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ARTICLE

Choline peroxydisulfate Oxidizing Bio-TSIL: Triple role player in one pot synthesis of Betti bases and gem-bisamides from aryl alcohols under solvent-free conditions

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One pot, multicomponent solvent free synthesis of Betti bases (amidoalkyl naphthols) and gem-bisamides directly from alcohol is proposed by an eco-friendly approach using new environmentally benign biodegradable oxidizing task specific ionic liquid (bio-TSIL), Choline peroxydisulfate monohydrate (ChPS) **1**. Choline bisulphate (ChBS) **2** reduced species is generated in situ from **1**, which catalyses formation of desired products in shorter reaction time, with good to excellent yields. This bio-TSIL **1** plays triple role as oxidant, catalyst and solvent. It was easily recycled and reused for five times.

Introduction

The multicomponent [1–7](MCRs) are beneficial sources for formulating large molecules with economic possibility.[8] On the grounds of green chemistry,[9] MCR under solvent-free reaction condition (SFRC)[10,11] is attractive since it involves the best reaction medium with "nomedium".[12] The Task Specific Ionic Liquids (TSILs) may be defined as ionic liquids in which functional group is covalently tethered to the cation or anion (or both) of the IL. By attaching different functional groups on the cation, ionic liquids, able to perform a specific task can be obtained. These ionic liquids combine their ability to perform a task with their green character, which makes them environmentally friendly solvents. Davis and co-workers introduced task-specific ionic liquids.[13]

A gem-bisamides[14] and 1-aminoalkyl-2-naphthol (Betti bases)[15] derivatives are present in most of biological and pharmaceutical intermediates. Specifically, bisamides are key fragments for the introduction of gem-diaminoalkyl residues in retro-inverse pseudo peptide derivatives and their derivatives are also found as key scaffold for the construction of peptidomimetic frameworks.

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The 1,3-oxazine derivatives[16] (Figure 1), derived from the Betti bases were frequently used as antibacterial,[17] antibiotic,[18] antitumor,[19] analgesic, anticonvulsant,[20] antipsychotic, antimalarial, antianginal, antihypertensive,[21] antirheumatic,[22] hypotensive and bradycardiac agents.

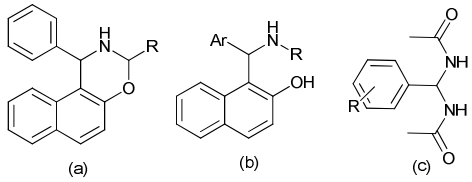


Fig 1. The general structure of 1,3-oxazines (a), Betti base(b) and gem-Bisamide (c)

Usually these gem-bisamides and Betti bases have been synthesized by the direct reaction of aldehydes with the amides and 2-naphthol using different catalysts such as H_2SO_4,[23] HCl, strong acidic catalysts such as triflic acids,[24] boric acid,[25] $B(HSO_4)_3$,[26] Phosphotungstic acid,[27] TEA-sulfonic acid,[28] Iodine, heteropoly acid,[29] NMP HSO_4[30], SiO_2-IL,[31] PEG-based dicationic acidic ionic liquids,[32] p-TSA,[33] zinc benzenesulfonate,[34] $Fe(HSO_4)_3$,[35] trityl chloride[36] at higher temperature ranging from 100 to 150°C. However these

protocols[37–42] have several drawbacks like, use of aldehyde, high toxicity, corrosion, catalyst waste, use of toxic organic solvents, rigorous condition, high reaction temperature, long reaction times, byproduct formation, difficulty in separation and recovery.

Therefore, the preparation of bisamides and Betti bases have received considerable attention. There are many reported literature for the synthesis using benzaldehyde[18-43], as starting material. Some of these methods have significant limitations such as stability and cost of benzaldehyde as compared to benzyl alcohols, use of toxic metal catalyst, drastic reaction conditions and tedious work-up procedures. Thus, the development of simple and efficient method for one pot synthesis of Betti bases and bisamides from benzyl alcohols using greener process remains an attractive goal. Therefore, introduction of clean procedures and utilization of recyclable, eco-friendly green catalyst can attract more attention.

To the best of our knowledge, the synthesis of bisamide and Betti bases from alcohol as a starting material is not yet reported. In the present study, as part of an our ongoing research on the development of green solvents in organic synthesis,[44,45] we proceeded to explore catalytic and oxidant activity of the recently reported environmental friendly biodegradable oxidizing TSIL ChPS[46] 1 (Fig. 2) which is used as efficient and selective oxidant for oxidation of alcohols to aldehydes under solvent free reaction condition (SFRC). 1 can be easily and inexpensively synthesized, starting from Choline chloride and potassium peroxydisulfate.[41] 1 is a choline based oxidizing TSIL; while ChBS 2 reduced TSIL (Fig. 2) formed insitu thermally, which facilitates gem-bisamides and Betti bases formation under SFRC. This TSIL possess a number of useful features such as non-toxicity, biodegradable and recyclability, while 1 plays triple role as solvent, oxidant and catalyst.

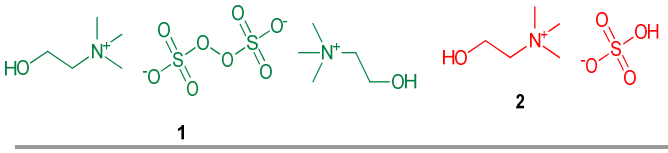


Fig 2. Structure of Choline peroxydisulfate (ChPS) **1** and Choline bisulfate (ChBS) **2**

Experimental

Materials and Methods

Choline Chloride, potassium peroxydisulfate, 2-naphthol, acetamide, thioacetamide, benzyl alcohol derivatives and solvents were procured from M/s S.D. Fine Chemicals, Mumbai. All solvents were purchased from commercial sources and were distilled prior to use. Melting points/boiling points are uncorrected and are presented in degrees Celsius. FT-IR spectra were recorded as solid or liquid on a Bomem Hartmann and Braun MB-Series FT-IR spectrometer. ^{1}H & ^{13}C NMR spectra were recorded on Bruker AVANCE II 400 MHz spectrometer, and chemical shifts are expressed in δ ppm using TMS as an internal standard. Mass spectral data were obtained using a micromass - Q - TOF (YA105) spectrometer. Elemental analysis was performed with Thermo Finnigan, FLASH EA 1112 series instrument.

