

# CHEMISTRY & SUSTAINABILITY

# CHEM5USCHEM

#### **ENERGY & MATERIALS**

## **Accepted Article**

Title: Novel Rh(III)-Catalyzed Asymmetric Transfer Hydrogenation of  $\alpha$ -Methoxy  $\beta$ -Ketoesters via DKR in Water: Toward a Greener Procedure

Authors: Virginie Vidal, Bin He, Long-Sheng Zheng, and Phannarath Phansavath

This manuscript has been accepted after peer review and appears as an Accepted Article online prior to editing, proofing, and formal publication of the final Version of Record (VoR). This work is currently citable by using the Digital Object Identifier (DOI) given below. The VoR will be published online in Early View as soon as possible and may be different to this Accepted Article as a result of editing. Readers should obtain the VoR from the journal website shown below when it is published to ensure accuracy of information. The authors are responsible for the content of this Accepted Article.

To be cited as: ChemSusChem 10.1002/cssc.201900358

Link to VoR: http://dx.doi.org/10.1002/cssc.201900358



WILEY-VCH

www.chemsuschem.org

#### COMMUNICATION

# Novel Rh(III)-Catalyzed Asymmetric Transfer Hydrogenation of $\alpha$ -Methoxy $\beta$ -Ketoesters *via* DKR in Water: Toward a Greener Procedure

Bin He,<sup>[a]</sup> Long-Sheng Zheng,<sup>[a]</sup> Phannarath Phansavath<sup>\*[a]</sup> and Virginie Ratovelomanana-Vidal<sup>\*[a]</sup>

The asymmetric reduction of  $\alpha$ -methoxy  $\beta$ -ketoesters through transfer hydrogenation using a new rhodium(III) complex is reported. The reaction was efficient in 2-MeTHF with formic acid/triethylamine or in water with sodium formate. The corresponding *syn*  $\alpha$ -methoxy  $\beta$ -hydroxyesters were obtained with high diastereoselectivities and excellent levels of enantioselectivity via a dynamic kinetic resolution process.

Although numerous methods are available the for enantioselective preparation of 1,2-diol derivatives,[1] most of them do not allow differentiation of the two hydroxyl functions and only few examples of the preparation of monodifferentiated diols have been described.<sup>[2]</sup> A straightforward and atomeconomical access to such compounds involves the asymmetric reduction through dynamic kinetic resolution (DKR)<sup>[3]</sup> of racemic  $\alpha$ -alkoxy  $\beta$ -ketoester derivatives. In this context, we have reported in a previous work the asymmetric transfer hydrogenation (ATH)<sup>[4]</sup> of these compounds through DKR to access the corresponding enantiomerically enriched syn aalkoxy  $\beta$ -hydroxyesters directly<sup>[5]</sup> by using ruthenium complexes in dichloromethane and a 5:2 mixture of formic acid/triethylamine as the hydrogen source. In search of a greener approach, we decided to investigate this reaction in more ecofriendly solvents and water appeared as the solvent of choice for this transformation. As far as rhodium-catalyzed asymmetric transfer hydrogenation through DKR in water is concerned, to the best of our knowledge, only two examples were previously disclosed<sup>[6]</sup> (Figure 1).





[a] B. He, L.-S. Zheng, Dr P. Phansavath, Dr V. Ratovelomanana-Vidal PSL Research University, Chimie ParisTech, CNRS, *i*-CLeHS (Institute of Chemistry for Life & Health Sciences), CSB2D team 75005 Paris, France phannarath.phansavath@chimieparistech.psl.eu; virginie.vidal@chimieparistech.psl.eu Supporting information for this article is given via a link at the end of the document. In these instances, the reaction was performed on bicyclic  $\beta$ ketoesters with a Rh catalyst formed from a chiral double-chain surfactant-type ligand giving high enantioselectivities and diastereoselectivities but moderate yield for the 6-membered  $\beta$ hydroxyester. Herein we report an environmentally sustainable procedure for the ATH/DKR of  $\alpha$ -alkoxy  $\beta$ -ketoesters in water involving a new rhodium complex (Figure 1). In line with the 12 principles of green chemistry,<sup>[7]</sup> one key point of our ATH/DKR process was to use an easy-to-handle and air-stable complex that would operate under environmentally sound conditions. As part of our ongoing studies aimed at developing efficient catalysts for the asymmetric reduction of unsaturated compounds, we recently developed a series of tethered rhodium complexes (R,R)-A-(R,R)-D,<sup>[8]</sup> analogous to Wills' complex,<sup>[9]</sup> that we chose to evaluate in this study and additionally, we prepared a new N-pentafluorophenylsulfonyl-DPEN-based tethered Rh(III) complex (R,R)- $\mathbf{E}^{[10]}$  (see the Supporting Information) (Figures 2 and 3).



