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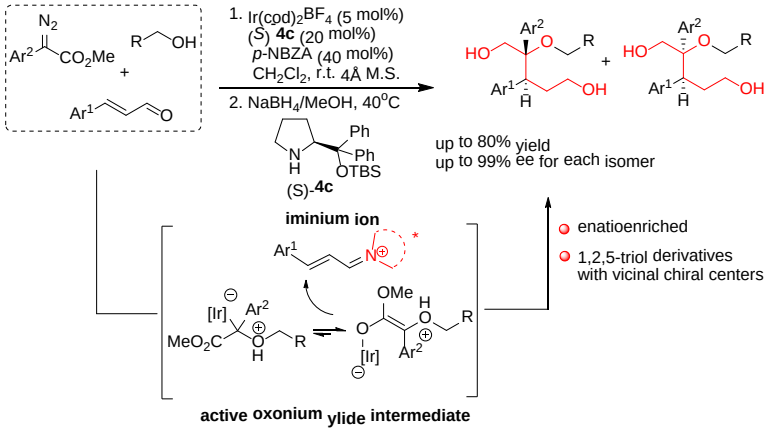
TOC:

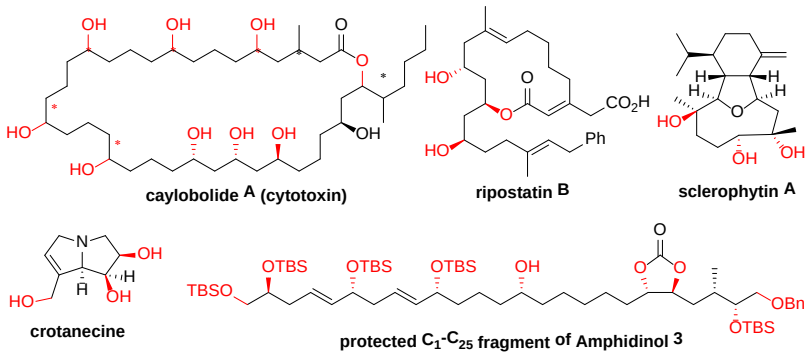


ABSTRACT: 1,2,5-triol derivatives with vicinal chiral centers have been synthesized from simple starting materials by one-pot method in good yields and with an excellent enantioselectivity. This process was promoted by a chiral secondary amine and iridium(I) co-catalyzed three-component reaction of aryldiazoacetates and alcohols with enals as electrophiles followed by a reduction with $NaBH_4$.. Iridium(I)-associated oxonium ylide intermediates were efficiently generated and successfully trapped by the amine-activated enals *via* a selective 1,4-addtition manner, generating enantioselective three-component coupling products.

Introduction

Chiral 1,5-pentanediol scaffolds, including 1,2,5-triols, are important substructures in natural products,[1] such as caylobolide A,[1a] ripostatin B, [1b] sclerophytin A[1c] (Scheme 1).They are also essential building blocks in medicinal chemistry and synthetic organic chemistry owing to their diverse functionalization. [2] A variety of elegant methods have been well-established for the preparation of enantiomerically pure 1,5-pentanediols, including kinetic resolution, [3] substrate induction [4] and asymmetric catalysis. [5] For instance, Zhou et al. developed a highly efficient and practical method by kinetic resolution of racemic aliphatic alcohols via catalytic hydrogenation of hydroxyl esters to prepare optically active *δ*-alkyl-*δ*-hydroxy esters and *δ*-alkyl-1,5-diols. [3a] However, the methods for rapid construction of 1,2,5-triol derivatives are rarely developed. Herein, we reported an efficient chiral secondary amine and iridium(I) complex co-catalyzed enantioselective three-component reaction for rapid construction of enantiomerically pure 1,2,5-triol derivatives with two vicinal chiral centers from simple starting materials under mild conditions.

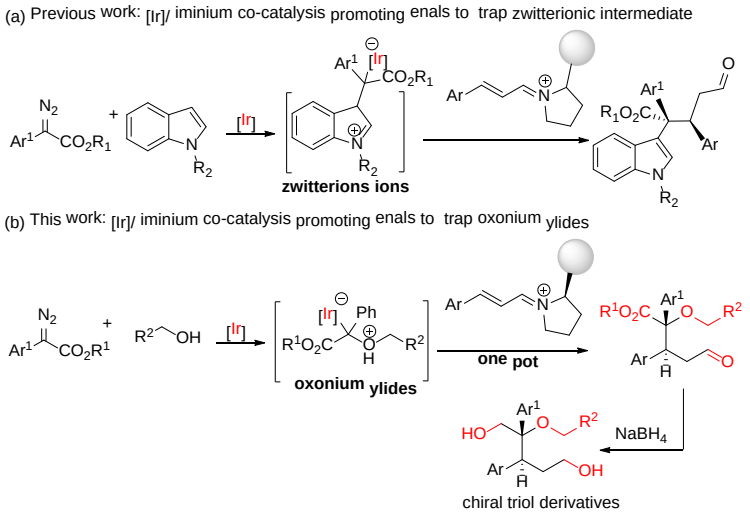
Scheme 1. Selected bioactive natural and synthetic compounds containing chiral 1,5-diols or 1,2,5-triols.



Asymmetric multi-component reaction (AMCR) is an efficient atom- and step-economical fashion for the rapid construction of structurally complex chiral compounds.[6] Based on our continuing interest in developing new AMCRs by trapping

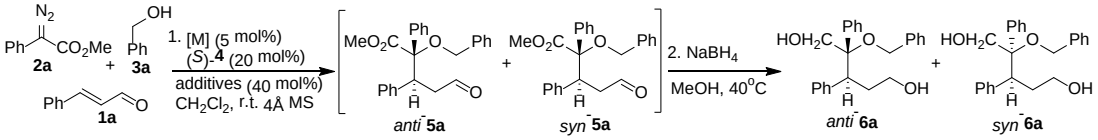
of active intermediates in situ generated from diazo compounds with appropriately activated electrophiles, several efficient co-catalyst systems have been developed.[7-13] For example, the co-catalyst system of $Rh_2(OAc)_4$ and chiral metal complexes afforded an efficient asymmetric trapping of oxonium ylides by aldehydes [8] or acyl imidazoles. [9] The combination of $Rh_2(OAc)_4$ and chiral phosphoric acid (CPA) successfully promoted an enantioselective trapping of oxonium ylides,[10] ammonium ylides[11] and zwitterions with imines, respectively.[12] Very recently, the co-catalytic strategy of combining iridium complex and chiral secondary amine, which is a readily accessible and inexpensive Lewis base co-catalyst, efficiently enabled the trapping of active zwitterionic intermediates with enals in a 1,4-addition manner (Scheme 2a).[13] Thus, we envisioned that the combination of iridium complexes and chiral secondary amines might present a compatible catalytic strategy to promote the trapping of active oxonium ylides generated in situ from diazo compounds and alcohols with enals to rapidly construct chiral 1,2,5-triol scaffolds (Scheme 2b). A possible challenge in this desired trapping process is to obtain a matching generation rate between the active ylide and the iminium-activated enals.

Scheme 2. AMCR of trapping active intermediates with enals.

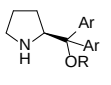


The reaction of cinnamyl aldehyde **1a** with methyl phenyldiazoacetate **2a** and benzyl alcohol **3a** was chosen as the model system for our initial investigetion under the conditions of $Rh_2(OAc)_4$ as the efficient diazo decompostion reagent, (*S*)-2-(diphenyl((trimethylsilyl)oxy)-methyl)pyrrolidine **4a** as co-catalyst and benzoic acid as additive in CH_2Cl_2. To our great delight, the desired 1,4-addition product **5a** was obtained in 70% yield within 2 hrs, although no diastereoselectivity was observed. The resluting product **5a** further gave 1,2,5-triol derivative **6a** in a quantitative yield and with a good ee value (88% ee for *anti*-**6a**, 91% ee for *syn*-**6a**) by a simple reduction with $NaBH_4$ in methanol at 40 ^oC (Table 1, entry1). The main side product was O-H insertion product **7a** derived from reaction of **2a** and **3a**, and no three-component 1,2-addition product was observed. The starting materials of **2a** and **3a** were consumed completely while 8% of cinnamyl aldehyde **1a** was recovered even prolonging the reaction time. These results indicate that the generation ratio of the (*S*)-**4a**-catalyzed iminium didn't match that of the $Rh_2(OAc)_4$-catalyzed ylide very well. The further screening of chiral secondary amine co-catalysts showed that (*S*)-**4b** and **4c** with larger steric triethylsilyl (TES) gave a similar yield and an improved enantioselectivity (entries 2-3). Other co-catalysts (*S*)-**4d-g** were much less effective in promoting this reaction, forming product **5a** in lower yields of less than 10% (entries 4-7). To obtain a more matching reactivity, other commonly used transition metal catalysts for the decomposition of diazo compounds, including $Ir(COD)_2BF_4$, were investigated. Most of these catalysts, such as $[PdCl(\eta^3\text{-}C_3H_5)]_2$,

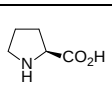
Table 1. Reaction condition optimization for the enantioselective three-component reaction of 1a, 2a, and 3a [a]



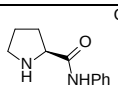
entry	M	(*S*)-**4**	Additives	t (hrs)	yield[b] (%)	dr[c] (*anti*:*syn*)	ee[d] (%, *anti*/*syn*)
1	$Rh_2(OAc)_4$	(*S*)-**4a**	$PhCO_2H$	2	70	50:50	88/91
2	$Rh_2(OAc)_4$	(*S*)-**4b**	$PhCO_2H$	2	80	50:50	93/94
3	$Rh_2(OAc)_4$	(*S*)-**4c**	$PhCO_2H$	2	60	50:50	96/97
4	$Rh_2(OAc)_4$	(*S*)-**4d**	$PhCO_2H$	2	<10	--	--
5	$Rh_2(OAc)_4$	(*S*)-**4e**	$PhCO_2H$	2	<10	--	--
6	$Rh_2(OAc)_4$	(*S*)-**4f**	$PhCO_2H$	2	<10	--	--
7	$Rh_2(OAc)_4$	(*S*)-**4g**	$PhCO_2H$	2	<10	--	--
8	$[PdCl(\eta^3\text{-}C_3H_5)]_2$	(*S*)-**4c**	$PhCO_2H$	2	20	50:50	95/96
9	AgOTf	(*S*)-**4c**	$PhCO_2H$	8	34	50:50	95/98
10	$[Ru(p\text{-cymene})Cl_2]_2$	(*S*)-**4c**	$PhCO_2H$	1	<10	--	--
11	$Cu(hfacac)_2$	(*S*)-**4c**	$PhCO_2H$	1	<10	--	--
12	$Ir(COD)_2BF_4$	(*S*)-**4c**	$PhCO_2H$	48	80	50:50	97/97
13	$[Ir(COD)OMe]_2$	(*S*)-**4c**	$PhCO_2H$	36	<10	--	--
14	$[Ir(COD)Cl]_2$	(*S*)-**4c**	$PhCO_2H$	48	75	50:50	93/94
15	Ir(COD)(hfacac)	(*S*)-**4c**	$PhCO_2H$	48	32	50:50	93/95
16	$Ir(COD)_2BF_4$	(*S*)-**4c**	*p*-NBZA	48	90	50:50	98/98
17	$Ir(COD)_2BF_4$	(*S*)-**4c**	*p*-$ClPhCO_2H$	48	58	50:50	96/96
18	$Ir(COD)_2BF_4$	(*S*)-**4c**	*p*-$MeOPhCO_2H$	48	32	50:50	94/96



(*S*)-**4a**: R=TMS (trimethylsilyl), Ar=Ph
(*S*)-**4b**: R=TES (triethylsilyl), Ar=Ph
(*S*)-**4c**: R=TBS (tert-butyldimethylsilyl), Ar=Ph
(*S*)-**4d**: R=TMS, Ar=3,5-$(CF_3)_2C_6H_3$



(*S*)-**4e**



(*S*)-**4f**

(*S*)-**4g**

[a] General reaction conditions: M:(*S*)-**4**: additives:**1a**:**2a**:**3a**= 0.05:0.2:0.4:1:1.5:1.5. [b] Isolated total yield of *anti*- and *syn*-**6a**. [c] Determined by ^{1}H NMR analysis of the crude mixture of *anti*- and *syn*-**6a**. [d] Determined by chiral HPLC analysis of *anti*- and *syn*-**6a**.

