Room Temperature, Open-Flask C–P Bond-Formation on Water under Catalyst-Free Conditions

Rakhee Choudhary†
Rekha Bai†
Pratibha Singh‡
Mahesh C. Sharma
Satpal Singh Badsara*  0000-0002-9839-5113

MFOS Laboratory, Department of Chemistry (Centre of Advanced Study), University of Rajasthan, JLN Marg, Jaipur, Rajasthan-302004, India
badsarass4@uniraj.ac.in
sattubhu2005@gmail.com
†Authors contributed equally

Abstract A catalyst-free C–P bond-formation in an open flask at room temperature between isatin derivatives and phosphorus surrogates on water is described. Isatin derivatives possessing different substitutes underwent C–P coupling reaction with a variety of phosphate oxides under the reaction conditions employed, providing the desired products in up to quantitative yields.

Key words catalyst-free, C–P bond formation, isatin

Organophosphorus compounds play important roles in organic synthesis,1 organometallic chemistry,2 medicinal chemistry,3 chemical biology,4 and material science.5 More specifically, α-hydroxy- and α-aminophosphonic acids have roles as biophosphate mimics, antibiotics, antivirals, and antitumor agents.6 Nucleophilic substitution of toxic phosphinoyl halides with organometallic reagents has been the traditional method for the synthesis of these compounds.1d Subsequently, the Hirao transition-metal-catalysed phospohonation of organohalides has emerged as a facile alternative.7 Use of toxic phosphorus halides, high catalyst loading, harsh reaction conditions or poor functional group tolerance are drawbacks of these approaches.

Oxindole frameworks bearing a C-3 quaternary stereocenter are important constituents of many natural products and biologically active molecules.8 These molecules are often synthesized via aldol reactions of aldehydes or ketones or other nucleophilic species to the 3-carbonyl of isatins.9

In recent years, organophosphorus compounds have been mostly synthesized via cross-coupling reactions,10 C–H activation,11 and dehydrogenative coupling reactions.12 Several catalytic systems such as the NHC/Icy.CO2 precatalyst, organocatalysts, and palladium pincer complexes have been employed for phospha-Michael additions to activated alkenes and alkynes.13 Recently, Cai and co-workers disclosed a copper catalyst with fluoruous bis(oxazoline) as a ligand for the asymmetric α-hydrophosphonylation of isatins.14a Swamy and co-workers have reported a catalyst-free addition of allenyl or alkynyl-phosphonates and phosphine oxides.14b Although various synthetic pathways using different catalytic systems have been developed for the preparation of α1-oxindole-α-hydroxy phosphonates,15,16 the synthesis of oxindoles containing α-hydroxy phosphinoyl compounds under mild conditions remains a major goal. As a part of our ongoing project to develop metal-free organic transformations,17 we have developed a facile and efficient synthetic protocol for preparation of oxindoles containing an α-hydroxyphosphinoyl group by a catalyst-free C–P bond formation between isatins and phosphate oxides or phosphites.

For optimization studies, we choose isatin 1a and diphenylphosphine oxide 2a as model substrates. Initially, the C–P coupling was carried out in toluene at 100 °C to afford the desired α1-hydroxyphosphinoyl oxindole 3a in 95% yield after 12 h (Table 1, entry 1). When the reaction was carried out at room temperature in toluene no improvement in yield was observed (entry 2). A slight improvement in yield (96%) was observed when the reaction was carried out in isopropanol as the solvent (entry 3), whereas C–P coupling reaction in the absence of solvent at ambient or elevated temperature led to lower yields (entries 4 and 5). Remarkably, the reaction between 1a and 2a proceeded smoothly and efficiently in water at room temperature, affording 3a in excellent yield (98%).

Received: 31.03.2018
Accepted after revision: 08.05.2018
Published online: 13.06.2018
DOI: 10.1055/s-0037-1610167; Art ID: so-2018-d0026-op

License terms: (C)
These results clearly rule out the possibility of a radical pathway during the formation of products 3. However, no coupled product was observed in these cases.

After optimization studies, we then turned our attention to study the substrate scope of this intriguing C–P bond formation. For this, isatin 1a and N-alkylated isatins 1b–k (prepared by following a known procedure) were employed for the C–P cross-coupling reaction with diphenylphosphine oxide 2a on water under the optimized reaction conditions. The corresponding oxindole containing α-hydroxyphosphonoyl compounds 3b–k were obtained in 91–99% yields (Scheme 1). Other phosphine oxides 2b and 2c also reacted well with different isatins to provide the desired products 3l–x in 86–96% yields. The structures of all the compounds 3a–x were established based on 1H NMR, 13C NMR, 31P NMR spectroscopy and HRMS analysis.

