SHORT PAPER

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Organic reactions in ionic liquids: oxidative dimerisation of thioamides with phenyliodine(III) diacetate†

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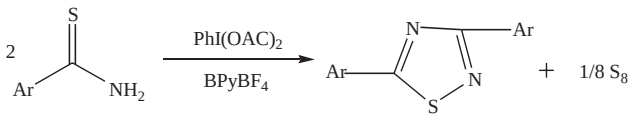
The room temperature ionic liquid, 1-*n*-butylpyridinium tetrafluoroborate ($BPyBF_4$), is used as a "green" recyclable solvent for the oxidative dimerisation of thioamides with phenyliodine(III) diacetate which provides a facile, efficient and environmentally benign method for the synthesis of 3,5-diaryl-1,2,4-thiadiazoles.

Keywords: ionic liquids, thioamides, phenyliodine(III) diacetale

In the last 10–15 years phenyliodine(III) diacetate (PID) has seen widespread application as general oxidising reagent.[1] The oxidative properties of PID are similar to those of Tl(III), Hg(II), and Pb(IV) derivatives, but without the toxic and concomitant environmental problems of these heavy-metal analogues. However, its oxidative reactions have been usually carried out in conventional solvents which are toxic, such as acetonitrile, halogenated hydrocarbons, *etc*.

The use of room temperature ionic liquids as environmentally benign reaction media for organic synthesis has been the subject of considerable recent attention.[2] To date some of the more important reactions, such as Friedel–Crafts reactions,[3] alkylations,[4] hydrogenation,[5] Diels–Alder reactions,[6] and Suzuki reactions,[7] *etc*. have been investigated in ionic liquids. These encouraging results, coupled with our recent study of clean synthesis for physiological active compounds, prompted us to examine the possibility of achieving oxidative reactions using PID in ionic liquids. We would now like to report the oxidative dimerisation of thioamides with PID in the ionic liquid ($BPyBF_4$), which provides a facile, efficient and environmentally benign method for the synthesis of 3,5-diaryl-1,2,4-thiadiazoles. 1,2,4-thiadiazoles have gained a position of commercial importance as effective bactericides, fungicides, herbicides, antibiotics *etc*.[8]

For this study, 1-*n*-butylpyridinium tetrafluoroborate ($BPyBF_4$) was synthesised according to the procedure reported in the literature.[9] Our method is limited to the synthesis of 3,5-diaryl-1,2,4-thiadiazoles(Scheme 1).



Scheme 1

We found that the oxidative dimerisations of thioamides with PID occurred easily in $BPyBF_4$ at 75°C reaching completion within 15min. In fact, simple stirring of a mixture of thioamide and PID in $BPyBF_4$ at 75°C formed the desired product which could be isolated by extracting with ether. The reaction is clean and efficient. The results are summarised in Table 1. The products were characterised by ^{1}H NMR, IR and m.p. which were consistent with literature data.

Table 1 Synthesis of 3,5-diaryl-1,2,4-thiadiazoles[a]

Entry	Ar	Yield/%[b]	M.p. lit/°C
1	C_6H_5	91	89.5–90.5(91–91.5[10f])
2	3-ClC_6H_4	93	128–128.5(129–129.5[10c])
3	4-ClC_6H_4	90	159.5–160.5(161.5–162.5[10f])
4	4-$NO_2C_6H_4$	93	198–199(210–211[10a])
5	4-$CH_3OC_6H_4$	89	137–138(139–139.5[10f])
6	3-pyridyl	85	134–135(136–137[11])
7	2-furyl	87	102–103.5(104–106[12])

[a]All reactions were run with thioamide (1mmol) and PID (1mmol) in $BuPyBF_4$ 2ml at 75°C for 15 min.
[b]Isolated yield of pure product.

As can be seen in Table 1, the reaction was found to be generally applicable to aromatic and heteroaromatic thioamides. Several aromatic thioamides containing various substituents, such as chloro-, nitro- and methoxyl, were successfully reacted. The ionic liquid can typically be recovered by extracting out the product first and then filtering the suspension to remove S_8. The recovered solvent can be reused with no appreciable decrease in yield. The results are summarised in Table 2.