Figure 2. Rhodium complexes used in this study.



**Figure 3.** X-Ray crystallographic structure of (R,R)-**E** (hydrogen atoms are omitted for clarity).

#### Table 1. Precatalyst screening.<sup>[a]</sup>

Í	O O OMe rac-1a	Me — H	Cat. (S/C = 200) OH O   HCO <sub>2</sub> H/Et <sub>3</sub> N (5:2) OMe   CH <sub>2</sub> Cl <sub>2</sub> , 30 °C OMe			
Entry	Cat.	<i>t</i> [h]	yield [%] <sup>[b]</sup>	dr [syn/anti] <sup>[c]</sup>	$ee_{syn}$ [%] <sup>[d]</sup>	
1	(R,R)- <b>A</b>	1	91	91:9	99	
2 <sup>[e]</sup>	(R,R)- <b>A</b>	22	90	88:12	99	
3	(R,R)- <b>B</b>	1	89	91:9	99	
4	(R,R)- <b>C</b>	3	89	91:9	99	
5	(R,R)- <b>D</b>	3	92	89:11	99	
6	( <i>R</i> , <i>R</i> )- <b>E</b>	3	94	93:7	>99	

[a] Conditions: **1a** (0.8 mmol), [Rh] complex (0.5 mol%), HCO<sub>2</sub>H/Et<sub>3</sub>N (5:2) (134  $\mu$ L, 2 equiv), CH<sub>2</sub>Cl<sub>2</sub> (4.0 mL) at 30 °C, full conversion. [b] Isolated yields. [c] Determined by <sup>1</sup>H NMR of the crude product after the ATH reaction. [d] Determined by HPLC analysis using a chiral stationary phase. [e] The reaction was carried out at 0 °C.

We first examined the catalytic activity of complexes (*R*,*R*)-**A**–(*R*,*R*)-**E** in the asymmetric reduction of methyl 2-methoxy-3-oxo-3-phenylpropanoate *rac*-**1a**. The ATH/DKR of *rac*-**1a** was initially performed in dichloromethane at 30 °C with 0.5 mol% of the Rh complexes (*R*,*R*)-**A**–(*R*,*R*)-**E** and a HCO<sub>2</sub>H/Et<sub>3</sub>N (5:2) azeotropic mixture as the hydrogen source (Table 1). Under these conditions, high yields (89–94%) and levels of diastereoselection (88:12 to 93:7 dr) were observed for the corresponding *syn*  $\alpha$ methoxy  $\beta$ -hydroxyester **2a** which was obtained with an excellent enantioselectivity (99% ee). When the reaction was carried out at 0 °C with complex (*R*,*R*)-**A**, a longer reaction time was required but no improvement was observed in terms of diastereoselectivity (88:12 dr) (Table 1, entry 2).