We next attempted the synthesis of α1-oxindole-α-hydroxyphosphonates using this interesting C–P bond formation methodology. Accordingly, we employed diphenyl phosphite 2d for C–P bond formation with isatin derivatives 1a–c and 1g under neat conditions at room temperature. Under these conditions, efficient coupling provided the desired α1-oxindole-α-hydroxyphosphonates 3y1–3y4 in 86–93% yields (Scheme 1).

To elucidate the reaction mechanism, we performed several control experiments as shown in Scheme 2. Initially, assuming that the reaction with diphenylphosphine oxide proceeded following a radical pathway, the reaction between 1b and 2a was carried out in the presence of the free radical quencher 2,2,6,6-tetramethylpiperidine-1-oxyl (TEMPO; Scheme 2, equiv 1), but we found that there was no effect on the reaction as the desired product 3a was obtained in 97% yield. We also performed the reaction between TEMPO and 2a (Scheme 2, equiv 2), TEMPO and 1b (Scheme 1, equiv 3) and TEMPO and 2d (Scheme 2, equiv 4). However, no coupled product was observed in these cases. These results clearly rule out the possibility of a radical pathway during the formation of products 3.

Table 1 Optimization of Reaction Conditions for C–P Bond Formation between Isatin 1a and Diphenylphosphine Oxide 2a

<table>
<thead>
<tr>
<th>Entry</th>
<th>Solvent</th>
<th>Temperature (°C)</th>
<th>Time (h)</th>
<th>Yield (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>toluene</td>
<td>100</td>
<td>12</td>
<td>95</td>
</tr>
<tr>
<td>2</td>
<td>toluene</td>
<td>RT</td>
<td>24</td>
<td>90</td>
</tr>
<tr>
<td>3</td>
<td>i-PrOH</td>
<td>RT</td>
<td>12</td>
<td>96</td>
</tr>
<tr>
<td>4</td>
<td>neat</td>
<td>100</td>
<td>24</td>
<td>74</td>
</tr>
<tr>
<td>5</td>
<td>neat</td>
<td>RT</td>
<td>24</td>
<td>58</td>
</tr>
<tr>
<td>6</td>
<td>water</td>
<td>RT</td>
<td>12</td>
<td>98</td>
</tr>
</tbody>
</table>

a Reaction conditions: Isatin 1a (0.5 mmol), diphenylphosphine oxide 2a (0.5 mmol), solvent or neat, r.t. to 100 °C.

b Isolated yields based on 1a.

A literature survey revealed that diarylphosphine oxides 2 in the presence of air can undergo tautomerism to generate the corresponding phosphinous acid 2′. On this basis, a plausible reaction mechanism for this interesting catalyst-
free C–P bond formation is depicted in Scheme 3 for the reaction between 1 and 2. Initially phosphine oxide 2 converts into its tautomer 2′. Then 2′ attacks the electrophilic C=O of isatin 1 to generate intermediate A, which is subsequently converted into the product 3.

In conclusion, we have reported a convenient protocol for the synthesis of oxindole α-hydroxyphosphinoyl compounds and α-1-oxindole-α-hydroxyphosphonates via a catalyst-free C–P bond formation between isatins and phosphine oxides or phosphites on aqueous medium. The corresponding products were obtained in excellent yields.

Scheme 3 Plausible reaction mechanism for C–P bond formation between isatin and diphenyl phosphine oxide

All chemicals were purchased from commercial suppliers and used without further purification. NMR spectra were recorded with a JEOL Ressonance-400 instrument using CDCl₃ or DMSO-d₆ as solvent. In some cases, one drop of DMSO-d₆ was added to CDCl₃ to improve solubility. Chemical shifts are reported in parts per million (ppm) and referenced to the residual solvent resonance. Coupling constants (J) are reported in Hertz (Hz). Standard abbreviations indicating multiplicity are used as follows: s = singlet, d = doublet, t = triplet, dd = double doublet, dt = double triplet, q = quartet, m = multiplet. HRMS data were collected with a Waters - Xevo G2S QTof LC-MS with UPLC.

