Solvent-Free Selective Cross-Aldol Condensation of Ketones with Aromatic Aldehydes Efficiently Catalyzed by a Reusable Supported Acidic Ionic Liquid

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Abstract: A newly prepared catalyst consisting of acidic ionic liquid 1-(4-sulfonic acid)butylpyridinium hydrogen sulfate supported on silica was used to catalyze the cross-aldol condensation of ketones with aromatic aldehydes under solvent-free conditions. The highly active and selective catalyst gave good to excellent yields of the desired cross-aldol products without the occurrence of any self-condensation reactions. Reaction times were short, the procedure and work-up were simple, and no volatile or hazardous organic solvents were necessary. Moreover, the catalyst could be reused at least four times with only a slight reduction in activity.

Key words: cross-aldol condensation, solvent-free condition, supported acidic ionic liquid; ketone; aromatic aldehyde

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The aldol condensation, in which an enol or enolate ion reacts with a carbonyl compound and subsequent dehydration forms a conjugated enone, is an important method for the formation of carbon-carbon bonds. For example, cross-aldol condensations between ketones and aromatic aldehydes (also referred to as Claisen-Schmidt condensations) are useful for the preparation of α,α' -bis-arylidene cycloalkanones and chalcones.

Arylidene cycloalkanones are important precursors for potentially bioactive pyrimidine derivatives [1], 2,7-disubstituted tropones [2], cytotoxic analogs [3], and monomers for liquid-crystalline polymers [4]. Arylidene cycloalkanones have also been reported to possess significant biological activities, including antiangiogenic activity [5], quinine reductase-inducing activity [6], and cholesterol-lowering activity [7]. Furthermore, they have been used as key starting materials for the synthesis of a new class of spiro-pyrrolidine antimicrobial and antifungal agents [8], tetraazadispiro[4.1.4.3]tetradeca-2,9-dien-6-ones [9], tricyclic thiazolo[3,2-a]thiapyrano[4,3-d]pyrimidines (which are potential anti-inflammatory agents) [10], and other heterocyclic compounds [11]. Chalcone natural products are potentially important synthetic intermediates for the preparation of flavonoids [12] and various heterocyclic compounds [13,14]. They also exhibit biological activities, including antimitotic [15], antimalarial [16], anticancer [17], and anti-inflammatory activity [18].

Aldol and cross-aldol condensations are traditionally

catalyzed by strong acids or bases such as HCl [19,20], *p*-toluenesulfonic acid [21], and potassium or sodium hydroxide [22,23]. However, the presence of a strong acid or base often induces the reverse reaction as well as self-condensation reactions, and thus the yields of the desired products can be low. Recently, researchers have performed the reaction in ionic liquids [24,25]. However, the use of homogeneous catalysts complicates product separation and catalyst recovery [26,27], and thus there have been efforts to replace homogeneous catalysts with easy-to-handle, noncorrosive, reusable, and environmentally friendly heterogeneous catalysts. For example, aldol condensations have been carried out with heterogeneous catalysts such as $\text{BF}_3\cdot\text{Et}_2\text{O}$ [28], $\text{Mg}(\text{HSO}_4)_2$ [29], sulfamic acid [30], $\text{Yb}(\text{OTf})_3$ [31], InCl_3 [32], hydrotalcite [33], a fluoroalkylated 1,4-disubstituted [1,2,3]triazole organocatalyst [34], bis(*p*-methoxyphenyl)telluroxide [35], Cp_2ZrH_2 in combination with metal salts [36], NaOAc [37], silica chloride [38], a sulfonated carbon nanocage [39], sulfated zirconia [40], polystyrene-supported sulfonic acid [41], cetyl trimethyl ammonium bromide [42], and $\text{KF}\cdot\text{Al}_2\text{O}_3$ [43]. Although these methods may be effective, some of them require long reaction times and give low yields, are complicated by side reactions, require hazardous solvents or catalysts or expensive catalysts, or contribute to environmental pollution. These findings prompted us to search for new species to cleanly and efficiently catalyze the aldol condensation under environmentally friendly conditions in high

yields and short reaction times.