Although all tested rhodium complexes (R,R)-A-(R,R)-E showed comparable results in terms of yields and stereoinduction, the newly prepared complex (R,R)-E gave the highest yield (94%) and the best level of diastereoselectivity (93:7) in favor of the syn 1,2-diol 2a (Table 1, entry 6). Therefore, rhodium complex (R,R)-E was used for further screening of the reaction parameters and the influence of greener solvents was next investigated (Figure 4). The results obtained in toluene, i-PrOH, AcOEt and dimethyl carbonate (DMC) matched those previously observed in CH<sub>2</sub>Cl<sub>2</sub> in terms of yields but not for the *de* values which were higher (88-90% *de vs* 86% *de* in CH<sub>2</sub>Cl<sub>2</sub>). The neat reaction gave high yield and enantiomeric excess, but a lower diastereoselectivity (62% de). Interestingly, the use of the ecofriendly solvent 2-MeTHF resulted in а high diastereoselectivity (94% de) affording a satisfying 93% yield of 2a. Aiming at ever greener procedures, we next sought to perform the reaction in aqueous media and we chose to use a 1:3 mixture of 2-MeTHF/H<sub>2</sub>O with sodium formate as the hydrogen source. These conditions did not allow a complete conversion (58% yield) but addition of 0.2 equiv of CTAB (cetyltrimethylammonium bromide) as a surfactant resulted in 82% yield of 2a. A higher yield of 90% could be reached when switching the reaction temperature from 30 °C to 40 °C whereas increasing the amount of water in the solvent mixture (from 2-MeTHF/H<sub>2</sub>O 1:3 to 1:6) had no significant effect. We next performed the reaction in water alone as a solvent under otherwise identical conditions (Figure 5).



Reaction conditions: **1a** (0.8 mmol), (R,R)-**E** (0.5 mol%), HCO<sub>2</sub>H/Et<sub>3</sub>N 5:2 (2 equiv) or HCO<sub>2</sub>Na (8 equiv), solvent (4.0 mL), 30 °C or 40 °C, 3-40 h. **Figure 4.** Optimization of the reaction conditions for the ATH of **1a** with (R,R)-**E**.

#### COMMUNICATION



Figure 5. Optimization of the reaction conditions in water at 40 °C with (R,R)-E.

In that case, a lower yield was obtained (84%), however, we found the amount of sodium formate to be essential for the asymmetric reduction, because decreasing the amount to 5 equiv provided a high yield of 92% whereas the use of 3 equiv afforded 2a in only 83% yield (Figure 5). It should be noted that lowering the catalyst loading to 0.25 mol% resulted only in longer reaction times with no beneficial impact on the stereoselectivity of the reduction. On the other hand, incomplete conversions were observed when SDS (sodium dodecyl sulfate) was used as a surfactant, or when ammonium formate acted as the hydrogen source. From these results, 2-MeTHF and water were selected as greener solvents for the remainder of the study and the optimized reaction conditions were set as follows: 2a, (R,R)-E (S/C 200), HCO<sub>2</sub>H/Et<sub>3</sub>N (5:2) (2.0 equiv), 2-MeTHF, 30 °C, or 2a, (R,R)-E (S/C 200), HCO<sub>2</sub>Na (5.0 equiv), H<sub>2</sub>O, CTAB (0.2 equiv), 40 °C. With these optimized conditions in hand, we then investigated the scope of the Rh-catalyzed ATH/DKR of  $\alpha$ -methoxy  $\beta$ -ketoesters with a series of variously substituted aryl ketones 1b-1m. We first studied the asymmetric reduction of substrates 1b-1f having electron-donating substituents on the aromatic ring. Compounds bearing methyl, methoxy or benzyloxy substituents on the benzene core at the or para positions afforded high levels meta of diastereoselectivities, from 95:5 to 98:2 dr, with excellent ee values observed in all cases (Table 2, entries 2-6). Substrates 1g-1j containing electron-withdrawing groups on the benzene ring such as fluoro, trifluoromethyl or bromo substituents, were investigated as well, and displayed good to high yields (68-97%), high levels of diastereocontrol (95:5 to 99:1 dr) and excellent enantioselectivities (>99% ee) (Table 2, entries 7-10). Interestingly, investigation of heteroaromatic substrates 1k-1l resulted in almost perfect diastereoselectivities (99:1 to >99:1 dr) and excellent enantioselectivities (Table 2, entries 11 and 12, >99% ee). To complete the substrate scope, the sterically demanding compound 1m having an ortho-substituted phenyl group was submitted to the ATH conditions and delivered the syn alcohol in good yield, high diastereoselectivy and good enantioselectivity in water, whereas the reaction was sluggish in 2-MeTHF and gave a lower yield (Table 2, entry 13). This study showed that homogeneously high levels of stereoselectivity were observed both in water in open flask and in 2-MeTHF, whereas higher yields were achieved in water in several instances (Table 2, entries 7-10 and 12-13). It should be noted that the methyl protecting group of compounds 2 could be removed to provide the corresponding syn-1,2-diols.[2a]