General Procedure for Table 1

3-(Diphenyl-phosphinoyl)-3-hydroxy-indolin-2-one (3a)
Diphenylphosphine oxide 2a (0.5 mmol, 101 g) was added to stirred isatin 1a (0.5 mmol, 0.073 g) in an open flask in solvent (1.0 mL) or neat and then the reaction mixture was stirred at the given temperature. The mixture was then diluted with EtOAc (10 mL). After usual workup, the organic layer was dried over Na₂SO₄, filtered, EtOAc was evaporated, and the crude product thus obtained was purified by crystallization (EtOAc) to afford the corresponding product 3a as a white solid. Yield: 0.171 g (98%); mp 142 °C.

1H NMR (400 MHz, DMSO-d₆): δ = 6.38 (d, J = 7.2 Hz, 1 H), 6.72 (s, 1 H), 6.75 (dd, J = 3.2, 7.6 Hz, 1 H), 7.18 (t, J = 7.6 Hz, 1 H), 7.25–7.32 (m, 1 H), 7.41–7.59 (m, 5 H), 7.63 (t, J = 7.6 Hz, 1 H), 7.85–8.02 (m, 4 H), 10.49 (s, 1 H).

13C NMR (100 MHz, DMSO-d₆): δ = 79.8 (d, J_C–P = 82.1 Hz), 109.5, 121.0, 125.5, 126.8, 127.8 (d, J_C–P = 11.5 Hz), 128.1, 128.3, 130.5 (d, J_C–P = 95.0 Hz), 130.7 (d, J_C–P = 95.2 Hz), 131.6, 132.1, 132.3 (d, J_C–P = 8.3 Hz), 142.9 (d, J_C–P = 5.9 Hz), 175.3.

31P NMR (162 MHz, DMSO-d₆): δ = 28.8.

HRMS: m/z [M + H] calcd. for C₂₀H₁₅NO₃P + H: 350.0946; found: 350.0941.

Scheme 2 Control experiments
General Procedure for Scheme 1

Phosphone oxide 2 (0.5 mmol) was added to a stirred mixture of isatin 1b-x (0.5 mmol) in water (1.0 mL) in an open flask at r.t. The stirring was continued for 12 h, then the reaction mixture was diluted with EtOAc (10 mL). After usual workup, the organic layer was dried over Na2SO4, filtered, the EtOAc was evaporated and the crude product thus obtained was purified by crystallization (EtOAc or EtOAc/methanol) to afford the corresponding products 3b-x.

For Compounds 3y1–y4
Isatin 1 (1.0 mmol) and diphenylphosphate 2d (0.2 mL) were reacted neat in an open flask at r.t. for 12 h and the reaction mixture was then diluted with EtOAc (10 mL). After usual workup, the organic layer was dried over Na2SO4, filtered, the EtOAc was evaporated and the crude product thus obtained was purified by column chromatography (EtOAc/hexanes, 1:1) to afford the corresponding products 3y1–y4.

3-(Diphenyl-phosphinoyl)-3-hydroxy-1-methylindolin-2-one (3b)
The title compound was prepared by following the general procedure for Scheme 1, using N-methylisatin 1(b) (0.5 mmol, 0.087 g), providing 3b as a white solid. Yield: 0.184 g (98%); mp 120 °C.

1H NMR (400 MHz, CDCl3): δ = 2.49 (s, 3 H), 6.67 (d, J = 8.4 Hz, 1 H), 7.25 (d, J = 8.4 Hz, 1 H), 7.45–7.54 (m, 3 H), 7.55–7.63 (m, 3 H), 7.68 (t, J = 7.2 Hz, 1 H), 7.85–8.04 (m, 4 H), 10.65 (s, 1 H).

31P NMR (162 MHz, CDCl3): δ = 79.9 (d, J = 80.5 Hz), 111.0, 125.0 (d, J = 2.5 Hz), 125.5 (d, J = 2.8 Hz), 128.0 (d, J = 11.5 Hz), 128.3 (d, J = 11.3 Hz), 128.7, 129.6, 129.9 (d, J = 95.6 Hz), 130.1 (d, J = 92.8 Hz), 131.9, 132.4 (d, J = 8.6 Hz), 132.5, 141.7 (d, J = 6.1 Hz), 175.1.

HRMS: m/z [M + H]+ calcd. for C20H15ClNO3P + H: 384.0556; found: 384.0540.