AgOTf, $[Ru(p\text{-cymene})Cl_2]_2$, and $Cu(hfacac)_2$, failed to achieve a good yield (entries 8-11 vs. 12). Compared to $Rh_2(OAc)_4$, which finished the reaction within 2 hrs, $Ir(COD)_2BF_4$ decomposed diazo compounds more slowly and it took 48 hrs to consume diazo compound **2a** totally. Gratifyingly, $Ir(COD)_2BF_4$ provided a higher yield of 80% with an excellent ee value (97% ee for both *anti*-**6a** and *syn*-**6a**) and 50:50 dr (entry 12 vs. 3). In this case, cinnamyl aldehyde **1a** was totally consumed within 48 hrs (detected by ^{1}H NMR). These results indicated the generation rate of oxonium ylides by

$Ir(COD)_2BF_4$ was slow enough to match that of the formation of iminium ions which derived from cinnamyl aldehyde **1a** and co-catalysts (*S*)-**4c**. Varying the counter anions or ligands in iridium complexes only afforded much lower yields but remaining a similar enantioselectivity (entries 13-15). Considering that the acidity of the additives might influence the formation rate of the iminium ions, the acids were screened in the trapping process (entries 16-18). *p*-Nitrobenzoic acid (*p*-NBZA) with a stronger acidity indeed improved both the reaction yield (from 80% to 90%) and the enantioselectivity (97% ee for *anti*-**6a** and 98% ee for *syn*-**6a**) than *p*-chlorobenzoic acid or *p*-methoxybenzoic acid. Screening of other solvents and reaction temperature gave no obvious improvement in the yield or in the stereoselectivity (see Supporting Information, Table S1). Therefore, the optimal reaction conditions were established as 5 mol% of $Ir(COD)_2BF_4$, 20 mol% of chiral secondary amine co-catalyst (*S*)-**4c** and 40 mol% of *p*-NBZA as additive in CH_2Cl_2 at room temperature in the presence of 4A molecular sieve (entry 16).

We next explored the substrate scope of this three-component reaction with the optimal reaction conditions and a series of 1,2,5-triol derivatives were obtained. The reaction proceeded smoothly with a variety of substitutions on the aromatic enals **1** (Table 2, entries 1-7), diazo compounds **2** (entries 9-14) and alcohols **3** (entries 15-18). In most cases, both a good yield (up to 95%) and an excellent enantioselectivity (up to 99% ee for *anti*-**6** and up to 99% ee for *syn*-**6**) were obtained. But unfortunately, *o*-Me substituted aromatic enal can't be applied here and only O-H insertion side product was obtained with a total recovery of cinnamaldehyde, indicating the reaction process might be sensitive to steric effect (Table 2, entry 8). The developed reaction provides an efficient approach for rapid access to chiral 1,2,5-triol derivatives under mild conditions even though the diastereoselectivity is poor. By single crystal X-ray crystallography,

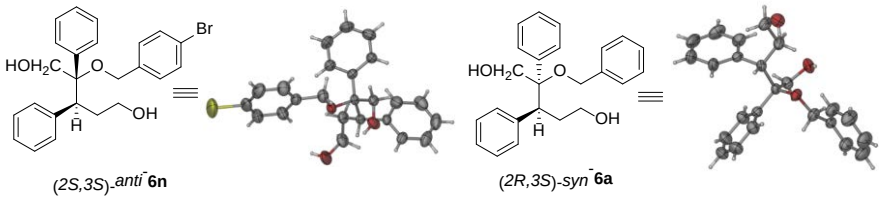
absolute configurations of the isomer of *anti*-**6n** and the isomer of *syn*-**6a** were determined as (2*S*, 3*S*) and (2*R*, 3*S*), respectively (Figure 1). That of other products were then assigned by analogy.

Table 2. Substrate scope of the Iridium/iminium co-catalyzed three-component reaction [a]

entry	Ar^1/ Ar^2/ R	**6**	yield(%)[b]	dr(*anti:syn*)[c]	ee(%,*anti/syn*)[d]
1	Ph/ Ph/Ph	**6a**	90	50:50	98/98
2	*p*-$NO_2C_6H_4$/ Ph/Ph	**6b**	88	50:50	96/99
3	*p*-ClC_6H_4/ Ph/Ph	**6c**	85	50:50	99/96
4	*p*-BrC_6H_4/ Ph/Ph	**6d**	81	50:50	97/99
5	*p*-$MeOC_6H_4$/ Ph/Ph	**6e**	84	50:50	97/98
6	*p*-MeC_6H_4/ Ph/Ph	**6f**	80	50:50	53/98
7	*m*-MeC_6H_4/ Ph/Ph	**6g**	75	50:50	99/95
8	*o*-MeC_6H_4/ Ph/Ph	--	--	--	--
9	Ph/*p*-FC_6H_4/ Ph	**6h**	59	50:50	98/98
10	Ph/*p*-BrC_6H_4/ Ph	**6i**	62	50:50	97/97
11	Ph/*p*-MeC_6H_4/ Ph	**6j**	66	50:50	96/98
12	Ph/*p*-$MeOC_6H_4$/ Ph	**6k**	50	50:50	96/98
13	Ph/*m*-$MeOC_6H_4$/ Ph	**6l**	81	50:50	96/97
14[e]	Ph/*o*-BrC_6H_4/ Ph	**6m**	68	37:63	92/98
15	Ph/Ph/*p*-BrC_6H_4	**6n**	75	50:50	98/99
16	Ph/Ph/*p*-$MeOC_6H_4$	**6o**	74	50:50	98/99
17	Ph/Ph/*m*-BrC_6H_4	**6p**	75	50:50	87/99
18	Ph/Ph/$TMSCH_2$	**6q**	95	50:50	94/95

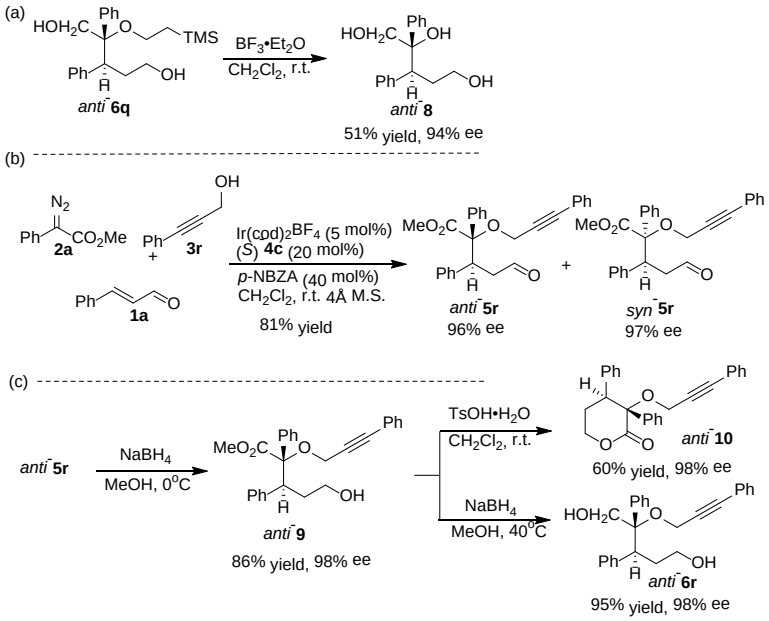
[a], [b], [c], [d]: Reaction conditions as performed in Table 1. [e]: LAH/THF was used for reduction reaction instead of $NaBH_4$/MeOH.

Figure 1. Single Crystal X-ray Diffraction Data of (*2S,3S*)-*anti*-6n and (*2R,3S*)-*syn*-6a.



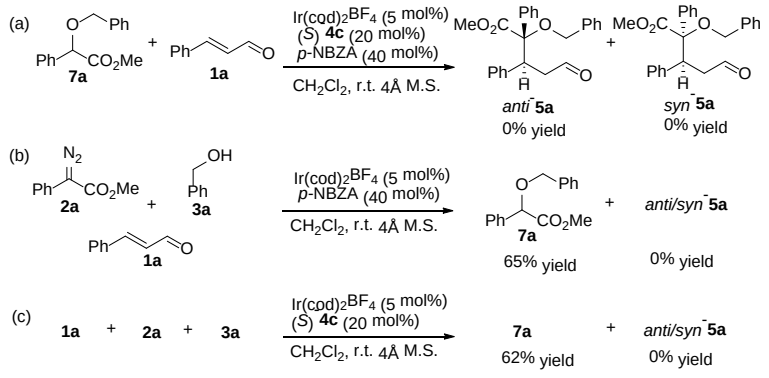
Due to the intriguing chiral 1,2,5-triol derivatives have been established through this method, we then sought to explore its synthetic applications. By a deprotection process of *O*-atom of *anti*-**6q** with $BF_3{\cdot}Et_2O$ in CH_2Cl_2, chiral 1,2,5-pentane-triol derivative *anti*-**8** was obtained, which is an admirable chiral scaffold to construct alkaloids (Scheme 3a). [1d] Furthermore, when 3-phenylpropargyl alcohol **3r** was used as starting material, the resulting product *anti*-**5r** (Scheme 3b) was performed by a simple reduction to chiral mono alcohol *anti*-**9** with $NaBH_4$ at 0 ^oC (Scheme 3c), which further afforded the corresponding chiral lactone *anti*-**10** by an intramolecular transesterification. Chiral lactones (five- and six-membered) are important building blocks for the synthesis of natural products and biologically active compounds, such as alkaloids, terpenoids,[14] and antiviral agents. [15] The mono alcohol *anti*-**9** can be also easily transferred into chiral 1,5-pentanediol derivative *anti*-**6r** by adding excess $NaBH_4$ at 40 ^oC (Scheme 3c).

Scheme 3. Synthetic application of the three-component products.



Control experiments were then carried out to confirm the reaction pathway. The reaction of O-H insertion product **7a** with cinnamaldehyde **1a** under the standard conditions (Scheme 4a) can't provide any three-component product **5a**, excluding a possible stepwise tandem process of the reaction. And only O-H insertion side product **7a** was obtained together with a total recovery of cinnamaldehyde **1a** without addition of co-catalyst (*S*)-**4c** or additive *p*-NBZA under the standard conditions (Scheme 4b and 4c). Additionally, iminium cation **II** generated from **1** and **4c** was detected in the reaction mixture solution by LC-MS spectra (see Supporting Information, Figure S1).

