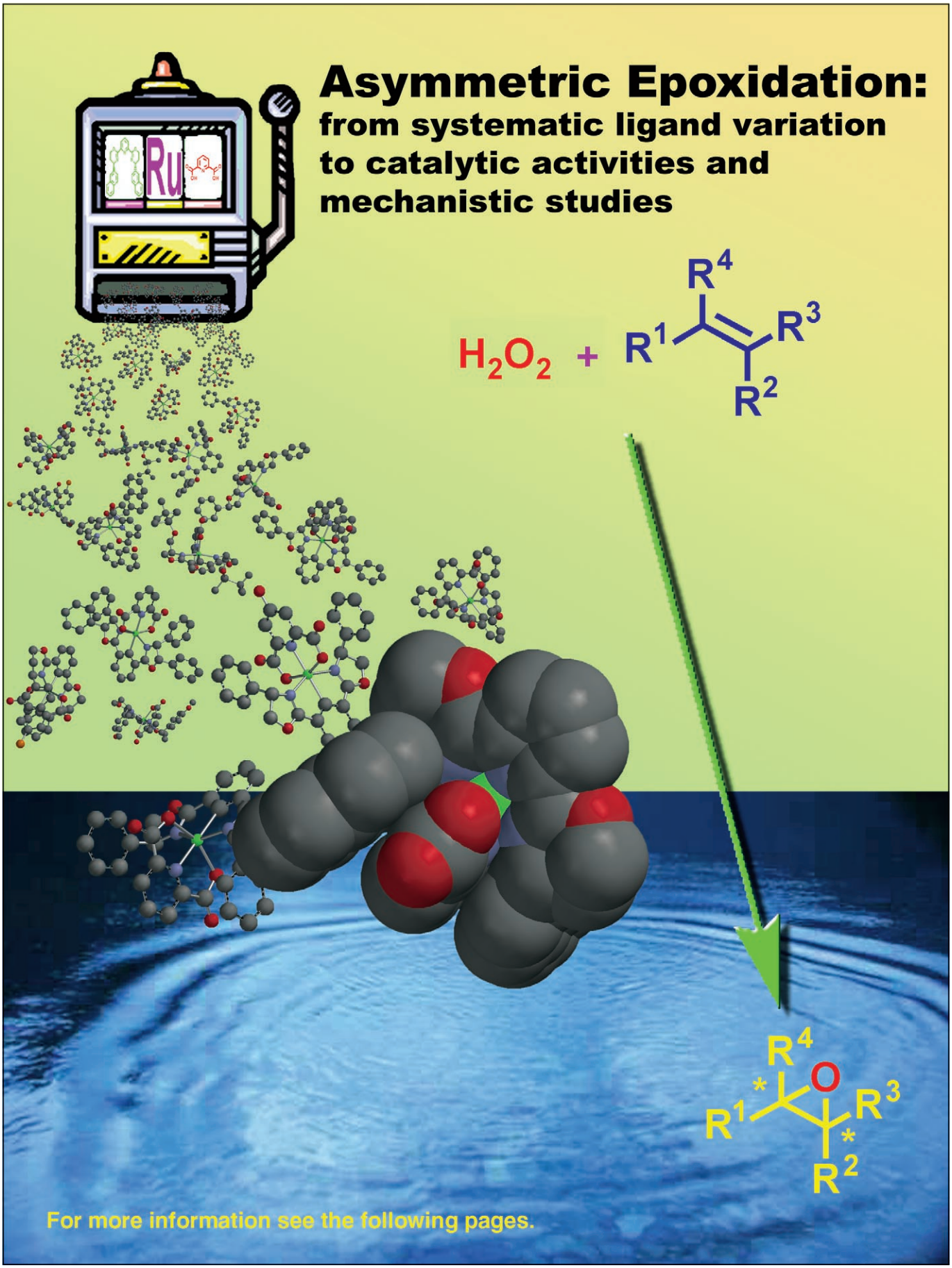

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Ruthenium-Catalyzed Asymmetric Epoxidation of Olefins Using H_2O_2, Part I: Synthesis of New Chiral *N*,*N*,*N*-Tridentate Pybox and Pyboxazine Ligands and Their Ruthenium Complexes

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Abstract: The synthesis of chiral tridentate *N*,*N*,*N*-pyridine-2,6-bisoxazolines **3** (pybox ligands) and *N*,*N*,*N*-pyridine-2,6-bisoxazines **4** (pyboxazine ligands) is described in detail. These novel ligands constitute a useful toolbox for the application in asymmetric catalysis. Compounds **3** and **4** are conveniently prepared by cyclization of enantiomerically pure α- or β-amino alcohols with dimethyl pyridine-2,6-dicarboximidate. The corresponding ruthenium complexes are efficient asymmetric epoxidation catalysts and have been prepared in good yield and fully characterized by spectroscopic means. Four of these ruthenium complexes have been characterized by X-ray crystallography. For the first time the molecular structure of a pyboxazine complex {2,6-bis-[(*4S*)-4-phenyl-5,6-dihydro-4*H*-[1,3]oxazinyl]pyridine}(pyridine-2,6-dicarboxylate)ruthenium (*S*)-**2aa**, is presented.

Keywords: epoxidation · homogeneous catalysis · N ligands · olefins · ruthenium

Introduction

Transition-metal-catalyzed asymmetric reactions provide us with efficient and direct methods for the synthesis of enantiomerically pure compounds.[1] For the development of new asymmetric reactions as well as the optimization of known processes the design and synthesis of a suitable chiral controller ligand is *the* crucial step.[2] In the last two decades certain types of ligands[3] for asymmetric catalysis have evolved such as binaphthol derivatives,[4] salens,[5] bisoxazolines,[6] phosphinooxazolines,[7] tartrate derivatives,[8] and cinchona alkaloids,[9] which allow for a more general use in various asymmetric reactions. Unfortunately, small structural variations within substrate molecules may dramatically change the outcome of the catalytic reaction. Basically, each substrate needs its own optimized catalyst and ligand system. Hence, it is a significant advantage of a given ligand class if it allows for easy steric and electronic tuning of the structure.

Some time ago we started a project on the development of efficient oxidation methods for olefins,[10] especially the use of ruthenium catalysts[11,15e] for olefin epoxidation.[12] In this regard, we became interested in pyridine-2,6-bisoxazolines (so-called pybox ligands).[13] The versatile coordination ability of the pybox structure, from early to late transition metals as well as lanthanides, and its rigidity as coplanar *N*,*N*,*N*-tridentate ligands makes them excellent chiral controller ligands for a variety of asymmetric reactions.[22a] Accordingly transition-metal complexes of pybox ligands show a wide range of reactivity pattern including reduction,[14] oxidation,[15] aldol-type reactions,[16] Diels–Alder reactions,[17] cyclopropanation,[18] aziridation,[19] cross-coupling reactions,[20] polymerization,[21] and others.[18c,22]

At the start of our investigations we were especially attracted by Nishiyama's catalyst [Ru-(pyridinebisoxazoline)-(pyridine-dicarboxylate)] (**1**) for asymmetric epoxidation (Scheme 1).[15e] Unfortunately, this system had several drawbacks such as low reactivity (96 h were needed for full conversion) and the limited scope of the catalyst (epoxidation was only demonstrated for *trans*-stilbene).

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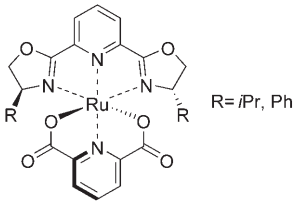
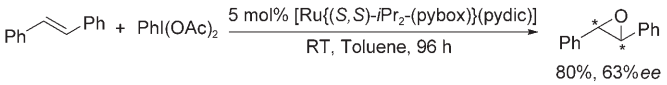
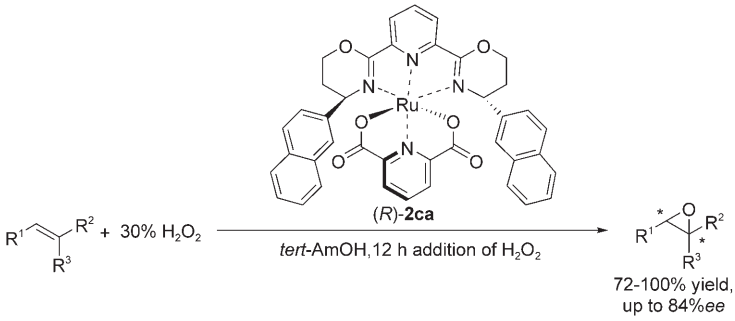




Scheme 1. Nishiyama's epoxidation of *trans*-stilbene.

By carefully studying the reaction we discovered that addition of a defined amount of water to the reaction mixture leads to a faster and more general epoxidation procedure.[12e] More recently, we developed enantioselective epoxidation protocols with these catalysts applying alkyl peroxides[12d] and hydrogen peroxide (Scheme 2).[12a–b] An important factor for the success was the use of a systematic varied toolbox of pybox ligands, which also led to the development of a novel class of ligands, the so-called pyboxazines.

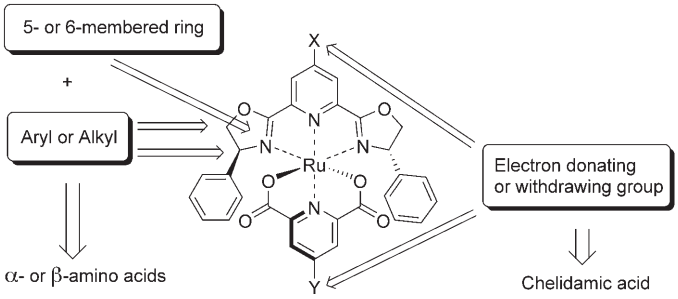


Scheme 2. Epoxidation of olefins catalyzed by [Ru(pyboxazine)(pydic)] (*R*)-**2ca**.[12b]

In this paper we report a full account of the strategy of the synthesis of these novel pybox and pyboxazine ligand library and their full characterization. In addition, their ruthenium complexes have also been synthesized and fully characterized. The comparison of the structures of pybox and pyboxazine are discussed in detail with the aid of their ruthenium complexes.[23]

Results and Discussion

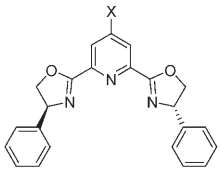
In order to apply (pybox)(pyridinedicarboxylate)ruthenium complexes in a more general sense and to find the optimal catalyst for a respective transformation, we were interested in systematic variations of steric and electronic parameters of the corresponding ligands. The obtained results should contribute to a more rational design of improved catalysts for asymmetric epoxidation. Therefore as a starting point for our synthetic work, we analyzed the possibility of modifications of catalyst **1** with respect to the availability of starting materials, literature knowledge, and the ease of synthesis (Scheme 3).



Scheme 3. Possible positions for modification of **1**.

It is clear that from the abundant naturally occurring amino acids, the corresponding 2-aminoethan-1-ol derivatives are in general obtained without much problem. Hence, the synthesis of the five-membered oxazoline becomes straightforward. Even if the substituted α-amino acid is not available for the synthesis of the corresponding chiral amino alcohol, asymmetric aminohydroxylation of olefins[24] or enzymatic resolution of the racemic amino acids[25] provide practical alternative pathways. In contrast to five-membered oxazolines, six-membered oxazines have been only sporadically studied due to the more difficult access of the corresponding 3-aminopropan-1-ol derivatives.[26] Nevertheless, resolution by co-crystallization of β-amino acid esters with enantiomerically pure organic acids,[26c,27] enzymatic resolution of β-amino acids[28] or direct asymmetric Mannich reaction[29] make chiral nonracemic 3-substituted 3-aminopropan-1-ols accessible. Some of the β-amino acids are even commercially available.[30] In addition to variations of the oxazoline moiety, we were also interested in the electronic effects to the catalyst. Therefore, we decided to synthesize *para*-substituted pybox[14b,31] and 2,6-pyridinedicarboxylic acid (H_2pydic)[32] derivatives as well.

The pybox ligands **3** used in this study are shown here. They cover a broad range of substitution patterns, including 4-, 5-, *cis*-4,5-di-, *trans*-4,5-di- and 4,5,5-tri-substitution on the oxazoline ring, *para*-substitution on the pyridine ring, *ortho*- or *meta*-substitution on the phenyl ring at the 4-position of the oxazoline, and a wide range of functional groups, such as halogen, alcohol, amine, silyl ether, ester, aryl- and alkyl-groups. Except for **3a**, **3n** and **3p**, which are commer-



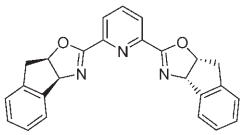
X = H **3a**[33]

Cl **3b**

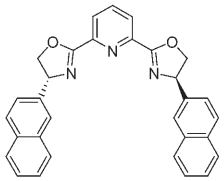
NMe_2 **3c**

Ph **3d**

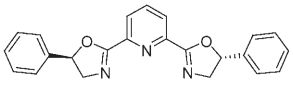
1-Np **3e**



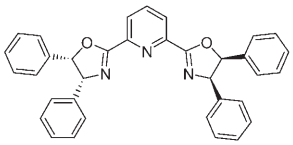
3f[34]



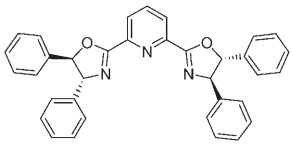
3g[35]



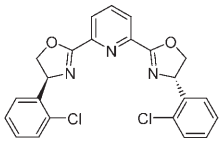
3h[36]



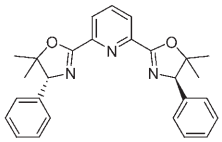
3i[35]



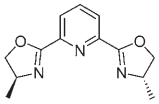
3j[16d]



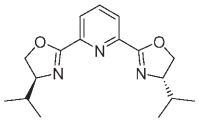
3k



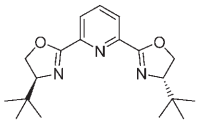
3l



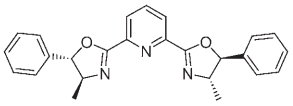
3m[37]



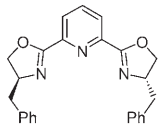
3n[33]



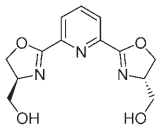
3o[38]



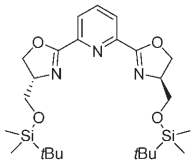
3p[33]



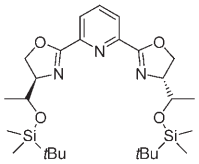
3q[16k,39]



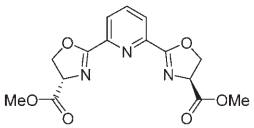
3r[40]



3s[40]



3t[41]

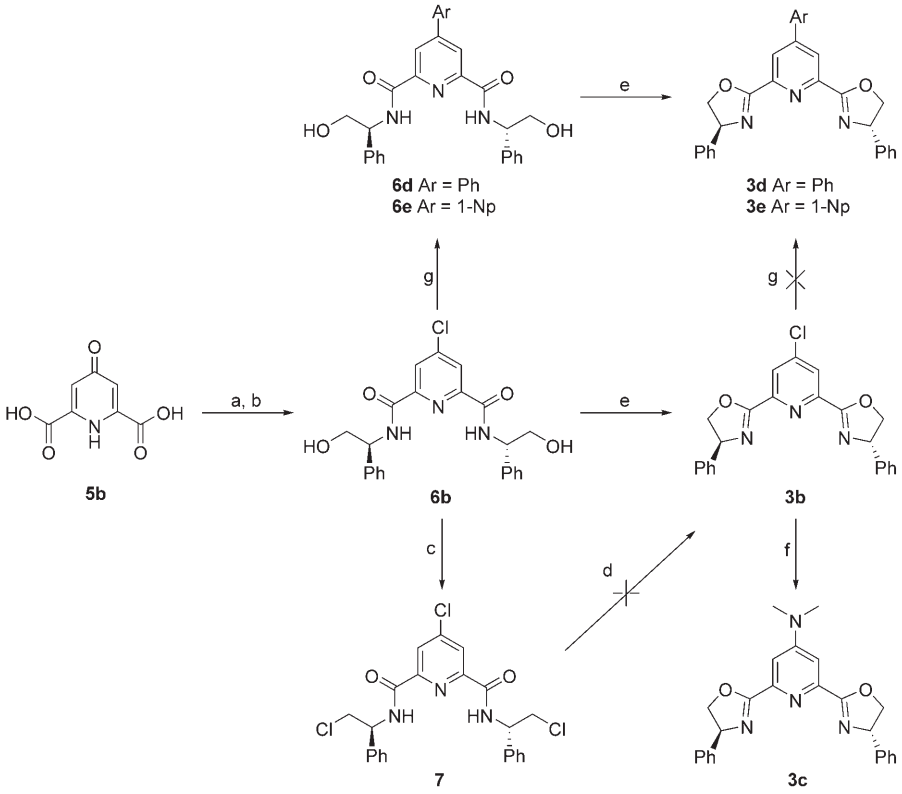


3u[42]

cially available,[33] all other pybox ligands were prepared in a straightforward manner.

The synthesis of the new ligands **3b–e** started from commercially available chelidamic acid **5b**, which was converted into the bis(hydroxyamide)pyridine **6b** in 90% yield in two steps with thionylchloride and (*S*)-phenylglycinol. For ring closure we initially followed the conventional method, which was developed mainly by Nishiyama and others,[22a] to convert the hydroxyl group to the chloride followed by intramolecular nucleophilic substitution. However, cyclization of the bis(chloroamide)pyridine **7** with NaH in THF did not yield the desired pybox **3b**.