#### WILEY-VCH

Table 2. Substrate scope.								
	$\begin{array}{c} (R,R) - \mathbf{E} \ (0.5 \ \text{mol}^{9}) \\ \hline \\ OMe \end{array} \qquad \begin{array}{c} (R,R) - \mathbf{E} \ (0.5 \ \text{mol}^{9}) \\ \hline \\ (R,R) - \mathbf{E} \ (0.5 \ \text{mol}^{9}) \\ \hline \end{array}$	$(R,R)-E (0.5 \text{ mol}\%), HCO_2H/Et_3 = \frac{2-MeTHF, 30 \circ C}{\sigma r}$						
rac- <b>1a-</b> 1	CTAB (0.2 ec	$(uiv), H_2$	0, 40 °C	2a-	2a-2m			
entry/ATH product <b>2</b> <sup>[a],[b]</sup>		<i>t</i> [h]	yield [%] <sup>[c]</sup>	dr <i>syn/anti<sup>[d]</sup></i>	ee <sub>svn</sub> [%] <sup>[e]</sup>			
1/ <b>2a</b>	OH O OMe OMe	5 4	93 92	97:3 98:2	99 >99			
2/ <b>2b</b>	Me OMe OMe	7 6	80 84	97:3 97:3	>99 >99			
3/ <b>2c</b>	MeO	8 6	80 83	96:4 97:3	>99 >99			
4/ <b>2</b> d	OH O OMe MeO	45 6	82 85	96:4 96:4	>99 >99			
5/ <b>2e</b>	OH O OMe BnO	8 24	92 93	97:3 98:2	>99 >99			
6/ <b>2f</b>	MeO OMe OMe	14 24	83 80	95:5 96:4	99 >99			
7/ <b>2</b> g	OH O OH O OMe	7 6	68 73	98:2 98:2	>99 >99			
8/ <b>2h</b>	GH O GMe F <sub>3</sub> C	8 24	80 89	97:3 95:5	>99 >99			
9/ <b>2i</b>	OH O OMe Br	22 4	82 97	97:3 96:4	>99 >99			
10/ <b>2j</b>	Br OMe OMe	8 4	68 92	99:1 96:4	>99 >99			
11/ <b>2k</b>	OH O OMe S OMe	14 6	91 88	>99:1 >99:1	>99 >99			
12/ <b>2I</b>	OH O OMe O OMe	10 4	86 98	99:1 >99:1	>99 >99			
13/ <b>2m</b>	MeO OH O	111 5	67 81	96:4 98:2	88 88			

[a] Conditions A: **1** (0.8 mmol), (*R*,*R*)-**E** (0.5 mol%), HCO<sub>2</sub>H/Et<sub>3</sub>N (5:2) (134  $\mu$ L, 2 equiv), 2-MeTHF (4.0 mL) at 30 °C, full conversion. [b] Conditions B: **1** (0.6 mmol), (*R*,*R*)-**E** (0.5 mol%), HCO<sub>2</sub>Na (5.0 equiv), H<sub>2</sub>O (1.5 mL), CTAB (0.2 equiv), 40 °C, full conversion. [c] Isolated yields. [d] Determined by <sup>1</sup>H NMR of the crude product after the ATH reaction. [e] Determined by HPLC analysis using a chiral stationary phase.

ŌMe

#### WILEY-VCH

### COMMUNICATION

Finally, a scale-up experiment performed on compound **1a** (1.25 g, 6.0 mmol) in water delivered the reduced  $\alpha$ -methoxy  $\beta$ -hydroxyester **2a** in 88% yield and the same high level of stereoselectivity as on a 0.6 mmol scale, demonstrating the usefulness of the procedure.