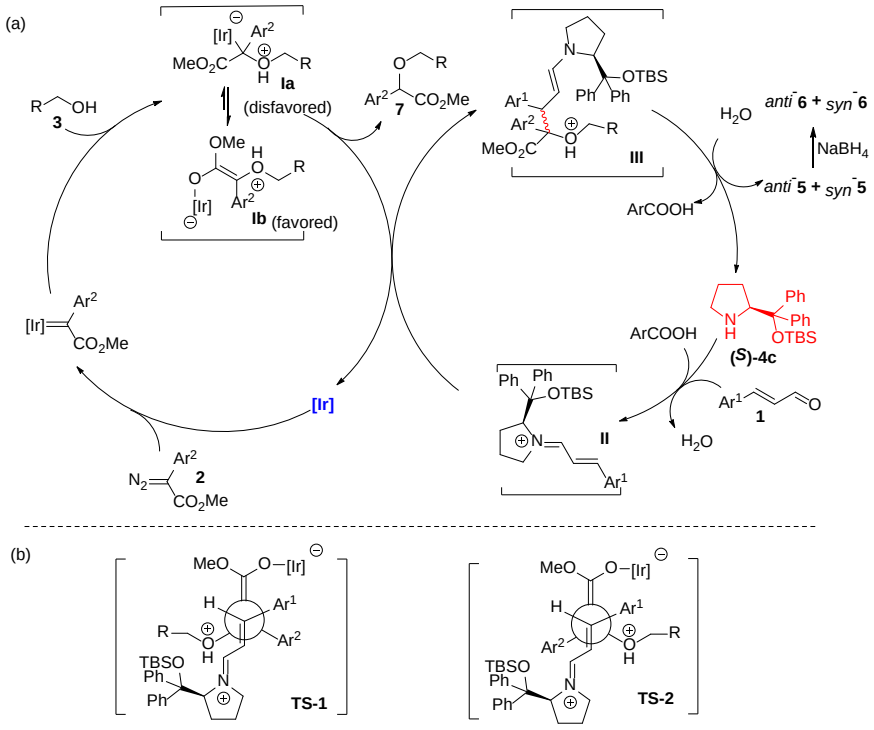
Scheme 4. Control experiments.



According to the control experiments, a possible mechanism was proposed and outlined in Scheme 5a. The reaction initially forms oxonium ylide intermediate **Ia** or

enolate **Ib** from **2** and **3** catalyzed by iridium. The planar **Ib** is a favored intermediate. On the other hand, chiral iminium ion **II** was formed from **1** and (*S*)-**4c** by the acceleration of acid additive, which can enaltioselectively trap intermediate **Ib** to give enamine **III** via transition states **TS-1** and **TS-2** (Scheme 5b). The addition of the planar enolate **Ib** from both sides to chiral iminium ion **II** is possibly responsible for the poor diastereoselectivity of the reaction. Three-component coupling product **5** would be subsequently formed by acid-promoted hydrolysis of enamine **III**, and meanwhile, chiral amine **4c** was regenerated. The reduction of the resulting product **5** with $NaBH_4$ delivered chiral 1,2,5-triol derivatives **6**.

Scheme 5. Proposed reaction mechanism of the iridium/iminium co-catalyzed three-component reaction.



In conclusion, we have reported an enantioselective iridium complex/chiral amine co-catalyzed three-component reaction of diazoacetates, alcohols and enals. The established reaction provides a mild method to rapid access to enantiomerically pure 1,2,5-triol derivatives with two vicinal chiral centers from simple starting materials in

good yields and with an excellent enantioselectivity. The enantioselective trapping of iridium (I)-associated oxonium ylide intermediates was promoted via selective 1,4-addtition to the chiral amine-activated enals. The further research of using this strategy in the improvement of the reaction diastereoselectivity and the synthetic application of 1,2,5-triol derivatives is currently underway in our lab.

EXPERIMENTAL SECTION

General. All ^{1}H NMR (400 MHz) and ^{13}C NMR (100 MHz) and ^{19}F NMR (376 MHz) spectra were recorded on Brucker spectrometers in $CDCl_3$. Tetramethylsilane (TMS) served as an internal standard (δ = 0) for ^{1}H NMR, and $CDCl_3$ was used as internal standard (δ = 77.0) for ^{13}C NMR. Chemical shifts are reported in parts per million as follows: chemical shift, multiplicity (s =singlet, d = doublet, t = triplet, q = quartet, m = multiplet, br = broad). High-resolution mass spectrometry (HRMS) was performed on IonSpec FT-ICR or Waters Micromass Q-TOF micro Synapt High Definition Mass Spectrometer. HPLC analysis was performed on Dalian Elite (UV230+ UV/Vis Detector and P230P High Pressure Pump). Chiralpak IC, IA, AD-H and OD-H column was purchased from Daicel Chemical Industries, LTD. Single crystal X-ray diffraction data were recorded on Bruker-AXS SMART APEX II single crystal X-ray diffractometer. The racemic standards used in HPLC studies were prepared according to the general procedure by using racemic (*S*)-2-(diphenyl((trimethylsilyl)oxy)methyl) pyrrolidine catalyst. Yields for all compounds were total yield of isolated *anti* and *syn* products unless otherwise indicated.

All reactions and manipulations were carried out under an argon atmosphere in a flame-dried or oven-dried flask containing magnetic stir bar. Dichloromethane (DCM), 1, 2-dichloroethane (DCE), $CHCl_3$ and toluene was distilled over calcium hydride. Cinnamaldehydes **3** were prepared from palladium-catalyzed synthesis of cinnamaldehydes from acrolein diethyl acetal and aryl iodides according to the literature method. Diarylprolinol silyl ethers **4a-d** were prepared according to the literature procedure. Solvents for the column chromatography were distilled before use.

4 Å molecular sieves were dried in a Muffle furnace at 250 ^{o}C over 5 hrs.

General Experimental Procedure for the Synthesis of Enantioselective Three-component Products: A mixture of $Ir(COD)_2BF_4$ (5 mol%), substituted cinnamaldehydes **1**(1.0 mmol), *p*-Nitrobenzoic acid (40 mol%), (*S*)-**4c** (20 mol%), and 4 Å MS (100 mg) in 1.0 mL of DCM under an argon atmosphere was stirred at room temperaure. The mixture of diazo compounds **2** (1.5 mmol) and alcohols **3** (1.5 mmol) in 1.0 mL of DCM was then added over 1.0 h via a syringe pump. After completion of the addition, the reaction mixture was stirred for another 48 h at room temperaure. After the completion of the reaction (monitored by TLC, until diazo compounds **2** disappeared), the reaction mixture was filtrated and evaporated *in vacuo* to give the crude products. The crude products was purified by flash chromatography on silica gel (EtOAc/light petroleum ether = 1:50 ~ 1:20) to give the mixture of *anti*-**5** and *syn*-**5**. Then the mixture were reduced with excess $NaBH_4$ (10.0 mmol) in batches in methanol for another 3 h at 40^{o}C. After the completion of the reaction (monitored by TLC, until *anti*-**5** and *syn*-**5** disappeared), the reaction was then quenched with 10 mL water. The aqueous layer was washed with DCM (2x40 mL) and the combined organic extracts were dried over anhydrous sodium sulfate, filtered, and concentrated *in vacuo*. The resulting residue was purified by flash column chromatography on silica gel (EtOAc/light petroleum ether = 1:20 ~ 1:10) to give the pure product of *anti*-**6** and *syn*-**6** as a white solid.

Procedure for the Synthesis of *anti*-8: To a flask charged with (*2S,3S*)-*anti*-**6q** (0.17 mmol, 65 mg) in CH_2Cl_2 (2 mL) was stirred at room temperature. $BF_3{\cdot}Et_2O$ (6.4 mmol, 0.8 mL) was added. After the completion of the reaction (monitored by TLC), the reaction mixture was quenched with saturated aqueous solution of $NaHCO_3$. Then the product was extracted with CH_2Cl_2. The combined organic phases were washed by water and brine, and dried over Na_2SO_4. The product was then purified by flash chromatography (EtOAc/light petroleum ether = 1:50 ~ 1:10) to give the pure product *anti*-**8**.

Procedure for the Synthesis of *anti*-5r and *syn*-5r: A mixture of $Ir(COD)_2BF_4$ (5 mol%), cinnamaldehydes **1a**(1.0 mmol), *p*-Nitrobenzoic acid (40 mol%), (*S*)-**4c** (20 mol%), and 4 Å MS (100 mg) in 1.0 mL of DCM under an argon atmosphere was stirred at room temperaure. The mixture of diazo compounds **2a** (1.5 mmol) and alcohols **3r** (1.5 mmol) in 1.0 mL of DCM was then added over 1.0 h via a syringe pump. After completion of the addition, the reaction mixture was stirred for another 48 h at room temperaure. After the completion of the reaction (monitored by TLC, until diazo compounds **2a** disappeared), the reaction mixture was filtrated and evaporated *in vacuo* to give the crude products. The crude products was purified by flash chromatography on silica gel (EtOAc/light petroleum ether = 1:50 ~ 1:20) to give the pure product of *anti*-**5r** and *syn*-**5r**.

Procedure for the Synthesis of *anti*-9: To a flask charged with (*2S,3S*)-*anti*-**5r** (0.4 mmol) in methanol (1 mL) was stirred at 0 ^oC. $NaBH_4$ (0.8 mmol) was added in batches for another 3 h at 0^oC. After the completion of the reaction (monitored by TLC), the reaction was then quenched with 1 mL water. The aqueous layer was washed with DCM (2x4 mL) and the combined organic extracts were dried over anhydrous sodium sulfate, filtered, and concentrated *in vacuo*. The resulting residue was purified by flash column chromatography on silica gel (EtOAc/light petroleum ether = 1:20 ~ 1:10) to give the pure product of *anti*-**9**.

Procedure for the Synthesis of *anti*-10: To a flask charged with *anti*-**9** (0.1 mmol) in DCM (0.3 mL) was stirred at room temperaure. Then $TsOH{\cdot}H_2O$ (0.05 mmol) was added. After the completion of the reaction (monitored by TLC), the reaction mixture was extracted with water. The combined organic phases were dried over Na_2SO_4 and the solvent was evaporated in vacuo. The product was then purified by flash chromatography (EtOAc/light petroleum ether = 1:50 ~ 1:10) to give the pure product *anti*-**10**.

Procedure for the Synthesis of *anti*-6r: To a flask charged with *anti*-**9** (0.1 mmol) in methanol (0.3 mL) was stirred at 40 ^oC. $NaBH_4$ (1.0 mmol) was added in batches.

After the completion of the reaction (monitored by TLC), the reaction mixture was quenched with 1 mL water. Then the product was extracted with DCM (2x3 mL). The combined organic phases were washed by water and brine, and dried over Na_2SO_4. The product was then purified by flash chromatography (EtOAc/light petroleum ether = 1:10 ~ 1:5) to give the pure product *anti*-**6r**.

(2S,3S)-2-(benzyloxy)-2,3-diphenylpentane-1,5-diol (**6a**)

(*2S,3S*)-*anti*-**6a**: white solid, 163.0 mg, 45% yield, 98% ee. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.56 – 7.35 (m, 4H), 7.34 – 7.23 (m, 4H), 7.19 – 7.08 (m, 3H), 7.06 – 6.92 (m, 2H), 6.91 – 6.57 (m, 2H), 4.43 (s, 2H), 3.93 (s, 2H), 3.57 (d, *J* = 9.8 Hz, 1H), 3.49 – 3.38 (m, 1H), 3.38 – 3.24 (m, 1H), 2.64 – 2.42 (m, 1H), 2.18 (s, 1H), 1.78 – 1.49 (m, 2H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 139.3, 138.6, 137.3, 130.1, 128.6, 127.9, 127.7, 127.7, 127.6, 127.2, 126.9, 84.0, 64.9, 62.0, 61.7, 47.9, 31.6.

