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Brønsted Acids as Additives for the Direct Asymmetric Aldol Reaction Catalyzed by L-Prolinethioamides. Direct Evidence for Enamine−Iminium Catalysis

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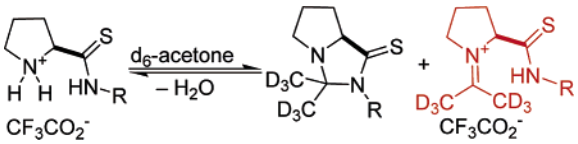

The use of protonated L-prolinethioamide instead of the free base derivative **1** as the organocatalyst for the direct aldol addition has a profound and appreciable effect on both the yield and the stereochemical course of the reaction. 4-Nitrobenzaldehyde (**2**) reacts with acetone in the presence of the protonated catalyst **1**·TFA, affording aldol product **3** with a yield up to 99% and an ee up to 98%. The catalyst loading can be lowered to 2.5 mol %. More than 20 different acids were investigated as an additive, and its role as cocatalyst has been discussed. Furthermore, reactions of L-prolinethioamide salts with acetone have been monitored using ESI-MS and ^{1}H NMR techniques, giving insight into the mechanism of the direct aldol reaction. The presumed formation of the iminium salt **10** has been unambiguously confirmed.

Introduction

The aldol reaction is one of the most powerful C−C bond-forming reactions in nature and in the repertoire of organic chemists.[1] Of particular interest recently is the direct connection of two carbonyl species catalyzed by L-proline and other amino acids, a process that mimics the type I aldolases.[2−7] The intramolecular version of this catalytic reaction was discovered by Hajos and Parrish and Wiechert et al. in the 1970s.[8,9] Thirty years later, the intermolecular version was presented by List et al.[10] The mechanism of the L-proline-catalyzed aldol reaction has been intensively studied, and it was unequivocally established that the reaction proceeded through the enamine−iminium catalysis and that only one proline molecule is involved in the enantioselectivity-determining step.[11−14] Moreover, using ESI-MS/MS technique, Metzger and Marquez were able to detect all intermediates proposed in the mechanism. Although a bicyclic oxazolidinone intermediate was observed for the reaction between L-proline and an aldehyde, Metzger and Marquez were not able to detect an oxazolidinone intermediate formed from L-proline and acetone.[15]

A number of proline-derived catalysts have been prepared, which in most cases involve a modification of the carboxylic acid functionality.[16−27] In spite of this effort, none of them is a

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universal catalyst for aldol reactions between various ketones and all types of aldehydes. We have recently demonstrated that L-prolinethioamides can catalyze the aldol reaction.[22,28] Our catalysts work well but have a tendency to form unwanted imidazolidinethione side product, which decreases the yield and enantioselectivity of the aldol product. During our preliminary work, we found that the addition of 1 equiv of trifluoroacetic acid (TFA) influenced the yield and the enantioselectivity of the reaction of 4-nitrobenzaldehyde (**2**) with acetone.[22]

In 2001, Yamamoto and co-workers described the use of protic acid diamines as catalysts for the aldol reaction.[29] The proposed role of the added acid was dual: (a) increase the rate of enamine formation and (b) orient the substrate. Moreover, Brønsted acids have been used in combination with MacMillan et al.'s imidazolidine catalysts.[30] Notably, it was found that the resulting salts catalyze many transformations better than the parent imidazolidines. While this manuscript was in preparation, Sun et al. reported the beneficial effect of the addition of TFA on the *N*′-benzyl-*N*′-L-prolyl-L-proline hydrazide-catalyzed aldol reaction.[31] The authors studied the application of the protonated catalyst to the aldol reaction of cyclohexanone with different aromatic aldehydes, but they did not provide an explanation for the beneficial effect of TFA on the stereochemical results. In this article, we would like to present our in-depth studies on the use of acid as an additive for the direct asymmetric aldol reaction catalyzed by L-prolinethioamide **1** (Figure 1).

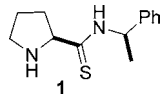

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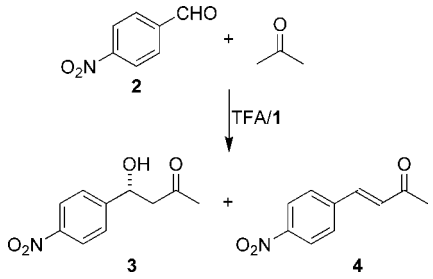
FIGURE 1. L-Prolinethioamide **1**.

Results and Discussion

Optimization Studies. We observed that the use of the TFA salt of L-prolinethioamide **1** as the catalyst for the reaction of 4-nitrobenzaldehyde (**2**) with acetone appreciably improved the yield and the enantioselectivity of the aldol product **3**.[22] Intrigued by this result, we decided to study this phenomenon in detail. Having previously optimized the catalyst's structure,[28] we analyzed various reaction parameters from the catalyst loading to solvent effects. Nonetheless, the greatest attention was focused on the influence of the type of acid as this had the most dramatic effect. For example, the reaction of model aldehyde **2** with acetone in the presence of 10 mol % of **1** (entry 1) afforded a 68% yield of **3** and 44% ee (entry 1, Table 1), while the same

SCHEME 1. Model Aldol Reaction of 4-Nitrobenzaldehyde (2) with Acetone in the Presence of TFA·1



reaction with TFA·**1** gave the aldol product **3** in 61% yield and 94% ee, accompanied by the α,β-unsaturated ketone **4** (Scheme 1).[22]

We were delighted to find that the yield improved further upon decreasing of the catalyst loading. The use of as little as 2.5 mol % of TFA·**1** furnished hydroxyketone **3** in 94% ee and in 81% yield (entry 3) as the subsequent dehydration was slowed. It is well-known that a number of L-proline-derived organocatalysts work best under solvent-free conditions;[2] however, the use of a large excess of ketone to push the reaction forward is neither economical nor practical. Since the free base catalyst **1** afforded a poor yield and low enantioselectivity in any solvent studied, we were surprised to find that the hydroxyketone **3** was obtained in a variety of solvents when an equimolar amount of TFA was added (entries 6−20, Table 1). The best results were obtained in THF (entry 13) and solvents commonly used in organocatalyzed reactions, namely DMF (entry 6) and NMP (entries 7 and 8), but not in DMSO (entry 5). In the latter case, only traces of the aldol product were observed. In other solvents studied, the reaction usually afforded **3** in low yields.