As part of our research on the development of reusable catalysts for the synthesis of organic compounds [44–54], we recently prepared a new solid acidic catalyst by impregnating silica (Aerosil 300) with ionic liquid 1-(4-sulfonic acid)butylpyridinium hydrogen sulfate. This reusable het-

erogeneous catalyst, designated $[\text{PYC}_4\text{SO}_3\text{H}][\text{HSO}_4]/\text{A300SiO}_2$, showed high catalytic activity in the synthesis of 2,3-dihydroquinazolin-4(1*H*)-ones [55]. These results encouraged us to explore the use of this catalyst for the cross-aldol condensation of ketones with aromatic aldehydes.

Scheme 1. Cross-aldol condensation of ketones with aromatic aldehydes catalyzed by $[\text{PYC}_4\text{SO}_3\text{H}][\text{HSO}_4]/\text{A300SiO}_2$.

1 Experimental

1.1 Preparation of $[\text{PYC}_4\text{SO}_3\text{H}][\text{HSO}_4]/\text{A300SiO}_2$

The catalyst $[\text{PYC}_4\text{SO}_3\text{H}][\text{HSO}_4]/\text{A300SiO}_2$ (cat. 2) was prepared by an impregnation method. Silica (Aerosil 300, 1.0 g) was added to a solution of $[\text{PYC}_4\text{SO}_3\text{H}][\text{HSO}_4]$ (0.75 g) in methanol (20 ml). The mixture was stirred at room temperature for 20 h to adsorb the ionic liquid on the surface of the support. The methanol was removed with a rotary evaporator, and the resulting solid powder was washed with cold chloroform and dried in vacuo at 100 °C for 120 min [55]. The amount of H^+ in the $[\text{PYC}_4\text{SO}_3\text{H}][\text{HSO}_4]/\text{A300SiO}_2$ was determined by acid-base titration to be 1.5 mmol/g.

1.2 General procedure for cross-aldol condensation of ketones with aromatic aldehydes

In a round-bottomed flask equipped with a reflux condenser, a mixture of acetophenone (**1a**, 1 mmol) or cyclohexanone (**1b**, 1 mmol) or acetone (**1c**, 1 mmol), an aromatic aldehyde **2** (1 mmol for acetophenone and 2 mmol for cyclohexanone and acetone), and $[\text{PYC}_4\text{SO}_3\text{H}][\text{HSO}_4]/\text{A300SiO}_2$ (cat. 2, 0.07 g) was heated in an oil bath at 130 °C for 25–40 min. After completion of the reaction, which was monitored by thin-layer chromatography, the reaction mixture was cooled to room temperature, and hot chloroform was added. The catalyst was insoluble in hot chloroform and could therefore be collected by a simple filtration. The filtrate was heated in vacuo to evaporate the solvent. The solid

residue was collected and recrystallized from ethanol to give the desired product in high yield.

Melting points were recorded on a Stuart SMP3 melting point apparatus. IR spectra were obtained with a Tensor 27 Bruker spectrophotometer on KBr disks. ^1H NMR (400 MHz) spectra were recorded with a Bruker 400 spectrometer.

3c (Ar = 4- ClC_6H_4). ^1H NMR (400 MHz, CDCl_3): δ 7.39 (d, 2H, J = 8.3 Hz, arom-H), 7.45–7.65 (m, 6H, arom-H & CH_{vinyl}), 7.76 (d, 1H, J = 15.7 Hz, CH_{vinyl}), 8.03 (d, 2H, J = 7.7 Hz, arom-H).

3d (Ar = 4- FC_6H_4). ^1H NMR (400 MHz, CDCl_3): δ 7.12 (t, 2H, J = 8.6 Hz, arom-H), 7.46 (d, 1H, J = 15.7 Hz, CH_{vinyl}), 7.49–7.68 (m, 5H, arom-H), 7.78 (d, 1H, J = 15.7 Hz, CH_{vinyl}), 8.02 (d, 2H, J = 7.2 Hz, arom-H).

3e (Ar = 4- MeC_6H_4). ^1H NMR (400 MHz, CDCl_3): δ 2.43 (s, 3H, CH_3), 7.26 (d, 2H, J = 8.0 Hz, arom-H), 7.48–7.66 (m, 6H, arom-H & CH_{vinyl}), 7.83 (d, 1H, J = 15.6 Hz, CH_{vinyl}), 8.05 (d, 2H, J = 7.6 Hz, arom-H).