HRMS(ESI): Calcd. for $C_{24}H_{26}NaO_3$ $[M+Na]^+$: 385.1780 , Found:385.1786.

HPLC (Chiral OD-H, λ= 220 nm, hexane/2-propanol = 4.7/1, Flow rate =0.8 mL/min), t_{major} = 9.12 min, t_{minor} = 7.59 min.

(2R,3S)-2-(benzyloxy)-2,3-diphenylpentane-1,5-diol (**6a**)

(*2R,3S*)-*syn*-**6a**: white solid, 163.0 mg, 45% yield, 98% ee. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.43 – 7.27 (m, 8H), 7.27 – 7.19 (m, 7H), 4.58 (q, *J* = 12.1 Hz, 2H), 4.19 – 3.97 (m, 2H), 3.35 (s, 1H), 3.24 – 3.04 (m, 2H), 2.21 – 2.01 (m, 1H), 2.01 – 1.87 (m, 1H), 1.83 – 1.47 (m, 2H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 140.2, 139.7, 139.3, 130.1, 128.5, 128.4, 128.0, 127.4, 127.2, 127.0, 126.9, 126.7, 84.2, 65.6, 65.5, 61.1, 52.2, 32.8.

HRMS(ESI): Calcd. for $C_{24}H_{26}NaO_3$ $[M+Na]^+$: 385.1780 , Found:385.1786.

HPLC (Chiral OD-H, λ= 220 nm, hexane/2-propanol = 4.7/1, Flow rate =0.8 mL/min), t_{major} = 9.67 min, t_{minor} = 7.20 min.

(2S,3S)- 2-(benzyloxy)-3-(4-nitrophenyl)-2-phenylpentane-1,5-diol (**6b**)

(*2S,3S*)-*anti*-**6b**: white solid, 175.0 mg, 43% yield, mp 126-127 ^{o}C, 96% ee. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.91 (d, *J* = 8.1 Hz, 2H), 7.46 – 7.20 (m, 8H), 7.07 – 6.76 (m, 4H), 4.37 (q, *J* = 11.7 Hz, 2H), 4.07 – 3.91 (m, 1H), 3.90 – 3.75 (m, 1H), 3.67 (d, *J* = 9.6 Hz, 1H), 3.40 (s, 1H), 3.31 – 3.14 (m, 1H), 2.62 – 2.43 (m, 1H), 2.04 (d, *J* = 8.2 Hz, 1H), 1.83 – 1.66 (m, 1H), 1.32 (s, 1H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 147.6, 146.9, 138.3, 137.0, 131.0, 128.7, 128.1, 127.8, 127.5, 127.1, 122.7, 83.8,

77.3, 77.0, 76.7, 65.2, 62.4, 61.1, 48.3, 31.6.

HRMS(ESI): Calcd. for $C_{24}H_{25}NNaO_5$ $[M+Na]^+$: 430.1630 , Found:430.1635.

HPLC (Chiral IC, λ= 220 nm, hexane/2-propanol = 4.5/1, Flow rate =1.0 mL/min), t_{major} = 13.22 min, t_{minor} = 10.01 min.

(2R,3S)- 2-(benzyloxy)-3-(4-nitrophenyl)-2-phenylpentane-1,5-diol (**6b**)

(*2R,3S*)-*syn*-**6b**: white solid, 183.2 mg, 45% yield, 99% ee. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.00 (d, J = 8.4 Hz, 2H), 7.38 – 7.25 (m, 7H), 7.20 (d, J = 7.4 Hz, 3H), 7.09 (d, J = 7.4 Hz, 2H), 4.44 (s, 2H), 4.04 (s, 2H), 3.52 – 3.28 (m, 2H), 3.20 – 3.02 (m, 1H), 2.08 – 1.96 (m, 1H), 1.95 – 1.84 (m, 1H), 1.78 (s, 1H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 147.9, 146.9, 138.7, 138.5, 131.2, 128.6, 127.9, 127.5, 127.0, 126.7, 122.7, 84.4, 77.3, 77.0, 76.7, 65.6, 64.2, 60.5, 50.5, 32.6.

HRMS(ESI): Calcd. for $C_{24}H_{25}NNaO_5$ $[M+Na]^+$: 430.1630 , Found:430.1639.

HPLC (Chiral IC, λ= 220 nm, hexane/2-propanol = 4.5/1, Flow rate =1.0 mL/min), t_{major} = 8.93 min, t_{minor} = 10.26 min.

(2S,3S)- 2-(benzyloxy)-3-(4-chlorophenyl)-2-phenylpentane-1,5-diol (**6c**)

(*2S,3S*)-*anti*-**6c**: white solid, 178.2 mg, 45% yield, mp 126-129 ^{o}C, 99% ee. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.37 – 7.28 (m, 4H), 7.26 – 7.17 (m, 4H), 7.02 (d, J = 8.6 Hz, 2H), 6.98 – 6.89 (m, 2H), 6.61 (d, J = 7.2 Hz, 2H), 4.34 (s, 2H), 3.95 – 3.75 (m, 2H), 3.50 (dd, J = 11.6, 3.1 Hz, 1H), 3.42 – 3.28 (m, 1H), 3.28 – 3.15 (m, 1H), 2.56 – 2.37 (m, 1H), 2.24 – 2.04 (m, 1H), 1.74 – 1.53 (m, 2H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 138.4, 137.9, 137.0, 132.7, 131.4, 128.6, 128.5, 127.9, 127.8, 127.8, 127.7, 127.2, 83.9, 77.4, 77.0, 76.7, 65.0, 62.0, 61.4, 47.3, 31.5.

HRMS(ESI): Calcd. for $C_{24}H_{25}ClNaO_3$ $[M+Na]^+$: 419.1390 , Found:419.1407.

HPLC (Chiral IC, λ= 220 nm, hexane/2-propanol = 4.5/1, Flow rate =1.0 mL/min), t_{major} = 10.02 min, t_{minor} = 5.69 min.

(2R,3S)- 2-(benzyloxy)-3-(4-chlorophenyl)-2-phenylpentane-1,5-diol (**6c**)

(*2R,3S*)-*syn*-**6c**: white solid, 158.4 mg, 40% yield, 96% **ee** .^{1}H NMR (400 MHz, $CDCl_3$) δ 7.43 – 7.25 (m, 8H), 7.22 – 7.12 (m, 4H), 7.05 (d, J = 8.3 Hz, 2H), 4.63 – 4.39 (m, 2H), 4.07 (s, 2H), 3.45 – 3.30 (m, 1H), 3.29 – 3.09 (m, 2H), 2.08 – 1.86 (m, 3H), 1.79 (brs, 1H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 139.3, 139.1, 138.1, 132.6, 131.6, 128.5, 128.4, 127.9, 127.6, 127.3, 127.0, 126.7, 84.2, 77.4, 77.0, 76.7, 65.5, 64.6, 60.7, 50.5, 32.6.

HRMS(ESI): Calcd. for $C_{24}H_{25}ClNaO_3$ $[M+Na]^+$: 419.1390 , Found:419.1405.

HPLC (Chiral IC, λ= 220 nm, hexane/2-propanol = 4.5/1, Flow rate =1.0 mL/min), t_{major} = 5.54 min, t_{minor} = 7.12 min.

(2S,3S)- 2-(benzyloxy)-3-(4-bromophenyl)-2-phenylpentane-1,5-diol (**6d**)

(*2S*,*3S*)-*anti*-**6d**: white solid, 176.0 mg, 40% yield, 97% **ee**. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.44 – 7.35 (m, 4H), 7.35 – 7.26 (m, 5H), 7.23 (s, 1H), 7.09 – 6.90 (m, 2H), 6.62 (d, *J* = 6.8 Hz, 2H), 4.41 (s, 2H), 4.02 – 3.83 (m, 2H), 3.56 (d, *J* = 10.8 Hz, 1H), 3.48 – 3.37 (m, 1H), 3.34 – 3.22 (m, 1H), 2.61 – 2.45 (m, 1H), 2.22 (brs, 1H), 1.82 – 1.59 (m, 2H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 138.4, 138.4, 137.0, 131.8, 130.8, 128.6, 128.5, 127.9, 127.8, 127.7, 127.2, 120.8, 83.8, 77.4, 77.0, 76.7, 65.0, 62.0, 61.3, 47.4, 31.5.

HRMS(ESI): Calcd. for $C_{24}H_{25}BrNaO_3$ $[M+Na]^+$: 463.0885 , Found:463.0901.

HPLC (Chiral IC, *λ*= 220 nm, hexane/2-propanol = 6.0/1, Flow rate =1.0 mL/min), t_{major} = 10.25 min, t_{minor} = 5.79 min.

(2R,3S)- 2-(benzyloxy)-3-(4-bromophenyl)-2-phenylpentane-1,5-diol (**6d**)

(*2R*,*3S*)-*syn*-**6d**: white solid, 180.4 mg, 41% yield, mp 99-100 °C, 99% **ee** .^{1}H NMR (400 MHz, $CDCl_3$) δ 7.41 – 7.27 (m, 10H), 7.20 (d, *J* = 7.4 Hz, 2H), 7.03 (d, *J* = 8.0 Hz, 2H), 4.53 (s, 2H), 4.12 – 3.98 (m, 2H), 3.43 – 3.31 (m, 1H), 3.25 – 3.09 (m, 2H), 2.07 – 1.90 (m, 2H), 1.77 (s, 1H), 1.62 (s, 1H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 139.4, 139.1, 138.7, 131.9, 130.9, 128.5, 127.6, 127.3, 127.0, 126.7, 120.8, 84.1, 77.3, 77.0, 76.7, 65.6, 64.9, 60.8, 50.9, 32.6.

HRMS(ESI): Calcd. for $C_{24}H_{25}BrNaO_3$ $[M+Na]^+$: 463.0885 , Found: 463.0896.

HPLC (Chiral IC, *λ*= 220 nm, hexane/2-propanol = 6.0/1, Flow rate =1.0 mL/min), t_{major} = 6.40 min, t_{minor} =8.99 min.

(2S,3R)- 2-(benzyloxy)-3-(4-methoxyphenyl)-2-phenylpentane-1,5-diol (**6e**)

(*2S*,*3R*)-*anti*-**6e**: white solid, 160.8 mg, 41% yield, mp 121-122 °C, 97% ee. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.48 – 7.36 (m, 4H), 7.35 – 7.24 (m, 4H), 7.08 – 6.95 (m, 2H), 6.67 (s, 4H), 4.43 (s, 2H), 3.93 (s, 2H), 3.76 (s, 3H), 3.52 (dd, *J* = 11.5, 2.6 Hz, 1H), 3.48 – 3.40 (m, 1H), 3.40 – 3.29 (m, 1H), 2.63 – 2.45 (m, 1H), 2.07 (brs, 1H), 1.80 – 1.56 (m, 2H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 158.5, 138.6, 137.3, 131.1, 131.0, 128.6, 127.9, 127.7, 127.7, 127.6, 127.1, 113.0, 84.2, 77.3, 77.0, 76.7, 64.9, 61.9, 61.8, 55.1, 47.1, 31.7.