There are a few reports where protonated forms of organocatalysts were used, but the influence of the choice of acid was not studied in detail.[29−31,33−36] Therefore, we obtained and, in

TABLE 1. Direct Aldol Reaction of Acetone to 4-Nitrobenzaldehyde (2) Catalyzed by TFA·1[a]

entry	solvent	catalyst loading (mol %)	yield of **3** (%)[b]	ee (%)[c]	yield of **4** (%)[b]
1	acetone	10[d,e]	68	44	nd
2[f]	acetone	20[d]	62	84	nd
3[f]	acetone	20	81	94	nd
4	**acetone**	**2.5**	**81**	**94**	**12**
5	DMSO	10	traces	nd	
6	**DMF**	**10**	**71**	**96**	**29**
7	**NMP**	**10**	**65**	**97**	**23**
8	**NMP/iPrOH**	**10**	**61**	**98**	**22**
9	CH_3CN	10	55	96	23
10	*i*PrOH	10	33	88	11
11	EtOH	10	28	87	7
12	*i*PrOH/H_2O	10	54	76	44
13	**THF**	**10**	**76**	**94**	**21**
14	dioxane	10	65	90	22
15	ether	10	18	93	6
16	MTBE	10	39	92	12
17	$CHCl_3$	10	26	87	11
18	CH_2Cl_2	10	57	88	17
19	toluene	10	21	91	5
20	BMIM[BF_4]	10	15	95	
21	SDS/H_2O	10	traces	nd	

[a] Conditions: 1 mmol of **2**, 0.4 mL of acetone, 2 mL of a solvent, 4 °C, 60 h. [b] Isolated yields. [c] Determined by HPLC on a Diacel AS-H column. [d] TFA was not added. [e] Freshly purified aldehyde **2** was used. [f] For further details, see refs 22 and 28.

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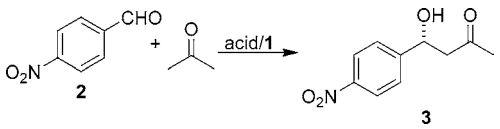
TABLE 2. Aldol Addition of Acetone to 4-Nitrobenzaldehyde (2) Catalyzed by Acid·1 in the Presence of Acids[a]



entry	acid	pK_a[b]	yield of **3** (%)[c,d]	ee (%)[e]
1	F_3CCO_2H	0.26	81	94
2	HCl	−8.00	0	
3	HBr	−9.00	0	
4	HCO_2H	3.75	24	89
5	CH_3CO_2H	4.76	20	86
6	F_2CHCO_2H	1.24	95	92
7	$ClCH_2CO_2H$	2.85	60	93
8	Cl_2CHCO_2H	1.29	99	93
9	Cl_3CCO_2H	0.65	10	93
10	$BrCH_2CO_2H$	2.86	28	94
11	ICH_2CO_2H	3.12	32	91
12	2-methylbenzoic acid	4.36	45	91
13	2-hydroxybenzoic acid	3.0	83	93
14	3,5-dinitrobenzoic acid	2.8	89	91
15	CH_3SO_3H	−2.0	0	
16	CF_3SO_3H	−13.0	0	
17	*p*-toluenesulfonic acid	−1.34	0	
18	$PhPHO_2H$[f]		89	84
19	D-mandelic acid[f]	3.14	53	93
20	L-mandelic acid[f]	3.14	38	93
21	D-tartaric acid[f]	2.99, 4.40	82	91
22	L-tartaric acid[f]	2.99, 4.40	85	89
23	$Zn(OTf)_2$		30	11

[a] All reactions were run on 1 mmol scale using 2 mL of a solvent and 0.025 mmol of the salt, isolated as pure compound unless specified otherwise, at 4 °C for 60 h. [b] pK_a of acid measured in water.[37,38] [c] Isolated yields. [d] Subsequent dehydration was not observed. [e] Determined by HPLC on a Diacel AS-H column. [f] These salts were generated in situ.

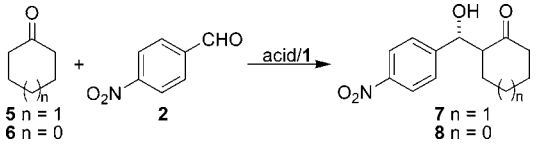
most cases, isolated and fully characterized a series of different salts of the L-prolinethioamide **1**. Eighteen different acids were used as an additive with the goal of finding a relationship between the pK_a of the acid and the aldol reaction outcome. The study included simple inorganic acids that were both stronger and weaker than TFA and derivatives of acetic and benzoic acid. Furthermore, to determine if the carboxylic acid functionality has to be an integral part of the acid's structure, we included sulfonic and phenyl phosphinic acids. All these compounds were easy to prepare by the treatment of L-prolinethioamide **1** with an equimolar amount of acid. TFA·**1** and CF_3SO_3H·**1** formed crystals suitable for X-ray structural analysis (Supporting Information). Their structures are very similar in that they have similar intermolecular interactions with anions. In the asymmetric unit cell, there are two independent molecules of CF_3SO_3H·**1**, whereas there is only one of TFA·**1**.

Careful analysis of the data included in Table 2 led to interesting observations and generalizations. L-Prolinethioamide salts derived from acids stronger than TFA led only to the recovery of the starting material **2** (entries 2, 3, 15−17). Other salts afforded aldol product **3** (accompanied only by **2**), but the yield strongly depended on the acid used. Among derivatives of acetic acid (entries 5−11), the highest yields (up to 99% with 93% ee) were obtained for those with p$K_a \approx 1.3$ (entries 6 and 8). Any deviation in the pK_a value led to a decrease in the yield (entries 4, 5, 7, 9−11). The only exception from this generalization is TFA, and the explanation of this phenomenon requires further experiments. On the other hand, benzoic acids, in spite of higher dissociation constants, catalyzed the model reaction effectively (entries 13 and 14). Presumably, in these cases the catalytic activity is additionally influenced by the presence of functional groups such as the hydroxyl- and nitro-, which can form hydrogen bonds, since 4-methylbenzoic acid gave only a moderate yield (45%). The electronic character of these groups (electron-donating versus electron-withdrawing) apparently has no effect (entries 12 and 13). Finally, the use of a Lewis acid such as $Zn(OTf)_2$ gave low yield and low enantioselectivity in the model reaction (entry 23), in contrast to the Barbas result with an L-proline-derived diamine and $Sc(OTf)_3$.[34]

Having observed the crucial role of acids, we have also studied the stereochemical outcome of the aldol reaction catalyzed by salts derived from simple chiral acids. To explore the possibility of a match or mismatch effect with the L-proline catalyst **1** and the chiral acids, we prepared two pairs: one derived from L- and D-mandelic acid, and the second from L- and D-tartaric acid. All four compounds catalyzed the reaction of 4-nitrobenzaldehyde (**2**) with acetone with virtually the same high enantioselectivity (entries 19−22), but salts derived from tartaric acids gave better yields. Thus, we assume that the counterion is not involved in the transition state and that there is no stereochemical communication with the chiral counteranion, contrary to the counterion-mediated organocatalytic transfer hydrogenation published by Mayer and List.[39]

Scope and Limitation Studies. Ketones other than acetone were also briefly investigated. The reaction of cyclohexanone (**5**) with 4-nitrobenzaldehyde (**2**) catalyzed by TFA·**1** afforded aldol product **7** in good yield, diastereoselectivity, and enantioselectivity (Scheme 2).