Preparation of Choline peroxydisulfate (ChPS)[46] 1

2-Hydroxy-N, N, N-trimethyl ethanaminium peroxydisulfate $[NMe_3CH_2CH_2OH]_2[S_2O_8]$ *} 1* 1 prepared by the reaction of Choline chloride (0.1 mol) with $K_2S_2O_8$ (0.055 mol) in acetone (100 mL). The mixture was stirred for 24 h at room temperature and then filtered to remove KCl. Acetone wash given to KCl, to get entrapped IL in it. The solvent was evaporated under reduced pressure to obtain a light yellow liquid, which was further dried under high vacuum for 4-5h and store at 0-5°C. Yield 88%. Silver nitrate test was carried out to detect halide ion present in 1, by dissolving it in Millipore water, which found to be negative.

Light yellow viscous liquid. M.P (Tm) = -6°C, ^{1}H NMR (400 MHz, $CDCl_3$): δ/ppm: 3.30 (9H, s, 3xCH_3-N), 3.58 (2H, br s, CH_2-N), 4.06 (2H, br s, CH_2-O); ^{13}C NMR (100 MHz, DMSO-d_6): δ/ppm: 53.26 ((CH_3)$_3$N), 55.33(CH_2-O), 66.99(CH_2-N); IR: $\tilde{\nu}$ = 3337, 1479, 1261, 1082, 1044, 952, 682 cm^{-1}. Anal. Calcd for ChPS C, 28.70; H, 7.23; N, 6.69; found C 28.82, H 7.72, N 6.26. ESI-MS (ChPS•H_2O) M^+ for $NMe_3CH_2CH_2OH$ = 104.17; S_2O_8 = 194.9

General procedure for the synthesis of bisamides from alcohols using 1 in neat condition

Mixture of 1 (1 mmol) and benzyl alcohols (0.5 mmol) was stirred at 70°C for 0.5 hr. Reaction was monitored by TLC and 2, 4 DNP test. After completion of alcohols to aldehydes, acetamide (1 mmol) was added in resulting mixture in one lot and again stirred at 70°C for 5 to 15 min. Reaction was carried out until all the starting material was consumed (TLC). For isolation of product, water was added to the reaction mixture and stirred for 5 min to r. t. and solid product obtained was separated by filtration. The compounds were recrystallized from ethanol to get pure compound.

General procedure for the synthesis of amidoalkyl naphthols using 1 in neat condition from alcohols

Mixture of 1 (1 mmol) and benzyl alcohols (0.5 mmol) was stirred at 70°C for 0.5 hr. Reaction was monitored by TLC and 2, 4-DNP test. After completion of alcohols to aldehydes, added (0.5 mmol) amide (thio-acetamide or acetamide or benzamide), and 2-naphthol (0.51 mmol) in resulting mixture in one lot and stirred at 70°C for 5 to 15 min. Reaction was carried out until all the starting material was consumed (TLC). For isolation of product, water was added to the reaction mixture and stirred for 5 min to r. t. and solid product obtained was separated by filtration. The compounds were recrystallized from ethanol to get pure compound.

Selected spectral data

N,N'-(Phenylmethylene)diacetamide Table 1, entry 1: White Solid. Yield: 97%. Melting point (measured) 250-251°C; IR (cm^{-1}): 3272, 3120, 2846, 1659, 1561, 1513, 1369, 1272, 1199,

1087, 987, 847, 769, 695. ^{1}H NMR (400 MHz, DMSO-d_6): δ (ppm) 8.51 (d, J= 8 Hz, 2H), 7.27-7.38 (m, 5H), 6.51 (t, J= 8 Hz, 1H), 1.86 (s, 6H); 1.90 (6H, s, CH_3); m/z (EI): 206.59 (M^+); Mol. Wt.: 206.

N,N′-((3-Nitrophenyl)methylene)diacetamide Table 1, entry 3: White Solid. Yield: 94%. Melting point (measured) 229-230°C; IR (cm^{-1}): 3270, 3118, 2369, 1664, 1562, 1512, 1371, 1269, 1092, 763. ^{1}H NMR (400 MHz, DMSO-d_6): δ (ppm) 8.70 (d, 2H), 8.21 (s, 1H), 8.15 (d, 1H), 7.78 (d, 1H), 7.63 (t, 1H), 6.60 (s, 1H), 1.92 (s, 6H); m/z (EI): 251.64 (M^+); Mol. Wt.: 251.

N,N′-((4-Methoxyphenyl)methylene)diacetamide Table 1, entry 7: White solid; Yield: 95%. Melting point measured 221–222°C. IR (cm^{-1}): 3298, 3259, 1664, 1561, 1509, 1372, 1296, 1180, 1087, 1029, 764. ^{1}H NMR (400 MHz, DMSO-d_6): δ (ppm) 8.40 (d, J = 7.9 Hz, 2H), 7.24 (d, J = 8.6 Hz, 2H), 6.86 (d, 2H), 6.47 (t, J = 7.9 Hz, 1H), 3.75 (s, 3H), 1.87 (s, 6H); m/z (EI): 236.59 (M^+); Mol. Wt.: 236.

N-((2-Hydroxynaphthalen-1-yl)(phenyl)methyl)acetamide Table 2, entry 1: White Solid. Yield: 95%. Melting point (measured) 242-243°C; IR (cm^{-1}): 3408, 3069, 1634, 1516, 1438, 1336, 1273, 1182, 1065, 983, 837, 767, 698. ^{1}H NMR (400 MHz, DMSO-d_6): δ (ppm) 9.86 (s, 1H), 8.39 (d, *J* = 8.5 Hz, 1H), 7.90 (d, *J* = 7.5 Hz, 1H), 7.77 (d, *J* = 7.8 Hz, 1H), 7.72 (d, *J* = 8.9 Hz, 1H), 7.35 (t, *J* = 7.5 Hz, 1H), 7.26 (s, 1H), 7.23 – 7.21 (m, 2H), 7.19 (d, *J* = 7.9 Hz, 3H), 7.15 (t, *J* = 7.3 Hz, 2H), 2.00 (s, 3H); m/z (EI): 291.15 (M^+); Mol. Wt.: 291.

N-((2-Hydroxynaphthalen-1-yl)(3-itrophenyl)methyl)acetamide Table 2, entry 2: Yellow Solid. Yield: 90%. Melting point (measured) 240-241°C; IR (cm^{-1}): 3371, 3184, 1664, 1577, 1515, 1348, 1277, 1167, 1060, 991, 701. ^{1}H NMR (400 MHz, DMSO-d_6): δ (ppm) 10.11 (d, *J* = 22.4 Hz, 1H), 8.59 (d, *J* = 8.1 Hz, 1H), 8.07 (s, 1H), 8.02 (d, *J* = 8.0 Hz, 1H), 7.92 (d, *J* = 7.5 Hz, 1H), 7.78 (dd, *J* = 12.9, 8.4 Hz, 2H), 7.59 (d, *J* = 7.7 Hz, 1H), 7.50 (t, *J* = 7.9 Hz, 1H), 7.41 (t, *J* = 7.5 Hz, 1H), 7.31 – 7.20 (m, 3H), 2.05 (s, 3H); m/z (EI): 335.29 (M^+); Mol. Wt.: 335.