In conclusion, we have prepared a new rhodium catalyst having electron-deficient diamine ligand an carrying а pentafluorobenzenesulfonyl substituent. The fully novel characterized Rh-complex is not sensitive to water or air, is convenient to handle and was efficiently used for the asymmetric transfer hydrogenation of  $\alpha$ -methoxy  $\beta$ -keto esters with either HCO<sub>2</sub>H/Et<sub>3</sub>N (5:2) at a low catalyst loading in an environmentally sound solvent, 2-MeTHF, or with HCO<sub>2</sub>Na in water in open flask. This catalytic atom-economical ATH reaction proceeds in water using a dynamic kinetic resolution process affording monodifferentiated β-hydroxyester derivatives in high yields (up to 98%), high levels of diastereoselection (up to >99:1), and excellent ee values (up to >99%).

#### **Experimental Section**

General procedure for the asymmetric transfer hydrogenation of compounds 1a-1m in 2-MeTHF: a round-bottomed tube equipped with a balloon of argon was charged with  $\alpha$ -methoxyl  $\beta$ -keto ester 1 (0.8 mmol) and the rhodium complex (R,R)-E (4.0  $\mu$ mol, 0.5 mol%). The solids were subjected to three vacuum/argon cycles before anhydrous 2-MeTHF (4.0 mL) was added. The mixture was stirred at rt for 3-5 min, and the tube was transferred into a 30 °C oil bath, before the HCO<sub>2</sub>H/Et<sub>3</sub>N (5:2) azeotropic mixture (134 µL, 1.6 mmol, 2.0 equiv) was added dropwise. After complete consumption of the starting material (monitored by TLC or <sup>1</sup>H NMR), the reaction mixture was concentrated under vacuum, quenched with sat. NaHCO<sub>3</sub>, and extracted with CH<sub>2</sub>Cl<sub>2</sub>. The combined organic layers were washed with brine, dried (MgSO<sub>4</sub>). filtered and concentrated under vacuum. The conversion and diastereomeric ratio were determined by <sup>1</sup>H NMR analysis of the crude product. After filtration of the crude product on silica gel, the enantiomeric excess was determined by HPLC analysis (CHIRALPAK IA, IB, IC or IE column).

General procedure for the asymmetric transfer hydrogenation of compounds 1a-1m in water: a round-bottomed tube was charged with  $\alpha$ -methoxyl  $\beta$ -keto ester 1 (0.6 mmol), sodium formate (3.0 mmol), cetyltrimethylammonium bromide (0.12 mmol, 20 mol%), the rhodium complex (*R*,*R*)-**E** (3.0  $\mu$ mol, 0.5 mol%), water (1.5 mL), and the mixture was stirred at 40 °C. After complete consumption of the starting material (monitored by TLC), the reaction mixture was extracted with 2-MeTHF, the combined organic layers were washed with brine, dried (MgSO<sub>4</sub>), filtered and concentrated under vacuum. The conversion and diastereomeric ratio were determined by <sup>1</sup>H NMR analysis of the crude product. After filtration of the crude product on silica gel, the enantiomeric excess was determined by HPLC analysis (CHIRALPAK IA, IB, IC or IE column).

#### Acknowledgements

This work was supported by the Ministère de l'Education Nationale, de l'Enseignement Supérieur et de la Recherche (MENESR) and the Centre National de la Recherche Scientifique (CNRS). We acknowledge the China Scholarship Council (CSC) for a grant to B. H. and L.-S. Z. B. H. and L.-S. Z. contributed equally. We thank C. Férard for technical assistance. We are grateful to G. Gontard for the X-ray analysis (Sorbonne Université, Paris), to M.-N. Rager for the NMR analysis (Chimie ParisTech, Paris) and to C. Fosse for the mass spectrometry analysis (Chimie ParisTech, Paris).