SCHEME 2. Aldol Reaction of 4-Nitrobenzaldehyde (2) with 5 and 6 in the Presence of Acid·1



In this case, the addition of TFA was crucial since only traces of the desired product (**7**) were observed in the parent reaction without an additive (Table 3, entries 1 and 2). Optimization studies showed that the use of NMP caused an increase in the *syn/anti* ratio to 95% and in ee for the *anti* diasteroisomer to 90%; however, 10 mol % of the catalyst was required (entry 3). The use of Cl_2CHCO_2H instead of TFA allowed a reduction in the catalyst loading (5%) and a slight improvement in yield (entry 3). It should be noted that cyclohexanone-derived aldols **7** are prone to racemization during column chromatography.

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TABLE 3. Cyclohexanone (5) and Cyclopentanone (6) as Donors in the Aldol Reaction with 4-Nitrobenzaldehyde (2)[a]

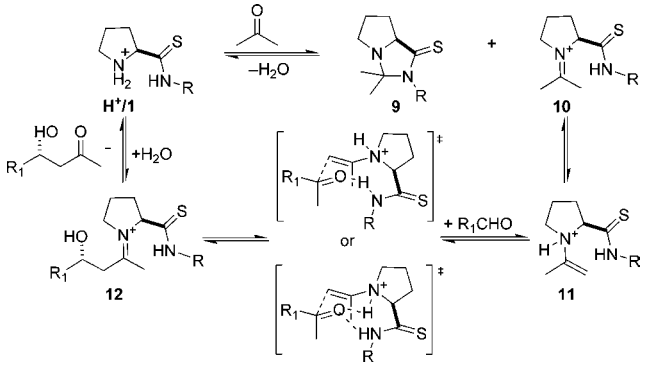
entry	ketone	acid	amount of acid **1** (mol %)	yield of **7** or **8** (%)[b]	*syn*/*anti*[c] ratio	ee of *syn* (%)[d]	ee of *anti* (%)[d]
1	**5**	none	10	traces	nd	nd	nd
2	**5**	TFA	10	82	13:77	63	86
3	**5**	**TFA**	10[e]	**88**	**5:95**	**75**	**90**
4	**5**	Cl_2CHCO_2H	5	96	17:83	27	91
5[f]	**6**	none	10	94	1.2:1	28	52
6	**6**	TFA	10[e]	48[g]	1.7:1	97	97
7	**6**	Cl_2CHCO_2H	5	85	1:1	80	98

[a] All reactions were run on 1 mmol scale using 2 mL of donor at 4 °C for 60 h. [b] Isolated yields. [c] Determined by ^{1}H NMR analysis of the crude reaction mixture. [d] Determined by HPLC on a Diacel AS-H column. [e] Reaction performed in NMP. [f] See ref 28. [g] Subsequent elimination took place.

Our initial experiments with cyclopentanone (**6**) showed that in NMP aldol product **8** was obtained in excellent enantioselectivity for both *syn* and *anti* diasteroisomer, but only in moderate yield since subsequent dehydration took place (Table 3, entry 6). The decrease in the catalyst loading slowed the rate of the reaction drastically, and therefore we turned to the less active catalyst, Cl_2CHCO_2H·**1**. To our delight, aldol **8** was obtained in 85% yield with only a slight loss of enantioselectivity.

Mechanistic Considerations. We assumed that the direct asymmetric aldol reaction catalyzed by L-prolinethioamides proceeds through the same mechanism as that proposed for L-proline. The general idea of the enamine-mediated mechanism has been discussed many times in the literature.[2,4,13−15] It has been shown that only one proline molecule is involved in the transition state and that the crucial proton transfer is mediated by proline's carboxylic acid functionality.[13,14] In our case, the crucial proton is transferred from the thioamide group (Scheme 3).

SCHEME 3. Proposed Mechanism for the Model Aldol Reaction of 4-Nitrobenzaldehyde (2) with Acetone in the Presence of HX·1



As previously reported, the level of stereocontrol in the aldol reaction catalyzed by **1** was influenced by the unwanted formation of imidazolidinethione **9**; the slower the formation of **9**, the higher the enantioselectivity of the process. The ^{1}H NMR spectrum of **1** in d_6-acetone changed with time, and after 80 min, **1** was quantitatively transformed into imidazolidinethione **9**. When the same experiment was carried out with TFA·**1**, the spectrum immediately showed three sets of signals that did not change over time. The three sets of signals persisted even after 12 h and could be assigned to three compounds present in the reaction mixture: iminium salt **10** (62%), TFA·**1** (26%), and imidazolidinethione **9** (12%). The complete assignment of the signals in ^{1}H and ^{13}C NMR was achieved through additional NMR experiments (COSY, HSQC, HMBC). The structure of iminium salt **10** was based on the presence of the iminium carbon signal at 189.8 ppm in the ^{13}C NMR spectrum. Crucial information came from the HMBC analysis. In particular, cross-peaks at 189.8−6.16 ppm and at 189.8−4.21 ppm correspond to the long distance coupling between the iminium carbon and the α proton and the iminium carbon and the CH_2N in the pyrrolidine ring, respectively. Other characteristic signals might be derived from the carbon atom present in the CD_3 group, but they are not seen in the ^{13}C NMR due to their coupling with three deuterium atoms.

The ESI-MS spectrum of TFA·**1** in acetone displayed intense peaks at *m*/*z* 235, 261, and 275 (100%) that correspond to **1**·**H**$^+$, an unknown species, and to the isomeric iminium ion **10**$^+$ or imidazolidinethione **9**·**H**$^+$, respectively. The latter two species can interconvert, and they have identical fragmentation patterns. Therefore, no precise assignment can be made with ESI-MS. Nevertheless, the presence of imidazolidinethione **9** was detected by performing an ESI-MS of TFA·**1** in acetone mixed with CH_3-COONa. The mass spectrum showed an intense peak at *m*/*z* 297, which corresponds to **9**·**Na**$^+$. Since only imidazolidinethione **9** is able to chelate Na^+, its presence is definitively confirmed.

When aldehyde **2** was added to TFA·**1** in acetone and analyzed after 25 h, the reaction exhibited signals at *m*/*z* 275, corresponding to the iminium ion **10**$^+$ and/or cationized enamine **11**$^+$; at 297, corresponding to oxazolidinethione **9**·**Na**$^+$; and at 448, corresponding to **12**-**H**$^+$ + **Na**$^+$. The detection of all four of these species supports the proposed mechanism (Scheme 3).