5-Chloro-3-(diphenyl-phosphinoyl)-3-hydroxy-1-methylindolin-2-one (3c)
The title compound was prepared by following the general procedure for Scheme 1, using 5-chloroisatin 1e (0.5 mmol, 0.091 g) and diphenylphosphate oxide 2a (0.5 mmol, 0.101 g), providing 3c as a white solid. Yield: 0.190 g (96%); mp 136 °C.

1H NMR (400 MHz, CDCl3): δ = 2.49 (s, 3 H), 6.55 (d, J = 7.6 Hz, 1 H), 7.06–7.10 (m, 2 H), 7.17 (t, J = 7.6 Hz, 1 H), 7.20–7.26 (m, 3 H), 7.32–7.65 (m, 6 H), 7.76 (d, J = 8.4 Hz, 1 H), 7.79 (d, J = 8.4 Hz, 1 H), 7.97 (d, J = 8.4 Hz, 1 H), 7.99 (d, J = 8.4 Hz, 1 H).

13C NMR (100 MHz, DMSO-d6): δ = 42.9, 79.6 (d, J = 81.9 Hz), 109.1, 121.8, 125.2, 126.1, 127.1, 127.2, 127.8 (d, J = 11.5 Hz), 128.2 (d, J = 11.4 Hz), 128.4, 129.8, 130.2 (d, J = 95.5 Hz), 130.4 (d, J = 95.7 Hz), 131.7, 132.4 (d, J = 8.6 Hz), 135.6, 143.2 (d, J = 5.6 Hz), 173.9.

HRMS: m/z [M + H]+ calcd. for C27H22NO3P + H: 440.1416; found: 440.1422.
The title compound was prepared by following the general procedure for Scheme 1, using 5-bromo-isatin \(1j\) (0.5 mmol, 0.101 g) and diphenylphosphine oxide as a white solid. Yield: 0.194 g (91%); mp 158 °C.

\[ \text{HRMS: } m/z [M + H] \text{ calcd. for } C_{27}H_{21}ClNO_3P + H: 474.1026; \text{ found: } 474.0892. \]

**3-(Diphenylphosphinoyl)-3-hydroxy-5-nitro-indolin-2-one (3k)**

The title compound was prepared by following the general procedure for Scheme 1, using 5-nitrosatin \(1k\) (0.5 mmol, 0.096 g) and diphenylphosphine oxide \(2a\) (0.5 mmol, 0.101 g), providing \(3k\) as a white solid. Yield: 0.181 g (92%); mp 142 °C.

\[ \text{HRMS: } m/z [M + H] \text{ calcd. for } C_{22}H_{20}NO_3P + H: 378.1259; \text{ found: } 378.1265. \]

**3-(Di(4-methylphenyl)phosphinoyl)-3-hydroxy-indolin-2-one (3l)**

The title compound was prepared by following the general procedure for Scheme 1, using 3-(Di(4-methylphenyl)phosphinoyl)-3-hydroxy-indolin-2-one \(3l\) (0.5 mmol, 0.113 g) and diphenylphosphine oxide \(2a\) (0.5 mmol, 0.101 g), providing \(3l\) as a white solid. Yield: 0.194 g (96%); mp 140 °C.

\[ \text{HRMS: } m/z [M + H] \text{ calcd. for } C_{23}H_{23}NO_3P + H: 395.0785; \text{ found: } 395.0784. \]
The title compound was prepared by following the general procedure for Scheme 1, using isatin \(1 \text{i} \) (0.5 mmol, 0.087 g) and bis (3,5-dimethylphenyl)phosphine oxide \(2 \text{c} \) (0.5 mmol, 0.129 g), providing \(3 \text{o} \) as a white solid. Yield: 0.192 g (92%); mp 138 °C.

HRMS: \([M + H]\) calcd. for \(C_{25}H_{26}NO_3P + H\): 420.1729; found: 420.1886.

5-Chloro-3-(di(3,5-dimethylphenyl)phosphinoyl)-3-hydroxy-1-ethylindolin-2-one (3q)

The title compound was prepared by following the general procedure for Scheme 1, using 5-chloroisatin \(1 \text{c} \) (0.5 mmol, 0.073 g) and di(p-tolyl)phosphine oxide \(2 \text{c} \) (0.5 mmol, 0.115 g), providing \(3 \text{q} \) as a white solid. Yield: 0.203 g (94%); mp 132 °C.