3f (Ar = 2- $\text{O}_2\text{NC}_6\text{H}_4$). ^1H NMR (400 MHz, CDCl_3): δ 7.35 (d, 1H, J = 15.6 Hz, CH_{vinyl}), 7.50–7.85 (m, 6H, arom-H), 8.00–8.13 (m, 3H, arom-H), 8.17 (d, 1H, J = 15.6 Hz, CH_{vinyl}).

4b (Ar = 4- BrC_6H_4). ^1H NMR (400 MHz, CDCl_3): δ 1.83 (quin, 2H, J = 6.0 Hz, CH_2), 2.91 (t, 4H, J = 6.0 Hz, 2CH_2), 7.35 (d, 4H, J = 8.4 Hz, arom-H), 7.56 (d, 4H, J = 8.4 Hz, arom-H), 7.74 (s, 2H, $2\text{CH}_{\text{vinyl}}$).

4d (Ar = 4- ClC_6H_4). ^1H NMR (400 MHz, CDCl_3): δ 1.80 (quin, 2H, J = 6.1 Hz, CH_2), 2.89 (t, 4H, J = 6.1 Hz, 2CH_2), 7.35–7.43 (m, 8H, arom-H), 7.73 (s, 2H, $2\text{CH}_{\text{vinyl}}$).

4e (Ar = 4- FC_6H_4). ^1H NMR (400 MHz, CDCl_3): δ 1.81

(quin, 2H, $J = 6.2$ Hz, CH₂), 2.90 (t, 4H, $J = 6.2$ Hz, 2CH₂), 7.10 (t, 4H, $J = 8.6$ Hz, arom-H), 7.45 (dd, 4H, $J = 8.6, 5.5$ Hz, arom-H), 7.75 (s, 2H, 2CH_{vinyl}).

4k (Ar = 3-O₂NC₆H₄). ¹H NMR (400 MHz, CDCl₃): δ 1.90 (quin, 2H, $J = 6.0$ Hz, CH₂), 3.00 (t, 4H, $J = 6.0$ Hz, 2CH₂), 7.64 (t, 2H, $J = 8.0$ Hz, arom-H), 7.79 (d, 2H, $J = 7.6$ Hz, arom-H), 7.84 (s, 2H, 2CH_{vinyl}), 8.24 (d, 2H, $J = 8.0$ Hz, arom-H), 8.35 (s, 2H, arom-H).

5b (Ar = 4-ClC₆H₄). ¹H NMR (400 MHz, CDCl₃): δ 7.03 (d, 2H, $J = 15.9$ Hz, CH_{vinyl}), 7.39 (d, 4H, $J = 8.1$ Hz, arom-H), 7.54 (d, 4H, $J = 8.1$ Hz, arom-H), 7.68 (d, 2H, $J = 15.9$ Hz, CH_{vinyl}).

1.3 Reuse of the catalyst

The catalyst recovered by filtration was washed with cold chloroform, dried in vacuo at 100 °C for 120 min, and re-used. The catalyst could be reused at least four times with only a slight reduction in the catalytic activity.

2 Results and discussion

To optimize the aldol reaction conditions, we used the reaction of acetophenone (**1a**, 1 mmol) and 4-chlorobenzaldehyde (1 mmol) as the model ketone and aromatic aldehyde, respectively, to afford product **3c**. We investigated the effect of the ionic liquid loading on the silica support, the catalyst amount, the solvent, and the temperature (Table 1). First, we confirmed that the reaction did not proceed at all in the absence of catalyst (entry 1). Then we varied the ionic liquid loading on the catalyst (0.5 (cat. 1), 0.75 (cat. 2), and 1.0 g (cat. 3) of ionic liquid per gram of silica support in methanol). No self-condensation reactions were observed with any of these three catalysts. The fastest reaction and the highest yield were obtained with cat. 2 (entry 21), so we used it to study the effects of the other parameters on the model reaction.

Using cat. 2, we evaluated the reaction in various solvents. Refluxing EtOH, AcOEt, CHCl₃, or CH₂Cl₂ gave moderate yields of the desired product (Table 1, entries 32–35). The product yield in refluxing H₂O was low even after 200 min of reaction (entry 31), whereas a relatively good yield was obtained in refluxing CH₃CN after 75 min (entry 36). To our surprise, when the reaction was performed under solvent-free conditions, the product was obtained in excellent yield after only 30 min at 130 °C (entry 21).