**Keywords:** asymmetric catalysis • hydrogen transfer • reduction • rhodium • water

- a) H. C. Kolb, M. S. VanNieuwenhze, K. B. Sharpless, *Chem. Rev.* **1994**, *94*, 2483; b) Y. Shi, *Acc. Chem. Res.* **2004**, *37*, 488; c) T. Ikariya, K. Murata, R. Noyori, *Org. Biomol. Chem.* **2006**, *4*, 393; d) G. Guillena, C. Nájera, D. Ramón, *Tetrahedron: Asymmetry* **2007**, *18*, 2249; e) F. Tanaka, C. F. Barbas III, in *Enantioselective Organocatalysis, Reaction and Experimental Procedures* (Ed.: P. I. Dalko), Wiley-VCH, Weinheim, **2007**, pp. 19–55; f) P. Jiao, M. Kawasaki, H. Yamamoto, *Angew. Chem.* **2009**, *121*, 3383; *Angew. Chem. Int. Ed.* **2009**, *48*, 3333.
- [2] a) S. E. Denmark, W.-J. Chung, Angew. Chem. 2008, 120, 1916; Angew. Chem. Int. Ed. 2008, 47, 1890; b) S. E. Denmark, W.-J. Chung, J. Org. Chem. 2008, 73, 4582; c) S. M. Lim, N. Hill, A. G. Myers, J. Am. Chem. Soc. 2009, 131, 5763; d) K. M. Steward, J. S. Johnson, Org. Lett. 2010, 12, 2864; e) S.-M. Son, H.-K. Lee, J. Org. Chem. 2013, 78, 8396; f) S.-M. Son, H.-K. Lee, J. Org. Chem. 2014, 79, 2666; g) N. Alnafta, J. P. Schmidt, C. L. Nesbitt, C. S. P. McErlean, Org. Lett. 2016, 18, 6520; h) L. Fang, S. Liu, L. Han, H. Li, F. Zhao, Organometallics 2017, 36, 1217.
- a) R. Noyori, M. Tokunaga, M. Kitamura, Bull. Chem. Soc. Jpn. 1995, [3] 68, 36; b) S. Caddick, K. Jenkins, Chem. Soc. Rev. 1996, 25, 447; c) R. S. Ward, Tetrahedron: Asymmetry 1995, 6, 1475; d) R. Stürmer, Angew. Chem. 1997, 109, 1221; Angew. Chem. Int. Ed. 1997, 36, 1173; e) M. T. El Gihani, J. M. J. Williams, Curr. Opin. Chem. Biol. 1999, 3, 11; f) V. Ratovelomanana-Vidal, J.-P. Genêt, Can. J. Chem. 2000, 851, 846; g) F. F. Huerta, A. B. E. Minidis, J.-E. Bäckvall, Chem. Soc. Rev. 2001, 30, 321; h) K. Faber, Chem. Eur. J. 2001, 7, 5005; i) O. Pàmies, J.-E. Bäckvall, Chem. Rev. 2003, 103, 3247; j) H. Pellissier, Tetrahedron 2003, 59, 8291; k) N. J. Turner, Curr. Opin. Chem. Biol. 2004, 8, 114; I) E. Vedejs, M. Jure, Angew. Chem. 2005, 117, 4040; Angew. Chem. Int. Ed. 2005, 44, 3974; m) B. Martín-Matute, J.-E. Bäckvall, Curr. Opin. Chem. Biol. 2007, 11, 226; n) H. Pellissier, Tetrahedron 2008, 64, 1563; o) H. Pellissier, Tetrahedron 2011, 67, 3769; p) P.-G. Echeverria, T. Ayad, P. Phansavath, V. Ratovelomanana-Vidal, Synthesis 2016, 48, 2523
- a) G. Zassinovich, G. Mestroni, S. Gladiali, Chem. Rev. 1992, 92, 1051; [4] b) C. F. de Graauw, J. A. Peters, H. van Bekkum, J. Huskens, Synthesis 1994, 1007; c) R. Noyori, S. Hashiguchi, Acc. Chem. Res. 1997, 30, 97; d) M. J. Palmer, M. Wills, Tetrahedron: Asymmetry 1999, 10, 2045; e) O. Pàmies, J.-E. Bäckvall, Chem. Eur. J. 2001, 7, 5052; f) K. Everaere, A. Mortreux, J.-F. Carpentier, Adv. Synth. Catal. 2003, 345, 67; g) S. Gladiali, E. Alberico, Chem. Soc. Rev. 2006, 35, 226; h) S. M. Joseph, J. S. Samec, J.-E. Bäckvall, P. G. Andersson, P. Brandt, Chem. Soc. Rev. 2006, 35, 237; i) Ikariya, T.; Blacker, A. J. Acc. Chem. Res. 2007, 40, 1300; j) A. J. Blacker, in Handbook of Homogeneous Hydrogenation (Eds.: J. G. de Vries, C. J. Elsevier), Wiley-VCH, Weinheim, 2007, pp. 1215–1244; k) C. Wang, X. Wu, J. Xiao, Chem. Asian J. 2008, 3, 1750; I) T. Ikariya, Bull. Chem. Soc. Jpn. 2011, 84, 1; m) A. Bartoszewicz, N. Ahlsten, B. Martín-Matute, Chem. Eur. J. 2013, 19, 7274; n) T. Slagbrand, H. Lundberg, H. Adolfsson, Chem. Eur. J. 2014, 20, 16102; o) B. Štefane, F. Požgan, Catal. Rev. 2014, 56, 82; p) D. Wang, D. Astruc, Chem. Rev. 2015, 115, 6621; g) F. Foubelo, C. Nájera, M. Yus, Tetrahedron: Asymmetry 2015, 26, 769; r) T. Ayad, P. Phansavath, V. Ratovelomanana-Vidal, Chem. Rec. 2016, 16, 2754; s) Matsunami, A.; Kayaki, Y. Tetrahedron Lett. 2018, 59, 504.
- [5] a) D. Cartigny, K. Püntener, T. Ayad, M. Scalone, V. Ratovelomanana-Vidal, *Org. Lett.* **2010**, *12*, 3788; b) L. Monnereau, D. Cartigny, M. Scalone, T. Ayad, V. Ratovelomanana-Vidal, *Chem. Eur. J.* **2015**, *21*, 11799.
- [6] J. Li, Z. Lin, Q. Huang, Q. Wang, L. Tang, J. Zhu, J. Deng, Green Chem. 2017, 19, 5367.
- [7] a) M. E. Eissen, J. O. Metzger, E. Schmidt, U. Schneidewind, Angew. Chem. 2002, 114, 402; Angew. Chem. Int. Ed. 2002, 41, 414; b) P. T. Anastas, J. C. Warner, Green Chemistry: Theory and Practice, Oxford University Press, New York, 1998, p. 15.