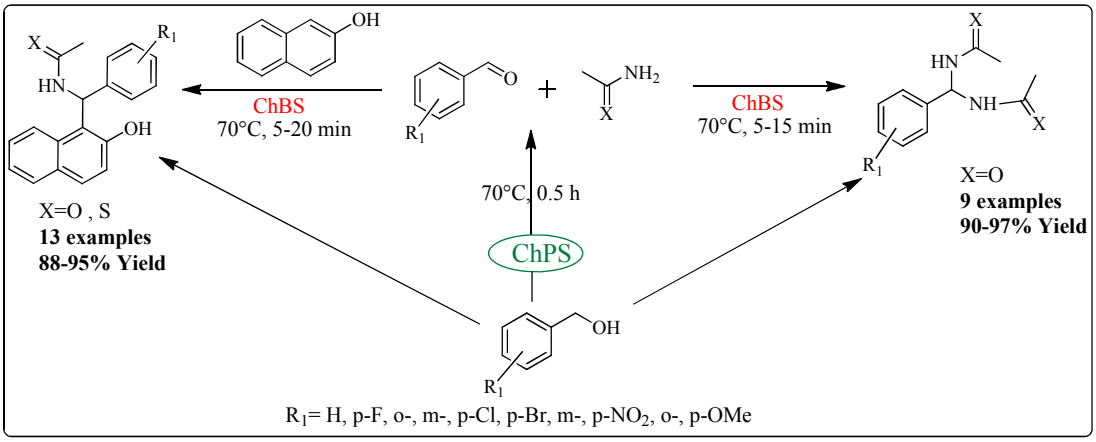
N-((2-Hydroxynaphthalen-1-yl)(4-methoxyphenyl) methyl) acetamide. Table 2, entry 6: White Solid. Yield: 94%. Melting point (measured) 177-179°C; IR (cm^{-1}): 3395, 2972, 1624, 1524, 1510, 1436, 1332, 1277, 1175, 1086, 982, 847, 763, 686. ^{1}H NMR (400 MHz, DMSO-d_6): δ (ppm) δ 9.91 (s, 1H), 8.40 (d, J = 8.6 Hz, 1H), 7.90 (d, J = 6.5 Hz, 1H), 7.76 (d, J = 7.9 Hz, 1H), 7.71 (d, J = 8.9 Hz, 1H), 7.35 (t, J = 7.4 Hz, 1H), 7.23 (dd, J = 8.0, 5.5 Hz, 2H), 7.11 (dd, J = 8.0, 4.6 Hz, 3H), 6.77 (d, J = 8.8 Hz, 2H), 3.67 (s, 3H), 1.98 (s, 3H); m/z (EI): 321.03 (M^+); Mol. Wt.: 321.

N-((2-Hydroxynaphthalen-1-yl)(3-nitrophenyl)methyl) ethanethioamide Table 2, entry 9, Yellow Solid. Yield: 88%. Melting point measured 156-158°C; IR (cm^{-1}): 3371, 3199, 1645, 1577, 1516, 1348, 1109, 923, 826, 746, 674; ^{1}H NMR (400 MHz, DMSO-d_6): δ (ppm) 2.63 (s, 3H), 7.28 (d, J=12.0 Hz, 1H), 7.31 (t, J=7.6 Hz, 1H) , 7.49 (t, J=7.6 Hz, 1H), 7.58 (d, J=5.2 Hz, 2H), 7.81-7.90 (m, 3H), 7.98 (s, 1H), 8.03 (d, J=8.4 Hz, 1H), 8.08-8.11 (m, 1H), 10.3 (s, 1H), 10.56 (d, J=8.0 Hz, 1H); m/z (EI): 352 (M^+); Mol. Wt.: 352.

N-((2-Hydroxynaphthalen-1-yl)(4-methoxyphenyl)methyl) ethanethioamide Table 2, entry 12: White Solid. Yield: 93%. Melting point (measured) 191-192°C; IR (cm^{-1}): 3396, 3053, 1625, 1581, 1510, 1235, 1175, 1040, 982, 847, 811, 744, 688. ^{1}H NMR (400 MHz, DMSO-d_6): δ (ppm) 9.89 (s, 1H), 8.38 (d, 1H), 7.86 (d, 1H), 7.73 (d, 1H), 7.68 (s, 1H), 7.30 (t, 1H), 7.21 (dd, 2H), 7.10 (dd, 3H), 6.80 (dd, 2H), 3.70 (s, 3H), 1.97 (s, 3H); m/z (EI): 337 (M^+); Mol. Wt.: 337.

Results and discussion

Considering the aim of environmental benign protocol for one pot multicomponent synthesis of bis amide and Betti bases using aryl alcohols led us to use of biodegradable TSIL 1 for synthesis of desired products. We evaluated oxidizing activity of 1 and catalytic



Scheme 1. One pot synthesis of Betti bases and bisamides from aryl alcohols using 1 under solvent-free conditions

activity of 2 in bisamide and Betti base formation under SFRC (Scheme 1). A facile one pot sequential multicomponent reaction of benzyl alcohol to benzaldehyde oxidation followed by condensation reaction of, acetamide/ thioacetamide and 2-naphthol was carried out to afford bisamides (Table1, entry 1-9) and Betti base (Table 2, entry 1-13) in good yield and short reaction time.

Physico-chemical properties, synthesis and characterisation of 1

Various physico-chemical properties such as density, conductivity, viscosity, cyclic voltammetry, solubility, thermal properties of 1 have been studied[41]. As per BOD_5 APHA[47] test, 1 was found to be easily biodegradable. Antimicrobial activity using *E.coli* and *S.aureus* are founds 4 mm and 6 mm. Density study using specific gravity bottle is 1.243g/cm^3 which indicates that **1** is denser than water. Viscosity studies at increasing temperature method also shows that viscosity decreases with increasing temperature and it is 111 Cp. Solubility or miscibility study reveals that 1 is highly soluble in polar solvents such as water, ethanol, and methanol.