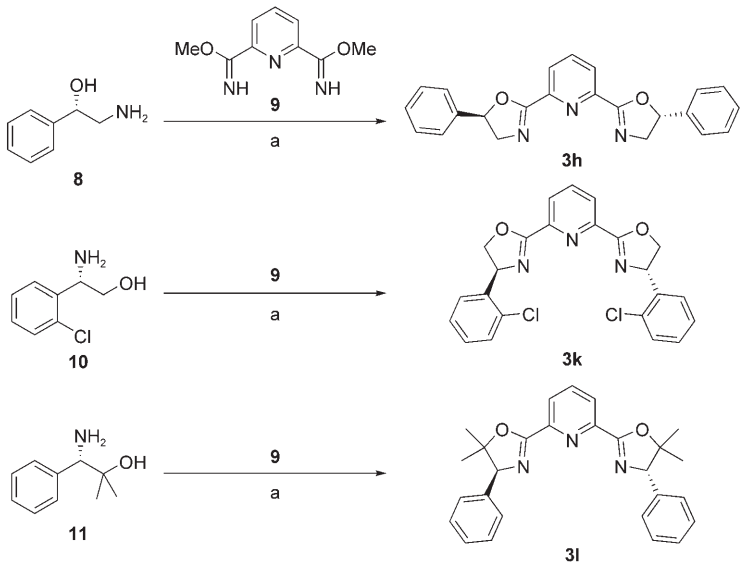
Therefore, we turned our interest to a recently developed method of direct cyclization of **6b**.[42] Treatment of the bishydroxyamide **6b** with diethylaminosulfur trifluoride (DAST) in dichloromethane at −20 °C gave the 4-chloropybox **3b** in 50% yield (Scheme 4). The corresponding 4-(dimethylamino)pybox **3c** was easily obtained in 73% yield by the substitution reaction of **3b** with aqueous dimethylamine (40 wt%) in THF at 40 °C. In addition, we were able to perform the synthesis of 4-phenyl- and 4-naphthyl-substituted ligands **3d**,**e** by palladium-catalyzed Suzuki reactions.[32b] Initial efforts of the direct synthesis from 4-chloropybox **3b** were unsuccessful. This can be explained by palladium deactivation due to its strong coordination with pybox. Therefore we changed our strategy to first perform the Suzuki reaction followed by cyclization. To our delight treatment of the bishydroxyamide **6b** with phenyl boronic acid or naphthyl



Scheme 4. a) $SOCl_2$, DMF, reflux, 2 d; b) (*S*)-phenyl glycinol, $CHCl_3$, NEt_3, 0 °C to RT, 18 h, 90 % in 2 steps; c) $SOCl_2$, reflux, 9 h; d) NaH, THF, RT; e) 3 equiv DAST, CH_2Cl_2, −20 °C, 30 min, **3b** 50 %, **3d** 55 %, **3e** 40 %; f) 40 wt % aqueous dimethylamine, THF, 40 °C, 24 h, 73 %; g) aryl boronic acid, 5 mol % $Pd(OAc)_2$, 10 mol % P(*o*-Tolyl)$_3$, 3.5 equiv CsF in DME at 100 °C for 18 h, **6d** 64 %, **6e** 75 %.

boronic acid using 5 mol % $Pd(OAc)_2$, 10 mol % P(*o*-Tolyl)$_3$, 3.5 equivalents CsF in DME (DME = 1,2-dimethoxyethane) at 100 °C for 18 h gave the corresponding 4-substituted bishydroxyamide **6d** and **6e** in 61 and 75 % yield, respectively. 4-Phenyl- and 4-naphthyl-substituted pybox ligands **3d** and **3e** were finally obtained by cyclization of **6d** and **6e**, respectively, with diethylaminosulfur trifluoride (DAST) in dichloromethane at −20 °C.

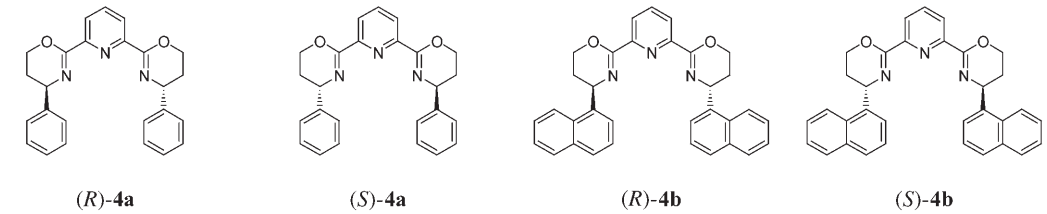
Pybox **3h**, which has two phenyl groups on the 5-position of the oxazoline rings and unsubstituted 4-positions, has been mentioned in the literature, but no experimental details have been reported.[36] Starting from (*R*)-2-amino-1-phenylethanol (**8**), compound **3h** was obtained in 35 % yield after refluxing **8** with imidate **9** in anhydrous CH_2Cl_2 for 2–4 days.[18a] Likewise, ligands **3k** and **3l** were synthesized from amino alcohol **10**[43] and **11**[44] in 81 % and 25 %, respectively (Scheme 5).

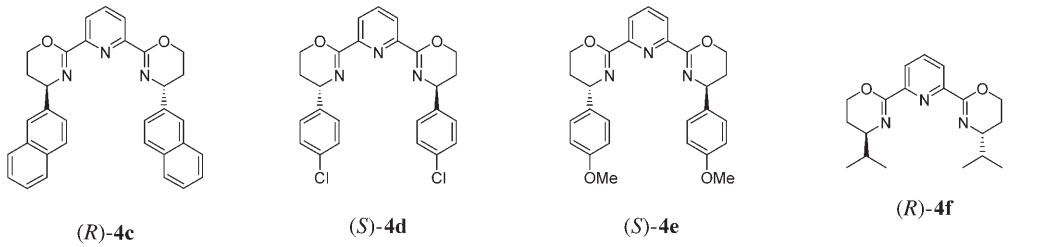


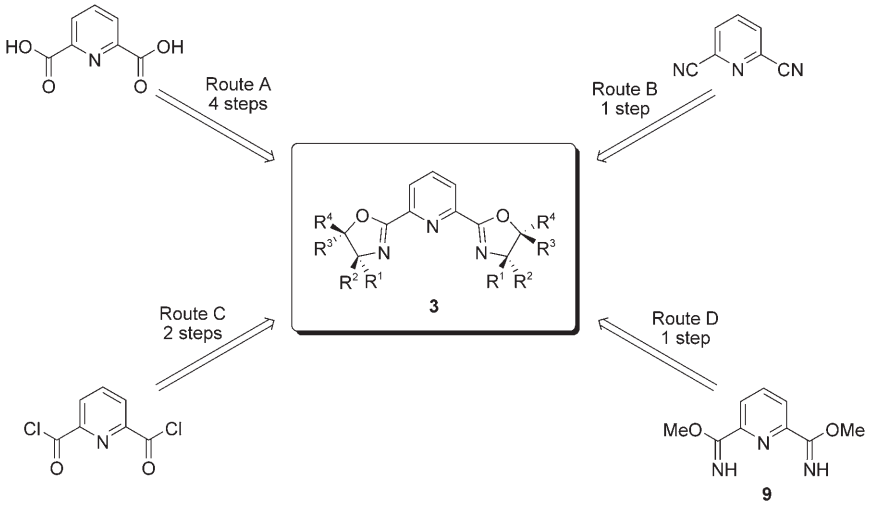
Scheme 5. a) CH_2Cl_2, reflux, 2–4 d, **3h** 35 %, **3k** 81 %, **3l** 25 %.

In general, there are four common synthetic routes for the preparation of pybox ligands **3** (Scheme 6). After the preparation of this toolbox of ligands, we found that the imidate method (route D) is the most convenient one. The short synthetic route, easy handling of reagents, mild reaction conditions and no heavy metal waste makes route D most advantageous. However, route C, which uses DAST as the key reagent for the cyclization, is preferable for the preparation of 4-substituted pyridine derivatives.

Next, we turned our interest to the synthesis of the pyboxazine ligands **4**. Due to above mentioned advantages all pyboxazine ligands were prepared according to route D. The availability of the enantiopure 3-aminopropan-1-ols is an important pre-requisite for the synthesis of novel pyboxazine ligands **4**. We successfully applied resolution of β-amino acid derivatives by co-crystallization[26c] and enzymatic resolution[28a] as well as commercial available starting materials[45] to synthesize eight enantiomerically pure pyboxazines **4**. These ligands include aryl groups with different electronic and steric properties as well as an alkyl group. In two cases both enantiomers of the ligands (**4a** and **4b**) were synthesized.

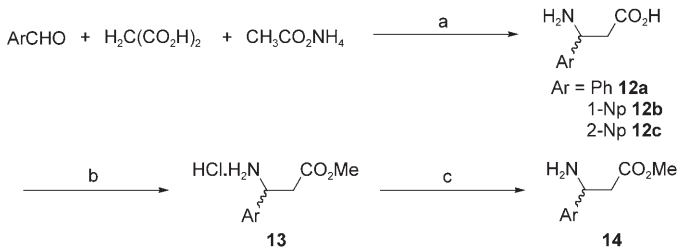




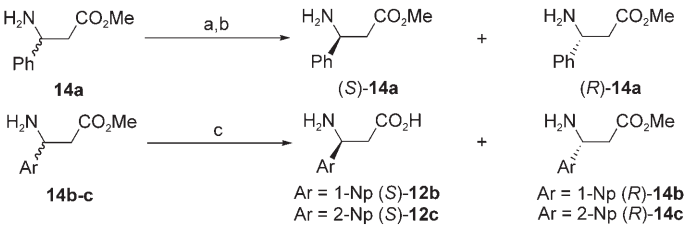


Scheme 6. Synthetic routes for pybox ligands **3**. Typical reaction conditions: Route A: i) $SOCl_2$, ii) amino alcohol, iii) $SOCl_2$, iv) NaOH; Route B: i) $ZnCl_2$, PhCl, reflux; Route C: i) amino alcohol, ii) DAST; Route D: i) amino alcohol, CH_2Cl_2, reflux.[21a]

Racemic 3-aryl β-amino acids and their derivatives were synthesized according to literature methods in good yields (Scheme 7).[26c,46] Co-crystallization of *rac*-**14a** with L-tartaric acid gave (*S*)-**14a** in 43% yield (>98% *ee*) and co-crystallization of the filtrate with D-tartaric acid yielded (*R*)-**14a** in 42% yield (>98% *ee*; (Scheme 8).[26c,27,47] However, *rac*-**14b** and *rac*-**14c** could not be resolved by this method. Therefore, we applied enzymatic resolution protocols for these substrates.[28a] Thus, *rac*-**14b** was hydrolyzed to (*S*)-**12b** with Amano Lipase PS at room temperature at pH 8.2 in 45% yield (>99% *ee*) with (*R*)-**14b** remained in 43–48% yield (>98% *ee*). Applying the same reaction conditions *rac*-**14c** was not hydrolyzed in the presence of Amano Lipase PS. However, prolonged reaction time (4 days) at 36°C gave (*S*)-**12c** in 45% yield (44% *ee*) with 35% (*R*)-**14c** (95% *ee*) unreacted. As 95% *ee* of (*R*)-**14c** is still not yet suitable for ligand preparation, we used only enantiopure **14a** and **14b**



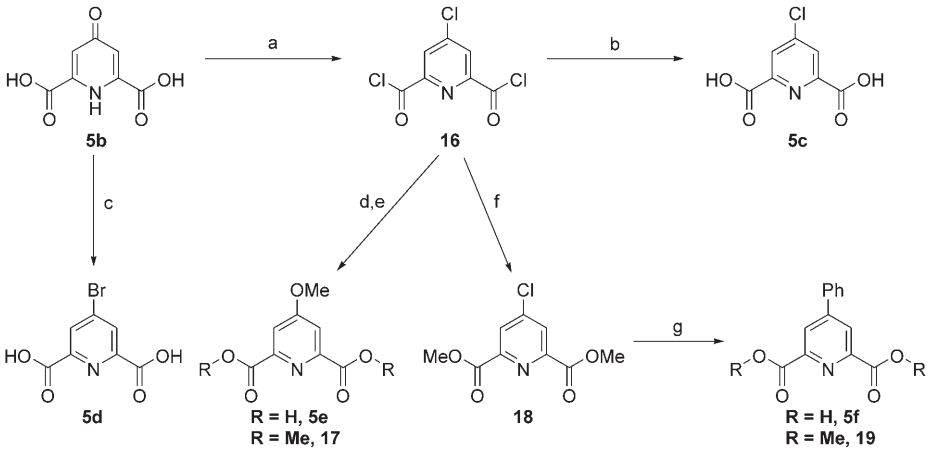
Scheme 7. Synthesis of racemic substituted β-amino acids and derivatives. a) EtOH, reflux, 6 h, **12a** 38–65%, **12b** 38%, **12c** 30–65%; b) HCl, MeOH, **13a** 74–96%, **13b** 68–86%, **13c** 81–88%; c) $NaHCO_3$, ethyl acetate, **14a** 78–96%, **14b** 92%, **14c** 87%.



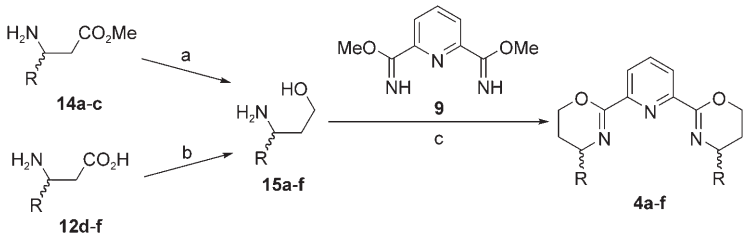
Scheme 8. Resolution of β-amino acids and derivatives. a) L-Tartaric acid crystallized with (*S*)-**14a** and the filtrate crystallized with D-tartaric acid for (*R*)-**14a**, MeOH, −20°C; b) $NaHCO_3$, ethyl acetate, (*S*)-**14a** 43% (>98% *ee*), (*R*)-**14a** 42% (>98% *ee*); c) Amano Lipase PS, pH 8.2 (phosphate buffer), RT, 24 h, (*S*)-**12b** 43–45% (>99% *ee*), (*R*)-**14b** 45% (>98% *ee*); Amano Lipase PS, pH 8.2 (phosphate buffer), 36°C, 96 h, (*S*)-**12c** 45% (44% *ee*), (*R*)-**14c** 35% (95% *ee*).

and commercially available **12c–f** to the following ligand syntheses.

Next, the enantiopure 3-amino-propan-1-ols **15a–f** were obtained by reduction of the corresponding β-amino acid ester with $NaBH_4$ in THF or the β-amino acids directly with $LiAlH_4$ (Scheme 9). Subsequently, cyclization with imidate **9** in anhydrous CH_2Cl_2 yielded pyboxazine ligands **4a–f**. Compounds **4a–f** can be used for complexation directly or purified by flash chromatography through alumina (CH_2Cl_2/Et_3N 100:1). The new pyboxazine ligands are stable in air as white solids, but slowly hydrolyze in the presence of water.



Scheme 10. a) $SOCl_2$, DMF, reflux, 2 d; b) H_2O; c) P_2O_5, Bu_4NBr, toluene; d) MeOH, NaOMe, reflux, 2 h; e) K_2CO_3, $MeOH/H_2O$, RT, 18 h; f) MeOH; g) phenyl boronic acid, 5 mol% $Pd(OAc)_2$, 10 mol% $P(o\text{-Tolyl})_3$, 3.5 equiv CsF in DME at 100 °C for 18 h.

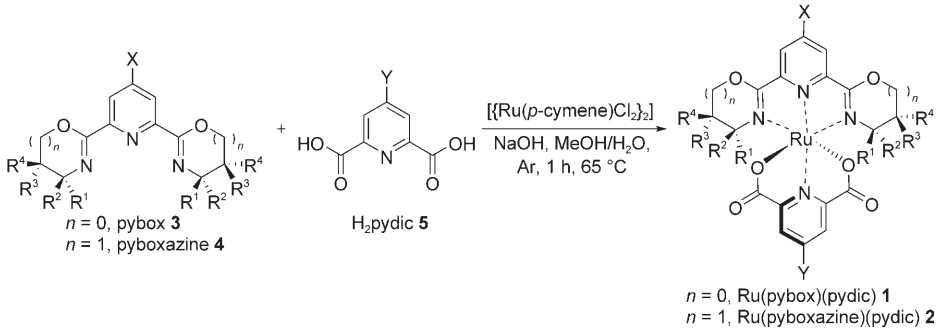


Scheme 9. Synthesis of pyboxazines **4a–f**. a) $NaBH_4$, THF, (*R*)-**15a** 78%, (*S*)-**15a** 72%, (*R*)-**15b** 55%, (*S*)-**15b** 45%, (*R*)-**15c** 97%; b) $LiAlH_4$, THF, (*R*)-**15d** 80%, (*R*)-**15e** 85%, (*R*)-**15f** 83%; c) CH_2Cl_2, reflux, 2–4 days, (*R*)-**4a** 52%, (*S*)-**4a** 51%, (*R*)-**4b** 59%, (*S*)-**4b** 68%, (*R*)-**4c** 81%, (*S*)-**4d** 79%, (*S*)-**4e** 26%, (*R*)-**4f** 61%.

To rationalize the electronic effects on the 2,6-pyridinedicarboxylate side of the catalysts, *para*-substituted 2,6-pyridinedicarboxylic acids were also synthesized according to literature procedures (Scheme 10).[32] All co-ligands were prepared starting from chelidamic acid (**5b**), which was first chlorinated with thionyl chloride under refluxing conditions to give **16**.[32d] Compound **16** was treated with water to give the 4-chloro-2,6-pyridinedicarboxylic acid (**5c**) and substitution of the chlorine of **16** to a methoxy group was achieved by using sodium methoxide in methanol to afford dimethyl 4-methoxy-2,6-pyridinedicarboxylate **17**. Compound **17** was hydrolyzed to 4-methoxy-2,6-pyridinedicarboxylic acid (**5e**) by using potassium carbonate in a mixture of methanol and water. Compound **18** was also transformed by palladium-catalyzed Suzuki coupling reaction with phenyl boronic acid to yield dimethyl 4-phenyl-2,6-pyridinedicarboxylate **19**.[32b] Hydrolysis of **19** yielded 4-phenyl-2,6-pyridinedicarboxylic acid (**5f**). In addition, preparation of 4-bromo-2,6-pyridinedicarboxylic acid (**5d**) was performed according to literature from chelidamic acid.[32a]

The different pybox **3a–u**, pyboxazine **4a–f**, and pydic **5a–f** ligands were then subjected to complex formation with $[\{Ru(p\text{-cymene})Cl_2\}_2]$ (Scheme 11).[15e] It is also possible to synthesize these complexes with $RuCl_3 \cdot x H_2O$, but drastic reaction conditions are needed (refluxing in *n*BuOH under Ar for 12 h)[12a] and only low yields are obtained.[48] [Ru(pybox)(pydic)] complexes (**1**) were obtained in moderate to excellent yields (47–98%) as crystalline solids, except **1oa** and **1ua**, since **3o** and **3u** are unstable under the reaction conditions (Table 1).

It is worth noting that pyboxazines **4** can be used for the preparation of the corresponding [Ru(pyboxazine)(pydic)] complexes (**2**) without any purification, though the yields



Scheme 11. Synthesis of [Ru(pybox)(pydic)] **1** and [Ru(pyboxazine)(pydic)] **2**.

Table 1. Synthesis of [Ru(pybox)(pydic)] **1** and [Ru(pyboxazine)(pydic)] **2** complexes.