#### WILEY-VCH

#### COMMUNICATION

- [8] a) P.-G. Echeverria, C. Férard, P. Phansavath, V. Ratovelomanana-Vidal, *Catal. Comm.* 2015, *62*, 95; b) L.-S. Zheng, Q. Llopis, P.-G. Echeverria, C. Férard, G. Guillamot, P. Phansavath, V. Ratovelomanana-Vidal, *J. Org. Chem.* 2017, *82*, 5607; c) L.-S. Zheng, C. Férard, P. Phansavath, V. Ratovelomanana-Vidal, *Chem. Commun.* 2018, *54*, 283.
- [9] D. S. Matharu, D. J. Morris, A. M. Kawamoto, G. J. Clarkson, M. Wills, Org. Lett. 2005, 7, 5489.
- [10] CCDC-1894366 contains the supplementary crystallographic data for this paper. These data can be obtained free of charge from The Cambridge Crystallographic Data Centre via http://www.ccdc.cam.ac.uk/data\_request/cif.

#### WILEY-VCH

# COMMUNICATION

#### COMMUNICATION



The asymmetric reduction of  $\alpha$ -methoxy  $\beta$ -ketoesters through transfer hydrogenation using a new rhodium(III) complex is reported. The reaction was efficient in 2-MeTHF with formic acid/triethylamine or in water with sodium formate. The corresponding *syn*  $\alpha$ -methoxy  $\beta$ -hydroxyesters were obtained with high diastereoselectivities and excellent levels of enantioselectivity via a dynamic kinetic resolution process. Bin He, Long-Sheng Zheng, Phannarath Phansavath\* and Virginie Ratovelomanana-Vidal\*

#### Page No. – Page No.

Novel Rh(III)-Catalyzed Asymmetric Transfer Hydrogenation of  $\alpha$ -Methoxy  $\beta$ -Ketoesters *via* DKR in Water: Toward a Greener Procedure