1 was synthesized by the metathesis/ion exchange reaction and characterised by FT-IR, ^{1}H NMR. The comparative FTIR spectrum of potassium peroxydisulfate, choline chloride and **1** is as shown in (Fig. 3). Bio-TSIL **1** shows S_2O_8 stretching vibration near 676 cm^{-1}, 1257 cm^{-1} and 1043 cm^{-1} for both in Fig. 3 (a) and (c). Also C-C-O stretching vibration near 952 cm^{-1}, 1083 cm^{-1} (–CH_2 rocking vibration), and 1481 cm^{-1} (CH_3 rocking vibration) were observed for both in Fig. 3 (b) and (c). The significant features observed for Fig. 3(c) are the appearance of the peaks at 3390-3221 cm^{-1} (OH stretching), 1483 cm^{-1} (CH_3 rocking vibration), 1257 cm^{-1}, 1043 cm^{-1}, 677 cm^{-1} (S_2O_8 stretching vibration), 952 cm^{-1} (C-C-O stretching) and at 1083 cm^{-1} (–CH_2 rocking vibration). These results provided the evidences that **1** were successfully synthesized. Overlay of IR spectra of **1** and **2** (Fig 4) also shows distinct differentiation in peaks at 1185 cm^{-1}, and 1257 cm^{-1}. Which concludes that **1** is differ from **2** and forms during course of reaction in presence of water and pH of medium is found to be 0.89, which indicates highly acidic in nature.

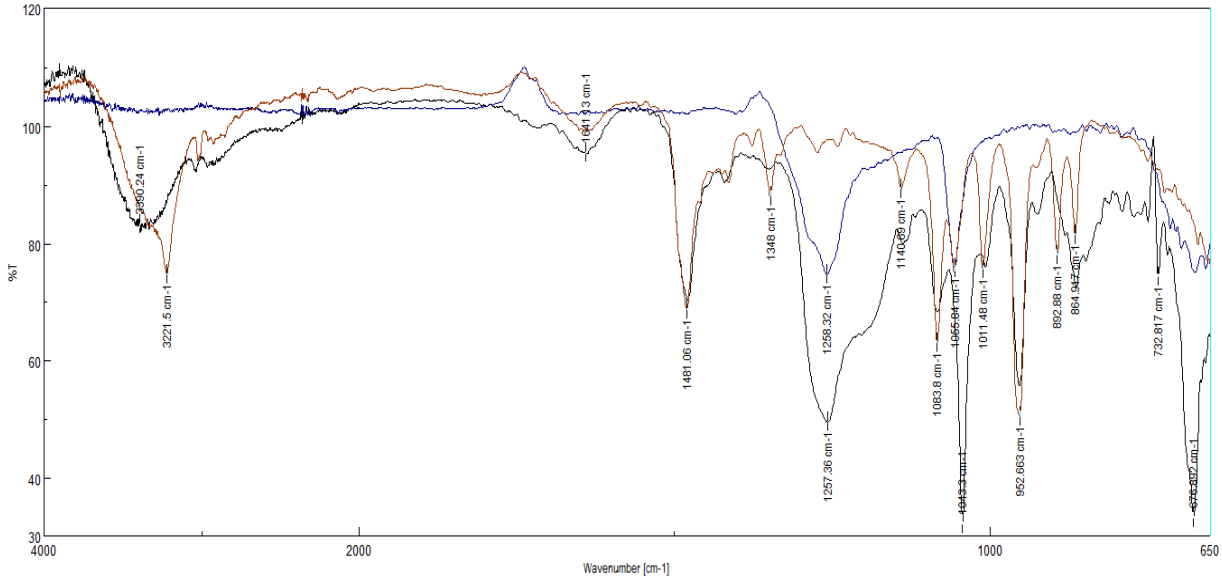


Fig. 3 FT-IR spectra overlay of (a) Choline peroxydisulfate **1** (black), (b) Potassium peroxydisulfate (blue) and (c) Choline chloride (red)

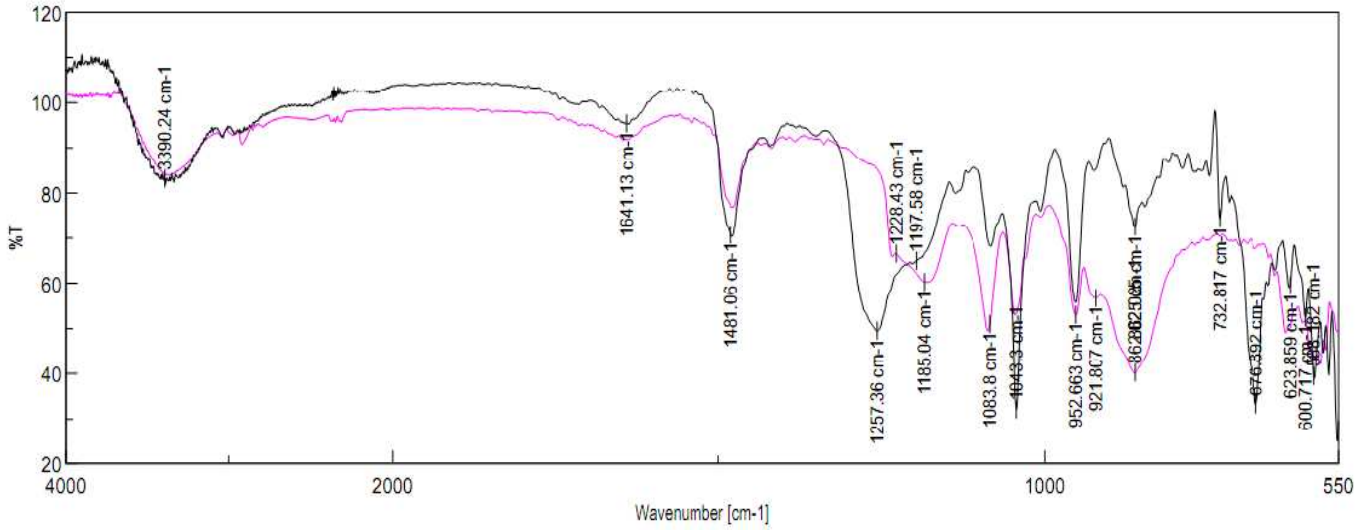


Fig 4. FT-IR spectra overlay of (a) Choline peroxydisulfate ChPS **1** (black) and (d) Choline bisulfate ChBS **2** (pink)

Oxidizing and catalytic performance

Initially, the model reaction of benzyl alcohol, acetamide, 2-naphthol was investigated at 70°C. When we consider various peroxydisulfate oxidant such as potassium peroxydisulfate, ammonium peroxydisulfate and 1(ChPS). It was found the reaction poorly proceeded in ammonium peroxydisulfate (APS) and potassium peroxydisulfate (KPS) in water (35%[a], 32%[b] and 64%[a], 60%[b]) for [a]Bisamide and [b]Betti bases at 70°C even after heating the reaction mixture for 24 hrs. (Fig 5).