HRMS: \([M + H]\) calcd. for \(C_{26}H_{28}NO_3P + H\): 434.1885; found: 434.1737.
The title compound was prepared by following the general procedure for Scheme 1, using isatin (1.0 mmol, 0.147 g) and diphenyl phosphite (0.5 mmol, 0.127 g) as a white solid. Yield: 0.165 g (52%); mp 291 °C.

1H NMR (400 MHz, CDCl3): δ = 8.57 (d, J = 7.9 Hz, 1 H), 7.72 (d, J = 7.9 Hz, 1 H), 7.60–7.63 (m, 1 H), 7.45–7.49 (m, 1 H), 7.38 (t, J = 3.6 Hz, 1 H), 7.32 (m, 1 H).

13C NMR (100 MHz, CDCl3): δ = 135.6 (d, Jc–p = 94.9 Hz), 129.9 (d, Jc–p = 2.4 Hz), 125.9 (d, Jc–p = 5.7 Hz), 113.9 (d, Jc–p = 6.2 Hz), 107.9 (d, Jc–p = 9.8 Hz), 104.8 (d, Jc–p = 6.2 Hz), 76.8 (d, Jc–p = 12.7 Hz), 68.1 (d, Jc–p = 3.6 Hz), 44.2 (d, Jc–p = 5.6 Hz), 31.5 (d, Jc–p = 2.9 Hz).

HRMS: m/z [M + H] calcd. for C15H14N2O4P: 388.0863; found: 388.0864.

3-(Bis(3,5-dimethylphenyl)phosphinoyl)-5-bromo-3-hydroxy-indolin-2-one (3x)
The title compound was prepared by following the general procedure for Scheme 1, using 5-bromoisatin (1.0 mmol, 0.234 g) and bis (3,5-dimethylphenyl)phosphine oxide (0.5 mmol, 0.129 g), providing 3x as a white solid. Yield: 0.152 g (49%); mp 274 °C.

1H NMR (400 MHz, DMSO-d6): δ = 8.72 (d, J = 7.8 Hz, 1 H), 7.65–7.67 (m, 3 H), 7.50–7.59 (m, 3 H), 7.40 (d, J = 7.8 Hz, 1 H), 7.22 (d, J = 7.8 Hz, 1 H), 7.05 (d, J = 7.8 Hz, 1 H).

13C NMR (100 MHz, DMSO-d6): δ = 138.5 (d, Jc–p = 94.8 Hz), 129.9 (d, Jc–p = 2.5 Hz), 125.9 (d, Jc–p = 12.9 Hz), 113.5 (d, Jc–p = 8.8 Hz), 109.2 (d, Jc–p = 9.8 Hz), 104.8 (d, Jc–p = 5.3 Hz), 76.8 (d, Jc–p = 12.2 Hz), 68.1 (d, Jc–p = 3.6 Hz), 44.2 (d, Jc–p = 5.6 Hz), 31.5 (d, Jc–p = 2.9 Hz).

HRMS: m/z [M + H] calcd. for C15H14N2O4P: 388.0863; found: 388.0864.

3-(Bis(3,5-dimethylphenyl)phosphinoyl)-5-chloro-3-hydroxy-1-ethylindolin-2-one (3y1)
The title compound was prepared by following the general procedure for Scheme 1, using 5-chloroisatin (0.5 mmol, 0.147 g) and bis (3,5-dimethylphenyl)phosphine oxide (0.5 mmol, 0.129 g), providing 3y1 as a white solid. Yield: 0.165 g (52%); mp 291 °C.

1H NMR (400 MHz, CDCl3): δ = 8.60 (d, J = 7.8 Hz, 1 H), 7.28 (d, J = 7.8 Hz, 1 H), 7.21 (d, J = 7.8 Hz, 1 H), 6.97 (d, J = 7.8 Hz, 1 H), 6.90–6.92 (m, 1 H), 6.82 (d, J = 8.8 Hz, 1 H), 6.68–6.70 (m, 1 H), 6.59 (d, J = 8.8 Hz, 1 H), 4.70 (s, 1 H), 3.20 (q, J = 3.6 Hz, 2 H), 1.41 (t, J = 3.6 Hz, 3 H).

13C NMR (100 MHz, CDCl3): δ = 136.6 (d, Jc–p = 94.8 Hz), 128.1 (d, Jc–p = 2.5 Hz), 125.7 (d, Jc–p = 6.2 Hz), 120.8 (d, Jc–p = 6.2 Hz), 119.7 (d, Jc–p = 6.2 Hz), 114.1 (d, Jc–p = 6.2 Hz), 109.2 (d, Jc–p = 6.2 Hz), 107.6 (d, Jc–p = 6.2 Hz), 75.3 (d, Jc–p = 12.7 Hz), 55.8 (d, Jc–p = 12.7 Hz), 21.9 (d, Jc–p = 2.9 Hz).

