L\(^{-1}\)

***** Nickel blank concentration (1–4) = 0.00 mg.L\(^{-1}\)
Table 3.11: A comparison of the percentage extraction of nickel(II) using 2-(1’-pyrazolyl)-methylpyridine (5), 2-(3,5-dimethyl-pyrazol-1-yl)-methylpyridine (6), 2-(3-methyl-pyrazol-1-yl)-methylpyridine / 2-(5-methyl-pyrazol-1-yl)-methylpyridine (7/7’). [Complimentary to Figure 3.11 in thesis]

<table>
<thead>
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<th>Ligand</th>
<th>Run</th>
<th>[Ni^{2+}] after extraction (mg.L^{-1})</th>
<th>% Extraction</th>
<th>Average % extraction</th>
<th>Standard deviation (σ)</th>
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<td>5.82</td>
<td>5.37</td>
<td>0.574</td>
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<td>2</td>
<td>60.9</td>
<td>4.72</td>
<td></td>
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</tr>
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<td>60.3</td>
<td>5.57</td>
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</tr>
<tr>
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<td>13.4</td>
<td>79.1</td>
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</table>

* pH = 5.03
** Synergist concentration = 0.05 M.
*** Nickel stock concentration (5) = 63.9 mg.L^{-1}
**** Nickel stock concentration (6 & 7/7’) = 62.1 mg.L^{-1}
***** Nickel blank concentration (5–7/7’) = 0.00 mg.L^{-1}
Table 3.12: A comparison of the percentage extraction of nickel(II) using 2-(3-butyl-pyrazol-5-yl)pyridine (8), 2-[3-(tert-butyl)-pyrazol-5-yl]pyridine (9) and 2-(3-octyl-pyrazol-5-yl)pyridine (10). [Complimentary to Figure 3.12 in thesis]

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<th>[Ni^{2+}] after extraction (mg.L^{-1})</th>
<th>% Extraction</th>
<th>Average % extraction</th>
<th>Standard deviation (σ)</th>
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</tr>
</tbody>
</table>

* pH = 5.03
** Synergist concentration = 0.05 M.
*** Nickel stock concentration (8) = 63.9 mg.L^{-1}
**** Nickel stock concentration (9 & 10) = 62.1 mg.L^{-1}
****** Nickel blank concentration (8) = 0.03 mg.L^{-1}
******* Nickel blank concentration (9 & 10) = 0.00 mg.L^{-1}
Table 3.13: Percentage extraction of nickel(II) over a 24-hour period using 2-(1-octyl-imidazol-2-yl)pyridine (4) and SDBS. [Complimentary to Figure 3.13 in thesis]

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<th>[Ni^{2+}] after extraction (mg.L^{-1})</th>
<th>% Extraction</th>
<th>Average % extraction</th>
<th>Standard deviation (σ)</th>
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* pH = 4.98
** SDBS concentration = 0.05 M.
*** Nickel stock concentration = 57.8 mg.L^{-1}
**** Nickel blank concentration = 0.00 mg.L^{-1}
**Table 3.14:** Percentage extraction of nickel(II) over a 24-hour period using 2-(1’-pyrazolyl)-methylpyridine (5) and SDBS. [Complimentary to Figure 3.14 in thesis]

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<th>Time (h)</th>
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<th>[Ni²⁺] after extraction (mg.L⁻¹)</th>
<th>% Extraction</th>
<th>Average % extraction</th>
<th>Standard deviation (σ)</th>
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</table>

* pH = 4.98
** SDBS concentration = 0.05 M.
*** Nickel stock concentration = 57.8 mg.L⁻¹
**** Nickel blank concentration = 0.00 mg.L⁻¹
Table 3.15: Percentage extraction of nickel(II) over a 24-hour period using 2-(3-butyl-pyrazol-5-yl)pyridine (8) and SDBS. [Complimentary to Figure 3.15 in thesis]

<table>
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<th>Time (h)</th>
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<th>[Ni^{2+}] after extraction (mg.L^{-1})</th>
<th>% Extraction</th>
<th>Average % extraction</th>
<th>Standard deviation (σ)</th>
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</table>