The reaction temperature also strongly influenced the reaction. No reaction occurred at room temperature in the presence of cat. 2 (Table 1, entries 8 and 9). Increasing the reaction temperature markedly enhanced both the yield and the reaction rate: the reaction was complete within 30 min at

Table 1 Optimization of reaction conditions for synthesis of **3c** catalyzed by [PYC₄SO₃H][HSO₄]/A300SiO₂

Entry	Catalyst	Catalyst amount (g)	Solvent	$T/^\circ\text{C}$	Time (min)	Isolated yield (%)
1	—	—	solvent-free	130	120	None
2	cat. 1	0.05	solvent-free	110	80	61
3	cat. 1	0.05	solvent-free	130	60	70
4	cat. 1	0.07	solvent-free	110	75	72
5	cat. 1	0.07	solvent-free	130	30	80
6	cat. 1	0.10	solvent-free	110	75	73
7	cat. 1	0.10	solvent-free	130	30	78
8	cat. 2	0.05	solvent-free	r.t.	120	none
9	cat. 2	0.07	solvent-free	r.t.	120	none
10	cat. 2	0.02	solvent-free	90	60	69
11	cat. 2	0.02	solvent-free	110	60	71
12	cat. 2	0.02	solvent-free	120	30	74
13	cat. 2	0.02	solvent-free	130	30	79
14	cat. 2	0.05	solvent-free	90	60	71
15	cat. 2	0.05	solvent-free	110	60	76
16	cat. 2	0.05	solvent-free	120	30	77
17	cat. 2	0.05	solvent-free	130	30	84
18	cat. 2	0.07	solvent-free	90	60	80
19	cat. 2	0.07	solvent-free	110	60	86
20	cat. 2	0.07	solvent-free	120	30	89
21	cat. 2	0.07	solvent-free	130	30	94
22	cat. 2	0.10	solvent-free	130	30	93
23	cat. 3	0.05	solvent-free	110	60	77
24	cat. 3	0.05	solvent-free	130	30	83
25	cat. 3	0.07	solvent-free	110	60	88
26	cat. 3	0.07	solvent-free	130	30	93
27	cat. 3	0.10	solvent-free	130	30	91
28	cat. 1	0.07	AcOEt	reflux	90	50
29	cat. 1	0.07	CHCl ₃	reflux	120	31
30	cat. 1	0.07	CH ₃ CN	reflux	120	44
31	cat. 2	0.07	H ₂ O	reflux	200	24
32	cat. 2	0.07	EtOH	reflux	120	43
33	cat. 2	0.07	AcOEt	reflux	60	55
34	cat. 2	0.07	CHCl ₃	reflux	90	45
35	cat. 2	0.07	CH ₂ Cl ₂	reflux	60	61
36	cat. 2	0.07	CH ₃ CN	reflux	75	72
37	cat. 3	0.07	AcOEt	reflux	60	56
38	cat. 3	0.07	CHCl ₃	reflux	90	47
39	cat. 3	0.07	CH ₃ CN	reflux	80	71

Reaction conditions: substrates were acetophenone (1 mmol) and 4-chlorobenzaldehyde (1 mmol) and cat. 1, cat. 2, and cat. 3 were prepared by stirring 0.5, 0.75, and 1.0 g of [PYC₄SO₃H][HSO₄], respectively, with 1.0 g silica in methanol for 20 h as described in the experimental section.

130 °C, and the yield was 94% (entry 21).

We also investigated the effect of the solvent used to prepare cat. 2. We prepared cat. 2 with acetonitrile or chloroform as the solvent, instead of methanol, with stirring at room temperature for 20 h. We then tested the performance of the resulting catalysts in the synthesis of **3c** and found

that the solvent in the preparation method of cat. 2 had no effect on the rate or yield of the aldol condensation.