Entry	Pybox **3** or pyboxazine **4**	H_2Pydic **5**	[Ru(pybox)(pydic)] **1** or [Ru(pyboxazine)(pydic)] **2**	Yield (%)
1	**3a**	**5a**	**1aa**	79
2	**3a**	**5b**	**1ab**	86
3	**3a**	**5c**	**1ac**	75
4	**3a**	**5d**	**1ad**	86
5	**3a**	**5e**	**1ae**	53
6	**3a**	**5f**	**1af**	98
7	**3b**	**5a**	**1ba**	53
8	**3c**	**5a**	**1ca**	64
9	**3d**	**5a**	**1da**	47
10	**3e**	**5a**	**1ea**	62
11	**3f**	**5a**	**1fa**	86
12	**3g**	**5a**	**1ga**	64
13	**3h**	**5a**	**1ha**	71
14	**3i**	**5a**	**1ia**	74
15	**3j**	**5a**	**1ja**	75
16	**3k**	**5a**	**1ka**	54
17	**3l**	**5a**	**1la**	70
18	**3m**	**5a**	**1ma**	79
19	**3n**	**5a**	**1na**	82
20	**3o**	**5a**	**1oa**	23
21	**3p**	**5a**	**1pa**	79
22	**3q**	**5a**	**1qa**	85
23	**3r**	**5a**	**1ra**	59
24	**3s**	**5a**	**1sa**	63
25	**3t**	**5a**	**1ta**	71
26	**3u**	**5a**	**1ua**	18
27	(*R*)-**4a**[a]	**5a**	(*R*)-**2aa**	40
28	(*R*)-**4a**[a]	**5c**	(*R*)-**2ac**	38
29	(*S*)-**4a**[a]	**5a**	(*S*)-**2aa**	29
30	(*R*)-**4b**[a]	**5a**	(*R*)-**2ba**	49
31	(*S*)-**4b**[a]	**5a**	(*S*)-**2ba**	48
32	(*R*)-**4c**[a]	**5a**	(*R*)-**2ca**	60 (89[b])
33	(*S*)-**4d**	**5a**	(*S*)-**2da**	54
34	(*S*)-**4e**	**5a**	(*S*)-**2ea**	53
35	(*R*)-**4f**	**5a**	(*R*)-**2fa**	28

[a] The ligand was used directly without purification. [b] Pure ligand was used.

are somewhat lower (Table 1, entries 27–35). All complexes are highly stable at room temperature and can be easily handled in air. In spite of the interesting catalytic performance of complexes **1** and **2**, so far no X-ray crystal structures of these complexes have been reported.[12b] We were interested in the detailed structural information in order to rationalize the catalytic activity to structural features. Crystals suitable for X-ray crystallography were obtained by slow diffusion of hexane to a solution of the complex (**1ja**, **1na** and (*S*)-**2aa**) in dichloromethane or chloroform at room temperature and single crystals of **1ia** were obtained by slow evaporation of a solution of **1ia** in hexane/CH_2Cl_2/MeOH. Crystallographic data of the complexes are given in Table 2 and selected distances and angles are shown in Table 3.

As shown in Figure 1 the central ruthenium atom is coordinated by the pybox(azine) unit as well as the pydic unit in a distorted octahedral geometry. The pybox(azine) coordinates to Ru on one plane as a *N*,*N*,*N*-tridentate ligand and the pydic acts as a dianionic *O*,*N*,*O*-tridentate ligand on another plane, in which they are nearly perpendicular to each other (86.9–93.0°). The bond lengths between Ru and all the core nitrogen and oxygen atoms in all the complexes in this study are comparable. This implies that the ligands mainly affect the steric environment of the metal center rather than disturb the electronic properties. The bond lengths of Ru1 to N2 and N4 (1.940(3)–1.976(3) Å) are shorter than those to N1 and N3 (2.053(3)–2.087(3) Å); this difference arises from the steric limitations of the pybox(azine) ligands. This is also reflected by the small bond angle α (108.0(3)–109.5(3)° in **1ia**, **1ja**, and **1na** and 110.8(2)–111.0(3)° in (*S*)-**2aa**). The angle between the planes defined by N1, N2, N3, Ru1 and O1, N4, O2, Ru1 are close to 90° (86.9–-93.0°) and the mean deviations from the best plane through the atoms N1, N2, N3, N4 and Ru1 are very small (0.0074–0.0375 Å). When all the nitrogen atoms are considered to coordinate all four equatorial positions of Ru with two *trans* axial oxygen atoms, this geometric feature resembles the well-established ruthenium–porphyrin structures.[49] Unlike the planar five-membered oxazoline rings, the six-membered oxazine rings adopt to a twist chair conformation. It is worth noting that (*S*)-**2aa** shows a defined geometry in the oxazine rings, whereas in some other cases it is quite flexible.[26] This may be due to the effect of the tridentate pydic ligand.

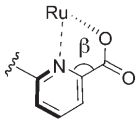
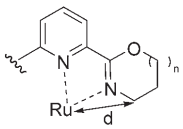
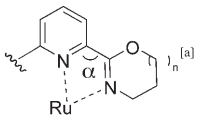
It should also been pointed out that the orientation of the substituent at the chiral center adjacent to the nitrogen donor atoms may change when the oxazoline is replaced by oxazine. Indeed this chiral center is 3.147/3.192 Å away from Ru in (*S*)-**2aa**, which is less than that of **1** (3.311–3.369 Å; Table 3).

The structures of the ligands **3i** and **3j** are controversial.[16d,35,50] Though the crystal structure of a La complex of

Table 2. Crystallographic data.

	1ia	**1ja**	**1na**	(*S*)-**2aa**
crystal system	monoclinic	orthorhombic	orthorhombic	monoclinic
space group	*C*2	$P2_12_12_1$	$P2_12_12_1$	$P2_1$
a [Å]	21.590(4)	10.061(2)	10.505(2)	9.072(2)
b [Å]	11.377(2)	15.844(3)	12.812(3)	10.456(2)
c [Å]	15.903(3)	24.035(5)	21.145(4)	14.714(3)
β [°]	101.40(3)			90.23(3)
V [Å^3]	3829.2(12)	3831.3(13)	2845.9(10)	1395.7(5)
Z	4	4	4	2
ρ_{calcd} [g cm^{-3}]	1.468	1.560	1.603	1.579
$\mu(Mo_{K\alpha})$ [mm^{-1}]	0.535	0.609	0.879	0.616
T [K]	200	200	200	200
reflns (measd)	12280	20627	15252	7532
reflns (indep)	7222	6103	4521	4186
reflns (obsd)	5317	5459	4284	3874
parameters	494	522	352	388
*R*1 [$I > 2\sigma(I)$]	0.0381	0.0350	0.0262	0.0228
*wR*2 (all data)	0.0625	0.0814	0.0709	0.0533

Table 3. Selected bond lengths [Å] and angles [°] in complexes **1na**, **1ia**, **1ja** and (*S*)-**2aa**.

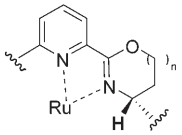
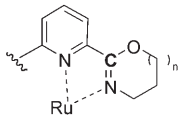
	1ia	**1ja**	**1na**	(*S*)-**2aa**
Ru1–N1/N3	2.053(3)/2.080(3)	2.064(3)/2.087(3)	2.081(3)/2.087(3)	2.065(3)/2.087(3)
Ru1–N2	1.970(4)	1.975(3)	1.965(3)	1.940(3)
Ru1–N4	1.975(4)	1.976(3)	1.976(3)	1.976(3)
Ru1–O1/O2	2.111(3)/2.072(3)	2.077(3)/2.114(3)	2.118(2)/2.090(2)	2.107(2)/2.083(2)
N1-Ru1-N2	78.05(15)	77.92(12)	78.08(12)	78.68(11)
N2-Ru1-N4	175.3(2)	178.45(15)	177.24(12)	176.01(11)
O1-Ru1-O2	157.26(13)	156.39(11)	156.47(9)	157.04(8)
	108.7(4)/109.4(4)	108.1(3)/108.9(4)	108.0(3)/109.5(3)	110.8(2)/111.0(3)
	112.4(4)/111.7(4)	112.6(3)/112.6(3)	112.3(3)/113.2(3)	112.5(3)/112.5(3)
	3.311/3.306	3.369/3.327	3.345/3.349	3.147/3.192
γ[b]	86.9	88.5	88.9	93.0
mean deviation[c]	0.0375	0.0074	0.0128	0.0315

[a] The distance between Ru and the carbon atom α to the imine. [b] The angle between mean plane N1, N2, N3, Ru1 and mean plane O1, N4, O2, Ru1. [c] Mean deviation from the best plane defined by N1, N2, N3, N4 and Ru1.

3j was reported, to the best of our knowledge, there is no direct comparison of the crystal structures of both the *cis*- and *trans*-isomers known. From the crystal structures of **1ia** and **1ja** (Figure 1), the structures reported by Desimoni are confirmed.[16d,35] There is no significant difference in the core structure of **1ia** and **1ja** observed. Therefore, one could expect that any reactivity and selectivity difference between **1ia** and **1ja** is probably due to steric reasons.

The signal pattern in both ^{1}H and ^{13}C NMR spectra confirmed a C_2-chiral monomeric complex also in solution. Comparing to the pybox(azine) ligands, the signal of the proton at the chiral center adjacent to the nitrogen donor atom in the ruthenium complexes moves about 0.5 ppm upfield in pybox and about 1 ppm in pyboxazine (Table 4). This also suggests that in the solution structure the chiral center adjacent to the nitrogen donor atom is closer to the

Table 4. Selected ^{1}H and ^{13}C chemical shifts [ppm] and UV/Vis absorption maxima [nm].

	1aa	**1ab**	**1ac**	**1ad**	**1ae**	**1af**	**1ba**	**1ca**	**1da**	**1ea**
^{1}H δ[a]	5.18	5.39	5.39	5.19	5.11	5.17	5.18 (5.70)[b]	5.11 (5.38)	5.18 (5.47)	5.18 (5.48)
^{13}C δ[c]	167.4	166.7	169.4	167.3	167.7	167.3	166.8 (163.1)	166.6 (163.6)	167.5 (163.7)	167.5 (162.7)
UV/Vis λ_{max}(1)[d]	375	359[e]	383	384	366	394	371	388	345	364
UV/Vis λ_{max}(2)[d]	484	472[e]	484	484	483	488	493	505	495	492

	(*R*)-**2aa**	(*R*)-**2ac**	(*R*)-**2ba**	(*R*)-**2ca**	(*S*)-**2da**	(*S*)-**2ea**	(*R*)-**2fa**
^{1}H δ[a]	3.75 (4.80)	3.72	4.50 (5.62)	3.89 (5.00)	3.72 (4.79)	3.68 (4.75)	2.51 (2.95)
^{13}C δ[c]	160.3 (155.1)	160.4	161.0 (155.8)	160.5 (155.1)	160.6 (155.3)	160.1 (155.0)	159.2 (153.5)
UV/Vis λ_{max}(1)[d]	384	393	383	384	386	387	395
UV/Vis λ_{max}(2)[d]	482	485	481	484	483	482	481

[a] Chemical shift of the proton at the chiral center adjacent to the nitrogen donor in ppm (shown above). [b] The corresponding chemical shift of the ligand is in the parentheses. [c] Chemical shift of the imine carbon in ppm (shown above). [d] λ_{max} of the UV/Vis absorption spectrum of the complex in CH_2Cl_2. [e] The UV/Vis absorption spectrum of the complex in MeOH.

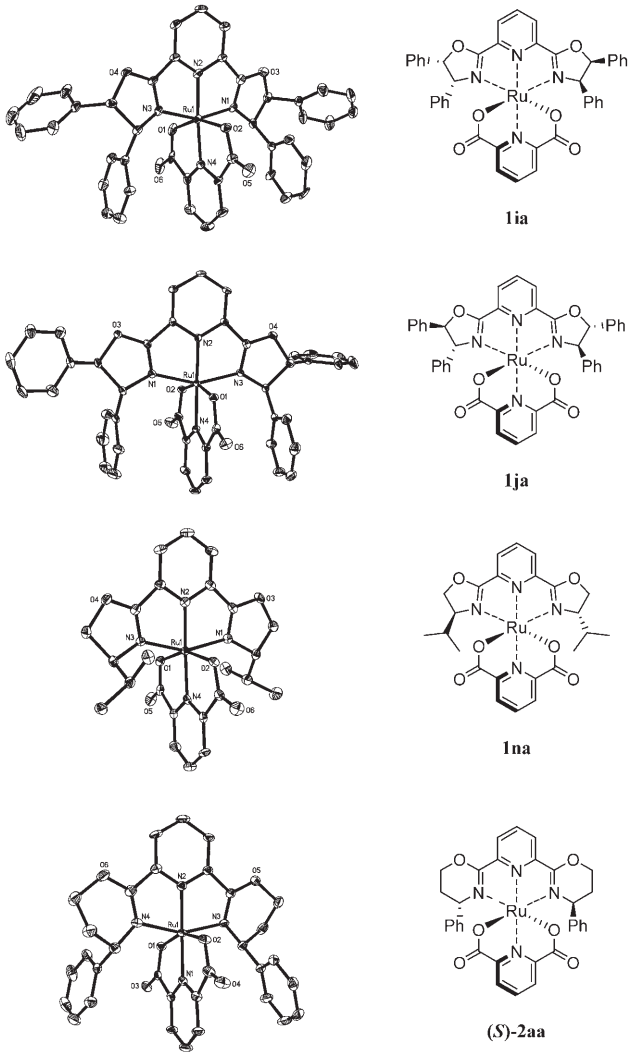
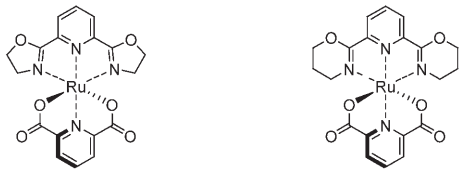


Figure 1. [Ru(pybox)(pydic)] and [Ru(pyboxazine)(pydic)] complexes **1ia**, **1ja**, **1na**, and (*S*)-**2aa**. Hydrogen atoms are omitted for clarity and the thermal ellipsoids correspond to 30% probability.

metal in [Ru(pyboxazine)(pydic)] **2** than that in [Ru(pybox)-(pydic)] **1** as shown in the crystal structures. The imine carbon of both the pybox and pyboxazine rings deshields (3 to 5 ppm) indicating loss of electron density due to coordination to the metal center.

The UV-visible absorption spectra of the ruthenium complexes gave us some insights in the electronic structure of the complexes and the effects of the substituents as well. As shown in Table 4, there are two absorption peaks for both complexes **1** and **2**. The absorption maximum at around 480 nm ($\varepsilon \sim 20000\,\mathrm{M^{-1}cm^{-1}}$) is about six times stronger than that at around 380 nm ($\varepsilon \sim 3000\,\mathrm{M^{-1}cm^{-1}}$). To assign these observed UV-visible adsorption spectra, we carried out time-dependent density functional theory computations (TD-DFT). Direct comparison between computed and observed adsorption maxima should provide a more detailed insight into the electronic interaction. Computations were done in two steps by geometry optimization and excitation energy. Here, the parent or unsubstituted complexes **1′** and **2′** (Scheme 12) were compared. The optimized structural parameters are given in Table 5.



Scheme 12. Parent complexes for structure optimization and excitation energy calculation.

Table 5. Selected bond lengths [Å], angles [°] and absorption maxima in calculated **1′** and **2′**.[a,b]

	1′	**2′**
Ru–N1	2.103	2.116
Ru–N2	1.988	1.967
Ru–N4	2.017	2.018
Ru–O1	2.123	2.127
N1-Ru-N2	77.6	78.2
N1-Ru-N3	155.2	156.3
N1-Ru-N4	102.4	101.8
O1-Ru-N1	92.6	93.0
O1-Ru-N2	102.0	102.1
O1-Ru-N3	92.6	91.9
O1-Ru-N4	78.0	77.9
O1-Ru-O2	156.0	155.9
λ_{max} (1)[c,d]	347 (0.11)	359 (0.07)
λ_{max} (2)[c,d]	440 (0.29)	441 (0.26)

[a] At B3LYP/LANL2DZ(d). [b] Using the same numbering systems in X-ray crystal structure. [c] At TD-B3P86/LANL2DZ(d)//B3LYP/LANL2DZ(d). [d] The oscillator strength in parenthesis.

All the structures have C_2 symmetry and they are found to be energy minima on the potential-energy surface. The close agreement between the computed bond parameters and that determined by X-ray crystallography in Table 3 demonstrates the quality of the computational method.

In addition to the structural parameters, the excitation energies for the comparison with the observed UV-visible spectra were computed. In the calculations we found two excited states with very strong oscillator strengths. Detailed analysis shows that the $\lambda_{max}(1)$ corresponds to the allowed excitation (347 (**1′**) and 359 nm (**2′**)) from the Ru d orbitals to the π* orbital of the pydic ligand (Ru(d)→pydic(π*)), and the $\lambda_{max}(2)$ corresponds mainly to the allowed excitation (440 (**1′**) and 441 nm (**2′**)) from the Ru d orbitals to the π* orbitals of the pybox or pyboxazine ligands (Ru(d)→pybox-(azine)(π*)). In addition, there is a set of excited states with very low oscillator strengths. As given in Table 5, both $\lambda_{max}(1)$ and $\lambda_{max}(2)$ agree reasonably with the experimental data for the phenyl-substituted systems.

Electron-deficient or aromatic *para*-substituents on the pyridine ring lead to significant red shifts on the 380 nm peak, while the electron-donating methoxy group gives a

blue shift (Table 4, **1aa**–**1af**, **1ab** could not be accounted, since the UV-visible spectrum was taken in MeOH rather than CH_2Cl_2 due to solubility problems). Evidently an electron-deficient or aromatic group substituted on the pydic side stabilizes the pydic(π*) orbital, which results in a red shift for **1aa** and **1ac**–**1af** for the transition of Ru(d) to pydic(π*). Stabilization of the pydic(π*) orbital by introducing an electron-withdrawing chloro group also leads to a red shift of the near UV absorption of **2ac** (384 nm) relative to **2aa** (393 nm). Electron-withdrawing or aromatic groups at the *para*-position of pybox stabilizes the Ru(d) orbital. Accordingly, blue shifts are observed for **1aa**, **1ba**, **1da**, and **1ea**. The red shift for **1ca** can be explained by protonation.[51] On the other hand the strong visible absorption at ~480 nm is influenced more by the electronic nature of the pybox ligands. As a *para*-substitution of the pyridine ring of the pybox ligand affects its π* orbital more than the Ru(d) orbital, the energy difference between Ru(d) and pybox(π*) orbitals decreases with an electron-withdrawing group. Therefore red shifts were observed in the visible absorption at ~480 nm (Table 4, **1aa**–**1ea**, except for **1ca** infra supra). This effect diminishes when the substituents are far away from the metal center (Table 4, **2aa**–**2ea**). It should be noted that the electronic environment of the metal complexes can be fine tuned easily by the *para*-substitution strategy on both ligands.