Additionally, ^{1}H NMR spectra of other salts in d_6-acetone were analyzed. The spectrum of CF_3SO_3H·**1** showed only one set of signals, which suggests that only the salt is present and that no reaction with acetone has occurred. A similar result was also obtained for HCl·**1**. These experiments clearly show that salts, which are not active in catalyzing the aldol reaction, did not form the reactive iminium intermediate **10**, thus preventing further reaction with an aldehyde. Subsequently, the same NMR experiment was run for the $BrCH_2CO_2H$-derived salt, which had provided aldol product **3** in low yield. In this event, the catalyst was entirely transformed into unwanted imidazolidinethione **9** after 30 min. This compound, as it was proved, could react with an aldehyde affording product but with low yield. Encouraged by these results, we explored the behavior of other salts in d_6-acetone. The calculated relative abundance of three compounds present in solution 45 min after dissolution is presented in Table 4 for a variety of salts.

These studies clearly showed that, depending on the acid added, the equilibrium was shifted toward the protonated catalyst **1** (Figure 2A), imidazolidinethione **9** (B), or iminium salt **10** (C), which subsequently reacted with an aldehyde. The presence of the iminium salt **10**, detected by ^{1}H NMR, correlated to high

TABLE 4. Relative Abundance of Three Compounds Present in Solutions of Salts Acid/1 in d_6-Acetone[a]

entry	acid	yield of **3** (%)	iminium salt **10** (%)	imidazolidinethione **9** (%)	acid·**1** (%)
1	CF_3CO_2H	81 (12)	62	12	26
2	Cl_2CHCO_2H	99	35	46	19
3	F_2CHCO_2H	95	28	57	15
4	2-hydroxybenzoic acid	83	3	90	7
5	ICH_2CO_2H	32	0	100	
6	$BrCH_2CO_2H$	28	0	100	
7	Cl_3CCO_2H	10	0	62	38
8	CF_3SO_3H	traces	0		100
9	HCl	traces	0		100

[a] All experiments were run on the same scale, 0.054 mmol of a salt was dissolved in 7 mL of d_6-acetone, and after 45 min ^{1}H NMR spectra were measured.

yield of the aldol product **3** in the title reaction (Table 4, entries 1−4). When the equilibrium is shifted toward imidazolidinethione **9**, the reaction afforded only a small amount of **3** (entries 5−7). The salts obtained from strong acids did not react with acetone, and only traces of **3** were formed. The differences in the catalytic activity of the salts derived from various acids were judged from the equilibrium, which was followed by ^{1}H NMR spectroscopy (Figure 2). The addition of an acid with the appropriate pK_a strongly shifted the reactivity of the catalyst toward the more reactive intermediates and diminished the formation of unwanted imidazolidinethione compound **9**.

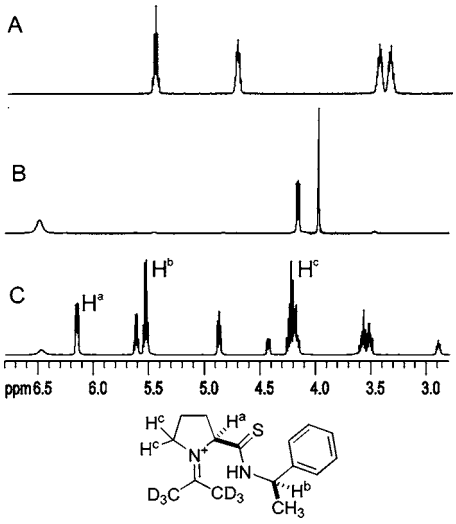


FIGURE 2. 500 MHz ^{1}H NMR spectra of 0.08 M solution in d_6-acetone. (A) **CF_3SO_3H·1**. In solution, only catalyst **CF_3SO_3H·1** was present. (B) **$BrCH_2CO_2H$·1**. The catalyst was completely transformed into imidazolidinethione **9**. (C) **TFA·1**. In solution, catalyst **TFA·1**, imidazolidinethione **9**, and iminium salt **10** were all present.

The reaction of acetone with different L-prolinethioamide salts was also studied using a time-of-flight spectrometer equipped with an electrospray ion source in positive ion mode. Regardless of the salt used, standard mass spectra recorded for these solutions showed signals at *m*/*z* 235, 261, and 275, corresponding to **1·H**$^+$, an unknown species, and isomeric iminium ion **10**$^+$, or imidazolidinethione **9·H**$^+$, respectively. Spectra of various salts differed from each other only in the intensity of peaks. Thus, the ESI-MS method proved unsuitable for the determination of the activity of the catalyst because the key catalytic species, iminium salt **10**, could not be unambiguously detected.

Conclusions

In conclusion, the chemistry described herein underlines the susceptibility of the aldol reaction to subtle changes in the reaction conditions. The addition of an appropriate acid to the L-prolinethioamide **1** effectively enhanced the activity of the catalyst, allowing it to be used in only 2.5 mol %. Among a number of acids screened, TFA and Cl_2CHCO_2H afforded the best results. The most spectacular case involved cyclohexanone (**5**) as a donor. The reaction of 4-nitrobenzaldehyde (**2**) with **5** without an acid led only to the recovery of the starting material, while in the presence of Cl_2CHCO_2H·**1** the aldol product **7** was isolated almost quantitatively.

Furthermore, these results give insights into details of the enamino−iminium mechanism and have led to the following conclusions: (1) in general, salts of **1** are more effective catalysts for the aldol reaction than **1** itself, (2) depending on the acid used, the equilibrium of the reaction of salts of **1** with acetone is shifted toward catalyst **1**, imidazolidinethione **9**, or the iminium salt **10**, which can subsequently react with an aldehyde, and (3) the combination of ^{1}H NMR and ESI-MS techniques revealed that the reaction proceeded through an enamine−iminium mechanism, which was unequivocally confirmed by the presence of the iminium ion **10**$^+$. These results provide new insight into the factors influencing the course of the aldol reaction, and they will also help with a design of the next generation of organocatalysts.

Experimental Section

General Procedure for the Deprotection of the *N*-Boc Amine Group and Salt Preparation. *N*-Boc thioamide (1.4 mmol) was dissolved in dry CH_2Cl_2 (2.8 mL) and was treated with TFA (18.2 mmol, 1.40 mL) and then Et_3SiH (3.30 mmol, 0.55 mL). After 3 h, the solvent and volatile compounds were removed. The remaining oil was treated with Et_2O, resulting in the precipitation of TFA·**1** as a white solid, which was filtered off. The precipitate was dissolved in $CHCl_3$, washed with saturated $NaHCO_3$, and dried over $NaSO_4$. After the removal of the solvent, catalyst **1** was obtained as a colorless oil that solidified. The free base catalyst was dissolved in Et_2O and then treated with an equimolar amount of an acid (solid acids were dissolved in Et_2O).