To evaluate the substrate scope of the optimized reaction conditions, we carried out cross-aldol condensations with acetophenone, cyclohexanone, and acetone and a series of aromatic aldehydes (Table 2). Aromatic aldehydes with electron-donating or -withdrawing substituents reacted efficiently and relatively quickly with acetophenone, cyclohexanone, and acetone, to give condensation products

3a–3g, **4a–4k**, and **5a–5d**, respectively, in high yields. In all cases, only one stereoisomer was produced, as indicated by ^1H NMR spectroscopy. Large coupling constants between the two vinylic protons in **3a–3g** and **5a–5d** indicated that the compounds were *E* stereoisomers. On the basis of previously reported results [24,29–31,37–43], however, we determined that **4a–4k** also had the *E* configuration (as shown in Scheme 1). On the other hand, we were unable to carry out selective monocondensation from only one side of cyclo-

Table 2 Cross-aldol condensation of ketones with aromatic aldehydes catalyzed by $[\text{PYC}_4\text{SO}_3\text{H}][\text{HSO}_4]/\text{A300SiO}_2$

Entry	Ketone	Aldehyde	Product ^a		Time (min)	Isolated yield (%)	m.p. (°C)
1				3a	30	89	83–85
2				3b	35	85	117–120
3				3c	30	94	112–115
4				3d	35	91	87–88
5				3e	40	82	90–92
6				3f	30	89	121–122
7				3g	30	85	141–142
8				4a	30	90	116–118
9				4b	25	92	164–165
10				4c	25	85	106–108
11				4d	25	92	145–147
12				4e	25	93	157–158

(To be continued)

Table 2 (Continued)

Entry	Ketone	Aldehyde	Product ^a	Time (min)	Isolated yield (%)	m.p. (°C)
13				30	89	161–163
14				35	88	143–145
15				30	84	166–167
16				35	87	252–255
17				25	92	158–159
18				35	85	198–199
19				35	85	117–119
20				30	87	192–193
21				35	84	175–177
22				40	84	128–129

Reaction conditions: acetophenone or cyclohexanone or acetone (1 mmol), aromatic aldehyde (1 mmol for acetophenone and 2 mmol for cyclohexanone and acetone), and [PYC₄SO₃H][HSO₄]/A300SiO₂ (cat. 2, 0.07 g) at 130 °C under solvent-free conditions.

^aAll the products were characterized by IR spectroscopy and by comparison of their melting points with those of authentic samples. The structures of some products were confirmed by ¹H NMR spectroscopy.

hexanone and acetone, and thin-layer chromatography indicated that the reactions produced mixtures of products, which we did not identify.

We compared the results we obtained using [PYC₄SO₃H][HSO₄]/A300SiO₂ as a heterogeneous catalyst with previously reported results for cross-aldol condensation reactions in the presence of various homogeneous, het-

erogeneous, and supported catalysts (Table 3). Our reaction conditions showed a shorter reaction time than all the other conditions (except catalysis by KF-Al₂O₃ with microwave irradiation) and gave high yields of the desired products.

We also used our optimized reaction conditions to evaluate the reusability of cat. 2 (Fig. 1). After the reaction was complete, the catalyst was recovered as described in the

Table 3 Comparison of catalyst performance in cross-aldol condensations of ketones with aldehydes

Catalyst	Conditions			Time (min)	Yield (%)	Ref.
	Solvent	$T/^{\circ}\text{C}$	Other			
Ionic liquid	— (for some cases: EtOH)	r.t.	—	60–180	86–96	24
Ionic liquid	—	r.t.	—	960–2880	78–96	25
$\text{Mg}(\text{HSO}_4)_2$	—	60	—	120–480	82–96	29
Sulfamic acid	—	80	—	150–1440	77–94	30
$\text{Yb}(\text{OTf})_3$	—	90	—	240–720	88–97	31
Fluoroalkylated 1,4-disubstituted [1,2,3]triazole organocatalyst	EtOH	reflux	—	600–1200	66–96	34
NaOAc	glacial AcOH	120	N_2 atmosphere	180–480	81–93	37
Silica chloride	—	100–110	—	120–900	65–95	38
Sulfonated carbon nanocage	—	70	—	30–120	72–92	39
Sulfated zirconia	—	170	—	240	63–96	40
Polystyrene-supported sulfonic acid	CHCl_3	reflux	—	240–360	75–94	41
Cetyl trimethyl ammonium bromide	H_2O	60	NaOH	360–480	80–98	42
$\text{KF-Al}_2\text{O}_3$	—	—	MW at 450 W	2–5 min	75–90	43
$\text{KF-Al}_2\text{O}_3$	CH_3CN	reflux	—	480–840	40–55	43
$[\text{PYC}_4\text{SO}_3\text{H}][\text{HSO}_4]/\text{A300SiO}_2$ (cat. 2)	—	130	—	25–40 min	84–94	this work