In conclusion, we have synthesized 29 neutral *N*,*N*,*N*-tridentate pybox and pyboxazine ligands. In combination of these ligands with 2,6-pyridinedicarboxylic acid and derivatives, 35 new ruthenium(II) complexes have been synthesized and fully characterized. In addition, four new ruthenium(II) complexes have been characterized by X-ray crystallography; this allows for detailed comparison of structure relationships. Structural investigations also revealed that pyboxazine ligands not only resemble the well-known pybox ligands, but also change the orientation of the α-carbon atom at the chiral center adjacent to the nitrogen donor atoms. In general, these novel ligands and catalysts constitute an interesting toolbox for a variety of catalytic asymmetric reactions. In the following paper their use in asymmetric epoxidation is described in detail.

Experimental Section

4-Chloro-2,6-bis[hydroxyamide]pyridine (6b): Chelidamic acid (**5b**; 1 g, 5.46 mmol) was treated with $SOCl_2$ (27 mL) at refluxing temperature for 2 d. Excess $SOCl_2$ was then removed under reduced pressure to give the acid chloride as a white solid. A solution of the acid chloride (1.3 g, 5.46 mmol) in $CHCl_3$ (25 mL) was slowly to a solution of (*S*)-phenyl glycinol (1.64 g, 12 mmol) and triethylamine (5.0 mL, 36 mmol) in $CHCl_3$ (25 mL), added at 0 °C. The mixture was stirred for 18 h at room temperature and water was added. The mixture was extracted with CH_2Cl_2 (50 mL × 2), dried over $MgSO_4$, and concentrated. The residue was purified by silica gel column chromatography with 1:2 ethyl acetate (EA) and hexane to give **6b** as a white solid (2.16 g, 4.9 mmol, 90 %). R_f = 0.14 (hexane/EA 1:1); m.p. 75–78 °C; $[\alpha]_D = -89.1°$ (c = 1.0 in $CHCl_3$); ^{1}H NMR (400.1 MHz, $CDCl_3$): δ = 4.03 (m, 4H), 5.18 (unresolved dd, 2H), 7.09–7.37 (m, 10H), 8.22 (s, 2H), 8.77 ppm (d, 2H); ^{13}C NMR (100.6 MHz, $CDCl_3$): δ = 55.9, 66.0, 116.3, 125.6, 126.8, 128.0, 128.9, 138.5, 150.0, 162.8 ppm; MS (EI, 70 eV): m/z (%): 408 (100), 390 (70), 288 (93), 258 (17), 91 (47); FAB-MS: m/z: 440 [M^+]; HRMS (ESI+): m/z calcd for $C_{23}H_{23}ClN_3O_4$: 440.13770; found: 440.13771.

Synthesis of 2,6-bis-[(4*S*)-4-phenyl-4,5-dihydrooxazol-2-yl]-4-chloropyridine (3b): Diethylaminosulfur trifluoride (DAST) (313.44 µl, 385.5 mg, 2.4 mmol) was slowly added to a solution of bishydroxyamide **6b** (350 mg, 0.8 mmol) in CH_2Cl_2 (5 mL) at −20 °C under argon. After 8 h stirring at −20 °C, ammonium hydroxide solution (1 mL) was added slowly. Subsequently the cooling bath was removed and water (20 mL) was added. When the reaction mixture had reached room temperature, two layers were separated and the aqueous layers were extracted with CH_2Cl_2 (20 mL × 2). The combined organic layer was dried over $MgSO_4$ and concentrated under reduced pressure. The crude product was purified by column chromatography to give **3b** as a white solid (60 mg, 0.4 mmol, 50 %). R_f = 0.35 (hexane/EA 1:1); m.p. 169–170 °C; $[\alpha]_D = -108.6°$ (c = 0.5 in $CHCl_3$); ^{1}H NMR (400.1 MHz, $CDCl_3$): δ = 4.67 (unresolved dd, 2H), 5.17 (unresolved dd, 2H), 5.70 (unresolved dd, 2H), 7.54–7.63 (m, 10H), 8.59 ppm (s, 2H); ^{13}C NMR (100.6 MHz, $CDCl_3$): δ = 70.8, 76.1, 126.9, 127.2, 128.4, 129.3, 141.8, 146.1, 148.4, 163.1 ppm; MS (EI, 70 eV): m/z (%): 403 (76) [M]$^+$, 253 (24), 118 (27), 104 (100), 91(51); HRMS (ESI+): m/z calcd for $C_{23}H_{18}ClN_3O_2$: 403.10876; found: 403.10474.

Synthesis of 2,6-bis-[(4*S*)-4-phenyl-4,5-dihydrooxazol-2-yl]-4-(*N*,*N*-dimethylamino)pyridine (3c): An aqueous solution of dimethylamine (40 wt %, 25 mL) was added to a solution of **3b** (250 mg, 0.62 mmol) in THF (8 mL). The mixture was stirred for one day at 40 °C. The mixture was then extracted with CH_2Cl_2 (25 mL), dried over $MgSO_4$, and concentrated under reduced pressure. The crude product was crystallized in ethyl acetate to give **3c** as white solid (185 mg, 0.45 mmol, 73 %). R_f = 0.52 (CH_2Cl_2/methanol 9:1); m.p. 154–156 °C; $[\alpha]_D = -9.5°$ (c = 0.26 in $CHCl_3$); ^{1}H NMR (400.1 MHz, CD_2Cl_2): δ = 3.06 (s, 6H), 4.31 (t, J = 8.5 Hz, 2H), 4.84 (dd, J = 10.3, 8.5 Hz, 2H), 5.38 (dd, J = 10.3, 8.5 Hz, 2H), 7.28–7.39 (m, 10H), 7.45 ppm (s, 1H); ^{13}C NMR (100.6 MHz, CD_2Cl_2): δ = 38.5, 69.4, 74.5, 107.6, 126.9, 127.9, 141.5, 146.0, 154.3, 163.6 ppm; MS (EI, 70 eV): m/z (%): 412 ([M]$^+$, 100), 147 (70), 91(30); elemental analysis calcd (%) for $C_{25}H_{24}N_4O_2 \cdot H_2O$: C 69.74, H 6.09, N 13.01; found: C 70.01, H 6.03, N 13.31.

4-Phenyl-2,6-bis[hydroxyamide]pyridine (6d): Bishydroxyamide **6b** (500 mg, 1.13 mmol), phenyl boronic acid (165.5 mg, 1.35 mmol) and P(*o*-Tolyl)$_3$ (5 mol %) were dissolved in DME (8 mL). CsF (2.5 equiv) was added and the mixture was purged with argon. $Pd(OAc)_2$ (5 mol %) was added and the mixture was refluxed for 18 h. After cooling to room temperature, water was added and the mixture was extracted with ethyl acetate (50 mL × 2). The organic layer was dried over $MgSO_4$ and concentrated. The residue was purified by silca gel column chromatography to give **6d** as a white solid (350 mg, 0.72 mmol, 64 %). R_f = 0.26 (hexane/EA 7:3); m.p. 84–85 °C; $[\alpha]_D = -15.7°$ (c = 0.20, $CHCl_3$); ^{1}H NMR (400.1 MHz, CD_2Cl_2): δ = 3.21 (brs, 2H), 3.95 (brs, 4H), 5.20 (ddd, J = 7.5, 4.9, 2.4 Hz, 2H), 7.24–7.44 (m, 13H), 7.65–7.68 (m, 2H), 8.43 (s, 2H), 8.75 ppm (d, J = 7.5 Hz, 2H); ^{13}C NMR (100.6 MHz, CD_2Cl_2): δ = 55.5, 65.6, 121.9, 126.3, 126.7, 128.3, 128.8, 129.5, 136.0, 138.8, 149.0, 151.1, 163.3 ppm; MS (EI, 70 eV): m/z (%): 450 (100), 450 (16), 330 (72), 197 (36), 91 (13); FAB-MS: m/z: 482 [M]$^+$.

Synthesis of 2,6-bis-[(4*S*)-4-phenyl-4,5-dihydrooxazol-2-yl]-4-phenylpyridine (3d): Diethylaminosulfur trifluoride (DAST) (204.3 µl, 251.3 mg, 1.6 mmol) was slowly added to a solution of bishydroxyamide **6d** (250 mg, 0.52 mmol) in CH_2Cl_2 (5 mL), at −20 °C under argon. After 8 h stirring at −20 °C, ammonium hydroxide solution (1 mL) was added slowly. Subsequently the cooling bath was removed and water (20 mL) was added. When the reaction mixture had reached room temperature, the two layers were separated and the aqueous layer was extracted with CH_2Cl_2 (2 × 20 mL). The combined organic layers were dried over $MgSO_4$, and concentrated under reduced pressure. The crude product was purified by column chromatography to give **3d** as a white solid (130 mg, 0.29 mmol, 55 %). R_f = 0.46 (hexane/EA 7:3); m.p. 178–181 °C; $[\alpha]_D = +10.1°$ (c = 0.12 in $CHCl_3$); ^{1}H NMR (400.1 MHz, $CDCl_3$): δ = 4.43 (t, J = 8.5 Hz, 2H), 4.44 (dd, J = 10.3, 8.5 Hz, 2H), 5.47 (dd, J = 10.3,

8.5 Hz, 2H), 7.30–7.35 (m, 10H), 7.44–7.46 (m, 3H), 7.73 (m. 2H), 8.58 ppm (s, 2H); ^{13}C NMR (100.6 MHz, $CDCl_3$): δ = 70.4, 75.6, 126.2, 127.8, 127.8, 128.8, 128.8, 128.9, 129.2, 129.8, 141.7, 147.3, 150.2, 163.7 ppm; MS (EI, 70 eV): *m/z* (%): 445 (78) $[M]^+$, 104 (100), 91(49); HRMS (ESI+): *m/z* calcd for $C_{29}H_{23}N_3O_2$: 445.17902; found: 445.17412.

4-(1-Naphthyl)-2,6-bis[hydroxyamide]pyridine (6e): Bishydroxyamide **6b** (500 mg, 1.13 mmol), 1-naphthyl boronic acid (165.5 mg, 1.35 mmol) and P(*o*-Tolyl)$_3$ (5 mol%) were dissolved in DME (8 mL). CsF (2.5 equiv) was added and mixture was purged with argon. $Pd(OAc)_2$ (5 mol%) was added and the mixture was refluxed for 18 h. After cooling to room temperature, water was added (25 mL) and the resulting mixture was extracted with ethyl acetate (50 mL×2). The organic layer was dried over $MgSO_4$ and concentrated. The residue was purified by silca gel column chromatography to give **6e** as a white solid (450 mg, 0.85 mmol, 75%). R_f = 0.26 (CH_2Cl_2/methanol 100:6); m.p. 109–111 °C; $[\alpha]_D$ = +14° (*c* = 0.15 in CH_2Cl_2); ^{1}H NMR (400.1 MHz, CD_2Cl_2): δ = 3.39 (unresolved d, 4H), 5.22 (unresolved ddd, *J* = 7.5, 5.1 Hz, 2H), 7.27 (tt, *J* = 7.1, 2.4 Hz, 2H), 7.32–7.43 (m, 10H), 7.47 (m, 2H), 7.70 (unresolved dd, *J* = 8.3 Hz, 2H), 7.90 (unresolved dd, *J* = 7.9 Hz, 2H), 8.35 (s, 2H), 8.80 ppm (d, *J* = 7.5 Hz, 2H); ^{13}C NMR (100.6 MHz, CD_2Cl_2): δ = 55.9, 66.2, 124.6, 125.3, 126.1, 126.3, 126.8, 127.4, 127.8, 128.8, 128.6, 128.8, 129.6, 130.4, 133.8, 136.0, 139.4, 149.1, 152.2, 163.7 ppm; MS (EI, 70 eV): *m/z* (%): 500 (100), 482 (38), 380 (36), 247 (31), 203 (17), 91 (14); FAB-MS: *m/z*: 532 $[M]^+$; HRMS (ESI+): *m/z* calcd for $C_{33}H_{30}N_3O_4$: 532.22363; found: 532.22401.

Synthesis of 2,6-bis-[(4*S*)-4-phenyl-4,5-dihydrooxazol-2-yl]-4-(1-naphthyl)pyridine (3e): Diethylaminosulfur trifluoride (DAST) (296.3 µl, 364.1 mg, 2.2 mmol) was slowly added to a solution of bishydroxyamide **6e** (400 mg, 0.75 mmol) in CH_2Cl_2 (8 mL) at −20 °C under argon. After 8 h stirring at −20 °C, ammonium hydroxide solution (1 mL) was added slowly. Subsequently the cooling bath was removed and water (25 mL) was added. When the reaction mixture had reached room temperature, the two layers were separated and the aqueous layer was extracted with CH_2Cl_2 (25 mL×2). The combined organic layers were dried over $MgSO_4$ and concentrated under reduced pressure. The crude product was purified by column chromatography to give **3e** as a white solid (130 mg, 0.26 mmol, 40%). R_f = 0.45 (CH_2Cl_2/methanol 100:6); m.p. 198–200 °C; $[\alpha]_D$ = +3.8° (*c* = 0.35 in CH_2Cl_2); ^{1}H NMR (400.1 MHz, CD_2Cl_2): δ = 4.21 (dd, *J* = 8.5, 8.5 Hz, 2H), 4.94 (dd, *J* = 10.3, 8.5 Hz, 2H), 5.48 (dd, *J* = 10.3, 8.5 Hz, 2H), 7.28–7.39 (m, 10H), 7.49–7.59 (m, 4H), 7.83–7.85 (m, 1H), 7.94–7.97 (m, 2H), 8.43 ppm (s, 1H); ^{13}C NMR (100.6 MHz, CD_2Cl_2): δ = 69.6, 74.7, 124.0, 124.6, 125.5, 126.0, 126.2, 126.5, 126.6, 126.9, 127.8, 127.9, 128.6, 129.8, 133.0, 135.28, 141.3, 146.2, 149.7, 162.7 ppm; MS (EI, 70 eV): *m/z* (%): 495 (100) $[M]^+$, 203 (69),104 (27), 91(50); HRMS (ESI+): *m/z* calcd for $C_{33}H_{25}N_3O_2$: 495.19467; found: 495.19453.

Dimethyl pyridine-2,6-dicaroximidate 9:[26c] Pyridine-2,6-carbodinitrile (5.35 g, 41.5 mmol) was dissolved in anhydrous MeOH (100 mL) under Ar. Na (120 mg, 5.2 mmol) was then added. After stirring for 40 h at room temperature, HOAc (300 µL, 5.25 mmol) was added, and the solvent was removed under reduced pressure. Compound **9** was obtained as a yellow powder (8.5 g, 100%) and was used directly.

General procedure A for pybox(azine) ligand synthesis: Compound **9** (1.044 g, 5.4 mmol), amino alcohol (10.8 mmol), and anhydrous dichloromethane (20 mL) were stirred at 40–50 °C in a pressure tube under Ar for 48 h. The reaction mixture was then washed with water and the organic layer was separated, dried over $MgSO_4$, and evaporated under reduced pressure to dryness. The product was then subjected to chromatography on silica gel with CH_2Cl_2/MeOH (98:2) as the eluent or recrystallized from EtOAc.

For the pyboxazine ligands, the solvent of the reaction mixture was first removed under reduced pressure. The crude mixture was subjected to chromatography under Ar over alumina by using CH_2Cl_2/Et_3N (100:1) as the eluent (alumina was dried at 200 °C under high vacuum; CH_2Cl_2 was dried over K_2CO_3).

Synthesis of 2,6-bis-[(5*S*)-5-phenyl-4,5-dihydrooxazol-2-yl]pyridine (3h): By general procedure **A** from compounds **8** and **9**, **3h** was obtained in 35% after recrystallization from EtOAc. R_f = 0.1–0.2 (EtOAc); m.p. 179.5–180.5 °C; $[\alpha]_D$ = +252° (*c* = 0.61 in CH_2Cl_2); ^{1}H NMR (400.1 MHz, CD_2Cl_2): δ = 4.01–4.11 (dd, *J* = 15.5, 8.1 Hz, 2H), 4.52 (dd, *J* = 15.5, 10.3 Hz, 2H), 5.74 (dd, *J* = 10.3, 8.1 Hz, 2H), 7.32–7.42 (m, 10H), 7.92 (t, *J* = 7.7 Hz, 1H), 8.20 ppm (d, *J* = 7.7 Hz, 2H); ^{13}C NMR (100.6 MHz, CD_2Cl_2): δ = 63.0, 82.0, 125.8, 126.1, 128.5, 128.8, 137.4, 140.7, 146.9, 162.6 ppm; MS (EI, 70 eV): *m/z* (%): 370 (27) $[M+1]^+$, 369 (96) $[M]^+$, 105 (23), 104 (100), 91 (35); HRMS: *m/z* calcd for $C_{23}H_{19}N_3O_2$: 369.14774; found: 369.14386; elemental analysis calcd (%) for $C_{23}H_{19}N_3O_2$: C 74.78, H 5.18, N 11.37; found: C 74.61, H 5.12, N 11.46.

(*S*)-2-Chlorophenyl glycinol (10): (*S*)-2-Chlorophenylglycine (2.5 gm, 13.4 mmol) was added to a stirred solution of $NaBH_4$ (1.26 gm, 33.5 mmol) in THF (15 mL). The mixture was immersed in an ice bath and solution of conc. H_2SO_4 (1 mL) in Et_2O was added dropwise, stirring was continued at room temperature for overnight. Methanol (15 mL) and NaOH (5 N 70 mL) were successively added. After removal of organic solvents, the aqueous solution was refluxed for two hours and extracted with CH_2Cl_2 (20 mL×3) after cooling. The residue was purified by crystallization in ethyl acetate and hexane to give **34** (850 mg, 40%). M.p. 63–64 °C; $[\alpha]_D$ = +40.1° (*c* = 0.5 in EtOH); ^{1}H NMR (400.1 MHz, $CDCl_3$): δ = 3.54 (dd, *J* = 10.7, 7.9 Hz, 1H), 3.81 (dd, *J* = 10.7, 3.8 Hz, 1H), 4.48 (dd, *J* = 10.7, 3.8 Hz, 1H), 7.15 (ddd, *J* = 8.9, 7.7, 1.5 Hz, 1H), 7.24 (ddd, *J* = 8.9, 7.8, 1.3 Hz, 1H), 7.30 (dd, *J* = 7.8, 1.5 Hz, 1H), 7.45 ppm (dd, *J* = 7.7, 1.3 Hz, 1H); ^{13}C NMR (100.6 MHz, $CDCl_3$): δ = 54.6, 65.6, 127.1, 127.4, 128.5, 129.7, 132.9, 139.3 ppm; MS (EI, 70 eV): *m/z* (%): 140 (100), 77 (38); HRMS (ESI+): *m/z* calcd for $C_8H_{10}ClNO$: 172.05292; found: 172.05243.