TFA·1: Obtained as white crystals in 99% (983 mg). Mp 163−165 °C (from Et_2O); $[\alpha]^{22}_D$ −25.8° (*c* 0.95 in CH_2Cl_2). IR (KBr) 3197, 3034, 2985, 1666, 1557, 1427 cm^{-1}; ^{1}H NMR (500 MHz; $CDCl_3$) 1.58 (d, 3 H, J = 7.0 Hz, C*H*$_3$), 1.80−1.92 (m, 2 H, C*H*$_2$), 1.92−2.00 (m, 1 H, CH*H*), 2.45−2.55 (m, 1 H, CH*H*), 3.25−3.35 (m, 2 H, C*H*$_2$N), 4.74 (dd, 1 H, J = 8.2 and 6.5 Hz, C*H*CS), 5.51 (m, 1 H, C*H*Ph), 7.19−7.29 (m, 5 H, Ph), 7.87 (brs, 1 H, N*H*$_2$), 11.03 (d, 1 H, J = 7.2 Hz, N*H*CS), 11.48 (1 H, brs, N*H*$_2$); ^{13}C NMR (125 MHz; $CDCl_3$) 20.1, 25.1, 33.3, 46.7, 56.8, 63.0, 116

(q, J_{CF} = 291 Hz), 126.9, 127.7, 128.7, 149.7, 162.2, 195.9. Anal. Calcd for $C_{15}H_{19}F_3N_2O_2S$: C, 51.71; H, 5.50; F, 16.36; N, 8.04; S, 9.20. Found: C, 51.74; H, 5.64; F, 16.52; N, 8.08; S, 9.02.

AcOH·1: Obtained as white crystals in 55% (43 mg). Mp 82−84 °C (from Et_2O/hexanes); $[\alpha]^{22}_D$ +40.7° (*c* 0.88 in CH_2Cl_2). IR (KBr) 3167, 2977, 2933, 2754, 1588, 1450 cm^{-1}; ^1H NMR (500 MHz; $CDCl_3$) 1.61 (d, 3 H, *J* = 7.0 Hz), 1.76−1.84 (m, 2 H), 1.93−2.00 (1 H, m), 1.99 (s, 3 H), 2.42 (ddt, 1 H, *J* = 13.3, 8.7, 6.8 Hz), 3.07 (dt, 1 H, *J* = 10.6, 6.7 Hz), 3.18 (dt, 1 H, *J* = 10.5, 6.7 Hz), 4.57 (dd, 1 H, *J* = 8.7, 6.4 Hz), 5.65 (m, 1 H), 6.35 (brs, 2 H), 7.24−7.28 (m, 2 H), 7.30−7.34 (m, 3 H), 10.35 (bs, 1 H); ^{13}C NMR(125 MHz; $CDCl_3$) 20.6, 21.6, 25.8, 34.1, 47.0, 54.3, 66.2, 126.5, 127.5, 128.7, 141.5, 176.5, 201.1. Anal. Calcd for $C_{15}H_{22}N_2O_2S$: C, 61.19; H, 7.53; N, 9.52. Found: C, 61.04; H, 7.54; N, 9.46.

F_2CHCO_2H·1: Obtained as white crystals in 99% (93 mg). Mp 146−149 °C (from Et_2O); $[\alpha]^{22}_D$ −24.6° (*c* 0.89 in CH_2Cl_2). IR (KBr) 3186, 3027, 2978, 1638, 1562, 1455, 1435 cm^{-1}; ^1H NMR (500 MHz; $CDCl_3$) 1.59 (d, 3 H, *J* = 7.0 Hz), 1.81−1.90 (m, 3 H), 1.93 (m, 1 H), 3.22−3.28 (m, 1 H), 3.30−3.35 (m, 1 H), 4.83 (dd, 1 H, *J* = 8.6, 6.4 Hz), 5.53 (m, 1 H), 5.64 (t, 1 H, *J* = 55.7 Hz), 7.17−7.30 (m, 5 H), 11.42 (d, 1 H, *J* = 6.9 Hz); ^{13}C NMR (125 MHz; $CDCl_3$) 20.2, 25.2, 33.5, 46.6, 56.6, 63.0, 109 (t, J_{CF} = 248.1 Hz), 126.9, 127.6, 128.7, 140.9, 168.5 (t, J_{CF} = 24 Hz), 196.3. Anal. Calcd for $C_{15}H_{20}F_2N_2O_2S$: C, 54.53; H, 6.10; N, 8.48. Found: C, 54.63; H, 6.37; N, 8.34.

$ClCH_2COOH$·1: Obtained as white crystals in 99% (67 mg). Mp 110−112 °C (from Et_2O); $[\alpha]^{22}_D$ −11.08° (*c* 0.77 in CH_2Cl_2). IR (KBr) 3185, 3027, 2976, 2481, 1619, 1598, 1564, 1455 cm^{-1}; ^1H NMR (500 MHz; $CDCl_3$) 1.63 (d, 3 H, *J* = 7.0 Hz), 1.83−1.95 (m, 3 H), 2.45−2.55 (m, 1 H), 3.20−3.31 (m, 2 H), 3.92 (s, 2 H), 4.87 (dd, 1 H, *J* = 8.3, 6.2 Hz), 5.56 (m, 1 H), 7.20−7.35 (m, 5 H), 11.42 (brd, 1 H, *J* = 5.5 Hz); ^{13}C NMR(125 MHz; $CDCl_3$) 20.2, 25.0, 33.4, 43.5, 46.3, 56.1, 63.2, 126.7, 127.4, 128.4, 140.6, 172.1, 196.7. Anal. Calcd for $C_{15}H_{21}ClN_2O_2S$: C, 54.78; H, 6.44; Cl, 10.78; N, 8.52; S, 9.75. Found: C, 54.78; H, 6.51; Cl, 10.86; N, 8.67; S, 9.45;

$Cl_2CHCOOH$·1: Obtained as white crystals in 99% (244 mg). Mp 140−142 °C (from Et_2O); $[\alpha]^{22}_D$ −34.5° (*c* 0.97 in CH_2Cl_2). IR (KBr) 3195, 3030, 2979, 2567, 1635, 1556, 1455 cm^{-1}; ^1H NMR (500 MHz; $CDCl_3$) 1.63 (d, 3 H, *J* = 7.0 Hz), 1.79−1.94 (m, 3 H), 2.51−2.59 (m, 1 H), 3.20−3.27 (m, 1 H), 3.30−3.37 (m, 1 H), 4.77 (dd, 1 H, *J* = 8.2, 6.5 Hz), 5.55 (m, 1 H), 5.75 (s, 1 H), 7.22−7.39 (m, 5 H), 7.77 (brs, 1 H), 11.24 (d, 1 H, *J* = 7.1 Hz), 11.72 (brs, 1 H). ^{13}C NMR (125 MHz; $CDCl_3$) 20.5, 25.2, 33.6, 46.8, 56.8, 63.2, 69.0, 127.1, 127.7, 128.7, 140.8, 169.0, 196.0. Anal. Calcd for $C_{15}H_{20}Cl_2N_2O_2S$: C, 49.46; H, 5.53; Cl, 19.47; N, 7.69; S, 9.06. Found: C, 49.45; H, 5.54; Cl, 19.39; N, 7.68; S, 9.07.