experimental section and was then reused for a similar reaction. We found that the catalyst could be used at least five times with only a slight reduction in activity. Furthermore, the FT-IR spectra of the recovered catalysts (Fig. 2(2)–(5)) were almost identical to the spectrum of the fresh catalyst (Fig. 2(1)), indicating that the structure of the catalyst was unchanged by the reaction.

Fig. 1. Effect of recycling on catalytic performance of $[\text{PYC}_4\text{SO}_3\text{H}][\text{HSO}_4]/\text{A300SiO}_2$ (cat. 2) in the synthesis of **3c**.

To confirm that the ionic liquid interacted strongly with the silica support under the optimal reaction conditions, we added hot chloroform to the reaction mixture 10 min after the first run and then filtered the mixture. When the reaction was resumed with the filtrate, in the absence of any externally added catalyst, no increase in conversion was observed after 1 h, indicating that the active catalyst was a heterogeneous

Fig. 2. FT-IR spectra of fresh catalyst (cat. 2, run 1, (1)) and recovered catalysts (cat. 2, runs 2–5, (2)–(5), respectively) for the synthesis of **3c**.

solid catalyst.

3 Conclusions

We showed that $[\text{PYC}_4\text{SO}_3\text{H}][\text{HSO}_4]/\text{A300SiO}_2$ efficiently catalyzed the cross-aldol condensation of ketones with aromatic aldehydes under solvent-free conditions. The method was fast and high yielding, the work-up was easy, and only one product was formed, as indicated by thin-layer chromatography and ^1H NMR spectroscopy. In addition, the reaction was environmentally friendly because it was solvent free, and the use of the solid acidic supported catalyst eliminated the need for soluble inorganic acids and thus

reduced waste. Moreover, the catalyst could be easily recycled by filtration and reused at least four times with only a slight reduction in activity.