Synthesis of 2,6-bis-[(4*S*)-4-(2-chlorophenyl)-4,5-dihydrooxazol-2-yl]pyridine (3k): By general procedure **A** from compounds **10** and **9** (281 mg, 1.45 mmol), **3k** was obtained as a white solid (520 mg, 1.18 mmol, 81%). R_f = 0.34 ($CHCl_3$/methanol 100:5); m.p. 199–200 °C; $[\alpha]_D$ = + 89.1° (*c* = 0.5 in $CHCl_3$); ^{1}H NMR (400.1 MHz, CD_2Cl_2): δ = 4.19 (t, *J* = 8.7 Hz, 2H), 4.99 (dd, *J* = 10.4, 8.7 Hz, 2H), 5.73 (dd, *J* = 10.4, 8.7 Hz, 2H), 7.13–7.21 (m, 4H), 7.30–7.37 (m, 4H), 7.90 (t, *J* = 7.7 Hz, 1H), 8.31 (d, *J* = 7.7 Hz, 2H); ^{13}C NMR (100.6 MHz, CD_2Cl_2): δ = 67.8, 75.4, 126.8, 127.6, 128.2, 129.2, 129.7, 132.7, 138.1, 140.4, 147.1, 164.6 ppm; MS (EI, 70 eV): *m/z* (%): 437 (52) $[M]^+$, 253 (31), 138 (72), 89 (100); HRMS (ESI+): *m/z* calcd for $C_{23}H_{17}Cl_2N_3O_2$: 437.06979; found: 437.06540.

(*S*)-1-Amino-1-phenyl-2-methylpropan-2-ol (11):[43] In a 100 mL round bottomed flask with reflux condenser and $CaCl_2$ drying tube, MeI (2.6 mL, 42 mmol) was added dropwise to the magnesium (1 g, 42 mmol) in anhydrous diethyl ether (~20 mL). The Grignard reagent was decanted under an argon atmosphere. (*S*)-Phenylglycine methyl ester hydrochloride (700 mg, 3.47 mmol) was added with care to this solution. The reaction mixture was stirred at room temperature for 20 h. The reaction mixture was then quenched with acetone. Ammonia solution (25%, 10 mL) and NH_4Cl solution (20 mL) were added and the reaction mixture was extracted with Et_2O (30 mL×2). The ether extract was further extracted with 5% HCl (30 mL×2). NaOH (4 g) was added to this solution and it was extracted with Et_2O (30 mL×2). The organic layer was dried over K_2CO_3. After removal of solvent, an oil was obtained that crystallized on standing. The crude product was then subjected to chromatography on silica gel with EtOAc/MeOH/Et_3N (50:50:2) as the eluent. Compound **11** was obtained in 43% yield. M.p. 47–50 °C; $[\alpha]_D$ = +25° (*c* = 1.21 in $CHCl_3$); ^{1}H NMR (400.1 MHz, $CDCl_3$): δ = 1.03 (s, 3H), 1.18 (s, 3H), 2.98–3.21 (br s, 3H), 3.82–3.95 (s, 1H), 7.20–7.34 ppm (m, 5H); ^{13}C NMR (100.6 MHz, $CDCl_3$): δ = 24.3, 27.7, 65.8, 72.2, 127.6, 127.9, 128.2, 140.6 ppm; MS (EI, 70 eV): *m/z* (%): 133 (3), 107 (27), 106 (100).

Synthesis of 2,6-bis-[(4*S*)-5,5-dimethyl-4-phenyl-4,5-dihydrooxazol-2-yl]-pyridine (3l): By general procedure **A** from compounds **11** and **9**, **3l** was obtained as a white solid in 25% yield. R_f = 0.7 (EtOAc); m.p. 137–138 °C; ^{1}H NMR (400.1 MHz, $CDCl_3$): δ = 0.94 (s, 6H), 1.64 (s, 6H), 5.03 (s, 2H), 7.18–7.30 (m, 10H), 7.88 (m, 1H), 8.24 ppm (m, 2H); ^{13}C NMR (100.6 MHz, $CDCl_3$). δ = 23.9, 29.2, 78.2, 89.2, 126.2, 127.2, 127.7, 128.3, 137.4, 138.0, 147.2, 162.8 ppm; MS (EI, 70 eV): *m/z* (%): 425 (23) $[M]^+$, 367 (36), 132 (100), 131 (54); HRMS (ESI+): *m/z* calcd for $C_{27}H_{27}N_3O_2+H^+$: 426.21814; found: 426.21861.

Synthesis of 2,6-bis-[(4*S*)-4-methyl-4,5-dihydrooxazol-2-yl]pyridine (3m): By the general procedure **A**, from (*S*)-(+)-2-amino-1-propanol and compound **9**, **3m** was obtained as a white solid in 53% yield. R_f = 0.1–0.2 (CH_2Cl_2/Et_3N 99:1); m.p. 163.0–165.5 °C; $[\alpha]_D$ = −131.8° (*c* = 0.72 in

CH_2Cl_2); ^{1}H NMR (400.1 MHz, CD_2Cl_2): δ = 1.36 (d, J = 6.5 Hz, 6H); 4.06 (dd, J = 8,1 Hz, 2H), 4.38–4.47 (m, 2H), 4.60 (dd, J = 9.5, 8,1 Hz, 2H), 7.85 (t, J = 7.7 Hz, 1H), 8.16 ppm (d, J = 7.7 Hz, 2H); ^{13}C NMR (100.6 MHz, $CDCl_3$): δ = 21.8, 62.7, 75.1, 126.0, 137.7, 147.3, 162.7 ppm; MS (EI, 70 eV): *m*/*z* (%): 245 (77) $[M]^+$, 230 (100), 202 (42), 131 (33), 104 (89), 102 (56); elemental analysis calcd (%) for $C_{13}H_{15}N_3O_2 \cdot 0.25\,H_2O$: C 62.51, H 6.25, N 16.82; found: C 62.74, H 6.21, N 17.09.

General procedure for 3-amino-propan-1-ol synthesis and resolution: β-Amino acids **12**,[26c,45] β-amino acid methyl ester **14**[27] were synthesized according to literature procedures. Compound **14a** was resolved by co-crystallization with D- or L-tartaric acids.[26c] Compounds **14b** and **14c** were enzymatically resolved by Amano Lipase PS (Aldrich).[28a] 3-Amino-propan-1-ols **15** were obtained by reduction of the methyl ester **14** with $NaBH_4$[26c] or the acid **12** directly with $LiAlH_4$.[53]

Methyl (*R*)-3-amino-3-phenylpropanoate ((*R*)-14a): HPLC (Chiralcel OD-H, hexane/EtOH 98:2, flow rate 1.0 mL min^{-1}) >99% *ee*; $[\alpha]_D$ = +21.3° (c = 1 in $CHCl_3$); ^{1}H NMR (400.1 MHz, CD_2Cl_2): δ = 1.69 (brs, 2H), 2.63 (d, J = 8.2 Hz, 1H), 2.63 (d, J = 5.6 Hz, 1H), 3.65 (s, 3H), 4.38 (dd, J = 8.2, 5.6 Hz 1H), 7.23–7.27 (m, 1H), 7.31–7.38 ppm (m, 4H); ^{13}C NMR (100.6 MHz, CD_2Cl_2): δ = 44.1, 51.5, 52.7, 126.2, 127.2, 128.5, 145.2, 172.3 ppm.

(*R*)-3-Amino-3-phenylpropan-1-ol ((*R*)-15a): HPLC (Crownpak CR(+), $HClO_4$ (pH 2), 10 °C, flow rate 0.5 mL min^{-1}) 98% *ee*; $[\alpha]_D$ = +24.2° (c = 0.5 in CH_2Cl_2); ^{1}H NMR (400.1 MHz, CD_2Cl_2): δ = 1.82–1.87 (m, 2H), 2.49 (brs, 3H), 3.69–3.80 (m, 2H), 4.09 (dd, J = 8.0, 5.1 Hz, 1H), 7.22–7.26 (m, 1H), 7.28–7.37 ppm (m, 4H); ^{13}C NMR (100.6 MHz, CD_2Cl_2): δ = 39.9, 56.5, 62.1, 125.8, 127.0, 128.6, 146.8 ppm.

Methyl (*S*)-3-amino-3-phenylpropanoate ((*S*)-14a): HPLC (Chiralcel OD-H, hexane/EtOH 98:2, flow rate 1.0 mL min^{-1}) 100% *ee*; $[\alpha]_D$ = −21.7° (c = 1 in $CHCl_3$); ^{1}H NMR (400.1 MHz, CD_2Cl_2): δ = 1.70 (brs, 2H), 2.63 (d, J = 8.2 Hz, 1H), 2.63 (d, J = 5.6 Hz, 1H), 3.65 (s, 3H), 4.38 (dd, J = 8.2, 5.6 Hz 1H), 7.23–7.27 (m, 1H), 7.31–7.38 ppm (m, 4H); ^{13}C NMR (100.6 MHz, CD_2Cl_2): δ = 44.1, 51.5, 52.7, 126.2, 127.2, 128.5, 145.2, 172.3 ppm.

(*S*)-3-Amino-3-phenylpropan-1-ol ((*S*)-15a): HPLC (Crownpak CR(+), $HClO_4$ (pH 2), 10 °C, flow rate 0.5 mL min^{-1}) 100% *ee*; $[\alpha]_D$ = −22.5° (c = 0.5 in CH_2Cl_2);^{1}H NMR (400.1 MHz, CD_2Cl_2): δ = 1.81–1.88 (m, 2H), 2.53 (brs, 3H), 3.69–3.80 (m, 2H), 4.10 (dd, J = 8.0, 5.1 Hz, 1H), 7.22–7.27 (m, 1H), 7.28–7.37 ppm (m, 4H); ^{13}C NMR (100.6 MHz, CD_2Cl_2): δ = 40.0, 56.5, 62.1, 125.8, 127.0, 128.6, 146.8 ppm.

Resolution of methyl *rac*-3-amino-3-(1-naphthyl)propanoate 14b: An appropriate quantity of freshly prepared sodium hydroxide solution (2 N, ~47 mL) was added to a solution of potassium dihydrogen phosphate (KH_2PO_4; 0.5 M, 200 mL), until the pH value was adjusted to 8.2. *rac*-**14b** (4 g) and Amano Lipase PS (1.8 g) were stirred in this phosphate buffer (120 mL) at room temperature for 24 h. The product was then filtered and washed with H_2O and dried over KOH under high vacuum. The powdery product was then stirred with EtOAc (50 mL) and filtered. After removal of solvent, (*R*)-**14b** was obtained in 45% (1.8 g). The residue was dissolved in NaOH solution (2 N) and filtered. The filtrate was acidified to pH 6 and the product precipitated. After filtration, washed with H_2O and dried over KOH under high vacuum, (*S*)-**12b** was obtained in 43–48% (1.6–1.8 g).

Methyl (*R*)-3-amino-3-(1-naphthyl)propanoate ((*R*)-14b): M.p. 57–59 °C; HPLC (Chiralcel OD-H, hexane/EtOH 95:5, flow rate 1.0 mL min^{-1}) >98% *ee*; $[\alpha]_D$ = +48.1° (c = 0.5 in MeOH); ^{1}H NMR (400.1 MHz, CD_2Cl_2): δ = 1.85 (brs, 2H), 2.68 (dd, J = 15.9, 9.7 Hz, 1H), 2.87 (dd, J = 15.9, 3.4 Hz, 1H), 3.70 (s, 3H), 5.24 (dd, J = 9.7, 3.4 Hz, 1H), 7.46–7.57 (m, 3H), 7.68 (d, J = 7.1 Hz, 1H), 7.78 (d, J = 8.1 Hz, 1H), 7.89 (d, J = 8.1 Hz, 1H), 8.18 ppm (d, J = 8.3 Hz, 1H); ^{13}C NMR (100.6 MHz, CD_2Cl_2): δ = 43.4, 48.1, 51.6, 122.6, 122.9, 125.6, 125.6, 126.2, 127.7, 129.0, 130.6, 134.0, 140.7, 172.6 ppm.

(*S*)-3-Amino-3-(1-naphthyl)propanoic acid ((*S*)-12b): M.p. 227–229 °C; HPLC (Crownpak CR(+), $HClO_4$ (pH 2)/MeOH 90:10, flow rate 1.5 mL min^{-1}) 100% *ee*; $[\alpha]_D$ = −24.1° (c = 1 in 0.1 N HCl), $[\alpha]_D$ = −49.5° (c = 1 in 0.5 N NaOH).

(*R*)-3-Amino-3-(1-naphthyl)propan-1-ol ((*R*)-15b): M.p. 42–45 °C; HPLC (Crownpak CR(−), $HClO_4$ (pH 2)/MeOH 90:10, flow rate 1.0 mL min^{-1}) 100% *ee*; $[\alpha]_D$ = +50.8° (c = 1 in CH_2Cl_2); ^{1}H NMR (400.1 MHz, CD_2Cl_2): δ = 1.90–1.99 (m, 1H), 2.02–2.09 (m, 1H), 2.73 (brs, 3H), 3.79 (ddd, J = 10.9, 5.8, 3.8 Hz, 1H), 3.89 (ddd, J = 10.9, 8.1, 3.2 Hz, 1H), 4.99 (dd, J = 9.0, 3.3 Hz, 1H), 7.48–7.57 (m, 3H), 7.60 (d, J = 7.1 Hz, 1H), 7.78 (d, J = 8.3 Hz, 1H), 7.90 (d, J = 7.9 Hz, 1H), 8.09 ppm (d, J = 8.3 Hz, 1H); ^{13}C NMR (100.6 MHz, CD_2Cl_2): δ = 39.2, 52.0, 62.3, 121.9, 122.7, 125.6, 126.2, 127.4, 129.0, 130.4, 134.0, 142.2 ppm.

(*S*)-3-Amino-3-(1-naphthyl)propan-1-ol ((*S*)-15b): HPLC (Crownpak CR(+), $HClO_4$ (pH 2)/MeOH 95:5, flow rate 1.0 mL min^{-1}) >99% *ee*.

Resolution of methyl *rac*-3-amino-3-(2-naphthyl)propanoate 14c: An appropriate quantity of freshly prepared sodium hydroxide solution (2 N, ~47 mL) was added to a solution of potassium dihydrogen phosphate (KH_2PO_4; 0.5 M, 200 mL), until the pH value was adjusted to 8.2. *rac*-**14c** (4 g) and Amano Lipase PS (2 g) were stirred in this phosphate buffer (120 mL) at 36 °C for 96 h. The product was then filtered and washed with H_2O and dried over KOH under high vacuum. The powdery product was then stirred with EtOAc (50 mL) and filtered. After removal of solvent, (*R*)-**14c** was obtained in 35% (1.4 g). The residue was dissolved in NaOH solution (2 N) and filtered. The filtrate was acidified to pH 6 and the product precipitated. After filtration, washed with H_2O and dried over KOH under high vacuum, (*S*)-**12c** was obtained in 45% (1.7 g).

Methyl (*R*)-3-amino-3-(2-naphthyl)propanoate ((*R*)-14c): HPLC (Chiralcel OD-H, hexane/EtOH 99:1, flow rate 1.0 mL min^{-1}) 95% *ee*.

(*S*)-3-Amino-3-(2-naphthyl)propanoic acid ((*S*)-12c): M.p. 227–229 °C; HPLC (Crownpak CR(+), $HClO_4$ (pH 2)/MeOH 90:10, 40 °C, flow rate 1.0 mL min^{-1}) 44% *ee*.

Methyl (*R*)-3-amino-3-(2-naphthyl)propanoate ((*R*)-14c): Gaseous HCl was purged for 2 h into the suspension of (*R*)-**12c** (5 g, 23 mmol, PepTech) in anhydrous MeOH (120 mL) at 0 °C. The product was dissolved in MeOH. After removal of solvent and dried over KOH under high vacuum, (*R*)-**13c** was obtained in 97% (6 g). It was further neutralized with Na_2CO_3 in EtOAc to give (*R*)-**14c** in 94% (4.85 g). M.p. 77–79 °C; $[\alpha]_D$ = −5.8° (c = 1 in MeOH); ^{1}H NMR (400.1 MHz, CD_2Cl_2): δ = 1.75 (brs, 2H), 2.69 (dd, J = 15.9, 8.7 Hz, 1H), 2.75 (dd, J = 15.9, 5.3 Hz, 1H), 3.66 (s, 3H), 4.57 (unresolved dd, 1H), 7.44–7.52 (m, 3H), 7.82–7.84 ppm (m, 4H); ^{13}C NMR (100.6 MHz, CD_2Cl_2): δ = 44.1, 51.5, 52.8, 124.7, 124.8, 125.8, 126.1, 127.6, 127.8, 128.2, 132.9, 133.5, 135.8, 172.3 ppm; elemental analysis calcd (%) for $C_{14}H_{16}NO_2$: C 73.34, H 6.59, N 6.11; found: C 73.26, H 6.74, N 6.00.

(*R*)-3-Amino-3-(2-naphthyl)propan-1-ol ((*R*)-15c): M.p. 68–69 °C; HPLC (Crownpak CR(−), $HClO_4$ (pH 2)/MeOH 90:10, flow rate 0.5 mL min^{-1}) >99% *ee*; $[\alpha]_D$ = +17.3° (c = 1 in CH_2Cl_2); ^{1}H NMR (400.1 MHz, CD_2Cl_2): δ = 1.92–1.97 (m, 2H), 2.59 (brs, 3H), 3.73–3.84 (m, 2H), 4.28 (unresolved dd, 1H), 7.44–7.51 (m, 3H), 7.75 (s, 1H), 7.83–7.85 ppm (m, 3H); ^{13}C NMR (100.6 MHz, CD_2Cl_2): δ = 39.9, 56.5, 62.1, 124.0, 124.5, 125.7, 126.2, 127.6, 127.8, 128.3, 132.7, 133.5, 144.1 ppm; elemental analysis calcd (%) for $C_{13}H_{15}NO$: C 77.58, H 7.51, N 6.96; found: C 77.46, H 7.55, N 6.69.