HRMS(ESI): Calcd. for $C_{25}H_{28}NaO_4$ $[M+Na]^+$: 415.1885 , Found: 415.1878.

HPLC (Chiral IC, λ= 220 nm, hexane/2-propanol = 4.5/1, Flow rate =1.0 mL/min), t_{major} = 22.97 min, t_{minor} = 8.82

min.

(2R,3R)- 2-(benzyloxy)-3-(4-methoxyphenyl)-2-phenylpentane-1,5-diol (**6e**)

(*2R,3R*)-*syn*-**6e**: white solid, 168.6 mg, 43% yield, mp 100-103 °C, 98% ee. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.50 – 7.26 (m, 8H), 7.24 (d, *J* = 7.6 Hz, 2H), 7.13 (d, *J* = 8.3 Hz, 2H), 6.79 (d, *J* = 8.4 Hz, 2H), 4.60 (d, *J* = 12.1 Hz, 1H), 4.54 (d, *J* = 12.1 Hz, 1H), 4.07 (s, 2H), 3.79 (s, 3H), 3.47 – 3.29 (m, 1H), 3.27 – 3.13 (m, 1H), 3.08 (dd, *J* = 11.4, 2.9 Hz, 1H), 2.13 – 1.85 (m, 2H), 1.66 (brs, 2H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 158.6, 140.3, 139.4, 131.6, 131.0, 128.4, 127.4, 127.2, 126.9, 126.7, 113.4, 84.2, 77.4, 77.0, 76.7, 65.6, 65.5, 61.1, 55.2, 51.4, 32.8.

HRMS(ESI): Calcd. for $C_{25}H_{28}NaO_4$ $[M+Na]^+$: 415.1885 , Found: 415.1881.

HPLC (Chiral IC, λ= 220 nm, hexane/2-propanol = 4.5/1, Flow rate =1.0 mL/min), t_{major} = 7.97 min, t_{minor} = 12.59 min.

(2S,3S)- 2-(benzyloxy)-2-phenyl-3-(p-tolyl)pentane-1,5-diol (**6f**)

(*2S,3S*)-*anti*-**6f**: white solid, 150.0 mg, 40% yield, mp 123-125 °C, 53% ee. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.40 – 7.27 (m, 4H), 7.27 – 7.16 (m, 4H), 7.00 – 6.82 (m, 4H), 6.59 – 6.30 (m, 2H), 4.37 (s, 2H), 3.86 (s, 2H), 3.44 (dd, *J* = 11.6, 3.2 Hz, 1H), 3.41 – 3.32 (m, 1H), 3.32 – 3.23 (m, 1H), 2.52 – 2.37 (m, 1H), 2.11 (s, 3H), 1.98 (brs, 1H), 1.71 – 1.61 (m, 1H), 1.37 (brs, 1H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 139.1, 138.6, 137.4, 137.0, 130.9, 128.6, 128.0, 127.7, 127.6, 127.6, 127.5, 127.2, 84.0, 77.3, 77.0, 76.7, 64.9, 62.0, 61.8, 47.9, 31.7, 21.3.

HRMS(ESI): Calcd. for $C_{25}H_{28}NaO_3$ $[M+Na]^+$: 399.1936 , Found: 399.1928.

HPLC (Chiral IC, λ= 220 nm, hexane/2-propanol = 4.5/1, Flow rate =1.0 mL/min), t_{major} = 17.58 min, t_{minor} = 6.54 min.

(2R,3S)- 2-(benzyloxy)-2-phenyl-3-(p-tolyl)pentane-1,5-diol (**6f**)

(*2R,3S*)-*syn*-**6f**: white solid, 150.5 mg, 40% yield, 98% ee. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.45 – 7.26 (m, 9H), 7.25 – 7.23 (m, 1H), 7.14 (t, *J* = 8.0 Hz, 1H), 7.04 (t, *J* = 8.0 Hz, 3H), 4.62 (d, *J* = 12.0 Hz, 1H), 4.55 (d, *J* = 12.0 Hz, 1H), 4.08 (s, 2H), 3.42 – 3.30 (m, 1H), 3.26 – 3.15 (m, 1H), 3.08 (dd, *J* = 11.6, 3.3 Hz, 1H), 2.29 (s, 3H), 2.13 – 2.01 (m, 1H), 1.98 – 1.85 (m, 1H), 1.35 (brs, 1H), 1.08 (brs, 1H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 140.4, 139.6, 139.3, 137.4, 131.0, 128.4, 127.9, 127.7, 127.4, 127.2, 127.0, 126.9, 126.8, 84.2, 77.3, 77.2, 77.0, 76.7, 65.7, 65.6, 61.2, 52.3, 32.7, 21.4.

HRMS(ESI): Calcd. for $C_{25}H_{28}NaO_3$ $[M+Na]^+$: 399.1936 , Found: 399.1938.

HPLC (Chiral IC, λ= 220 nm, hexane/2-propanol = 4.5/1, Flow rate =1.0 mL/min), t_{major} = 7.46 min, t_{minor} = 9.88

min.

(2S,3S)- 2-(benzyloxy)-2-phenyl-3-(m-tolyl)pentane-1,5-diol (**6g**)

(*2S,3S*)-*anti*-**6g**: white solid, 146.7 mg, 39% yield, mp 164-165 °C, 99% ee. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.39 – 7.28 (m, 4H), 7.26 – 7.20 (m, 3H), 7.19 (s, 1H), 7.00 – 6.92 (m, 2H), 6.87 (d, *J* = 7.0 Hz, 2H), 6.57 (d, *J* = 7.0 Hz, 2H), 4.37 (s, 2H), 3.86 (s, 2H), 3.46 (dd, *J* = 11.6, 3.2 Hz, 1H), 3.40 – 3.23 (m, 2H), 2.52 – 2.39 (m, 1H), 2.21 (s, 3H), 1.93 (brs, 1H), 1.71 – 1.56 (m, 1H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 138.6, 137.3, 136.5, 136.1, 129.9, 128.6, 128.4, 128.0, 127.7, 127.6, 127.1, 84.1, 77.3, 77.0, 76.7, 64.8, 62.0, 61.8, 47.6, 31.7, 21.0.

HRMS(ESI) :Calcd. for $C_{25}H_{28}NaO_3$ $[M+Na]^+$: 399.1936 , Found: 399.1936.

HPLC (Chiral IC, λ= 220 nm, hexane/2-propanol = 4.5/1, Flow rate =1.0 mL/min), t_{major} = 33.13 min, t_{minor} = 8.15 min.

(2R,3S)- 2-(benzyloxy)-2-phenyl-3-(m-tolyl)pentane-1,5-diol (**6g**)

(*2R,3S*)-*syn*-**6g**: white solid, 135.5 mg, 36% yield, 95% ee. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.39 – 7.25 (m, 6H), 7.20 (dd, *J* = 12.1, 4.5 Hz, 4H), 7.06 (d, *J* = 7.6 Hz, 2H), 6.99 (d, *J* = 7.6 Hz, 2H), 4.55 (d, *J* = 12.1 Hz, 1H), 4.48 (d, *J* = 12.1 Hz, 1H), 4.07 – 3.90 (m, 2H), 3.34 – 3.22 (m, 1H), 3.18 – 3.05 (m, 1H), 2.99 (dd, *J* = 11.4, 2.7 Hz, 1H), 2.23 (s, 3H), 2.06 – 1.93 (m, 1H), 1.92 – 1.78 (m, 1H), 1.68 – 1.42 (m, 2H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 140.5, 139.4, 136.6, 136.5, 129.9, 128.8, 128.4, 128.4, 127.3, 127.2, 126.9, 126.7, 84.1, 77.3, 77.0, 76.7, 65.7, 65.7, 61.2, 52.1, 32.8, 21.1.

HRMS(ESI) :Calcd. for $C_{25}H_{28}NaO_3$ $[M+Na]^+$: 399.1936 , Found: 399.1928.

HPLC (Chiral IC, λ= 220 nm, hexane/2-propanol = 4.5/1, Flow rate =1.0 mL/min), t_{major} = 7.39 min, t_{minor} = 12.91 min.

(2S,3S)- 2-(benzyloxy)-2-(4-fluorophenyl)-3-phenylpentane-1,5-diol (**6h**)

(*2S,3S*)-*anti*-**6h**: white solid, 114.2 mg, 30% yield, 98% ee. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.55 – 7.35 (m, 4H), 7.34 – 7.27 (m, 1H), 7.21 – 7.09 (m, 3H), 7.07 – 6.89 (m, 4H), 6.86 – 6.61 (m, 2H), 4.42 (q, *J* = 11.7 Hz, 2H), 3.91 (s, 2H), 3.55 (dd, *J* = 11.7, 2.9 Hz, 1H), 3.50 – 3.39 (m, 1H), 3.38 – 3.25 (m, 1H), 2.58 – 2.42 (m, 1H), 2.20 (brs, 1H), 1.82 – 1.46 (m, 2H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 162.2 (d, *J* = 246.9 Hz), 139.1, 138.4, 133.3 (d, *J* = 3.2 Hz), 130.1, 129.6 (d, *J* = 7.9 Hz), 128.6, 127.8, 127.7, 127.1, 127.0, 114.6 (d, *J* = 21.1 Hz), 83.7, 64.8, 62.2, 61.5, 47.8, 31.5.

HRMS(ESI) :Calcd. for $C_{24}H_{25}O_3NaF$ $[M+Na]^+$: 403.1685 , Found: 403.1695.

^{19}F NMR (376 MHz, $CDCl_3$) δ -114.6.

HPLC (Chiral IA, λ= 220 nm, hexane/2-propanol = 4.5/1, Flow rate =1.0 mL/min), t_{major} = 8.02 min, t_{minor} = 6.36 min.

(2R,3S)- 2-(benzyloxy)-2-(4-fluorophenyl)-3-phenylpentane-1,5-diol (**6h**)

(*2R,3S*)-*syn*-**6h**: white solid, 110.3 mg, 29% yield, 98% ee.^{1}H NMR (400 MHz, $CDCl_3$) δ 7.42 – 7.33 (m, 4H), 7.32 – 7.26 (m, 1H), 7.25 – 7.19 (m, 3H), 7.19 – 7.05 (m, 4H), 6.99 (t, *J* = 8.7 Hz, 2H), 4.56 (d, *J* = 12.1 Hz, 1H), 4.45 (d, *J* = 12.1 Hz, 1H), 4.12 – 4.00 (m, 2H), 3.40 – 3.29 (m, 1H), 3.24 – 3.06 (m, 2H), 2.02 – 1.91 (m,2H), 1.86 (brs, 1H), 1.28 – 1.20 (m, 1H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 162.0 (d, *J* = 246.4 Hz), 139.4, 139.1, 135.8 (d, *J* = 3.2 Hz), 130.2, 128.8, 128.7 (d, *J* = 7.9 Hz), 127.9, 127.3, 127.0, 126.6, 115.1 (d, *J* = 21.2 Hz), 83.9, 65.4, 64.8, 60.9, 51.6, 32.6.

^{19}F NMR (376 MHz, $CDCl_3$) δ -115.1.

HRMS(ESI) :Calcd. for $C_{24}H_{25}O_3NaF$ $[M+Na]^+$: 403.1685, Found: 403.1669.

HPLC (Chiral IC, λ= 220 nm, hexane/2-propanol = 4.5/1, Flow rate =1.0 mL/min), t_{major} = 5.47 min, t_{minor} = 6.99 min.