1 afforded the best results (97%[a], 95%[b]) among the all peroxydisulfate in short reaction time and in high yield. Thus 1 is considered to be the best alternative oxidant TSIL efficiently carrying one pot synthesis, which does not contain any halogen, metal, polymer or imidazolium IL which are not only toxic, non-biodegradable but also are harmful to the environment.

1 plays a main role of effective oxidant as well as it's reduce species 2 plays a catalytic role in bisamide and Betti bases formation. Also due to its green character and easy separation from the reaction media represent a convenient and environmental friendly alternative for the traditional oxidants. Thus, the results obtained, figure out the effectiveness of the 1 over other metal peroxydisulfate.

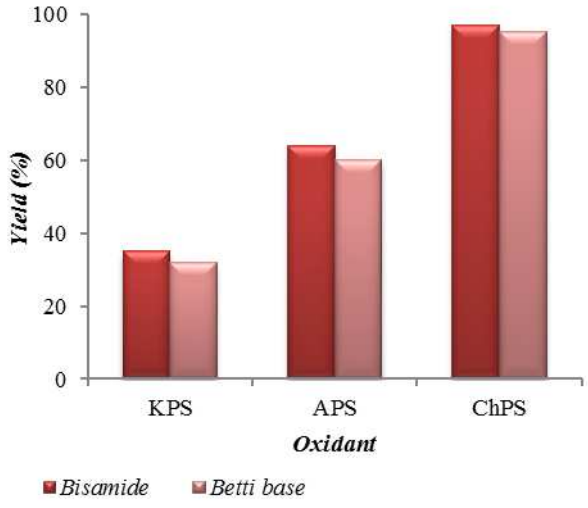


Fig 5. Screening of peroxydisulfate oxidant (in water) and 1 (neat)

(Reaction conditions: benzyl alcohol, 0.5 mmol; [KPS, 1 mmol; water, 5 ml] [APS, 1 mmol; water, 5ml; acetamide 1 mmol (in case of bisamide synthesis) and 2-naphthol, 1 mmol; acetamide/ thioacetamide 1 mmol (in case of Betti base synthesis); TSIL; temperature 70 °C; speed of agitation, 150 rpm).

Influence of Reaction Media

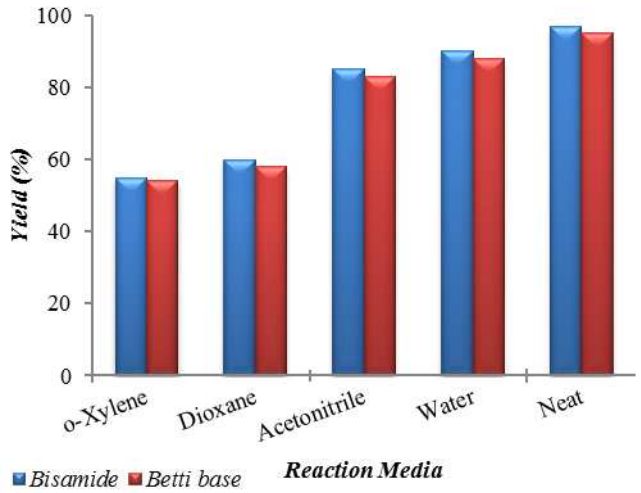


Fig 6. Influence of reaction media

(Reaction conditions: benzyl alcohol, 0.5 mmol; acetamide 1 mmol (in case of bisamide synthesis) and 2-naphthol, 1 mmol; acetamide/ thioacetamide 1 mmol (in case of Betti base synthesis); TSIL; temperature 70 °C; speed of agitation, 150 rpm).

In order to study the effect of solvent on synthesis of various derivatives, we performed synthesis of bisamide and Betti bases in various organic solvent at optimized reaction condition. Initially oxidation reaction was carried out in water as solvent using 1 at 70°C, this reaction showed 90%[a], 88%[b] yield in 0.5 hr (Fig 6).

1 in acetonitrile exhibited efficient conversion but provides only 85%[a], 83%[b]. High boiling solvent such as dioxane and o-xylene were also used for the reaction but it did not show significant effect (55%[a], 54%[b] and 60%[a], 58%[b] respectively).

Influence of speed of agitation

The effect of speed of agitation on the synthesis of bisamide and Betti bases was determined by carrying out the reaction at 50, 100, 150, 200 rpm while all the other parameters were constant. The yield of bisamide and Betti bases derivatives was found to increase (55%[a], 54%[b] to 97%[a], 95%[b]) upon increasing the rpm from 50 to 150 while it remained almost unaffected (96%[a], 95%[b]) on further increasing the rpm from 150 to 200 (Fig 7).

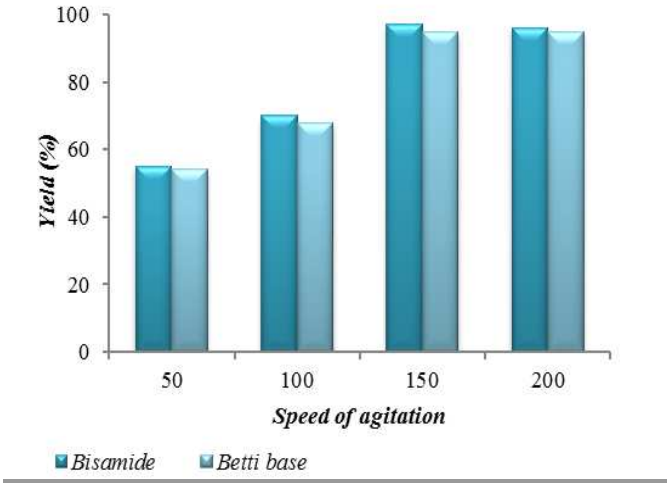


Fig 7. Influence of speed of agitation
(Reaction conditions: benzyl alcohol, 0.5 mmol; acetamide 1 mmol (in case of bisamide synthesis) and 2-naphthol, 1 mmol; acetamide/ thioacetamide 1 mmol (in case of Betti base synthesis); TSIL; temperature 70 °C; speed of agitation, 50-200 rpm.

Influence of Temperature

The effect of temperature on the conversion was determined by carrying out the reaction at R.T.(30°C), 50°C, 70°C and 90 °C while all the other parameters were constant (Benzyl alcohol : 1 = 1:2, 0.5h). The conversion was found to increase (35%[a], 39%[b] to 60%[a], 65%[b] to 97%[a], 95%[b]) upon increasing the temperature from RT to 70°C, while it remained almost unaffected (96%[a], 94%[b]) on further increasing the temperature from 70°C to 90 °C (Fig 8).