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References

- 1 Deli J, Lorand T, Szabo D, Foldesi A. *Pharmazie*, 1984, **39**: 539
- 2 Leonard N J, Miller L A, Berry J W. *J Am Chem Soc*, 1957, **79**: 1482
- 3 Dimmock J R, Padmanilayam M P, Zello G A, Neinaber K H, Allen T M, Santos C L, De Clercq E, Balzarini J, Manavathu E K, Stables J P. *Eur J Med Chem*, 2003, **38**: 169
- 4 Gangadhara, Kishore K. *Polymer*, 1995, **36**: 1903
- 5 Robinson T P, Ehlers T, Hubbard R B, Bai X, Arbiser J L, Goldsmith D J, Bowena J P. *Bioorg Med Chem Lett*, 2003, **13**: 115
- 6 Dinkova-Kostova A T, Abeygunawardana C, Talalay P. *J Med Chem*, 1998, **41**: 5287
- 7 Piantadosi C, Hall I H, Irvine J L, Carlson G L. *J Med Chem*, 1973, **16**: 770
- 8 Raj A A, Raghunathan R, Sridevi Kumari M R, Raman N. *Bioorg Med Chem*, 2003, **11**: 407
- 9 Girgis A S, Ibrahim Y A, Mishriky N, Lisgarten J N, Potter B S, Palmer R A. *Tetrahedron*, 2001, **57**: 2015
- 10 Rovnyak G, Shu V, Schwartz J. *J Heterocycl Chem*, 1981, **18**: 327
- 11 Amarasekara A S. *Tetrahedron Lett*, 2005, **46**: 2635
- 12 Drexler M T, Amiridis M D. *J Catal*, 2003, **214**: 136
- 13 Karthikeyan M S, Holla B S, Kumari N S. *Eur J Med Chem*, 2007, **42**: 30
- 14 Rateb N M. *Phosphorus, Sulfur Silicon Relat Elem*, 2007, **182**: 2393
- 15 Ducki S, Forrest R, Hadfield J A, Kendall A, Lawrence N J, McGown A T, Rennison D. *Bioorg Med Chem Lett*, 1998, **8**: 1051
- 16 Mishra N, Arora P, Kumar B, Mishra L C, Bhattacharya A, Awasthi S K, Bhasin V K. *Eur J Med Chem*, 2008, **43**: 1530
- 17 Wattenberg L W, Coccia J B, Galbraith A R. *Cancer Lett*, 1994, **83**: 165
- 18 Dimmock J R, Elias D W, Beazel M A, Kandepu N M. *Curr Med Chem*, 1999, **6**: 1125
- 19 Sipos G, Sirokman F. *Nature*, 1964, **202**: 489
- 20 Kozlov N G, Basalaeva L I. *Russ J Gen Chem*, 2004, **74**: 926
- 21 Le Gall E, Texier-Boullet F, Hamelin J. *Synth Commun*, 1999, **29**: 3651
- 22 Li J T, Chen G F, Wang J X, Li T S. *Synth Commun*, 1999, **29**: 965
- 23 Sivakumar P M, Seenivasan S P, Kumar V, Doble M. *Bioorg Med Chem Lett*, 2007, **17**: 1695
- 24 Wan Y, Chen X M, Pang L L, Ma R, Yue C H, Yuan R, Lin W, Yin W, Bo R C, Wu H. *Synth Commun*, 2010, **40**: 2320
- 25 Yang S D, Wu L Y, Yan Z Y, Pan Z L, Liang Y M. *J Mol Catal A*, 2007, **268**: 107
- 26 Jana S K. *Catal Surv Asia*, 2005, **9**: 25
- 27 Davoodnia A, Heravi M M, Rezaei-Daghigh L, Tavakoli-Hoseini N. *Chin J Chem*, 2010, **28**: 429
- 28 Narender T, Papi Reddy K. *Tetrahedron Lett*, 2007, **48**: 3177
- 29 Salehi P, Khodaei M M, Zolfogol M A, Keyvan A. *Monatsh Chem*, 2002, **133**: 1291
- 30 Rostami A, Ahmad-Jangi F. *Chin Chem Lett*, 2011, **22**: 1029
- 31 Wang L, Sheng J, Tian H, Han J, Fan Z, Qian C. *Synthesis*, 2004, **18**: 3060
- 32 Deng G, Ren T. *Synth Commun*, 2003, **33**: 2995
- 33 Sharma S K, Parikh P A, Jasra R V. *J Mol Catal A*, 2007, **278**: 135
- 34 Zhu Y W, Yi W B, Cai C. *J Fluorine Chem*, 2011, **132**: 71
- 35 Zheng M, Wang L, Shao J, Zhong Q. *Synth Commun*, 1997, **27**: 351
- 36 Nakano T, Irifune S, Umamo S, Inada A, Ishii Y, Ogawa M. *J Org Chem*, 1987, **52**: 2239
- 37 Motiur Rahman A F M, Jeong B S, Kim D H, Park J K, Lee E S, Jahng Y. *Tetrahedron*, 2007, **63**: 2426
- 38 Hazarkhani H, Kumar P, Kondiram K S, Shafi Gadwal I M. *Synth Commun*, 2010, **40**: 2887
- 39 Lin P, Li B, Li J, Wang H, Bian X, Wang X. *Catal Lett*, 2011, **141**: 459
- 40 Rawal K, Mishra M K, Dixit M, Srinivasarao M. *J Ind Eng Chem*, 2012, **18**: 1474
- 41 An L T, Zou J P, Zhang L L. *Catal Commun*, 2008, **9**: 349
- 42 Shrikhande J J, Gawande M B, Jayaram R V. *Catal Commun*, 2008, **9**: 1010
- 43 Yadav J S, Reddy B V S, Nagaraju A, Sarma J A R P. *Synth Commun*, 2002, **32**: 893
- 44 Moghaddas M, Davoodnia A, Heravi M M, Tavakoli-Hoseini N. *Chin J Catal*, 2012, **33**: 706
- 45 Tavakoli-Hoseini N, Davoodnia A. *Asian J Chem*, 2010, **22**: 7197
- 46 Heravi M M, Saeedi M, Karimi N, Zakeri M, Beheshtiha Y S, Davoodnia A. *Synth Commun*, 2010, **40**: 523
- 47 Seifi N, Zahedi-Niaki M H, Reza Barzegari M, Davoodnia A, Zhiani R, Kaju A A. *J Mol Catal A*, 2006, **260**: 77
- 48 Davoodnia A. *Asian J Chem*, 2010, **22**: 1595
- 49 Norouzi H, Davoodnia A, Bakavoli M, Zeinali-Dastmalbaf M, Tavakoli-Hoseini N, Ebrahimi M. *Bull Korean Chem Soc*, 2011, **32**: 2311
- 50 Zeinali-Dastmalbaf M, Davoodnia A, Heravi M M, Tavakoli-Hoseini N, Khojastehnezhad A, Zamani H A. *Bull Korean Chem Soc*, 2011, **32**: 656
- 51 Tavakoli-Hoseini N, Davoodnia A. *Chin J Chem*, 2011, **29**: 203