(2S,3S)- 2-(benzyloxy)-2-(4-bromophenyl)-3-phenylpentane-1,5-diol (**6i**)

(*2S,3S*)-*anti*-**6i**: white solid, 132.4 mg, 30% yield, 97% ee. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.55 – 7.36 (m, 6H), 7.35 – 7.30 (m, 1H), 7.22 – 7.07 (m, 3H), 6.89 (d, *J* = 8.2 Hz,2H), 6.83 – 6.62 (m, 2H), 4.44 – 4.40 (m, 2H), 3.90 (s, 2H), 3.56 (dd, *J* = 11.7, 3.0 Hz, 1H), 3.51 – 3.39 (m, 1H), 3.39 – 3.25 (m, 1H), 2.58 – 2.40 (m, 1H), 2.11 (brs, 1H), 1.78 – 1.65 (m, 1H), 1.42 (brs, 1H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 138.9, 138.3, 136.7, 130.8, 130.0, 129.7, 128.6, 127.8, 127.7, 127.1, 121.9, 83.8, 64.9, 62.1, 61.5, 47.7, 31.5.

HRMS(ESI) :Calcd. for $C_{24}H_{25}O_3NaBr$ $[M+Na]^+$: 463.0885 , Found: 463.0896.

HPLC (Chiral IA, λ= 220 nm, hexane/2-propanol = 4.5/1, Flow rate =1.0 mL/min), t_{major} = 9.38 min, t_{minor} =6.88 min.

(2R,3S)- 2-(benzyloxy)-2-(4-bromophenyl)-3-phenylpentane-1,5-diol (**6i**)

(*2R,3S*)-*syn*-**6i**: white solid, 131.6 mg, 32% yield, 97% ee. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.52 – 7.43 (m, 2H), 7.42 – 7.34 (m, 4H), 7.34 – 7.28 (m, 1H), 7.27 – 7.19 (m, 5H), 7.13 (d, *J* = 8.5 Hz, 2H), 4.59 (d, *J* = 12.1 Hz, 1H), 4.48 (d, *J* = 12.1 Hz, 1H), 4.05 (s, 2H), 3.46 – 3.32 (m, 1H), 3.28 – 3.15 (m, 1H), 3.13 (dd, *J* = 11.7, 3.3 Hz, 1H), 2.13 – 1.99 (m, 1H), 1.98 – 1.86 (m, 1H), 1.61 (brs, 2H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 139.5, 139.4, 139.0, 131.5, 130.1, 128.8, 128.5, 128.1, 127.3, 127.1, 126.7, 121.5, 84.0, 65.6, 65.2, 60.9, 51.8, 32.6.

HRMS(ESI) :Calcd. for $C_{24}H_{25}O_3NaBr$ $[M+Na]^+$: 463.0885 , Found: 463.0871.

HPLC (Chiral IC, λ= 220 nm, hexane/2-propanol = 4.5/1, Flow rate =1.0 mL/min), t_{major} = 5.37 min, t_{minor} =4.66 min.

(2S,3S)- 2-(benzyloxy)-3-phenyl-2-(p-tolyl)pentane-1,5-diol (**6j**)

(*2S,3S*)-*anti*-**6j**: white solid, 124.2 mg, 33% yield, 96% ee. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.53 – 7.32 (m, 4H), 7.32 – 7.25 (m, 1H), 7.21 – 7.01 (m, 5H), 6.88 (d, *J* = 7.4 Hz, 2H), 6.83 – 6.52 (m, 2H), 4.40 (s, 2H), 3.88 (s, 2H), 3.54 (dd, *J* = 11.3, 2.5 Hz, 1H), 3.48 – 3.35 (m, 1H), 3.35 – 3.21 (m, 1H), 2.64 – 2.44 (m, 1H), 2.34 (s, 3H), 2.31 – 2.10 (m, 1H), 1.91 – 1.49 (m, 2H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 139.5, 138.7, 137.3, 134.2, 130.2, 128.6, 128.4, 127.9, 127.7, 127.5, 127.2, 126.9, 83.9, 64.7, 62.1, 61.7, 47.9, 31.7, 21.1.

HRMS(ESI) :Calcd. for $C_{25}H_{28}O_3Na$ $[M+Na]^+$: 399.1936 , Found: 399.1935.

HPLC (Chiral IC, λ= 220 nm, hexane/2-propanol = 4.5/1, Flow rate =1.0 mL/min), t_{major} = 18.20 min, t_{minor} =6.11 min.

(2R,3S)- 2-(benzyloxy)-3-phenyl-2-(p-tolyl)pentane-1,5-diol (**6j**)

(*2R,3S*)-*syn*-**6j**: white solid, 124.2 mg, 33% yield, 98% ee. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.47 – 7.32 (m, 4H), 7.30 – 7.26 (m, 1H), 7.25 – 7.17 (m,5H), 7.15 – 7.01 (m, 4H), 4.56 (d, *J* = 12.2 Hz, 1H), 4.50 (d, *J* = 12.2 Hz, 1H), 4.02 (s, 2H), 3.46 – 3.26 (m, 1H), 3.12 (d, *J* = 7.8 Hz, 2H), 2.32 (s, 3H), 2.10 – 1.84 (m, 3H), 1.69 (brs, 1H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 139.8, 139.5, 137.0, 136.9, 130.3, 129.1, 128.4, 127.9, 127.1, 127.0, 126.9, 126.7, 84.1, 65.5, 65.3, 61.0, 51.7, 32.8, 21.1.

HRMS(ESI) :Calcd. for $C_{25}H_{28}O_3Na$ $[M+Na]^+$: 399.1936 , Found: 399.1919.

HPLC (Chiral IC, λ= 220 nm, hexane/2-propanol = 4.5/1, Flow rate =1.0 mL/min), t_{major} = 5.91 min, t_{minor} =8.33 min.

(2S,3S)-2-(benzyloxy)-2-(4-methoxyphenyl)-3-phenylpentane-1,5-diol (**6k**)

(*2S,3S*)-*anti*-**6k**: white solid, 98.2 mg, 25% yield, 96% ee. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.48 – 7.32 (m, 4H), 7.31 – 7.25 (m, 1H), 7.18 – 7.04 (m, 3H), 7.00 – 6.86 (m, 2H), 6.84 – 6.65 (m, 4H), 4.38 (s, 2H), 3.85 (s, 2H), 3.79 (s,3H), 3.54 (d, *J* = 11.1 Hz, 1H), 3.43 – 3.33 (m, 1H), 3.32 – 3.20 (m, 1H), 2.62 – 2.30 (m, 2H), 2.05 (brs, 1H), 1.69 (s, 1H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 159.0, 139.5, 138.7, 130.2, 129.3, 129.1, 128.6, 127.7, 127.5, 127.2, 126.8, 113.0, 83.7, 64.6, 62.1, 61.5, 55.2, 47.9, 31.7.

HRMS(ESI) :Calcd. for $C_{25}H_{28}O_4Na$ $[M+Na]^+$: 415.1885 , Found: 415.1898.

HPLC (Chiral IA, λ= 220 nm, hexane/2-propanol = 4.5/1, Flow rate =1.0 mL/min), t_{major} = 13.59 min, t_{minor} =7.80 min.

(2R,3S)- 2-(benzyloxy)-2-(4-methoxyphenyl)-3-phenylpentane-1,5-diol (**6k**)

(*2R,3S*)-*syn*-**6k**: white solid, 98.1 mg, 25% yield, 98% ee. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.55 – 7.31 (m, 4H), 7.31 – 7.26 (m, 1H), 7.25 – 7.19 (m, 3H), 7.15 (s, 2H), 7.08 (d, *J* = 8.2 Hz, 2H), 6.84 (d, *J* = 8.2 Hz, 2H), 4.77 – 4.35 (m, 2H), 4.14 – 3.91 (m, 2H), 3.78 (s, 3H), 3.41 – 3.26 (m, 1H), 3.25 – 2.93 (m, 2H), 2.18 – 1.91 (m, 3H), 1.71 (brs, 1H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 158.8, 139.8, 139.4, 131.7, 130.3, 128.4, 128.2, 127.8, 127.1, 126.8, 126.6, 113.7, 83.9, 65.3, 65.0, 61.0, 55.3, 51.7, 32.7.

HRMS(ESI) :Calcd. for $C_{25}H_{28}O_4Na$ $[M+Na]^+$: 415.1885 , Found: 415.1866.

HPLC (Chiral IC, λ= 220 nm, hexane/2-propanol = 4.5/1, Flow rate =1.0 mL/min), t_{major} = 7.47 min, t_{minor} =10.55 min.

(2S,3S)- 2-(benzyloxy)-2-(3-methoxyphenyl)-3-phenylpentane-1,5-diol (**6l**)

(*2S,3S*)-*anti*-**6l**: white solid, 157.0 mg, 40% yield, 96% ee. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.46 – 7.27 (m, 4H), 7.26 – 7.19 (m, 1H), 7.16 – 6.96 (m, 4H), 6.81 – 6.62 (m, 3H), 6.58 – 6.39 (m, 2H), 4.38 (s, 2H), 3.93 – 3.76 (m, 2H), 3.59 (s, 3H), 3.48 (dd, *J* = 11.6, 3.1 Hz, 1H), 3.41 – 3.30 (m, 1H), 3.30 – 3.17 (m, 1H), 2.52 – 2.35 (m, 1H), 2.11 (brs, 1H), 1.79 – 1.65 (m, 1H), 1.53 (brs, 1H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 158.0, 138.2, 138.1, 137.6, 129.1, 127.6, 127.5, 126.6, 126.5, 126.1, 125.9, 119.2, 112.7, 112.2, 83.0, 63.9, 61.2, 60.6, 54.1, 47.0, 30.6.

HRMS(ESI): Calcd. for $C_{25}H_{28}O_4Na$ $[M+Na]^+$: 415.1885 , Found: 415.1870.

HPLC (Chiral IA, *λ*= 220 nm, hexane/2-propanol = 4.5/1, Flow rate =1.0 mL/min), t_{major} = 9.22 min, t_{minor} =8.06 min.

(2R,3S)- 2-(benzyloxy)-2-(3-methoxyphenyl)-3-phenylpentane-1,5-diol (**6l**)

(*2R,3S*)-*syn*-**6l**: white solid, 160.9 mg, 41% yield, 97% ee. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.40 – 7.34 (m, 4H), 7.31 – 7.19 (m, 7H), 6.86 – 6.79 (m,2H), 6.77 (s, 1H), 4.58 (q, *J* = 12.2 Hz, 2H), 4.04 (q, *J* = 12.7 Hz, 2H), 3.64 (s, 3H), 3.40 – 3.27 (m, 1H), 3.24 – 3.08 (m, 2H), 2.13 – 1.98 (m, 1H), 1.99 – 1.86 (m, 1H), 1.79 (brs, 1H), 1.42 (brs, 1H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 159.7, 141.8, 139.7, 139.4, 130.2, 129.5, 128.4, 127.9, 127.2, 127.0, 126.6, 119.0, 113.0, 112.9, 84.3, 65.7, 65.4, 61.1, 55.1, 51.8, 32.7.

HRMS(ESI): Calcd. for $C_{25}H_{28}O_4Na$ $[M+Na]^+$: 415.1885 , Found: 415.1881.

HPLC (Chiral IC, *λ*= 220 nm, hexane/2-propanol = 4.5/1, Flow rate =1.0 mL/min), t_{major} = 6.61 min, t_{minor} =10.59

min.