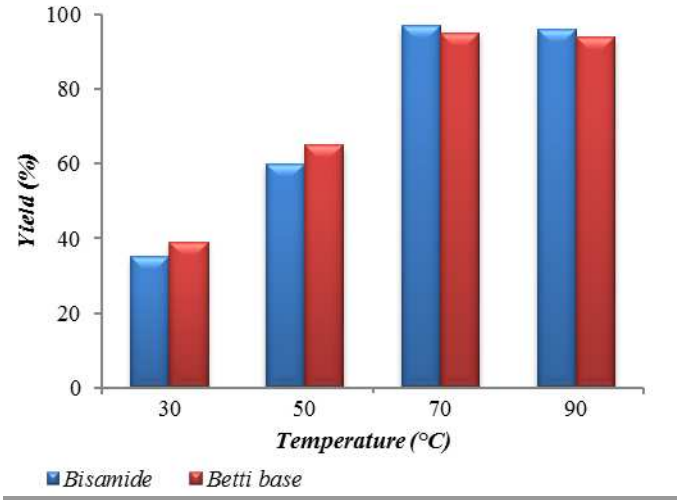


Fig 8. Influence of temperature
(Reaction conditions: benzyl alcohol, 0.5 mmol; acetamide 1 mmol (in case of bisamide synthesis) and 2-naphthol, 1 mmol; acetamide/ thioacetamide 1 mmol (in case of Betti base synthesis); TSIL; temperature 70 °C; speed of agitation, 150 rpm.

Influence of Molar Ratio

The conversion of benzyl alcohol was studied with varying benzyl alcohol to 1 molar ratios of 1:1, 1:1.5, 1:2, and 1:3 and all the other reaction conditions were fixed (70 °C, 0.5 h). We found that the percentage yield increased significantly from 50%[a], 48%[b] to 80%[a], 78%[b] to 97%[a], and 95%[b] upon increasing from 1:1 to 1:1.5 to 1:2 while it remained almost unaffected (95%[a], 94%[a]) upon increasing the ratio from 1:2 to 1:3. Therefore, a Benzyl alcohol: 1 molar ratio of 1:2 was found to be optimum. When benzyl alcohol: 1 ratio was 1:1 and 1:1.5 the yield was low to moderate, which may be due to insufficiently available oxygen. It seems that the amount of oxygen required to react with the whole fraction of active molecule of benzyl alcohol was sufficiently produced in the case molar ratio of 1:2 (Fig 9).

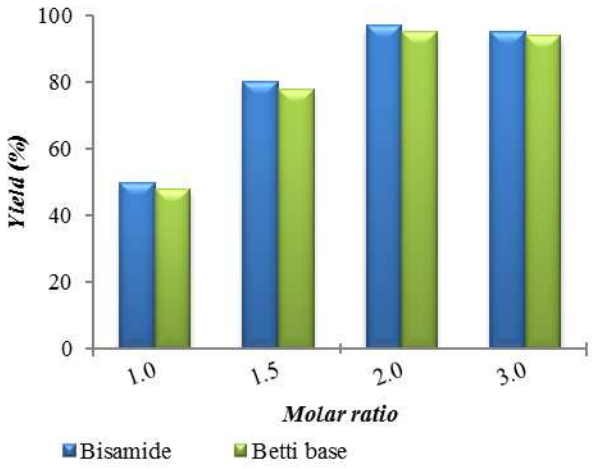


Fig 9. Influence of molar quantity of 1

(Reaction conditions: benzyl alcohol, 0.5 mmol; acetamide 1 mmol (in case of bisamide synthesis) and 2-naphthol, 1 mmol; acetamide/ thioacetamide 1 mmol (in case of Betti base synthesis); ChPS, 1-3 mmol; temperature 70 °C; speed of agitation, 150 rpm.

Recycling of Ch-bisulphate (ChBS) 2 system

After completion of reaction, water was added to the reaction mass. In situ generated **2** is soluble in water and product gets precipitated. The solid product was isolated by filtration, and the filtrate containing ionic liquid was extracted with ethyl acetate to remove non- ionic organic impurities. Then the water was evaporated under reduced pressure and the recovered catalyst was dried at 70°C under vacuum for 2 h. This catalytic system comprised in situ generated **2** was recycled using benzaldehyde as starting material up to five runs. It gave good yield (97%[a], 95%[b]) of product (bisamide and Betti base) from benzaldehyde without significant loss in catalytic activity (Fig 10).

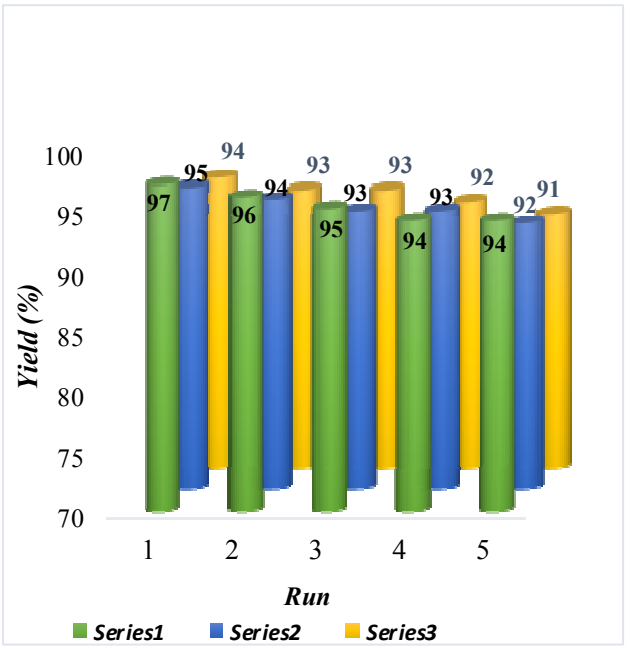
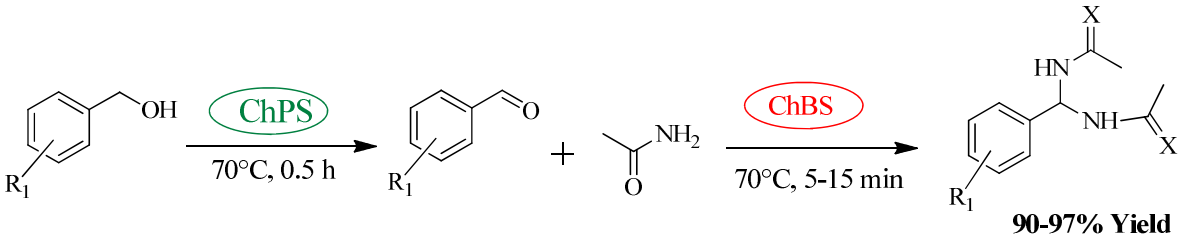


Fig 10. Recyclability of 2

(Reaction conditions: benzaldehyde, 0.5 mmol; acetamide 1 mmol (in case of bisamide synthesis Series 1) and 2-naphthol, 1 mmol; acetamide/ thioacetamide 1 mmol (in case of Betti base synthesis Series 2 &3); 1 mmol; temperature 70 °C.