$Cl_3CHCOOH$·1: Obtained as white crystals in 95% (87 mg). Mp 108−109 °C (from Et_2O); $[\alpha]^{22}_D$ −37.5° (*c* 0.93 in CH_2Cl_2). IR (KBr) 3216, 3043, 2980, 1660, 1545, 1432 cm^{-1}. ^1H NMR (500 MHz; $CDCl_3$) 1.63 (d, 3 H, *J* = 7.0 Hz), 1.81−1.96 (m, 3 H), 2.58−2.65 (m, 1 H), 3.26 (m, 1 H), 3.38 (m, 1 H), 4.80 (brs, 1 H), 5.53 (m, 1 H), 7.23−7.40 (m, 5 H), 7.79 (brs, 1 H), 10.82 (d, 1 H, *J* = 7.0 Hz), 11.14 (brs, 1 H); ^{13}C NMR (125 MHz; $CDCl_3$) 20.4, 25.0, 33.4, 46.8, 56.7, 63.2, 95.3, 126.9, 127.6, 128.5, 140.4, 165.1, 195.6. Anal. Calcd for $C_{15}H_{19}Cl_3N_2O_2S$: C, 45.30; H, 4.82; Cl, 26.74; N, 7.04; S, 8.06. Found: C, 45.35; H, 4.90; Cl, 26.81; N, 6.99; S, 7.98.

$BrCH_2COOH$·1: Obtained as white crystals in 91% (61 mg). Mp 76−77 °C (from Et_2O); $[\alpha]^{22}_D$ −7.6° (*c* 0.98 in CH_2Cl_2). IR (KBr) 3200, 3038, 2984, 2448, 1616, 1591, 1554, 1458 cm^{-1}; ^1H NMR (500 MHz; $CDCl_3$) 1.63 (d, 3 H, *J* = 7.0 Hz), 1.82−1.94 (m, 3 H), 2.45−2.55 (m, 1 H), 3.16−3.24 (m, 1 H), 3.24−3.30 (m, 1 H), 3.74 (s, 2 H), 4.78 (m, 1 H), 5.56 (m, 1 H), 7.20−7.37 (m, 5 H), 7.35−8.40 (brs, 2 H), 10.94 (brs, 1 H). ^{13}C NMR (125 MHz; $CDCl_3$) 20.2, 25.0, 31.0, 33.4, 46.4, 55.9, 63.4, 126.7, 127.4, 128.4, 140.7, 171.9, 197.0. Anal. Calcd for $C_{15}H_{21}BrN_2O_2S$: C, 48.26; H, 5.67; N, 7.50. Found: C, 48.30; H, 5.59; N, 7.61.

ICH_2COOH·1: Obtained as white crystals in 91% (88 mg). Mp 77−79 °C (from Et_2O); $[\alpha]^{22}_D$ −0.55° (*c* 1.07 in CH_2Cl_2). IR (KBr) 3201, 3041, 2981, 2953, 2442, 1618, 1586, 1548 cm^{-1}. ^1H NMR (500 MHz; $CDCl_3$) 1.64 (d, 3 H, *J* = 6.7 Hz), 1.85−1.95 (m, 3 H), 2.45−2.55 (m, 1 H), 3.17−3.24 (m, 1 H), 3.25−.32 (m, 1 H), 3.55 (s, 2 H), 4.77−4.82 (m, 1 H), 5.59 (m, 1 H), 7.21−7.40 (m, 5 H), 7.35−8.10 (m, 2 H), 10.68 (brs, 1 H). ^{13}C NMR (125 MHz; $CDCl_3$) 20.7, 25.3, 33.8, 46.7, 56.0, 63.9, 127.0, 127.7, 128.7, 141.0, 173.7, 197.8. Anal. Calcd for $C_{15}H_{21}IN_2O_2S$: C, 42.87; H, 5.04; N, 6.67. Found: C, 42.96; H, 5.00; N, 6.58.

HCl·1: Obtained as white crystals in 96% (90 mg). Mp 177−178 °C (from Et_2O); $[\alpha]^{22}_D$ +70.9° (*c* 0.53 in MeOH). IR (KBr) 3391, 3160, 3010, 2970, 2737, 1551, 1441 cm^{-1}. ^1H NMR (500 MHz; $CDCl_3$) 1.67 (d, 3 H, *J* = 7.0 Hz), 1.80−1.90 (m, 1 H), 1.92−2.03 (m, 2 H), 2.74 (m, 1 H), 3.25−3.34 (m, 1 H), 3.43−3.52 (m, 1 H), 5.00 (m, 1 H), 5.49 (quintet, 1 H, *J* = 7.1 Hz), 7.20 (m, 1 H), 7.26 (m, 2 H), 7.38−7.41 (m, 2 H), 7.96 (brs, 1 H), 10.84 (brs, 1 H), 11.54 (d, 1 H, *J* = 7.4 Hz). ^{13}C NMR (125 MHz; $CDCl_3$) 21.1, 25.4, 34.0, 47.0, 57.0, 63.3, 127.1, 127.6, 128.6, 141.0, 195.3. Anal. Calcd for $C_{13}H_{19}ClN_2S$: C, 57.65; H, 7.07; N, 10.34. Found: C, 57.61; H, 7.09; N, 10.34.

HBr·1: Obtained as white crystals in 87% (55 mg). Mp 178−180 °C (from Et_2O/hexanes); $[\alpha]^{22}_D$ +60.6° (*c* 0.99 in MeOH). IR (KBr) 3469, 3165, 3024, 2970, 2921, 2734, 2684, 1547, 1458 cm^{-1}. ^1H NMR (500 MHz; $CDCl_3$) 1.69 (d, 3 H, *J* = 7.0 Hz), 1.80−1.91 (m, 1 H), 1.99 (m, 2 H), 2.81 (m, 1 H), 3.30 (m, 1 H), 3.52 (m, 1 H), 5.09 (m, 1 H), 5.51 (m, 1 H), 7.19−7.30 (m, 3 H), 7.40−7.45 (m, 2 H), 8.17 (brs, 1 H), 10.02 (brs, 1 H), 11.02 (d, 1 H, *J* = 7.5 Hz). ^{13}C NMR (125 MHz; $CDCl_3$) 21.2, 25.3, 34.1, 47.1, 57.2, 63.0, 127.2, 127.7, 128.6, 140.8, and 195.2. Anal. Calcd for $C_{13}H_{19}BrN_2S$: C, 49.53; H, 6.07; N, 8.89. Found: C, 49.73; H, 5.93; N, 8.74.