HRMS: m/z [M + H] calcd. for C15H16ClNO3P: 351.0714; found: 351.0715.

3-(Bis(3,5-dimethylphenyl)phosphinoyl)-5-chloro-3-hydroxy-1-ethylindolin-2-one (3y2)
The title compound was prepared by following the general procedure for Scheme 1, using 5-chloroisatin (0.5 mmol, 0.234 g) and diphenyl phosphite (0.5 mmol, 0.2 mL) as a white solid. Yield: 0.165 g (52%); mp 291 °C.

1H NMR (400 MHz, CDCl3): δ = 8.65 (d, J = 7.8 Hz, 1 H), 7.26 (d, J = 7.8 Hz, 1 H), 7.21 (d, J = 7.8 Hz, 1 H), 6.97 (d, J = 7.8 Hz, 1 H), 6.82 (d, J = 8.8 Hz, 1 H), 6.68–6.70 (m, 1 H), 6.59 (d, J = 8.8 Hz, 1 H), 4.70 (s, 1 H), 3.20 (q, J = 3.6 Hz, 2 H), 1.41 (t, J = 3.6 Hz, 3 H).

13C NMR (100 MHz, CDCl3): δ = 137.3 (d, Jc–p = 94.8 Hz), 128.0 (d, Jc–p = 2.5 Hz), 125.6 (d, Jc–p = 6.2 Hz), 120.8 (d, Jc–p = 6.2 Hz), 119.7 (d, Jc–p = 6.2 Hz), 114.1 (d, Jc–p = 6.2 Hz), 109.2 (d, Jc–p = 6.2 Hz), 107.6 (d, Jc–p = 6.2 Hz), 75.3 (d, Jc–p = 12.7 Hz), 55.8 (d, Jc–p = 12.7 Hz), 21.9 (d, Jc–p = 2.9 Hz).

HRMS: m/z [M + H] calcd. for C15H16ClNO3P: 351.0714; found: 351.0715.
The title compound was prepared by following the general procedure for Scheme 1, using N-methylisatin 1b (1.0 mmol, 0.234 g, 0.2 mL), providing 3y2 as a white solid. Yield: 0.367 g (93%); mp 106 °C.

3-Diphenylphosphoryl-3-hydroxy-1-methylindolin-2-one (3y2)
The title compound was prepared by following the general procedure for Scheme 1, using N-methylisatin 1b (1.0 mmol, 0.161 g) and diphenyl phosphite 2d (1.0 mmol, 0.234 g, 0.2 mL), providing 3y2 as a white solid. Yield: 0.372 g (91%).

The title compound was prepared by following the general procedure for Scheme 1, using 5-chloro-1-ethylisatin 3y3 (1.0 mmol, 0.175 g) and diphenyl phosphite 2d (1.0 mmol, 0.234 g, 0.2 mL), providing 3y3 as a colorless viscous liquid. Yield: 0.397 g (91%).

The title compound was prepared by following the general procedure for Scheme 1, using 5-chloro-1-ethylisatin 1g (1.0 mmol, 0.209 g) and diphenyl phosphite 2d (1.0 mmol, 0.234 g, 0.2 mL), providing 3y4 as a colorless viscous liquid. Yield: 0.381 g (86%).

3-Diphenylphosphoryl-3-hydroxy-1-ethylindolin-2-one (3y3)

3-Diphenylphosphoryl-5-chloro-3-hydroxy-1-methylindolin-2-one (3y4)

HRMS: m/z [M + Na] calcd. for C22H19ClNO5P + Na: 466.0587; found: 466.0542.

Funding Information

The authors thank SERB-DST, New Delhi (YSS/2015/001870), DST-New Delhi for INSPIRE Faculty Award (IFA-2014/CH-167) and the Council of Scientific & Industrial Research-India (02/0341/18/EMR-II).

Acknowledgment

R.C. and P.S. acknowledge the UGC-India for Fellowships. R.B. thanks MRC-MNIT Jaipur and USIC University of Rajasthan, Jaipur for spectroscopic analyses.

Supporting Information

Supporting information for this article is available online at https://doi.org/10.1005/s-0037-1610167.

References and Notes