(*S*)-3-Amino-3-(4-chlorphenyl)propan-1-ol ((*S*)-15d): R_f = 0.45 (EtOAc/MeOH/Et_3N 49:49:2); m.p. 53–56 °C; $[\alpha]_D$ = −17.6° (c = 0.97 in CH_2Cl_2); ^{1}H NMR (400.1 MHz, CD_2Cl_2): δ = 1.79–1.85 (m, 2H), 2.32 (brs, 3H), 3.67–3.77 (m, 2H), 4.10 (t, J = 6.5 Hz, 1H),7.24–7.34 ppm (m, 4H); ^{13}C NMR (100.6 MHz, CD_2Cl_2): δ = 40.3, 56.0, 62.1, 127.7, 128.9, 132.7, 145.6 ppm; MS (EI, 70 eV): *m*/*z* (%): 185 (1) $[M]^+$, 184, (1) $[M-1]^+$, 142 (32), 140 (100); HRMS (ESI+): *m*/*z* calcd for $C_9H_{12}ClNO$: 185.06075; found: 185.06103.

(*S*)-3-Amino-3-(4-methoxyphenyl)propan-1-ol ((*S*)-15e): R_f = 0.3 (EtOAc/MeOH/Et_3N 49:49:2); m.p. 70.5–73.5 °C; $[\alpha]_D$ = −17.9° (c = 0.43 in CH_2Cl_2); ^{1}H NMR (400.1 MHz, $CDCl_3$): δ = 1.80–1.96 (m, J = 8.92, 4.16 Hz, 2H), 2.69 (brs, 3H), 3.79 (s, 3H), 3.77–3.81 (m, 2H), 4.10 (dd, J = 8.92, 4.16 Hz, 1H), 6.87 (m, J = 8.72 Hz, 2H), 7.22 ppm (m, J = 8.72 Hz, 2H); ^{13}C NMR (100.6 MHz, $CDCl_3$): δ = 39.2, 55.3, 56.0, 62.2, 114.0, 126.9, 135.7, 158.7 ppm; MS (EI, 70 eV): *m*/*z* (%): 181 (2) $[M]^+$, 180 (2) $[M-1]^+$, 137 (32), 136 (100), 109 (48); elemental analysis calcd

(%) for $C_{10}H_{15}NO_2$: C 66.27, H 8.34, N 7.73; found: C 66.57, H 8.15, N 7.67.

(*R*)-3-Amino-4-methyl-pentan-1-ol ((*R*)-15f): M.p. 70.5–73.5 °C; $[\alpha]_D = +19.8°$ ($c = 0.97$ in CH_2Cl_2); ^{1}H NMR (400.1 MHz, $CDCl_3$): $\delta = 0.83$ (d, $J = 5.4$ Hz, 3H), 0.85 (d, $J = 5.2$ Hz, 3H), 1.37–1.58 (m, 3H), 2.65 (ddd, $J = 10.5$, 5.0, 2.8 Hz, 1H), 2.94 (br s, 3H), 3.71–3.81 ppm (m, 2H); ^{13}C NMR (100.6 MHz, $CDCl_3$): $\delta = 17.3$, 18.6, 34.3, 34.6, 58.5, 63.1 ppm; MS (CI, Isobutane): *m/z* (%): 119 (8) $[M+2]^+$, 118 (100) $[M+1]^+$. MS (EI, 70 eV): *m/z* (%): 74 (100), 72 (28), 56 (34), 44 (48).

Synthesis of 2,6-bis-[(4*R*)-4-phenyl-5,6-dihydro-4*H*-[1,3]oxazinyl]pyridine ((*R*)-4a): By general procedure **A** from (*R*)-**15a** and **9**, (*R*)-**4a** was obtained as white needles in 52% yield. $R_f = 0.8$ (alumina, CH_2Cl_2/Et_3N 98:2); m.p. 114.0–116.5 °C; $[\alpha]_D = +28.3°$ ($c = 0.79$ in CH_2Cl_2); ^{1}H NMR (400.1 MHz, CD_2Cl_2): $\delta = 1.91$–2.02 (m, 2H), 2.31–2.39 (m, 2H), 4.44–4.52 (m, 4H), 4.80 (dd, $J = 8.3$, 5.0 Hz, 2H), 7.24–7.31 (m, 2H), 7.34–7.40 (m, 8H), 7.83 (t, $J = 7.9$ Hz, 1H), 8.22 ppm (d, $J = 7.9$ Hz, 2H); ^{13}C NMR (100.6 MHz, CD_2Cl_2): $\delta = 30.4$, 55.6, 64.7, 124.5, 127.0, 127.1, 128.7, 137.1, 144.6, 151.5, 155.1 ppm; MS (EI, 70 eV): *m/z* (%): 398 (9) $[M+1]^+$, 397 ($[M]^+$, 30), 264 (11), 239 (18), 238 (100), 209 (20), 132 (29), 117 (31), 104 (31), 77 (44); HRMS (ESI+): *m/z* calcd for $C_{25}H_{23}N_3O_2$: 397.17902; found: 397.17968; elemental analysis calcd (%) for $C_{25}H_{23}N_3O_2$: C 75.54. H 5.83, N 10.57; found: C 76.04, H 5.79, N 10.57.

Synthesis of 2,6-bis-[(4*S*)-4-phenyl-5,6-dihydro-4*H*-[1,3]oxazinyl]pyridine ((*S*)-4a): By general procedure **A** from (*S*)-**15a** and **9**, (*S*)-**4a** was obtained as white needles in 52% yield. $R_f = 0.8$ (alumina, CH_2Cl_2/Et_3N 98:2); m.p. 115.0–116.5 °C; $[\alpha]_D = -29.1°$ ($c = 0.77$ in CH_2Cl_2); ^{1}H NMR (400.1 MHz, CD_2Cl_2): $\delta = 1.91$–2.02 (m, 2H), 2.31–2.39 (m, 2H), 4.44–4.52 (m, 4H), 4.80 (dd, $J = 8.3$, 5.0 Hz, 2H), 7.24–7.31 (m, 2H), 7.34–7.40 (m, 8H), 7.82 (t, $J = 7.9$ Hz, 1H), 8.22 ppm (d, $J = 7.9$ Hz, 2H); ^{13}C NMR (100.6 MHz, CD_2Cl_2): $\delta = 30.4$, 55.6, 64.7, 124.5, 127.0, 127.1, 128.7, 137.1, 144.6, 151.5, 155.1 ppm; MS (EI, 70 eV): *m/z* (%): 398 (15) $[M+1]^+$, 397 (47) $[M]^+$, 264 (13), 239 (22), 238 (100), 209 (25), 132 (32), 117 (32), 104 (31), 77 (40); HRMS (ESI+): *m/z* calcd for $C_{25}H_{23}N_3O_2$: 397.17902; found: 397.18024.

Synthesis of 2,6-bis-[(4*R*)-4-(1-naphthyl)-5,6-dihydro-4*H*-[1,3]oxazinyl]-pyridine ((*R*)-4b): By General procedure **A** from (*R*)-**15b** and **9**, (*R*)-**4b** was obtained as white needles in 68% yield. $R_f = 0.9$ (alumina, CH_2Cl_2/Et_3N 98:2); m.p. 172.5–174.0 °C; $[\alpha]_D = +111.1°$ ($c = 0.65$ in CH_2Cl_2); ^{1}H NMR (400.1 MHz, CD_2Cl_2): $\delta = 2.04$–2.13 (m, 2H), 2.49–2.60 (m, 2H), 4.45 (ddd, $J = 10.9$, 6.3, 3.8 Hz, 2H), 4.56 (ddd, $J = 11.3$, 8.3, 3.0 Hz, 2H), 5.62 (dd, $J = 6.7$, 5.6 Hz, 2H), 7.45–7.60 (m, 8H), 7.81 (dd, $J = 7.9$, 1.4, 2H), 7.88 (t, $J = 7.9$ Hz, 1H), 7.93 (dd, $J = 8.1$, 1.4 Hz, 2H), 8.12 (d, $J = 8.3$ Hz, 2H), 8.30 ppm (d, $J = 7.9$ Hz, 2H); ^{13}C NMR (100.6 MHz, CD_2Cl_2): $\delta = 29.4$, 52.4, 64.4, 123.2, 124.6, 125.0, 125.8, 126.4, 127.8, 129.3, 130.8, 134.3, 136.1, 137.3, 139.7, 151.6, 155.8 ppm; MS (EI, 70 eV): *m/z* (%): 499 (4) $[M+2]^+$ 498 (18) $[M+1]^+$, 497 (46) $[M]^+$, 469 (18), 467 (13), 453 (14), 314 (12), 302 (24), 289 (21), 288 (100), 259 (31), 167 (73), 154 (45), 153 (39), 127 (34); HRMS (ESI+): *m/z* calcd for $C_{33}H_{27}N_3O_2$: 497.21033; found: 497.21041.

Synthesis of 2,6-bis-[(4*S*)-4-(1-naphthyl)-5,6-dihydro-4*H*-[1,3]oxazinyl]-pyridine ((*S*)-4b): By general procedure **A** from (*S*)-**15b** and **9**, (*S*)-**4b** was obtained as white needles in 59% yield. $R_f = 0.9$ (alumina, CH_2Cl_2/Et_3N 98:2); m.p. 171.0–174.5 °C; $[\alpha]_D = +111.3°$ ($c = 0.67$ in CH_2Cl_2); ^{1}H NMR (400.1 MHz, CD_2Cl_2): $\delta = 1.94$–2.04 (m, 2H), 2.43–2.51 (m, 2H), 4.36 (ddd, $J = 10.9$, 6.1, 3.8 Hz, 2H), 4.47 (ddd, $J = 10.9$, 8.3, 3.4 Hz, 2H), 5.53 (dd, $J = 6.5$, 5.6 Hz, 2H), 7.36–7.51 (m, 8H), 7.72 (d, $J = 7.53$ Hz, 2H), 7.78 (t, $J = 7.9$ Hz, 1H), 7.84 (d, $J = 7.9$ Hz, 2H), 8.03 (d, $J = 8.3$ Hz, 2H), 8.22 ppm (d, 7.93 Hz, 2H); ^{13}C NMR (100.6 MHz, CD_2Cl_2): $\delta = 29.4$, 52.4, 64.4, 123.2, 124.6, 125.0, 125.8, 126.4, 127.8, 129.3, 130.8, 134.3, 136.1, 137.3, 139.7, 151.6, 155.8 ppm; MS (EI, 70 eV): *m/z* (%): 499 (5) $[M+2]^+$, 498 (16) $[M+1]^+$, 497 (9) $[M]^+$, 469 (18), 467 (14), 453 (14), 302 (22), 289 (23), 288 (100), 259 (29), 167 (70), 154 (41), 153 (32), 127 (30); HRMS (ESI+): *m/z* calcd for $C_{33}H_{27}N_3O_2$: 497.21033; found: 497.21114; elemental analysis calcd (%) for $C_{33}H_{27}N_3O_2 \cdot H_2O$: C 76.87, H 5.67, N 8.15; found: C 77.11, H 5.65, N 8.05.

Synthesis of 2,6-bis-[(4*R*)-4-(2-naphthyl)-5,6-dihydro-4*H*-[1,3]oxazinyl]-pyridine ((*R*)-4c): By general procedure **A** from (*R*)-**15c** and **9**, (*R*)-**4c** was obtained as white needles in 81% yield. $R_f = 0.9$ (alumina, CH_2Cl_2/Et_3N 98:2); m.p. >80 °C (glassy melting); $[\alpha]_D = +3.8°$ ($c = 0.55$ in CH_2Cl_2); ^{1}H NMR (400.1 MHz, CD_2Cl_2): $\delta = 2.02$–2.12 (m, 2H), 2.40–2.47 (m, 2H), 4.46–4.57 (m, 4H), 5.00 (dd, $J = 8.1$, 5.0 Hz, 2H), 7.46–7.50 (m, 4H), 7.52 (dd, $J = 8.5$, 1.8 Hz, 2H), 7.80–7.91 (m, 9H), 8.31 ppm (d, $J = 7.9$ Hz, 2H); ^{13}C NMR (100.6 MHz, CD_2Cl_2): $\delta = 29.9$, 55.3, 64.3, 124.3, 125.3, 125.3, 125.6, 126.1, 127.6, 127.9, 128.1, 132.6, 133.5, 136.9, 141.7, 151.3, 155.1 ppm; MS (EI, 70 eV): *m/z* (%): 499 (5) $[M+2]^+$, 498 (22) $[M+1]^+$, 497 (51) $[M]^+$, 289 (24), 288 (100), 259 (22), 182 (32), 168 (29), 167 (55); HRMS (ESI+): *m/z* calcd for $C_{33}H_{27}N_3O_2$: 497.21033; found: 497.21015; elemental analysis calcd (%) for $C_{33}H_{27}N_3O_2$: C 79.66, H 5.47, N 8.44; found: C 79.74, H 5.48, N 8.50.

Synthesis of 2,6-bis-[(4*S*)-4-(4-chlorophenyl)-5,6-dihydro-4*H*-[1,3]oxazinyl]pyridine ((*S*)-4d): By general procedure **A** from (*S*)-**15d** and **9**, (*S*)-**4d** was obtained as white needles in 79% yield. $R_f = 0.7$ (alumina, CH_2Cl_2/Et_3N 98:2); m.p. 164–169 °C; $[\alpha]_D = -30.0°$ ($c = 0.88$ in CH_2Cl_2); ^{1}H NMR (400.1 MHz, CD_2Cl_2): $\delta = 1.88$–1.98 (m, 2H), 2.30–2.38 (m, 2H), 4.43–4.51 (m, 4H), 4.79 (dd, $J = 8.7$, 5.0 Hz, 2H), 7.31–7.37 (m, 8H), 7.84 (t, $J = 7.9$ Hz, 1H), 8.21 ppm (d, $J = 7.9$ Hz, 2H); ^{13}C NMR (100.6 MHz, CD_2Cl_2): $\delta = 30.3$, 55.0, 64.8, 124.6, 128.5, 128.7, 132.7, 136.1, 137.3, 143.2, 151.4, 155.3 ppm. MS (EI, 70 eV): *m/z* (%): 468 (8) $[M+3]^+$, 467 (23) $[M+2]^+$, 466 (12) $[M+1]^+$, 465 (30) $[M]^+$, 274 (30), 273 (19), 272 (100), 103 (33); HRMS (ESI+): *m/z* calcd for $C_{25}H_{21}N_3O_2Cl_2$: 465.10107; found: 465.09933; elemental analysis calcd (%) for $C_{25}H_{21}N_3O_2Cl_2$: C 64.39, H 4.54, N 9.01, Cl 15.20; found: C 64.40, H 4.71, N 8.76, Cl 15.07.

Synthesis of 2,6-bis-[(4*S*)-4-(4-methoxyphenyl)-5,6-dihydro-4*H*-[1,3]oxazinyl]pyridine ((*S*)-4e): By general procedure **A** from compounds (*S*)-**15e** and **9**, (*S*)-**4e** was obtained as white needles in 26% yield. $R_f = 0.6$ (alumina, CH_2Cl_2/Et_3N 98:2); m.p. 164.5–166 °C; $[\alpha]_D = -6.0°$ ($c = 0.44$ in CH_2Cl_2); ^{1}H NMR (400.1 MHz, CD_2Cl_2): $\delta = 1.89$–1.99 (m, 2H), 2.27–2.35 (m, 2H), 3.80 (s, 6H), 4.40–4.50 (m, 4H), 4.75 (dd, $J = 8.3$, 5.0 Hz, 2H), 6.88–6.92 (m, 4H), 7.25–7.29 (m, 4H), 7.82 (t, $J = 7.9$ Hz, 1H), 8.20 ppm (d, $J = 7.9$ Hz, 2H); ^{13}C NMR (100.6 MHz, CD_2Cl_2): $\delta = 30.4$, 55.0, 55.6, 64.7, 114.0, 124.4, 128.0, 136.7, 137.1, 151.5, 155.0, 158.9 ppm; MS (EI, 70 eV): *m/z* (%): 459 (4) $[M+2]^+$, 458 (21) $[M+1]^+$, 457 (61) $[M]^+$, 269 (18), 268 (100), 162 (53), 148 (58), 147 (85); MS (EI, 70 eV): *m/z* (%): 468 (8) $[M+3]^+$, 467 (23) $[M+2]^+$, 466 (12) $[M+1]^+$, 465 (30) $[M]^+$, 274 (30), 273 (19), 272 (100), 103 (33); HRMS (ESI+): *m/z* calcd for $C_{27}H_{27}N_3O_4$: 457.20016; found: 457.20275; elemental analysis calcd (%) for $C_{27}H_{27}N_3O_4$: C 70.88, H 5.95, N 9.18; found: C 70.38, H 6.06, N 8.86.

Synthesis of 2,6-bis-[(4*R*)-4-isopropyl-5,6-dihydro-4*H*-[1,3]oxazinyl]pyridine ((*R*)-4f): By general procedure **A** from compounds (*R*)-**15f** and **9**, (*R*)-**4f** was obtained as white needles in 61% yield. $R_f = 0.7$ (alumina, CH_2Cl_2/Et_3N 98:2); m.p. 90–95 °C; $[\alpha]_D = +8.9°$ ($c = 0.62$ in CH_2Cl_2); ^{1}H NMR (400.1 MHz, CD_2Cl_2): $\delta = 0.67$ (d, $J = 6.9$ Hz, 3H), 0.75 (d, $J = 6.7$ Hz, 3H), 1.40–1.50 (m, 4H), 1.60–1.66 (ddt, $J = 13.7$, 4.8, 2.8 Hz, 2H), 2.95 (ddd, $J = 10.7$, 6.3, 4.8 Hz, 2H), 3.93–4.01 (dddd, $J = 11.9$, 10.7, 3.0, 1.2 Hz, 2H), 4.15–4.20 (dddd, $J = 10.7$, 4.6, 2.8, 0.6 Hz, 2H), 7.42 (t, $J = 7.7$ Hz, 1H), 7.77 ppm (d, $J = 7.7$ Hz, 2H); ^{13}C NMR (100.6 MHz, CD_2Cl_2): $\delta = 18.5$, 18.7, 24.3, 33.9, 57.7, 65.3, 123.7, 136.5, 151.3, 153.5 ppm; MS (EI, 70 eV): *m/z* (%): 329 (2) $[M]^+$, 314 (2), 288 (14), 287 (80), 286 (100), 203 (46); HRMS (ESI+): *m/z* calcd for $C_{19}H_{27}N_3O_2$: 329.21033; found: 329.21016; elemental analysis calcd (%) for $C_{19}H_{27}N_3O_2$: C 69.27, H 8.26, N 12.76; found: C 69.15, H 8.12, N 12.46.