4-Methylbenzoic Acid·1: Obtained as white crystals in 25% (30 mg). Mp 101−103 °C (from Et_2O/hexanes). $[\alpha]^{22}_D$ −5.58° (*c* 0.97 in CH_2Cl_2). IR (KBr) 3166, 3062, 3032, 2958, 2920, 2879, 1606, 1591, 1551, 1455 cm^{-1}. ^1H NMR (500 MHz; $CDCl_3$) 1.63 (d, 3 H, *J* = 7.0 Hz), 1.80−2.00 (m, 2 H), 1.96 (m, 1 H), 2.42 (s, 3 H), 2.52 (m, 1 H), 3.13 (dt, 1 H, *J* = 10.7, 6.7 Hz), 3.26 (dt, 1 H, *J* = 10.7, 6.6 Hz), 4.79 (dd, 1 H, *J* = 8.5, 6.6 Hz), 5.62 (brs, 1 H), 7.20−7.30 (m, 5 H), 7.31−7.35 (m, 2 H), 7.65 (brs, 1 H), 7.92−7.96 (m, 2 H), 10.61 (brs, 1 H). ^{13}C NMR (125 MHz; $CDCl_3$) 20.8, 21.7, 25.7, 34.1, 47.0, 54.9, 65.6, 126.6, 127.5, 128.3, 128.7, 129.0, 130.0, 141.4, 143.5, 171.4, 200.0. Anal. Calcd for $C_{21}H_{26}N_2O_2S$: C, 68.08; H, 7.07; N, 7.56. Found: C, 68.09; H, 7.08; N, 7.46.

3,5-Dinitrobenzoic Acid·1: Obtained as white crystals in 91% (69 mg). Mp 159−161 °C dec (from Et_2O). $[\alpha]^{22}_D$ +42.24° (*c* 0.54 in MeOH). IR (KBr) 3202, 3030, 2980, 2944, 1631, 1544 cm^{-1}. ^1H NMR (500 MHz; d_6-DMSO) 1.52 (d, 3 H, *J* = 6.9 Hz), 1.82−1.95 (m, 3 H), 2.34−2.42 (m, 1 H), 3.20−3.32 (m, 2 H), 4.51 (m, 1 H), 5.54 (m, 1 H), 7.23−7.27 (m, 1 H), 7.30−7.38 (m, 4 H), 8.85 (t, 1 H, *J* = 2.2 Hz), 8.91 (d, 2 H, *J* = 2.2 Hz), 11.11 (brs, 1 H). ^{13}C NMR (125 MHz; d_6-DMSO) 20.7, 24.2, 32.7, 46.0, 54.3, 64.5, 95.4, 119.4, 126.4, 127.2, 128.3, 128.4, 141.7, 141.8, 147.8, 164.5, 197.8. Anal. Calcd for $C_{20}H_{22}N_4O_6S$: C, 53.80; H, 4.97; N, 12.55; S, 7.18. Found: C, 53.86; H, 4.81; N, 12.64; S, 7.21.

2-Hydroxybenzoic Acid·1: Obtained as white crystals in 90% (64 mg). Mp 140−142 °C (from Et_2O); $[\alpha]^{22}_D$ −36.50° (*c* 0.95 in CH_2Cl_2). IR (KBr) 3454, 3176, 3066, 2977, 2936, 2897, 1638, 1590, 1550, 1485 cm^{-1}. ^1H NMR (500 MHz; $CDCl_3$) 1.59 (d, 3 H, *J* = 6.9 Hz), 1.90−1.98 (m, 3 H), 2.45−2.55 (m, 1 H), 3.19−3.25 (m, 1 H), 3.31 (m, 1 H), 4.88 (dd, 1 H, *J* = 8.0, 6.4 Hz), 5.57 (quintet, 1 H, *J* = 7.0 Hz), 6.80 (m, 1 H), 6.91 (d, 1 H, *J* = 7.8 Hz), 7.18−7.27 (m, 4 H), 7.29−7.36 (m, 3 H), 7.77 (dd, 1 H, *J* = 7.8, 1.8 Hz), 9.05 (brs, 2 H), 10.67 (brd, 1 H, *J* = 5.6 Hz). ^{13}C NMR (125 MHz; $CDCl_3$) 20.3, 25.3, 33.5, 46.7, 56.2, 63.8, 116.9, 118.3, 126.9, 127.8, 128.8, 130.5, 133.9, 140.6, 161.6, 174.8, 197.0; HRMS (ESI) (positive ion) calcd for $C_{13}H_{19}N_2S$ [**1** + H]$^+$ 235.1264; found 235.1268; (negative ion) calcd for $C_7H_5O_3$ 137.0244; found 137.0241.

4-Methylbenzenesulfonic Acid·1: Obtained as white crystals in 97% (62 mg). Mp 197−199 °C dec (from Et_2O); $[\alpha]^{22}_D$ −23.6° (*c* 1.10 in CH_2Cl_2). IR (KBr) 3214, 3047, 2977, 1569, 1465, 1451 cm^{-1}. ^1H NMR (500 MHz; $CDCl_3$) 1.55 (d, 3 H, J = 7.0 Hz), 1.75−1.85 (m, 3 H), 2.34 (s, 3 H), 2.60−2.70 (m, 1 H), 3.15−3.25 (m, 1 H), 3.35−3.45 (m, 1 H), 5.05 (m, 1 H), 5.48 (m, 1 H), 7.08−7.12 (m, 2 H), 7.16−7.20 (m, 2 H), 7.31−7.36 (m, 3 H), 7.65−7.69 (m, 2 H), 8.11 (brs, 1 H), 9.95 (brs, 1 H), 10.89 (d, 1 H, J = 7.5 Hz). ^{13}C NMR (125 MHz; $CDCl_3$) 21.0, 21.3, 25.1, 33.7, 47.1, 57.0, 63.9, 125.9, 127.0, 127.4, 128.5, 129.0, 140.6, 141.1, 141.5, 196.1. Anal. Calcd for $C_{20}H_{26}N_2O_3S_2$: C, 59.08; H, 6.45; N, 6.89; S, 15.77. Found: C, 58.78; H, 6.41; N, 6.75; S, 15.56.