Table 1 & 2 demonstrates the synthesis of bisamide and Betti bases from the oxidation of various aromatic alcohols using standard reaction condition in good to excellent yield.

Table 1. Synthesis of bisamides from benzyl alcohols in presence of 1 in neat condition.



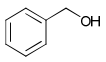
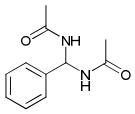
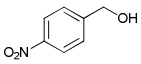
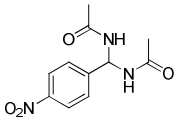
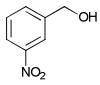
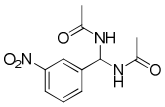
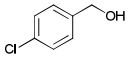
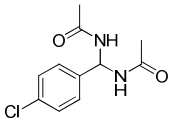
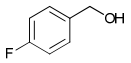
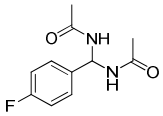
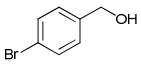
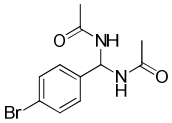
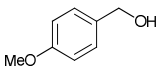
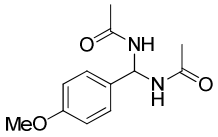
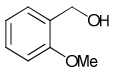
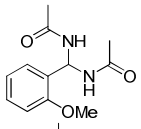
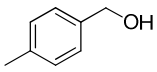
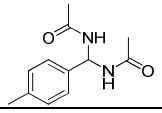
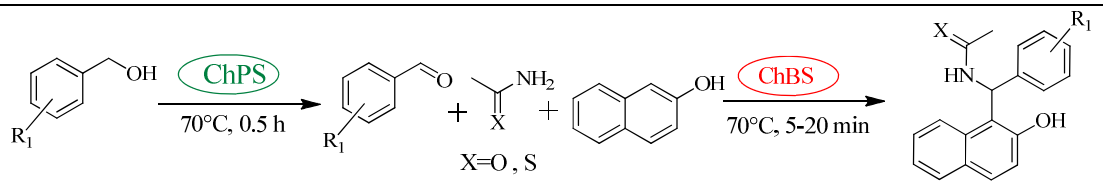
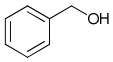
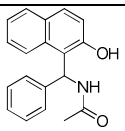
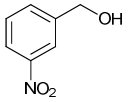
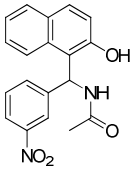
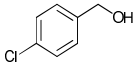
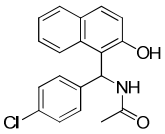
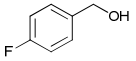
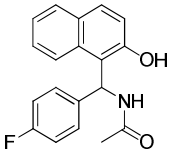
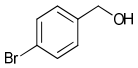
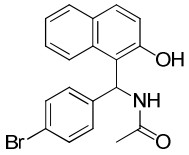
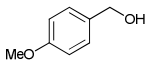
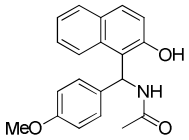
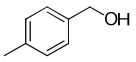
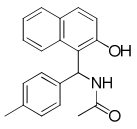
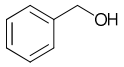
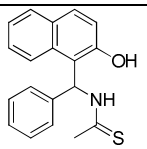
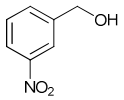
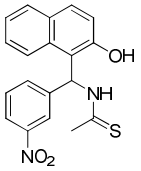
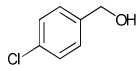
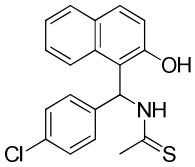
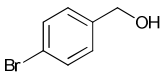
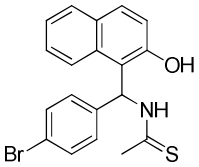
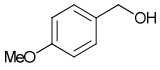
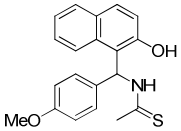
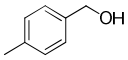
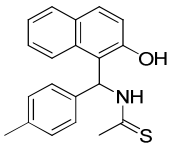
Entry	Alcohols	Bisamides	Time (min)	Yield (%)	M.P (°C) Found	M.P (°C) Reported (lit)
1.			5	97	250-251	251-253[26]
2.			9	92	243-244	244-246[26]
3.			7	94	229-230	230-233[33]
4.			7	93	260-261	260-263[26]
5.			9	92	254-255	257-259[26]
6.			10	94	245-246	246-248[33]
7.			10	95	221-222	221-223[26]
8.			12	93	225-227	225-228[26]
9.			12	90	269-270	270-272[33]

Table 2. Synthesis of Betti bases from benzyl alcohols in the presence of 1 in neat condition



88-95% Yield

Entry	Alcohols	Amide	Betti bases	Time (min)	Yield (%)	M.P (°C) Lit
1.				5	95	242-243 242-244[32]
2.				10	90	240-241 241-242[32]
3.				7	92	225-227 226-228[32]
4.				9	91	229-231 230-232[42]
5.				10	93	229-230 228-230[32]
6.				10	94	177-179 181-183[32]
7.				12	90	220-221 221-223[32]
			Thio-Betti bases			

8.				10	94	189-191 190-193[36]
9.				8	88	156-158 157-159[36]
10.				12	90	245-246 246-248[35]
11.				14	91	178-179 178-180[36]
12.				15	93	191-192 192-194[35]
13.				20	92	179-181 180-183[36]

Plausible mechanism for oxidant and catalytic activity of 1 and 2

The role of **1** and **2** formed in situ in the present work has been propose by the following mechanism (Scheme 3). In our TSIL system, the peroxydisulfate anion and choline cation may be a possible participant in the reaction. The co-existence of peroxydisulfate and the hydrogen bonding donors of Choline is perhaps the main reason for the high oxidising activity of the TSIL. Generally peroxydisulfate decomposes to bisulphate (Eq.1-3) in presence of water via sulphate anion radical formation[48,49] (Eq.1). Similarly **1** decomposes in presence of water to give **2** ($[Ch]^+HSO_4^-$) by evolving oxygen.