(2S,3S)- 2-(benzyloxy)-2-(2-bromophenyl)-3-phenylpentane-1,5-diol (**6m**)

(*2S,3S*)-*anti*-**6m**: white solid, 154.5 mg, 35% yield, 92% ee. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.54 – 7.36 (m, 4H), 7.34 – 7.27 (m, 3H), 7.22 – 7.08 (m, 3H), 7.06 – 6.97 (m, 2H), 6.88 – 6.60 (m, 2H), 4.56 – 4.29 (m, 2H), 3.94 (d, *J* = 4.8 Hz, 2H), 3.57 (dd, *J* = 11.6, 3.2 Hz, 1H), 3.49 – 3.26 (m, 2H), 2.63 – 2.46 (m, 1H), 2.15 – 2.00 (m, 1H), 1.82 – 1.67 (m, 1H), 1.36 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 139.3, 138.6, 137.3, 130.1, 128.6, 127.9, 127.7, 127.7, 127.6, 127.1, 126.9, 84.0, 64.9, 62.0, 61.7, 48.0, 31.7.

HRMS(ESI) :Calcd. for $C_{24}H_{25}O_3NaBr$ $[M+Na]^+$: 463.0885 , Found: 463.0877.

HPLC (Chiral IC, λ= 220 nm, hexane/2-propanol = 4.5/1, Flow rate =1.0 mL/min), t_{major} = 15.82 min, t_{minor} =5.99 min.

(2R,3S)- 2-(benzyloxy)-2-(2-bromophenyl)-3-phenylpentane-1,5-diol (**6m**)

(*2R,3S*)-*syn*-**6m**: white solid, 145.7 mg, 33% yield, 98% ee. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.45 – 7.35 (m, 5H), 7.34 – 7.26 (m, 4H), 7.25 – 7.18 (m, 5H), 4.59 (q, *J* = 12.2 Hz, 2H), 4.17 – 3.98 (m, 2H), 3.44 – 3.31 (m, 1H), 3.25 – 3.16 (m, 1H), 3.13 (dd, *J* = 11.6, 3.3 Hz, 1H), 2.14 – 2.03 (m, 1H), 2.01 – 1.90 (m, 1H), 1.09 (brs, 1H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 140.2, 139.8, 139.3, 130.1, 128.5, 128.4, 128.0, 127.4, 127.2, 127.0, 126.9, 126.7, 84.2, 65.7, 65.5, 61.1, 52.3, 32.8.

HRMS(ESI) :Calcd. for $C_{24}H_{25}O_3NaBr$ $[M+Na]^+$: 463.0885 , Found: 463.0908.

HPLC (Chiral IC, λ= 220 nm, hexane/2-propanol = 4.5/1, Flow rate =1.0 mL/min), t_{major} = 5.77 min, t_{minor} =8.11 min.

(2S,3S)- 2-((4-bromobenzyl)oxy)-2,3-diphenylpentane-1,5-diol (**6n**)

(*2S,3S*)-*anti*-**6n**: white solid, 167.7 mg, 38% yield, mp 119-122 °C, 98% **ee**. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.50 (d, *J* = 7.7 Hz, 1H), 7.39 – 7.24 (m, 3H), 7.22 – 7.06 (m, 2H), 7.03 – 6.89 (m, 1H), 6.88 – 6.61 (m, 1H), 4.52 – 4.27 (m, 1H), 3.95 (s, 1H), 3.55 (d, *J* = 10.6 Hz, 1H), 3.43 (s, 1H), 3.33 (d, *J* = 6.6 Hz, 1H), 2.56 – 2.40 (m, 1H), 2.12 (s, 1H), 1.87 – 1.60 (m, 1H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 139.1, 137.6, 137.2, 131.6, 130.1, 128.8, 128.5, 128.0, 127.8, 127.7, 127.0, 126.1, 121.4, 84.1, 77.3, 77.0, 76.7, 64.2, 62.2, 61.5, 48.0, 31.6.

HRMS (ESI) calcd for $C_{24}H_{25}BrNaO_3$ $[M+Na]^+$= 463.0885 found 463.0879.

HPLC (Chiral IA, λ= 220 nm, hexane/2-propanol = 10/1, Flow rate =1.0 mL/min), t_{major} = 26.81 min, t_{minor} =13.34 min.

(2R,3S)- 2-((4-bromobenzyl)oxy)-2,3-diphenylpentane-1,5-diol (**6n**)

(*2R,3S*)-*syn*-**6n**: white solid, 163.3 mg, 37% yield, 99% **ee** .^{1}H NMR (400 MHz, $CDCl_3$) δ 7.50 (d, J = 7.9 Hz, 2H), 7.43 – 7.14 (m, 12H), 4.52 – 4.54(m, 2H), 4.06 – 4.08 (m, 2H), 3.35 (d, J = 3.7 Hz, 1H), 3.25 – 3.07 (m, 2H), 2.00 – 2.01 (m, 2H), 1.64 (s, 2H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 139.9, 139.6, 138.3, 131.5, 130.1, 128.5, 128.4, 128.0, 127.5, 127.1, 126.8, 120.9, 84.3, 77.3, 77.0, 76.7, 65.6, 65.0, 61.0, 52.0, 32.7.

HRMS (ESI) calcd for $C_{24}H_{25}BrNaO_3$ $[M+Na]^+$= 463.0885 found 463.0887.

HPLC (Chiral IA, λ= 220 nm, hexane/2-propanol = 8.0/1, Flow rate =1.0 mL/min), t_{major} = 19.29 min, t_{minor} =14.99 min.

(2S,3S)- 2-((4-methoxybenzyl)oxy)-2,3-diphenylpentane-1,5-diol (**6o**)

(*2S,3S*)-*anti*-**6o**: white solid, 145.2 mg, 37% yield, 98% ee. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.36 – 7.28 (m, 5H), 7.20 – 7.08 (m, 3H), 7.02 (d, J = 4.2 Hz, 2H), 6.93 (d, J = 8.6 Hz, 2H), 6.74 (d, J = 5.7 Hz, 2H), 4.44 – 4.28 (m, 2H), 3.92 (s, 2H), 3.83 (s, 3H), 3.55 (dd, J = 11.3, 4.0 Hz, 1H), 3.43 (ddd, J = 11.3, 7.4, 4.0 Hz, 1H), 3.35 – 3.38 (m, 1H), 2.59 – 2.46 (m, 1H), 2.07 (s, 1H), 1.78 – 1.67 (m, 1H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 159.2, 139.4, 137.3, 130.6, 130.1, 128.8, 128.0, 127.7, 127.3, 126.9, 114.0, 84.0, 77.3, 77.0, 76.7, 64.6, 61.9, 61.8, 55.3, 48.0, 31.7.

HRMS (ESI) calcd for $C_{25}H_{28}NaO_4$ $[M+Na]^+$= 415.1885 found 415.1875.

HPLC (Chiral IC, λ= 220 nm, hexane/2-propanol = 4.5/1, Flow rate =1.0 mL/min), t_{major} = 38.04 min, t_{minor} =20.48 min.

(2R,3S)- 2-((4-methoxybenzyl)oxy)-2,3-diphenylpentane-1,5-diol (**6o**)

(*2R,3S*)-*syn*-**6o**: white solid, 145.0 mg, 37% yield, mp 133-135 ^{o}C, 99% ee. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.47 – 7.28 (m, 6H), 7.27 – 7.13 (m, 6H), 6.93 (d, J = 8.5 Hz, 2H), 4.48 – 4.52 (m, 2H), 4.19 – 3.98 (m, 2H), 3.83 (s, 3H), 3.45 – 3.28 (m, 1H), 3.24 – 3.14 (m, 1H), 3.11 (dd, J = 11.4, 3.3 Hz, 1H), 2.13 – 1.86 (m, 2H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 158.9, 140.3, 139.8, 131.4, 130.1, 128.4, 128.3, 128.0, 127.4, 126.9, 113.9, 84.1, 77.3, 77.0, 76.7, 65.4, 61.1, 55.3, 52.3, 32.8.

HRMS (ESI) calcd for $C_{25}H_{28}NaO_4$ $[M+Na]^+$= 415.1885 found 415.1890.

HPLC (Chiral IC, λ= 220 nm, hexane/2-propanol = 4.5/1, Flow rate =1.0 mL/min), t_{major} = 22.18 min, t_{minor} =38.56 min.

(2S,3S)- 2-((3-bromobenzyl)oxy)-2,3-diphenylpentane-1,5-diol (**6p**)

(*2S,3S*)-*anti*-**6p**: white solid, 158.9 mg, 36% yield, 87% ee. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.56 (s, 1H), 7.43 (d, J = 7.7 Hz, 1H), 7.34 (d, J = 5.0 Hz, 2H), 7.29 (s, 3H), 7.13 – 7.15 (m, 3H), 6.99 (d, J = 4.6 Hz, 2H), 6.76 (d, J = 5.7

Hz, 2H), 4.40 – 4.42 (m, 2H), 3.96 (s, 2H), 3.55 (d, *J* = 10.3 Hz, 1H), 3.43 (d, *J* = 3.6 Hz, 1H), 3.38 – 3.22 (m, 1H), 2.56 – 2.40 (m, 1H), 2.19 (s, 1H), 1.76 (s, 2H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 141.0, 139.1, 137.3, 130.6, 130.1, 130.1, 128.5, 127.8, 127.8, 127.7, 127.0, 126.1, 125.6, 122.6, 84.1, 77.4, 77.0, 76.7, 64.1, 62.3, 61.5, 48.1, 31.6.

HRMS (ESI) calcd for $C_{24}H_{25}BrNaO_3$ $[M+Na]^+$= 463.0885 found 463.0877.

HPLC (Chiral IC, λ= 220 nm, hexane/2-propanol = 4.5/1, Flow rate =1.0 mL/min), t_{major} = 6.15 min, t_{minor} =9.43 min.

(2R,3S)- 2-((3-bromobenzyl)oxy)-2,3-diphenylpentane-1,5-diol (**6p**)

(*2R,3S*)-*syn*-**6p**: white solid, 172.1 mg, 39% yield, 99% ee. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.54 (s, 1H), 7.42 (d, *J* = 7.7 Hz, 1H), 7.39 – 7.33 (m, 2H), 7.33 – 7.25 (m, 5H), 7.24 – 7.18 (m, 5H), 4.59 (d, *J* = 12.5 Hz, 1H), 4.51 (d, *J* = 12.5 Hz, 1H), 4.16 – 3.99 (m, 2H), 3.45 – 3.32 (m, 1H), 3.26 – 3.09 (m, 2H), 2.11 – 1.98 (m, 1H), 1.98 – 1.86 (m, 1H), 1.61 (s, 1H), 1.14 (brs, *J* = 8.2 Hz, 1H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 141.7, 139.8, 139.5, 130.22, 130.1, 129.9, 129.7, 128.5, 128.1, 127.5, 127.1, 126.8, 125.1, 122.6, 84.4, 77.3, 77.0, 76.7, 65.5, 64.9, 61.0, 51.8, 32.7.

HRMS (ESI) calcd for $C_{24}H_{25}BrNaO_3$ $[M+Na]^+$= 463.0885 found 463.0883.

HPLC (Chiral IA, λ= 220 nm, hexane/2-propanol = 20/1, Flow rate =1.0 mL/min), t_{major} = 5.76 min, t_{minor} =9.71 min.