Table 2 Results obtained using recycled ionic liquid for the synthesis of 3,5-diphenyl-1,2,4-thiadiazole

Entry	Cycle	Yield/%
1	1	91
2	2	88
3	3	90

Even though numerous procedures for the synthesis of 3, 5-diaryl-1,2,4-thiadiazoles by oxidative dimerization of thioamides with different oxidants are available,[10] the present method is a valuable addition to the existing ones with the advantages of ease of manipulation, short reaction times, high yields and especially environmentally friendliness. Further, it is the first example of oxidative reaction using PID as an oxidant in ionic liquids.

Study of further elaborations of oxidative reactions with PID in ionic liquids is now under way in our laboratory.

Experimental

IR spectra were recorded as KBr pellets on a VECTOR-22 *Infrared* Spectrophotometer. ^{1}H NMR spectra were recorded on a Bruker-400MHz Spectrometer using $CDCl_3$ as the solvent with TMS as an internal standard. Ionic liquids were dried *in vacuo* at 60°C for 15–20 hours.

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† This is a Short Paper, there is therefore no corresponding material in *J Chem. Research (M).*

Typical procedure for the synthesis 3,5-diaryl-1,2,4-thiadiazoles: Thioamide (1mmol) and PID (1mmol) were added to $BPyBF_4$ (2ml) directly. The mixture was stirred at 75°C for 15 min. After completion of the reaction, the product was extracted from the reaction mixture with diethyl ether (4×25ml). The combined extracts were concentrated in vacuum and the residue was crystallised from ethanol to give the pure product.

Spectroscopic data: 3, 5-diphenyl-1, 2, 4-thiadiazole: ^{1}H NMR: δ 7.48–7.53 (m, 6H) 8.02–8.05 (m, 2H) 8.38–8.40 (m, 2H). IR: 1478, 1440, 1418, 131, 1277, 1119, 760cm^{-1}.

3, 5-bis(3-chlorophenyl)-1, 2, 4-thiadiazole ^{1}H NMR: δ 7.43–7.48 (m,3H), 7.52 (t,1H), 7.89 (t,1H), 8.07 (s,1H), 8.25–8.27 (m,1H), 8.38 (s,1H). IR: 1573, 1467, 1417, 1101, 1090, 860, 790, 730cm^{-1}.

3, 5-bis(4-chlorophenyl)-1, 2, 4-thiadiazole: ^{1}H NMR: δ 7.46–7.51 (m,4H) 7.97 (d, 2H) 8.30 (d, 2H). IR: 1594, 1467, 1401, 1315, 1090, 1014, 827, 739cm^{-1}.

3, 5-bis(4-nitrophenyl)-1, 2, 4-thiadiazole: ^{1}H NMR: δ 7.62–7.68 (m,4H) 7.91 (d, 2H) 8.25 (d, 2H). IR: 1604, 1537, 1408, 1350, 1324, 852, 717cm^{-1}.

3, 5-bis(4-methoxyphenyl)-1, 2, 4-thiadiazole: ^{1}H NMR: δ 3.88 (s,6H) 6.99–7.01 (m,4H) 7.98 (d, 2H) 8.31 (d, 2H). IR: 1608, 1520, 1476, 1420, 1302, 1280, 1168, 835, 747cm^{-1}.

3, 5-di(3-pyridyl)-1, 2, 4-thiadiazole: ^{1}H NMR: δ 7.47–7.53 (m,2H) 8.36–8.38 (m,1H) 8.73–8.74 (m,1H) 8.75–8.80 (m,1H) 8.81–8.82 (m, 1H) 9.27–9.28 (m,1H) 9.61–9.62 (m,1H). IR: 1589, 1479, 1400, 1339, 1297, 1024, 727, 698cm^{-1}.

3, 5-di(2-furyl)-1, 2, 4-thiadiazole: ^{1}H NMR: δ 6.56–6.57 (m,1H) 6.63 (m,1H) 7.22–7.23 (m,1H) 7.27–7.28 (m,1H) 7.60–7.61 (m,1H) 7.63 (m,1H). IR: 3141, 1588, 1502, 1411, 1368, 1249, 1035, 864, 762cm^{-1}.

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