* pH = 4.98
** SDBS concentration = 0.05 M.
*** Nickel stock concentration = 57.8 mg.L^{-1}
**** Nickel blank concentration = 0.00 mg.L^{-1}
Table 3.16: Competitive extraction of various base metal ions in the presence of the synergist, SDBS, only. [Complimentary to Figure 3.16 in thesis]

<table>
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<th>Metal ion</th>
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<th>Average ([\text{M}^{2+}] \text{ after extraction (mg.L}^{-1})</th>
<th>Average % extraction</th>
<th>Standard deviation (σ)</th>
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</table>

* pH = 5.07
** SDBS concentration = 0.05 M
*** Stock concentrations (mg.L\(^{-1}\)): \([\text{Cd}^{2+}] = 116\), \([\text{Co}^{2+}] = 62.8\), \([\text{Cu}^{2+}] = 68.6\), \([\text{Ni}^{2+}] = 61.5\), \([\text{Pb}^{2+}] = 226\) and \([\text{Zn}^{2+}] = 69.9\).
Table 3.18: Competitive extraction of various base metal ions using 2-(1H-imidazol-2-yl)pyridine (1), both in the presence and absence of SDBS. [Complimentary to Figure 3.18 in thesis]

<table>
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<th>Synergist</th>
<th>Metal ion</th>
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<th>[M²⁺] after extraction (mg.L⁻¹)</th>
<th>Average [M²⁺] after extraction (mg.L⁻¹)</th>
<th>Average % extraction</th>
<th>Standard deviation (σ)</th>
</tr>
</thead>
<tbody>
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* pH = 5.07
** SDBS concentration = 0.05 M
Table 3.19: Competitive extraction of various base metal ions using 2-(1-methyl-imidazol-2-yl)pyridine (2), both in the presence and absence of SDBS. [Complimentary to Figure 3.19 in thesis]

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* pH = 5.07
** SDBS concentration = 0.05 M
*** Stock concentrations (mg.L\(^{-1}\)): [Cd\(^{2+}\)] = 116, [Co\(^{2+}\)] = 62.8, [Cu\(^{2+}\)] = 68.6, [Ni\(^{2+}\)] = 61.5, [Pb\(^{2+}\)] = 226 and [Zn\(^{2+}\)] = 69.9.
Table 3.20: Competitive extraction of various base metal ions using 2-(1-butyl-imidazol-2-yl)pyridine (3), both in the presence and absence of SDBS. [Complimentary to Figure 3.20 in thesis]

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* pH = 5.07  
** SDBS concentration = 0.05 M  
Table 3.21: Competitive extraction of various base metal ions using 2-(1-octyl-imidazol-2-yl)pyridine (4), both in the presence and absence of SDBS. [Complimentary to Figure 3.21 in thesis]

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* pH = 5.07  
** SDBS concentration = 0.05 M  
Table 3.23: Competitive extraction of various base metal ions using 2-(1’-pyrazolyl)-methylpyridine (5), both in the presence and absence of SDBS. [Complimentary to Figure 3.23 in thesis]

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* pH = 5.07  
** SDBS concentration = 0.05 M  
Table 3.24: Competitive extraction of various base metal ions using 2-(3,5-dimethyl-pyrazol-1-yl)-methylpyridine (6), both in the presence and absence of SDBS. [Complimentary to Figure 3.24 in thesis]

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* pH = 5.07
** SDBS concentration = 0.05 M
*** Stock concentrations (mg.L^{-1}): [Cd^{2+}] = 116, [Co^{2+}] = 62.8, [Cu^{2+}] = 68.6, [Ni^{2+}] = 61.5, [Pb^{2+}] = 226 and [Zn^{2+}] = 69.9.
Table 3.25: Competitive extraction of various base metal ions using 2-(3-methyl-pyrazol-1-yl)-methylpyridine / 2-(5-methyl-pyrazol-1-yl)-methylpyridine (7/7'), both in the presence and absence of SDBS. [Complimentary to Figure 3.25 in thesis]