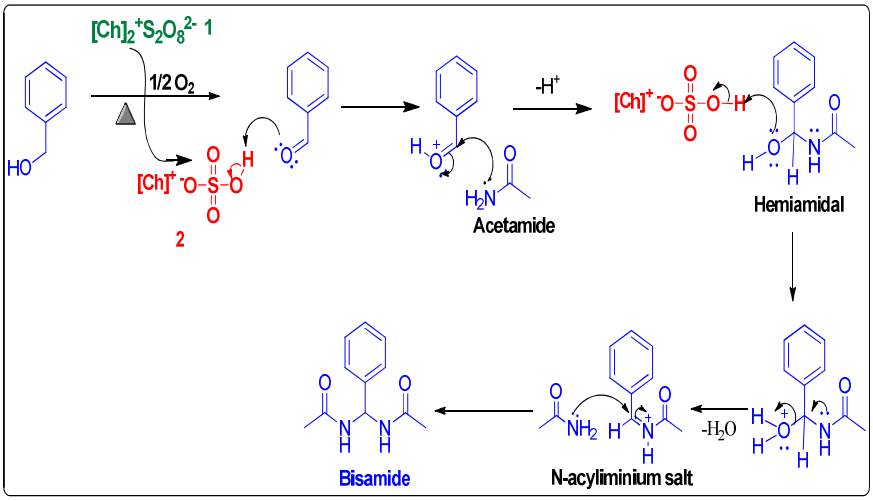
$S_2O_8^{2-}$ can be thermally decomposed to Oxygen and giving HSO_4^- as following:

$$S_2O_8^{-2} \longrightarrow 2SO_4^{\bullet -} \quad \text{..... Eq. 1}$$

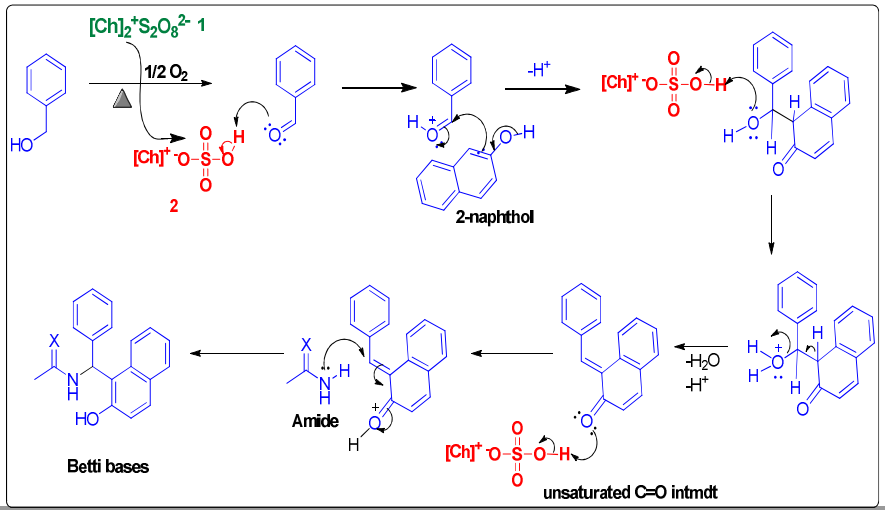
$$2\,SO_4^{\bullet -} + H_2O \longrightarrow 2\,HSO_4^- + 2\,^{\bullet}OH \quad \text{.....Eq. 2}$$

$$2\,^{\bullet}OH \longrightarrow H_2O^- + 1/2O_2 \quad \text{.....Eq. 3}$$

Choline helps make the solution homogeneous and serves the role of phase transfer catalyst in both the reactions. Alcohols reacted with **1** (using oxygen evolved) under neat condition at 70°C to form aldehydes and reduced TSIL **2**, which is highly acidic (pH 0.89) in nature, It seems that initially H^+ of **2** activates the carbonyl group of aldehydes for reaction with amide to form a hemiamidal intermediate. Subsequently hemiamidal dehydrates to an acyliminium intermediate and finally condenses with another molecule of amide to produce the gem-bisamide (Scheme 2). Similarly in case of Betti bases synthesis, after oxidation of alcohol to aldehyde, H^+ (from **2**) activates the carbonyl group, on which nucleophilic attack 2-naphthol to form alpha-beta unsaturated carbonyl intermediate, which subsequently attack by amide (Michael addition) to form desired b-amido alkyl naphthols (Scheme 3).



Scheme 2. Proposed reaction mechanism in bisamides synthesis from benzyl alcohol



Scheme 3. Proposed reaction mechanism in Betti bases synthesis from benzyl alcohol

In order to show the advantages of ChPS over other catalysts reported in the literature, results with this Bio-TSIL were related with other catalysts exploited for the synthesis of Betti bases and bisamides. It can be seen from Table 3, ChPS appears to encourage the reaction more effectively than a number of other catalysts, even ILs mostly in terms of use of the starting material i.e. benzyl alcohol and also in terms of time and yield of both reactions.

Table 3 Comparison of results using ChPS with other catalysts for synthesis of symmetrical bisamides and Betti bases

Entry	Starting Material	Catalyst	Solvent	Temp (°C)	Time	Yield (%)	Ref.
1.		CF_3SO_3H	MDC	Reflux	0.25-48 h	67-99	24
2.		H_3BO_3	Toluene	Reflux	16-70 h	38-92	25
3.		Phosphotungstic acid	Toluene	110	15-40 h	44-94	27
4.		TEA-sulfonic acid	Neat	110	15-50 min	86-96	28
5.		Iodine	Toluene	110	0.5h	93	
6.	Aldehyde	Heteropoly acid	$TEA^+ Cl^-$	100	80 min	90	29
7.		NMP HSO4	Neat	125	3 min	92	30
8.		SiO_2-IL	Neat	85	5 min	90	31
9.		PEG-dicationic acidic ionic liquids	Neat	80	5-15 min	95	32
10.		Zinc benzenesulfonate	Neat	80	6.5h	51	33
11.		$Fe(HSO_4)_3$	1,2 dichloro ethane	60	8 h	79	34
12.	Alcohol	ChPS TSIL	Neat	70	5-20min	88-97	This work

Conclusions

In conclusion, Choline peroxydisulfate **1** plays triple role as an oxidant, catalyst and as a solvent in one pot multicomponent synthesis of bisamides and Betti bases using benzyl alcohol. 1 is a novel biodegradable oxidizing task specific ionic liquid based on peroxydisulfate anion and choline cation was synthesized and characterized. 1 was screened for its oxidizing activity, while insitu formed reduced species Choline bisulfate 2 was screened for it's catalytic activity in solvent free mild reaction condition with high yields (90% to 97% in case of bisamide, 88% to 95% in case of Betti bases) and excellent selectivity. This task specific ionic liquid is cheap, easy to prepare, recyclable and biodegradable.

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Supporting information

^{1}H NMR, IR, Mass spectral data are included in supporting information.

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