CF_3SO_3H·1: Obtained as white crystals in 85% (83 mg). Mp 135−136 °C (from Et_2O); $[\alpha]^{22}_D$ −21.6° (*c* 0.57 in CH_2Cl_2). IR (KBr) 3281, 3031, 3009, 2979, 2948, 1541, 1456 cm^{-1}. ^1H NMR (500 MHz; $CDCl_3$) 1.61 (d, 3 H, J = 7.0 Hz), 1.84−1.90 (m, 1 H), 1.93−2.03 (m, 2 H), 2.66 (m, 1 H), 3.30−3.39 (m, 1 H), 3.40−3.50 (m, 1 H), 4.73 (m, 1 H), 5.47 (m, 1 H), 7.23−7.37 (m, 5 H), 8.30 (brs, 1 H), 8.60 (brs, 1 H), 9.86 (d, 1 H, J = 7.1 Hz). ^{13}C NMR (125 MHz; $CDCl_3$) 20.9, 25.0, 33.5, 47.5, 57.1, 64.0, 126.9, 127.7, 128.7, 140.7, 195.8. Anal. Calcd for $C_{14}H_{19}F_3N_2O_3S$: C, 43.74; H, 4.98; N, 7.29. Found: C, 43.55; H, 4.87; N, 7.19.

HCO_2H·1: Obtained as white crystals in 82% (43 mg). Mp 99−101 °C (from Et_2O); $[\alpha]^{22}_D$ −5.9° (*c* 0.95 in CH_2Cl_2). IR (KBr) 3427, 3176, 2973, 2773, 1619, 1561, 1455 cm^{-1}. ^1H NMR (500 MHz; $CDCl_3$) 1.60 (d, 3 H, J = 7.0 Hz), 1.82−1.94 (m, 3 H), 2.36−2.46 (m, 1 H), 3.15−3.20 (m, 1 H), 3.22−3.28 (m, 1 H), 4.70 (dd, 1 H, J = 8.2, 5.9 Hz), 5.60 (m, 1 H), 7.20−7.25 (m, 1 H), 7.27−7.32 (m, 4 H), 8.09−8.50 (brs, 2 H), 8.32 (s, 1 H), 11.43 (brs, 1 H). ^{13}C NMR (125 MHz; $CDCl_3$) 20.5, 25.4, 33.8, 46.5, 55.5, 64.1, 126.7, 127.6, 128.6, 141.2, 168.1, 198.5. Anal. Calcd for $C_{14}H_{20}N_2O_2S$: C, 59.97; H, 7.19; N, 9.99; S, 11.44. Found: C, 60.03; H, 7.17; N, 9.76; S, 11.38.

(*R*)-Mandelic Acid·1: Obtained as white crystals in 90% (89 mg). Mp 111−113 °C (from Et_2O); $[\alpha]^{22}_D$ +9.54° (*c* 0.81 in CH_2Cl_2). IR (KBr) 3379, 3180, 3028, 2970, 2878, 1615, 1559, 1453 cm^{-1}. ^1H NMR (500 MHz; $CDCl_3$) 1.54 (d, 3 H, J = 7.0 Hz), 1.58−1.71 (m, 3 H), 2.07−2.16 (m, 1 H), 2.86−2.92 (m, 2 H), 4.53 (dd, 1 H, J = 6.7, 6.6 Hz), 4.86 (s, 1 H), 5.51 (brd, 1 H, J = 6.0 Hz), 7.20−7.32 (m, 8 H), 7.35−7.40 (m, 2 H), 11.00 (brs, 1 H). ^{13}C NMR (125 MHz; $CDCl_3$) 20.6, 25.1, 33.3, 46.5, 55.9, 63.8, 74.5, 126.8, 127.0, 127.5, 127.7, 128.3, 128.7, 141.0, 141.6, 178.1, 197.0, 225.7. Anal. Calcd for $C_{21}H_{26}N_2O_3S$: C, 65.26; H, 6.78; N, 7.25. Found: C, 65.14; H, 6.82; N, 7.12.

(*S*)-Mandelic Acid·1: Obtained as white crystals in 92% (91 mg). Mp 113−114 °C (from Et_2O); $[\alpha]^{22}_D$ +8.60° (*c* 0.97 in CH_2Cl_2). IR (KBr) 3380, 3179, 3028, 2970, 1615, 1559, 1453 cm^{-1}. ^1H NMR (500 MHz; $CDCl_3$) 1.54 (d, 3 H, J = 7.0 Hz), 1.58−1.71 (m, 3 H), 2.01−2.19 (m, 1 H), 2.88 (t, 2 H, J = 6.8 Hz), 4.53 (dd, 1 H, J = 8.2, 6.6 Hz), 4.86 (s, 1 H), 5.51 (m, 1 H), 7.20−7.33 (m, 8 H), 7.35−7.40 (m, 2 H), 11.03 (brs, 1 H). ^{13}C NMR (125 MHz; $CDCl_3$) 20.6, 25.1, 33.2, 46.5, 56.0, 63.7, 74.5, 126.8, 127.0, 127.5, 127.7, 128.3, 128.7, 141.0, 141.6, 178.1, 197.0. Anal. Calcd for $C_{21}H_{26}N_2O_3S$: C, 65.26; H, 6.78; N, 7.25; S, 8.30. Found: C, 65.18; H, 6.56; N, 7.21; S, 8.32.

General Procedure for the Aldol Reaction Catalyzed by Isolated L-Prolinethioamide Salts. To a solution of HX**·1** (as noted in table, mmol) in acetone (2 mL) was added aldehyde **2** (1 mmol) at 0 °C. The resulting solution was stirred at 4 °C for 60 h. After this time, the solution was quenched with saturated aqueous ammonium chloride and extracted with ethyl acetate (3×). The combined organic layers were dried over $NaSO_4$, filtered, and evaporated in vacuo. Purification using column chromatography (hexanes/AcOEt) gave aldol product **3**.[32]

General Procedure for the Aldol Reaction Catalyzed by L-Prolinethioamide Salts Prepared in Situ. 1 (as noted in table, mmol) was dissolved in acetone (2 mL) and treated with an equimolar amount of an acid. The resulting solution was stirred for 5 min, and then it was cooled to 0 °C. Aldehyde **2** (1 mmol) was added, and the resulting solution was stirred at 4 °C for 60 h. After this time, the solution was quenched with saturated aqueous ammonium chloride and extracted with ethyl acetate (3×). The combined organic layers were dried over $NaSO_4$, filtered, and evaporated in vacuo. Purification using column chromatography (hexanes/AcOEt) gave aldol product **3**.[32]

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Supporting Information Available: ^1H NMR spectra of TFA, Cl_2CHCO_2H, Cl_3CCO_2H, $BrCH_2CO_2H$, CF_3SO_3H, ICH_2CO_2H, and HCl salts of **1** in d_6-acetone. COSY, GHSQC, and GHMBQ spectra of TFA**·1** in d_6-acetone with the complete assignment. ESI-MS spectra of TFA, Cl_2CHCO_2H, ICH_2CO_2H, and CF_3SO_3H salts of **1** in acetone. X-ray structure of TFA**·1** and CF_3SO_3H**·1** and crystallographic information files. This material is available free of charge via the Internet at http://pubs.acs.org.

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