- 52 Khojastehnezhad A, Davoodnia A, Bakavoli M, Tavakoli-Hoseini N, Zeinali-Dastmalbaf M. *Chin J Chem*, 2011, **29**: 297
- 53 Mohammadzadeh-Dehsorkh N, Davoodnia A, Tavakoli-Hoseini N, Moghaddas M. *Synth React Inorg Met-Org Nano-Met Chem*, 2011, **41**: 1135
- 54 Davoodnia A, Tavakoli-Nishaburi A, Tavakoli-Hoseini N. *Bull Korean Chem Soc*, 2011, **32**: 635
- 55 Yassaghi G, Davoodnia A, Allameh S, Zare-Bidaki A, Tavakoli-Hoseini N. *Bull Korean Chem Soc*, 2012, **33**: 2724

第十三届全国均相催化学术讨论会第一轮通知

时间: 2013 年 9 月 25 ~ 27 日 地点: 江苏省苏州市

承办单位: 中国科学院兰州化学物理研究所 苏州大学材料与化学化工学部

一、会议介绍

由中国化学会催化委员会均相催化专业委员会主办, 中国科学院兰州化学物理研究所和苏州大学材料与化学化工学部联合承办的第十三届全国均相催化学术讨论会定于 2013 年 9 月 25~27 日在美丽的城市苏州举行。本届会议是全国均相催化和相关领域专家学者的一次聚会, 将全面展示两年来我国在这些领域取得的研究成果, 交流和讨论均相催化发展的新趋势和所面临的机遇与挑战, 以推动我国均相催化领域的研究和相关产业向更高的目标迈进。

会议拟邀请著名专家学者与会, 会议组委会热忱欢迎从事均相催化科学研究与技术开发的专家、同行及在读研究生积极投稿, 并莅临本届盛会。会议期间将颁发第二届“中国均相催化青年奖”和第十三届全国均相催化学术讨论会“优秀墙报奖”。

二、会议主办单位: 均相催化专业委员会

主任: 夏春谷

副主任: 丁奎岭 李贤均

秘书长: 孙伟

委员: 包明 陈静 范青华 龚流柱 郭灿城 贺德华 胡信全 华瑞茂 江焕峰 金国新 雷爱文 李光兴 梁永民 陆维敏 施章杰 王公应 王向宇 吴鹏 吴静 徐杰 夏清华 游书力 袁友珠 周永贵

三、征文范围

1. 均相催化剂的设计、合成和表征; 2. 均相酸碱催化反应; 3. 不对称催化反应; 4. 小分子催化; 5. 生物催化与仿生催化反应; 6. 胶束和胶体催化以及微乳催化反应; 7. 纳米催化剂的制备、表征和催化反应; 8. 光、电催化反应; 9. 生物质催

化转化; 10. 均相催化剂的多相化; 11. 均相催化的工业应用; 12. 与均相催化相关的反应机理、理论和计算化学等。

四、投稿要求及日期

关于详细论文摘要的格式要求请登录会议网站查看: <http://13nchc.csp.escience.cn/dct/pag>。论文经评审录用后发出录用通知。被录用的论文一般不再退回修改, 作者在寄论文摘要时应做好一次性定稿准备, 文责自负。论文录用与否, 一概不退, 请作者自留底稿。征文截止日期为 2013 年 6 月 30 日, 请登陆会议网站进行在线投稿或通过 E-mail (13nchc@licp.cas.cn) 发送征文电子版。

五、会议承办单位及联系人

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