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* pH = 5.07
** SDBS concentration = 0.05 M
Table 3.27: Competitive extraction of various base metal ions using 2-(3-butyl-pyrazol-5-yl)pyridine (8), both in the presence and absence of SDBS. [Complimentary to Figure 3.27 in thesis]

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* pH = 5.07
** SDBS concentration = 0.05 M
*** Stock concentrations (mg.L^{-1}): [Cd^{2+}] = 116, [Co^{2+}] = 62.8, [Cu^{2+}] = 68.6, [Ni^{2+}] = 61.5, [Pb^{2+}] = 226 and [Zn^{2+}] = 69.9.
Table 3.28: Competitive extraction of various base metal ions using 2-[3-(tert-butyl)-pyrazol-5-yl]pyridine (9), both in the presence and absence of SDBS. [Complimentary to Figure 3.28 in thesis]

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* pH = 5.07
** SDBS concentration = 0.05 M
**Table 3.29:** Competitive extraction of various base metal ions using 2-(3-octyl-pyrazol-5-yl)pyridine (10), both in the presence and absence of SDBS. [Complimentary to Figure 3.29 in thesis]

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* pH = 5.07  
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Table 3.30: Copper selectivity study using 2-(3-butyl-pyrazol-5-yl)pyridine (8), 2-[3-(tert-butyl)-pyrazol-5-yl]pyridine (9) and 2-(3-octyl-pyrazol-5-yl)pyridine (10). Copper concentration was decreased tenfold, whilst no synergist was added. [Complimentary to Figure 3.30 in thesis]

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*pH = 4.95
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Table 3.31: Copper selectivity study using 2-(3-butyl-pyrazol-5-yl)pyridine (8), 2-[3-(tert-butyl)-pyrazol-5-yl]pyridine (9) and 2-(3-octyl-pyrazol-5-yl)pyridine (10). Copper concentration was decreased hundredfold, whilst no synergist was added. [Complimentary to Figure 3.31 in thesis]
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* pH = 4.97
** SDBS concentration = 0.05 M
*** Stock concentrations (mg.L^{-1}): [Cd^{2+}] = 108, [Co^{2+}] = 55.7, [Cu^{2+}] = 0.720, [Ni^{2+}] = 58.3, [Pb^{2+}] = 203 and [Zn^{2+}] = 65.0.
Table 3.32: Percentage copper(II) and nickel(II) stripped from 2-(3-butyl-pyrazol-5-yl)pyridine (8), 2-[3-(tert-butyl)-pyrazol-5-yl]pyridine (9) and 2-(3-octyl-pyrazol-5-yl)pyridine (10) at pH ≈ 1. [Complimentary to Figure 3.32 in thesis]

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* Copper stock concentration = 70.6 mg.L$^{-1}$
** Nickel stock concentration = 57.8 mg.L$^{-1}$
Table 3.3: Percentage extraction of copper(II) over a 24-hour period using 2-(3-butyl-pyrazol-5-yl)pyridine (8), 2-[3-(tert-butyl)-pyrazol-5-yl]pyridine (9) and 2-(3-octyl-pyrazol-5-yl)pyridine (10). [Complimentary to Figure 3.33 in thesis]

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* No SDBS added.
** Copper stock concentration = 63.9 mg.L⁻¹
*** Copper blank concentration = 0.00 mg.L⁻¹
Table 3.34: pH isotherm study: the percentage extraction of nickel(II) over an acidic pH range (0–7), using 2-(3-buty1-pyrazol-5-yl)pyridine (8), 2-[3-(tert-butyl)-pyrazol-5-yl]pyridine (9) and 2-(3-octyl-pyrazol-5-yl)pyridine (10). [Complimentary to Figure 3.34 in thesis]

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* Nickel stock concentration = 57.8 mg.L$^{-1}$
Table 3.35: pH isotherm study: the percentage extraction of copper(II) over an acidic pH range (0–7), using 2-(3-butyl-pyrazol-5-yl)pyridine (8), 2-[3-(tert-butyl)-pyrazol-5-yl]pyridine (9) and 2-(3-octyl-pyrazol-5-yl)pyridine (10). [Complimentary to Figure 3.35 in thesis]

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