Synthesis of 4-substituted 2,6-pyridine dicarboxylic acids 5: 4-Substituted 2,6-pyridine dicarboxylic acids **5a–e** were synthesized by literature methods.[32] **5f** was synthesized as follows:

Compound **18** (360 mg, 1.57 mmol), phenyl boronic acid (230 mg, 1.88 mmol) and P(*o*-Tolyl)$_3$ (5 mol%) were dissolved in DME (8 mL). CsF (2.5 equiv) was added and mixture was purged with argon. $Pd(OAc)_2$ (5 mol%) was added and the mixture was refluxed for 18 h. After cooling to room temperature, water was added and the resulting mixture was extracted with ethyl acetate (50 mL×2). The organic layer was dried over $MgSO_4$ and concentrated. The residue was purified by silca gel column chromatography to give ester **19** as a white solid (220 mg, 52%). Potassium carbonate (0.5 g) was added to a solution of **19** (150 mg, 0.55 mmol) in methanol and water (2:1, 7.5 mL). The reaction mixture was stirred for 18 h at room temperature and was then poured onto a mixture of ice and conc. HCl. A white solid precipitated, which after filtration and drying

gave **5f** (115 mg, 86%). M.p. 218–220°C; ^{1}H NMR (400.1 MHz, [D$_6$]DMSO): δ=7.75 (m, 3H), 7.85 (dd, J=1.8, 8.2 Hz, 2H), 8.54 ppm (s, 2H); ^{13}C NMR (100.6 MHz, [D$_6$]DMSO): δ=124.9, 127.5, 129.8, 130.4, 136.1, 149.5, 150.3, 165.9 ppm; MS (EI, 70 eV): m/z (%): 243 (43) $[M]^+$, 199 (100), 181 (78), 153 (46), 126 (39), 77 (29).

General procedure B for the synthesis of (pybox)(pydic)ruthenium 1 or (pyboxazine)(pydic)ruthenium 2: The synthesis of Ru{2,6-bis-[(*4R*)-4-(2-naphthyl)-5,6-dihydro-4*H*-[1,3]oxazinyl]pyridine}(pyridine-2,6-dicarboxylate) (*R*)-(**2ca**) is taken as an example.

Synthesis of {2,6-bis-[(4*R*)-4-(2-naphthyl)-5,6-dihydro-4*H*-[1,3]oxazinyl]-pyridine}(pyridine-2,6-dicarboxylate)ruthenium ((*R*)-2ca): Disodium pyridine-2,6-dicarboxylate (Na$_2$pydic) (64 mg, 0.30 mmol) in MeOH/H$_2$O 1:1 (2 mL) was added via a cannula to a solution of (*R*)-**4a** (150 mg, 0.30 mmol) and [{Ru(*p*-cymene)Cl$_2$}$_2$] (92 mg, 0.15 mmol) in MeOH (2 mL) under Ar. The whole reaction mixture was heated to 65°C for 1 h. The reaction mixture was then diluted with CH_2Cl_2 (30 mL) and washed with H$_2$O (30 mL). The deep orange organic layer was dried over MgSO$_4$, filtered, and evaporated to dryness under reduced pressure. The reaction mixture was then subjected to chromatography over silica gel (70–230 mesh) with CH_2Cl_2/MeOH 100:2 to CH_2Cl_2/MeOH 100:5 as the gradient eluent. After removal of solvent under reduced pressure, the product was recrystallized over CH_2Cl_2/*n*-hexane to give a brown solid (138 mg, 60%). R_f=0.09 (CH_2Cl_2/MeOH 100:5); ^{1}H NMR (400.1 MHz, $CDCl_3$): δ=1.95–2.02 (m, 2H), 2.22–2.30, (m, 2H), 3.88–3.90 (m, 2H), 4.39–4.51 (m, 4H), 6.57–6.62 (m, 3H), 6.72–6.75 (m, 4H), 7.31–7.41 (m, 6H), 7.53 (d, J=8.5 Hz, 2H), 7.63 (t, J=7.9 Hz, 1H), 7.73 (d, J=7.9 Hz, 2H), 8.10 ppm (d, J=7.9 Hz, 2H); ^{13}C NMR (100.6 MHz, $CDCl_3$): δ=30.7, 58.2, 63.6, 123.5, 124.2, 124.4, 125.2, 125.3, 126.0, 127.7, 127.8, 128.8, 132.3, 132.4, 132.6, 135.7, 136.7, 149.1, 152.0, 160.5, 171.4 ppm; FAB-MS: m/z: 764 $[M]^+$; UV/Vis (CH_2Cl_2) λ_{max} ($\log\varepsilon$)=384 (3.45), 484 nm (4.27); elemental analysis calcd (%) for $C_{40}H_{30}N_4O_6Ru{\cdot}H_2O$: C 61.45, H 4.12, N 7.17; found: C 61.19, H 4.09, N 6.81.

Synthesis of {2,6-bis-[(4*S*)-4-phenyl-4,5-dihydrooxazol-2-yl]pyridine}(pyridine-2,6-dicarboxylate)ruthenium (1aa): From general procedure **B** by using **3a** (500 mg, 1.35 mmol), [{Ru(*p*-cymene)Cl$_2$}$_2$] (414 mg, 0.68 mmol), and disodium pyridine-2,6-dicarboxylate (286 mg, 1.35 mmol), a brown solid of **1aa** (665 mg, 78%) was obtained. R_f=0.08 (CH_2Cl_2/MeOH 100:5); ^{1}H NMR (400.1 MHz, $CDCl_3$): δ=4.59–4.68 (m, 4H), 5.15–5.21 (m, 2H), 6.68 (d, J=6.8 Hz, 4H), 7.02–7.05 (unresolved dd, 4H), 7.14 (t, J=7.0 Hz, 2H), 7.54 (m, 3H), 7.65 (t, J=7.7 Hz, 1H), 7.95 ppm (d, J=7.7 Hz, 2H); ^{13}C NMR (100.6 MHz, $CDCl_3$): δ=67.8, 78.5, 124.0, 125.9, 127.3, 128.6, 129.1, 133.7, 135.6, 136.0, 147.1, 149.2, 167.4, 171.1 ppm; FAB-MS: m/z: 636 $[M]^+$; UV/Vis (CH_2Cl_2): λ_{max} ($\log\varepsilon$)=375 (3.36), 484 nm (4.47); elemental analysis calcd (%) for $C_{30}H_{22}N_4O_6Ru{\cdot}0.5\,CH_2Cl_2$: C 54.03, H 3.42, N 8.26; found: C 54.37, H 3.79, N 8.50.

Synthesis of {2,6-bis-[(4*S*)-4-phenyl-4,5-dihydrooxazol-2-yl]pyridine}(4-hydroxypyridine-2,6-dicarboxylate)ruthenium (1ab): From General procedure **B** by using **3a** (185 mg, 0.50 mmol), [{Ru(*p*-cymene)Cl$_2$}$_2$] (153 mg, 0.25 mmol), **5b** (101 mg, 0.50 mmol), and NaOH (40 mg, 1.0 mmol), a brown solid of **1ab** (280 mg, 86%) was obtained. R_f=0.19 (CH_2Cl_2/MeOH 10:1); ^{1}H NMR (400.1 MHz, CD_3OD): δ=4.82–4.87 (m, 4H), 5.38–5.40 (m, 2H), 6.77 (d, J=7.3 Hz, 4H), 7.05 (s, 2H), 7.10 (unresolved dd, 4H), 7.21 (unresolved dd, 2H), 7.92 (t, J=6.9 Hz, 1H), 8.09 ppm (d, J=6.9 Hz, 1H); ^{13}C NMR (100.6 MHz, CD_3OD): δ=69.2, 80.1, 116.2, 126.6, 128.5, 128.9, 129.9, 130.3, 138.6, 149.4, 150.8, 166.7, 170.6, 173.1 ppm; FAB-MS: m/z: 652 $[M]^+$; UV/Vis (MeOH) λ_{max} ($\log\varepsilon$)=359 (3.53), 472 nm (4.24); elemental analysis calcd (%) for $C_{30}H_{22}N_4O_7Ru{\cdot}CH_3OH$: C 54.46, H 3.83, N 8.20; found: C 54.35, H 4.16, N 7.96.

Synthesis of {2,6-bis-[(4*S*)-4-phenyl-4,5-dihydrooxazol-2-yl]pyridine}(4-chloropyridine-2,6-dicarboxylate)ruthenium (1ac): From general procedure **B** by using **3a** (185 mg, 0.50 mmol), [{Ru(*p*-cymene)Cl$_2$}$_2$] (153 mg, 0.25 mmol), **5c** (101 mg, 0.50 mmol), and NaOH (40 mg, 1.0 mmol), a deep green crystalline solid of **1ac** (252 mg, 75%) was obtained. R_f=0.11 (CH_2Cl_2/MeOH 100:5); ^{1}H NMR (400.1 MHz, CD_3OD): δ=4.46 (dd, J=9.5, 11.3 Hz, 2H), 4.77 (dd, J=8.5, 11.3 Hz, 2H), 5.39 (dd, J=8.5, 9.5 Hz, 2H), 6.79 (d, J=7.1 Hz, 4H), 7.10 (unresolved dd, 4H), 7.25 (t, J=7.5 Hz, 2H), 7.58 (s, 2H), 8.02 (t, J=7.9 Hz, 1H), 8.30 ppm (d, J=7.9 Hz, 2H); ^{13}C NMR (100.6 MHz, CD_3OD): δ=69.6, 80.3, 126.2, 128.4, 129.1, 130.0, 130.4, 131.1, 138.1, 142.8, 149.6, 151.9, 169.4, 172.8 ppm; FAB-MS: m/z: 670 $[M]^+$; UV/Vis (CH_2Cl_2): λ_{max} ($\log\varepsilon$)=383 (3.54), 484 nm (4.30); elemental analysis calcd (%) for $C_{30}H_{21}ClN_4O_6Ru$: C 53.78, H 3.16, N 8.36; found: C 53.51, H 3.54, N 8.23.

Synthesis of {2,6-bis-[(4*S*)-4-phenyl-4,5-dihydrooxazol-2-yl]pyridine}(4-bromopyridine-2,6-dicarboxylate)ruthenium (1ad): From general procedure **B** by using **3a** (150 mg, 0.41 mmol), [{Ru(*p*-cymene)Cl$_2$}$_2$] (124 mg, 0.20 mmol), **5d** (100 mg, 0.41 mmol), and NaOH (33 mg, 0.81 mmol), a green solid of **1ad** (251 mg, 86%) was obtained. R_f=0.19 (CH_2Cl_2/MeOH 100:5); ^{1}H NMR (400 MHz, $CDCl_3$): δ=4.65 (m, 4H), 5.15–5.22 (m, 2H), 6.71 (d, J=6.2 Hz, 4H), 7.09 (unresolved dd, 4H), 7.21 (t, J=6.9 Hz, 2H), 7.61 (s, 2H), 7.68 (t, J=7.5 Hz, 1H), 7.97 ppm (d, J=7.5 Hz, 2H); ^{13}C NMR (100.61 MHz, $CDCl_3$): δ=68.0, 78.4, 124.1, 126.6, 127.4, 128.7, 129.1, 135.7, 147.2, 149.9, 167.3, 169.8 ppm; FAB-MS: m/z: 714 $[M]^+$, 716 $[M+2]^+$; UV/Vis (CH_2Cl_2) λ_{max} ($\log\varepsilon$)=384 (3.59), 484 nm (4.33); elemental analysis calcd (%) for $C_{30}H_{21}BrN_4O_6Ru{\cdot}CH_3OH$: C 49.88, H 3.38, N 7.50; found: C 49.56, H 3.26, N 7.79.

Synthesis of {2,6-bis-[(4*S*)-4-phenyl-4,5-dihydrooxazol-2-yl]pyridine}(4-methoxypyridine-2,6-dicarboxylate)ruthenium (1ae): From general procedure **B** by using **3a** (105 mg, 0.28 mmol), [{Ru(*p*-cymene)Cl$_2$}$_2$] (87 mg, 0.14 mmol), **5e** (56 mg, 0.28 mmol), and NaOH (23 mg, 0.56 mmol), a green solid of **1ae** (98 mg, 53%) was obtained. R_f=0.29 (CH_2Cl_2/MeOH 100:5); ^{1}H NMR (400 MHz, $CDCl_3$): δ=3.93 (s, 3H), 4.57–4.65 (m, 4H), 5.11–5.12 (m, 2H), 6.70 (d, J=7.3 Hz, 4H), 7.04–7.07 (unresolved dd, 4H), 7.12–7.17 (m, 4H), 7.60 (t, J=7.7 Hz, 1H), 7.93 ppm (d, J=7.7 Hz, 2H); ^{13}C NMR (100.61 MHz, $CDCl_3$): δ=56.3, 67.7, 78.4, 112.4, 124.1, 124.9, 127.3, 128.6, 136.2, 147.7, 149.8, 166.0, 167.7, 170.8 ppm; FAB-MS: m/z: 666 $[M]^+$; UV/Vis (CH_2Cl_2): λ_{max} ($\log\varepsilon$)=366 (3.56), 483 (4.25); elemental analysis calcd (%) for $C_{30}H_{22}N_4O_7Ru{\cdot}0.5\,CH_2Cl_2$: C 53.43, H 3.56, N 7.91; found: C 53.07, H 3.76, N 8.03.

Synthesis of {2,6-bis-[(4*S*)-4-phenyl-4,5-dihydrooxazol-2-yl]pyridine}(4-phenylpyridine-2,6-dicarboxylate)ruthenium (1af): From general procedure **B** by using **3a** (144 mg, 0.39 mmol), [{Ru(*p*-cymene)Cl$_2$}$_2$] (119 mg, 0.20 mmol), **5f** (95 mg, 0.39 mmol), and NaOH (31 mg, 0.78 mmol), a green solid of **1af** (272 mg, 98%) was obtained. R_f=0.12 (CH_2Cl_2/MeOH 100:5); ^{1}H NMR (400 MHz, $CDCl_3$): δ=4.60–4.70 (m, 4H), 5.17 (m, 2H), 6.71 (d, J=6.7 Hz, 4H), 7.00 (unresolved dd, 4H), 7.14–7.17 (m, 2H), 7.51 (t, J=7.3 Hz, 1H), 7.56–7.59 (m, 2H), 7.65 (t, J=7.7 Hz, 1H), 7.69 (d, J=7.3 Hz, 2H), 7.75 (s, 2H), 7.96 ppm (d, J=7.7 Hz, 2H); ^{13}C NMR (100.61 MHz, $CDCl_3$): δ=67.9, 78.3, 123.6, 123.9, 125.8, 126.7, 127.4, 128.4, 128.9, 129.4, 129.4, 135.9, 137.5, 146.6, 147.0, 149.2, 167.3, 171.1 ppm; FAB-MS: m/z: 712 $[M]^+$; UV/Vis (CH_2Cl_2): λ_{max} ($\log\varepsilon$)=394 (3.63), 488 nm (4.34); elemental analysis calcd (%) for $C_{36}H_{26}N_4O_6Ru{\cdot}H_2O$: C 59.26, H 3.87, N 7.68; found: C 59.096, H 3.38, N 7.68.

Synthesis of {2,6-bis-[(4*S*)-4-phenyl-4,5-dihydrooxazol-2-yl]-4-chloropyridine}(pyridine-2,6-dicarboxylate)ruthenium (1ba): From general procedure **B** by using **3b** (100 mg, 0.25 mmol), [{Ru(*p*-cymene)Cl$_2$}$_2$] (76 mg, 0.13 mmol), and disodium pyridine-2,6-dicarboxylate (52 mg, 0.25 mmol), a green solid of **1ba** (88 mg, 53%) was obtained. R_f=0.15 (CH_2Cl_2/MeOH 100:5); ^{1}H NMR (400.1 MHz, $CDCl_3$): δ=4.60–4.69 (m, 4H), 5.17–5.18 (m, 2H), 6.66 (d, J=6.9 Hz, 4H), 7.03 (unresolved dd, 4H), 7.14 (t, J=7.1 Hz, 2H), 7.54 (m, 3H), 7.95 ppm (s, 2H); ^{13}C NMR (100.6 MHz, $CDCl_3$): δ=68.0, 78.7, 124.0, 126.0, 127.3, 128.7, 129.1, 132.5, 134.2, 135.7, 147.4, 149.0, 166.8, 170.9 ppm; FAB-MS: m/z: 670 $[M]^+$; UV/Vis (CH_2Cl_2): λ_{max} ($\log\varepsilon$)=371 (3.48), 493 nm (4.29); elemental analysis calcd (%) for $C_{30}H_{21}N_4O_6Ru{\cdot}CH_2Cl_2$: C 51.41, H 3.11, N 7.86; found: C 51.08, H 3.10, N 7.93.

Synthesis of {2,6-bis-[(4*S*)-4-phenyl-4,5-dihydrooxazol-2-yl]-4-(*N*,*N*-dimethylamino)pyridine}(pyridine-2,6-dicarboxylate)ruthenium (1ca): From general procedure **B** by using **3c** (70 mg, 0.17 mmol), [{Ru(*p*-cymene)Cl$_2$}$_2$] (52 mg, 0.085 mmol), and disodium pyridine-2,6-dicarboxylate (36 mg, 0.17 mmol), a green crystalline solid of **1ca** (74 mg, 64%) was obtained. R_f=0.05 (CH_2Cl_2/MeOH 100:5); ^{1}H NMR (400.1 MHz, $CDCl_3$): δ=3.36 (s, 6H), 4.55 (dd, J=8.8, 11.0 Hz, 2H), 4.70 (unresolved dd, 2H), 5.11 (dd, J=8.8, 9.8 Hz, 2H), 6.65 (d, J=7.2 Hz, 4H), 7.00 (unresolved

dd, 4H), 7.10 (t, J = 7.4 Hz, 2H), 7.26 (br s, 2H), 7.33–7.36 (m, 1H), 7.42–7.44 ppm (m, 2H); ^{13}C NMR (100.6 MHz, $CDCl_3$): δ = 40.1, 68.0, 78.2, 106.4, 125.6, 127.1, 128.3, 128.8, 131.2, 136.2, 147.1, 150.8, 150.9, 166.6, 172.0 ppm; FAB-MS: *m/z*: 679 $[M]^+$; UV/Vis (CH_2Cl_2): λ_{max} ($\log\varepsilon$) = 388 (3.64), 505 nm (4.33); HRMS (ESI+): *m/z* calcd for $C_{32}H_{27}N_5O_6{}^{102}Ru+H^+$: 679.10880; found: 679.10046.