(2S,3S)- 2,3-diphenyl-2-(2-(trimethylsilyl)ethoxy)pentane-1,5-diol (**6q**)

(*2S,3S*)-*anti*-**6q**: white solid, 175.1 mg, 47% yield, 94% ee. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.41 – 7.00 (m, 10H), 3.99 (s, 2H), 3.61 – 3.51 (m, 1H), 3.50 – 3.42 (m, 1H), 3.42 – 3.32 (m, 1H), 3.27 – 3.14 (m, 1H), 3.04 (dd, *J* = 10.5, 3.8 Hz, 1H), 2.12 – 1.89 (m, 2H), 1.58 (brs, 2H), 1.11 – 0.93 (m, 2H), -0.00 (s, 9H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 142.2, 141.4, 131.3, 129.5, 129.2, 128.5, 128.2, 128.1, 84.9, 66.3, 62.6, 62.2, 53.7, 34.3, 20.3, -0.0.

HRMS (ESI) calcd for $C_{22}H_{32}SiNaO_3$ $[M+Na]^+$= 395.2110 found 395.2111.

HPLC (Chiral AD-H, λ= 220 nm, hexane/2-propanol = 12.0/1, Flow rate =1.0 mL/min), t_{major} = 20.23 min, t_{minor} = 8.21 min.

(2R,3S)- 2,3-diphenyl-2-(2-(trimethylsilyl)ethoxy)pentane-1,5-diol (**6q**)

(*2R,3S*)-*syn*-**6q**: white solid, 178.9 mg, 48% yield, 95% ee. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.38 – 7.24 (m, 3H), 7.21 – 7.07 (m, 3H), 7.04 – 6.86 (m, 2H), 6.82 – 6.55 (m, 2H), 3.92 – 3.73 (m, 2H), 3.54 – 3.24 (m, 5H), 2.57 – 2.41 (m, 1H), 2.13 (brs, 1H), 1.77 (brs, 1H), 1.70 – 1.54 (m, 1H), 1.18 – 0.94 (m, 2H), -0.00 (s, 9H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 141.0, 138.7, 131.4, 129.2, 128.9, 128.8, 128.8, 128.1, 84.8, 63.2, 63.1, 61.2, 49.4, 33.2, 20.2, -0.0.

HRMS (ESI) calcd for $C_{22}H_{32}O_3NaSi$ $[M+Na]^+$= 395.2018, found 395.1989.

HPLC (Chiral AD-H, λ= 220 nm, hexane/2-propanol = 6.0/1, Flow rate =1.0 mL/min), t_{major} = 8.37 min, t_{minor} =12.36 min.

(2S,3S)-2,3-diphenylpentane-1,2,5-triol (**8**)

(*2S*,*3S*)-*anti*-**8**: white solid, 23.6 mg, 51% yield, 94%ee. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.35 – 7.02 (m, 8H), 6.96 – 6.79 (m, 2H), 3.82 (q, *J* = 24.1, 11.2 Hz, 2H), 3.59 – 3.46 (m, 1H), 3.38 – 3.23 (m, 2H), 2.48 (brs, 1H), 2.35 – 2.08 (m, 2H), 1.79 – 1.66 (m, 1H), 1.36 – 1.27 (m, 1H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 141.0, 139.5, 130.0, 127.8, 127.6, 127.2, 127.0, 126.8, 78.6, 68.0, 61.2, 49.7, 32.0.

HRMS(ESI) :Calcd. for $C_{17}H_{20}O_3Na$ $[M+ Na]^+$: 295.1310, Found: 295.1349.

HPLC (Chiral IC, λ= 220 nm, hexane/2-propanol = 4.5/1, Flow rate =1.0 mL/min), t_{major} = 13.72 min, t_{minor} = 11.20 min.

(2S,3S)-methyl-5-oxo-2,3-diphenyl-2-((3-phenylprop-2-yn-1-yl)oxy)pentanoate (**5r**)

(*2S*,*3S*)-*anti*-**5r**: white solid, 165.0 mg, 40% yield, 96% ee. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.41 (s, 1H), 7.66 (d, *J* = 7.2 Hz, 2H), 7.57 – 7.46 (m, 2H), 7.38 (ddd, *J* = 9.6, 6.4, 2.7 Hz, 6H), 7.26 – 7.18 (m, 5H), 4.73 (d, *J* = 15.6 Hz, 1H), 4.30 (d, *J* = 15.6 Hz, 1H), 3.88 (dd, *J* = 9.8, 4.6 Hz, 1H), 3.60 (s, 3H), 3.08 – 2.82 (m, 2H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 200.9, 171.2, 138.6, 136.4, 131.8, 130.1, 128.5, 128.5, 128.40, 128.3, 127.9, 127.7, 127.3, 122.8, 88.6, 85.8, 85.8, 77.4, 77.0, 76.7, 56.4, 52.0, 51.0, 44.3.

HRMS(ESI) :Calcd. for $C_{27}H_{24}O_4Na$ $[M+ Na]^+$: 435.1572, Found: 435.1564.

HPLC (Chiral IC, λ= 220 nm, hexane/2-propanol = 15/1, Flow rate =0.8 mL/min), t_{major} = 13.34 min, t_{minor} = 16.69 min.

(2R,3S)-methyl-5-oxo-2,3-diphenyl-2-((3-phenylprop-2-yn-1-yl)oxy)pentanoate (**5r**)

(*2R*,*3S*)-*syn*-**5r**: white solid, 169.1 mg, 41% yield, 97% ee. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.53 (t, *J* = 1.9 Hz, 1H), 7.48 – 7.42 (m, 2H), 7.35 – 7.31 (m, 3H), 7.28 – 7.21 (m, 3H), 7.20 – 7.13 (m, 5H), 7.04 – 6.97 (m, 2H), 4.51 (d, *J* = 15.5 Hz, 1H), 4.21 (d, *J* = 15.5 Hz, 1H), 4.13 (dd, *J* = 9.9, 4.6 Hz, 1H), 3.83 (s, 3H), 3.03 (ddd, *J* = 17.3, 9.9, 2.0 Hz, 1H), 2.86 (ddd, *J* = 17.3, 4.6, 2.0 Hz, 1H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 200.9, 171.6, 137.6, 135.1, 131.7, 130.2, 128.4, 128.3, 128.3, 128.0, 127.8, 127.8, 127.4, 122.8, 88.9, 85.6, 85.6, 77.4, 77.0, 76.7, 55.9, 52.3, 49.4, 45.1.

HRMS(ESI) :Calcd. for $C_{27}H_{24}O_4Na$ $[M+ Na]^+$: 435.1572, Found: 435.1564.

HPLC (Chiral IC, λ= 220 nm, hexane/2-propanol = 15/1, Flow rate =0.8 mL/min), t_{major} = 18.14 min, t_{minor} = 17.11 min.

(2S,3S)-methyl--5-hydroxy-2,3-diphenyl-2-((3-phenylprop-2-yn-1-yl)oxy)pentanoate (**9**)

(*2S,3S*)-*anti*-**9**: white solid, 142.6 mg, 86% yield, 98% ee. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.70 – 7.57 (m, 2H), 7.51 – 7.44 (m, 2H), 7.40 – 7.29 (m, 6H), 7.21 (s, 5H), 4.67 (d, *J* = 15.6 Hz, 1H), 4.28 (d, *J* = 15.6 Hz, 1H), 4.11 (s, 1H), 3.58 (s, 3H), 3.48 – 3.32 (m, 2H), 3.21 (dd, *J* = 15.8, 9.2 Hz, 1H), 2.33 (t, *J* = 7.6 Hz, 1H), 2.13 – 1.89 (m, 2H), 1.17 (s, 1H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 171.8, 139.0, 136.6, 131.8, 130.3, 128.4, 128.3, 128.0, 127.6, 127.0, 123.0, 89.2, 86.1, 85.6, 77.4, 77.1, 76.7, 61.0, 56.3, 52.9, 51.9, 32.3.

HRMS(ESI) :Calcd. for $C_{27}H_{26}O_4Na$ $[M+ Na]^+$: 437.1729, Found: 437.1725.

HPLC (Chiral IC, λ= 220 nm, hexane/2-propanol = 15/1, Flow rate =0.8 mL/min), t_{major} = 17.50 min, t_{minor} = 16.62 min.

(3R,4S)-3,4-diphenyl-3-((3-phenylprop-2-yn-1-yl)oxy)tetrahydro-2H-pyran-2-one (**10**)

(*3R,4S*)-*anti*-**10**: white solid, 23.0 mg, 60% yield, 98% ee. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.45 (dd, *J* = 6.6, 3.0 Hz, 2H), 7.38 – 7.29 (m, 3H), 7.24 – 7.10 (m, 6H), 6.89 (d, *J* = 7.6 Hz, 4H), 4.76 – 4.58 (m, 3H), 4.32 (d, *J* = 15.6 Hz, 1H), 3.70 (dd, *J* = 11.0, 4.4 Hz, 1H), 2.35 (dtd, *J* = 14.3, 11.0, 6.2 Hz, 1H), 2.15 (dtd, *J* = 14.3, 4.4, 2.2 Hz, 1H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 170.9, 138.1, 134.8, 131.7, 129.4, 128.5, 128.3, 128.3, 128.2, 127.6, 127.3, 127.2, 122.9, 86.0, 85.8, 85.6, 77.4, 77.0, 76.7, 68.8, 55.8, 49.6, 26.4.

HRMS(ESI) :Calcd. for $C_{26}H_{22}O_3Na$ $[M+ Na]^+$: 405.1467, Found: 405.1482.

HPLC (Chiral IC, λ= 220 nm, hexane/2-propanol = 15/1, Flow rate =0.8 mL/min), t_{major} = 31.84 min, t_{minor} = 25.32 min.

(2S,3S)-2,3-diphenyl-2-((3-phenylprop-2-yn-1-yl)oxy)pentane-1,5-diol (**6r**)

(*2S,3S*)-*anti*-**6r**: white solid, 36.7 mg, 95% yield, 98% ee. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.46 (dd, *J* = 6.6, 3.1 Hz, 2H), 7.39 – 7.28 (m, 6H), 7.24 – 7.17 (m, 5H), 7.13 (dd, *J* = 6.6, 2.8 Hz, 2H), 4.36 – 4.38 (m, 2H), 4.18 – 4.05 (m, 2H), 3.40 (dt, *J* = 11.2, 5.7 Hz, 1H), 3.28 – 3.12 (m, 2H), 2.11 – 2.00 (m, 3H), 1.63 (s, 1H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 139.8, 139.5, 131.7, 130.2, 128.5, 128.4, 128.3, 127.8, 127.5, 127.0, 126.8, 122.5, 86.5, 85.5, 85.3, 77.3, 77.0, 76.7, 64.7, 61.2, 53.5, 52.0, 32.7.

HRMS(ESI) :Calcd. for $C_{26}H_{26}O_3Na$ $[M+ Na]^+$: 409.1780, Found: 409.1774.

HPLC (Chiral IC, λ= 220 nm, hexane/2-propanol = 10/1, Flow rate =0.8 mL/min), t_{major} = 15.77 min, t_{minor} = 18.22 min.

ASSOCIATED CONTENT

Supporting Information

^{1}H and ^{13}C NMR spectra data and HPLC spectra data for compounds **6a**–**6r**, **8**-**10**, and X-ray crystal data for compound *anti*-**6n** and *syn*-**6a.**

The Supporting Information is available free of charge on the ACS Publications website.

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Notes

The authors declare no competing financial interest.

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