Synthesis of {2,6-bis-[(4*S*)-4-phenyl-4,5-dihydrooxazol-2-yl]-4-phenylpyridine}(pyridine-2,6-dicarboxylate)ruthenium (1da): From general procedure **B** by using **3d** (69 mg, 0.15 mmol), [{Ru(*p*-cymene)Cl_2}$_2$] (47 mg, 0.077 mmol), and disodium pyridine-2,6-dicarboxylate (33 mg, 0.15 mmol), a brown solid of **1da** (50 mg, 47%) was obtained. R_f = 0.20 (CH_2Cl_2/MeOH 100:5); ^{1}H NMR (400.1 MHz, $CDCl_3$): δ = 4.59–4.68 (m, 4H), 5.16–5.19 (m, 2H), 6.67 (d, *J* = 7.3 Hz, 4H), 7.03 (unresolved dd, 4H), 7.14 (t, *J* = 7.3 Hz, 2H), 7.48–7.60 (m, 6H), 7.84 (d, *J* = 7.7 Hz, 2H), 8.19 ppm (s, 2H); ^{13}C NMR (100.6 MHz, $CDCl_3$): δ = 67.8, 78.5, 121.9, 126.0, 127.0, 127.2, 128.6, 129.1, 129.3, 129.6, 133.7, 136.0, 137.4, 139.6, 147.1, 149.3, 167.5, 171.2 ppm; FAB-MS: *m/z*: 712 $[M]^+$; UV/Vis (CH_2Cl_2): λ_{max} ($\log\varepsilon$) = 345 (3.62), 495 nm (4.23); HRMS (ESI+): *m/z* calcd for $C_{36}H_{26}N_4O_6{}^{102}Ru$: 712.09618; found: 712.08960.

Synthesis of {2,6-bis-[(4*S*)-4-phenyl-4,5-dihydrooxazol-2-yl]-4-(1-naphthylpyridine}(pyridine-2,6-dicarboxylate)ruthenium (1ea): From general procedure **B** by using **3e** (46 mg, 0.093 mmol), [{Ru(*p*-cymene)Cl_2}$_2$] (28 mg, 0.046 mmol), and disodium pyridine-2,6-dicarboxylate (20 mg, 0.093 mmol), a green crystalline solid of **1ea** (44 mg, 62%) was obtained. R_f = 0.17 (CH_2Cl_2/MeOH 100:5); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 4.62–4.74 (m, 4H), 5.17–5.19 (m, 2H), 6.72 (d, *J* = 6.7 Hz, 4H), 7.07 (unresolved dd, 4H), 7.17 (t, *J* = 6.7 Hz, 2H), 7.58–7.65 (m, 7H), 7.99–8.01 (m, 2H), 8.03–8.04 (m, 1H), 8.13 ppm (s, 2H); ^{13}C NMR (100.61 MHz, $CDCl_3$): δ = 67.9, 78.6, 124.8, 125.4, 125.5, 126.1, 126.5, 127.3, 127.7, 128.7, 128.8, 129.2, 129.6, 130.9, 133.8, 133.9, 135.7, 136.1, 136.4, 139.5, 146.9, 149.3, 167.5, 172.2 ppm; FAB-MS: *m/z*: 763 $[M]^+$; UV/Vis (CH_2Cl_2): λ_{max} ($\log\varepsilon$) = 364 (sh; 3.65), 492 nm (4.39); elemental analysis calcd (%) for $C_{40}H_{28}N_4O_6Ru{\cdot}0.5\,H_2O$: C 62.33, H 3.79, N 7.27; found: C 62.36, H 3.73 N 7.35.

Synthesis of {2,6-bis-[(4*S*,5*R*)-8,8a-dihydro-3a*H*-indeno[1,2-*d*]oxazolyl]-pyridine}(pyridine-2,6-dicarboxylate)ruthenium (1fa): From general procedure **B** by using **3f** (200 mg, 0.51 mmol), [{Ru(*p*-cymene)Cl_2}$_2$] (156 mg, 0.25 mmol), and disodium pyridine-2,6-dicarboxylate (107 mg, 0.57 mmol), a deep red solid of **1fa** was obtained (290 mg, 86%). R_f = 0.11 (CH_2Cl_2/MeOH 100:5); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 3.37 (dd, *J* = 2.2, 18.2 Hz, 2H), 3.50 (dd, *J* = 7.3, 18.2 Hz, 2H), 4.99 (d, *J* = 8.1 Hz, 2H), 5.83–5.87 (m, 2H), 5.95 (d, *J* = 7.7 Hz, 2H), 7.00–7.03 (m, 2H), 7.12–7.18 (m, 4H), 7.59 (t, *J* = 7.7 Hz, 1H), 7.86 (d, *J* = 7.7 Hz, 2H), 8.31 (t, *J* = 7.7 Hz, 1H), 8.57 ppm (d, *J* = 7.7 Hz, 2H); ^{13}C NMR (100.61 MHz, $CDCl_3$): δ = 73.7, 78.6, 87.7, 116.5, 124.2, 125.1, 125.3, 127.5, 127.9, 129.7, 135.1, 136.8, 139.2, 147.4, 152.1, 171.3, 192.7 ppm; FAB-MS: *m/z*: 660 $[M]^+$; UV/Vis (CH_2Cl_2): λ_{max} ($\log\varepsilon$) = 383 (3.62), 484 nm (4.39); HRMS (ESI+): *m/z* calcd for $C_{36}H_{23}N_4O_6{}^{102}Ru$: 661.06538; found: 661.06610.

Synthesis of {2,6-bis-[(4*R*)-4-(2-naphthyl)-4,5-dihydrooxazol-2-yl]-4-(1-naphthyl-pyridine}(pyridine-2,6-dicarboxylate)ruthenium (1ga): From general procedure **B** by using **3g** (235 mg, 0.50 mmol), [{Ru(*p*-cymene)Cl_2}$_2$] (153 mg, 0.25 mmol), and disodium pyridine-dicarboxylate (106 mg, 0.50 mmol), a green solid of **1ga** (236 mg, 64%) was obtained. R_f = 0.31 (CH_2Cl_2/MeOH 10:1); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 4.69 (unresolved dd, 2H), 4.83 (unresolved dd, 2H), 5.19 (unresolved dd, 2H), 6.41 (t, *J* = 7.5 Hz, 1H), 6.66 (d, *J* = 7.5 Hz, 2H), 6.92 (m, 4H), 7.31–7.34 (m, 4H), 7.39–7.43 (m, 2H), 7.63–7.65 (m, 3H), 7.75 (d, *J* = 8.1 Hz, 2H), 7.95 ppm (d, *J* = 7.7 Hz, 2H); ^{13}C NMR (100.61 MHz, $CDCl_3$): δ = 68.4, 77.6, 123.5, 123.9, 124.3, 125.6, 126.1, 126.5, 127.4, 127.7, 127.8, 129.7, 132.4, 132.5, 133.0, 133.3, 147.0, 148.5, 167.4, 171.0 ppm; FAB-MS: *m/z*: 736 $[M]^+$; UV/Vis (CH_2Cl_2): λ_{max} ($\log\varepsilon$) = 369 (3.67), 486 nm (4.27); elemental analysis calcd (%) for $C_{38}H_{26}N_4O_6Ru{\cdot}H_2O$: C 60.55, H 3.74, N 7.43; found: C 60.49, H 3.85, N 7.30.

Synthesis of {2,6-bis-[(5*S*)-5-phenyl-4,5-dihydrooxazol-2-yl]pyridine}(pyridine-2,6-dicarboxylate)ruthenium (1ha): From general procedure **B** by using **3h** (200 mg, 0.54 mmol), [{Ru(*p*-cymene)Cl_2}$_2$] (166 mg, 0.27 mmol), and disodium pyridine-2,6-dicarboxylate (114 mg, 0.54 mmol), a brown solid of **1ha** (245 mg, 71%) was obtained. R_f = 0.14 (CH_2Cl_2/MeOH 100:5); ^{1}H NMR (400 MHz, CD_3OD): δ = 3.31 (dd, *J* = 14.7, 8.3 Hz, 2H), 3.88 (dd, *J* = 14.7, 10.1 Hz, 2H), 6.32 (dd, *J* = 10.1, 8.3 Hz, 2H), 7.37–7.42 (m, 10H), 7.98 (t, *J* = 7.9 Hz, 1H), 8.24 (d, *J* = 7.9 Hz, 2H), 8.30 (dd, *J* = 8.7, 6.9 Hz, 1H), 8.39 (d, *J* = 6.9 Hz, 1H), 8.39 ppm (d, *J* = 8.7 Hz, 1H); ^{13}C NMR (100.61 MHz, $CDCl_3$): δ = 58.1, 86.1, 123.9, 126.4, 126.6, 127.2, 129.2, 129.6, 134.9, 136.8, 147.3, 150.4, 167.5, 171.7 ppm; FAB-MS: *m/z*: 636 $[M]^+$; UV/Vis (CH_2Cl_2) λ_{max} ($\log\varepsilon$) = 377 (3.65), 480 nm (4.36); elemental analysis calcd (%) for $C_{30}H_{22}N_4O_6Ru{\cdot}H_2O$: C 55.13, H 3.70, N 8.57; found: C 55.00, H 3.59, N 8.59.

Synthesis of {2,6-bis-[(4*R*,5*S*)-4,5-diphenyl-4,5-dihydrooxazol-2-yl]pyridine}(pyridine-2,6-dicarboxylate)ruthenium (1ia): From general procedure **B** by using **3i** (522 mg, 1.0 mmol), [{Ru(*p*-cymene)Cl_2}$_2$] (306 mg, 0.50 mmol), and disodium pyridine-2,6-dicarboxylate (211 mg, 1.0 mmol), a dark green crystalline solid of **1ia** was obtained (584 mg, 74%). R_f = 0.14 (CH_2Cl_2/MeOH 100:5); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 5.01 (d, *J* = 10.5 Hz, 2H), 5.26 (s, 1H, 0.5 CH_2Cl_2), 6.23 (d, *J* = 7.5 Hz, 4H), 6.36 (d, *J* = 10.5 Hz, 2H), 6.71 (unresolved dd, 4H), 6.80–6.85 (m, 6H), 7.01–7.02 (m, 6H), 7.33–7.40 (m, 3H), 7.76 (t, *J* = 7.7 Hz, 1H), 8.14 ppm (d, *J* = 7.7 Hz, 2H); ^{13}C NMR (100.61 MHz, $CDCl_3$): δ = 71.5, 88.2, 124.3, 125.6, 125.7, 125.8, 127.7, 127.8, 128.0, 128.1, 128.2, 132.5, 133.9, 134.1, 147.1, 149.1, 167.6, 171.4 ppm; FAB-MS: *m/z*: 788 $[M]^+$, 84 $[CH_2Cl_2]^+$; UV/Vis (CH_2Cl_2): λ_{max} ($\log\varepsilon$) = 389 (3.63), 485 nm (4.28); elemental analysis calcd (%) for $C_{42}H_{30}N_4O_6Ru{\cdot}0.5\,CH_2Cl_2$: C 61.48, H 3.76, N 6.75; found: C 61.27, H 3.74, N 6.76.

Synthesis of {2,6-bis-[(4*R*,5*R*)-4,5-diphenyl-4,5-dihydrooxazol-2-yl]pyridine}(pyridine-2,6-dicarboxylate)ruthenium (1ja): From general procedure **B** by using **3j** (200 mg, 0.38 mmol), [{Ru(*p*-cymene)Cl_2}$_2$] (117 mg, 0.19 mmol), and disodium pyridine-2,6-dicarboxylate (81 mg, 0.38 mmol), a dark brown crystalline solid of was obtained (224 mg, 75%). R_f = 0.13 (CH_2Cl_2/MeOH 100:5); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 4.48 (d, *J* = 10.2 Hz, 2H), 5.85 (d, *J* = 10.2 Hz, 2H), 6.66 (d, *J* = 7.1 Hz, 4H), 7.02–7.05 (m, 4H), 7.14–7.18 (m, 6H), 7.30–7.34 (m, 6H), 7.47 (m, 3H), 7.70 (t, *J* = 7.8 Hz, 1H), 8.04 ppm (d, *J* = 7.8 Hz, 2H); ^{13}C NMR (100.61 MHz, $CDCl_3$): δ = 75.4, 93.6, 124.1, 125.9, 126.0, 127.3, 128.6, 128.9, 129.0, 129.2, 129.4, 133.7, 135.5, 135.7, 147.2, 149.1, 166.9, 171.2 ppm; FAB-MS: *m/z*: 788 $[M]^+$; UV/Vis (CH_2Cl_2): λ_{max} ($\log\varepsilon$) = 374 (3.77), 486 nm (4.51); elemental analysis calcd (%) for $C_{42}H_{30}N_4O_6Ru$: C 64.03, H 3.84, N 7.11; found: C 64.21, H 4.05, N 7.12.

Synthesis of {2,6-bis-[(4*S*)-4-(2-chlorophenyl)-4,5-dihydrooxazol-2-yl]pyridine}(pyridine-2,6-dicarboxylate)ruthenium (1ka): From general procedure **B** by using **3k** (150 mg, 0.34 mmol), [{Ru(*p*-cymene)Cl_2}$_2$] (105 mg, 0.17 mmol) and disodium pyridine-2,6-dicarboxylate (72 mg, 0.34 mmol), a deep green solid of **1ka** (130 mg, 54%) was obtained. R_f = 0.14 (CH_2Cl_2/MeOH 100:5); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 4.57–4.61 (m, 2H), 5.12–5.22 (m, 4H), 6.76 (m, 2H), 6.98–7.00 (m, 2H), 7.07–7.09 (m, 4H), 7.63–7.64 (m, 3H), 7.67 (t, *J* = 7.7 Hz, 1H), 7.97 ppm (d, *J* = 7.7 Hz, 2H); ^{13}C NMR (100.61 MHz, $CDCl_3$): δ = 63.9, 77.7, 124.3, 125.9, 126.1, 128.3, 128.7, 129.1, 129.8, 132.6, 134.2, 147.0, 149.5, 168.0, 170.9 ppm; FAB-MS: *m/z*: 704 $[M]^+$; UV/Vis (CH_2Cl_2): λ_{max} ($\log\varepsilon$) = 374 (3.46), 484 nm (4.22); elemental analysis calcd (%) for $C_{30}H_{20}Cl_2N_4O_6Ru{\cdot}H_2O$: C 49.87, H 3.07, N 7.75; found: C 49.85, H 3.08, N 7.59.

Synthesis of {2,6-bis-[(4*S*)-5,5-dimethyl-4-phenyl-4,5-dihydrooxazol-2-yl]-pyridine}-(pyridine-2,6-dicarboxylate)ruthenium (1la): From general procedure **B** by using **3l** (71 mg, 0.17 mmol), [{Ru(*p*-cymene)Cl_2}$_2$] (51 mg, 0.083 mmol), and disodium pyridine-2,6-dicarboxylate (35 mg, 0.17 mmol), a green solid of **1la** (82 mg, 70%) was obtained. R_f = 0.20 (CH_2Cl_2/MeOH 100:5); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 0.97 (s, 6H), 1.58 (s, 6H), 4.29 (s, 2H), 6.58 (d, *J* = 7.0 Hz, 4H), 6.99–7.07 (m, 6H), 7.33 (t, *J* = 7.6 Hz, 1H), 7.43 (d, *J* = 7.6 Hz, 2H), 7.63 (t, *J* = 7.9 Hz, 1H), 7.90 ppm (d, *J* = 7.9 Hz, 2H); ^{13}C NMR (100.61 MHz, $CDCl_3$): δ = 24.0, 28.6, 75.7, 93.3, 123.9, 125.5, 125.7, 127.4, 128.1, 128.4, 133.4, 133.5, 147.6, 149.6, 167.1, 171.7 ppm; FAB-MS: *m/z*: 692 $[M]^+$; UV/Vis (CH_2Cl_2): λ_{max} ($\log\varepsilon$) = 378 (3.57), 484 nm (4.30); elemental analysis calcd (%) for $C_{34}H_{30}N_4O_6Ru{\cdot}H_2O$: C 57.54, H 4.54, N 7.89; found: C 57.33, H 4.41, N 7.84.

Synthesis of {2,6-bis-[(4*S*)-4-methyl-4,5-dihydrooxazol-2-yl]pyridine)(pyridine-2,6-dicarboxylate)ruthenium (1ma): From general procedure **B** by using **3m** (245 mg, 1.0 mmol), [{Ru(*p*-cymene)Cl_2}$_2$] (306 mg, 0.5 mmol),

and disodium pyridine-2,6-dicarboxylate (211 mg, 1.0 mmol), a deep red solid of **1ma** was obtained (177 mg, 79%). R_f=0.07 (CH_2Cl_2/MeOH 100:5); ^{1}H NMR (400 MHz, $CDCl_3$): δ=0.74 (d, J=6.6 Hz, 6H), 3.77–3.86 (m, 2H), 4.25–4.30 (unresolved dd, 2H), 4.87–4.92 (unresolved dd, 2H), 7.60 (t, J=7.7 Hz, 1H), 7.83 (t, J=7.7 Hz, 2H), 8.08 (t, J=7.7 Hz, 1H), 8.30 ppm (d, J=7.7 Hz, 2H); ^{13}C NMR (100.61 MHz, $CDCl_3$): δ= 18.9, 33.8, 60.0, 123.6, 126.7, 127.0, 134.8, 147.3, 151.0, 166.6, 171.5 ppm; FAB-MS: m/z: 512 $[M]^+$; UV/Vis (CH_2Cl_2): λ_{max} ($\log\varepsilon$)=381 (3.57), 480 nm (4.30); HRMS (ESI+): m/z calcd for $C_{20}H_{19}N_4O_6{}^{102}Ru+H^+$: 513.03380; found: 513.03479.

Synthesis of {2,6-bis-[(4*S*)-4-isopropyl-4,5-dihydrooxazol-2-yl]pyridine}-(pyridine-2,6-dicarboxylate)ruthenium (1na): From general procedure **B** by using **3n** (201 mg, 0.66 mmol), [{Ru(*p*-cymene)Cl_2}$_2$] (204 mg, 0.33 mmol), and disodium pyridine-2,6-dicarboxylate (141 mg, 0.66 mmol), a green crystalline solid of **1na** (309 mg, 82%) was obtained. R_f=0.33 (CH_2Cl_2/MeOH 10:1); ^{1}H NMR (400 MHz, $CDCl_3$): δ=0.44 (d, J=6.8 Hz, 6H), 0.59 (d, J=7.2 Hz, 6H), 1.03–1.10 (m, 2H), 3.66–3.71 (m, 2H), 4.56–4.60 (unresolved dd, 2H), 4.64–4.68 (unresolved dd, 2H), 7.61 (t, J=7.8 Hz, 1H), 7.85 (d, J=7.8 Hz, 2H), 8.08 (t, J=7.7 Hz, 1H), 8.30 ppm (d, J=7.7 Hz, 2H); ^{13}C NMR (100.61 MHz, $CDCl_3$): δ=13.8, 18.8, 68.9, 71.0, 123.8, 126.6, 127.0, 134.7, 147.1, 150.9, 166.5, 171.5 ppm; FAB-MS: m/z: 568 $[M]^+$; UV/Vis (CH_2Cl_2) λ_{max} ($\log\varepsilon$)=382 (3.56), 480 nm (4.30).

Synthesis of {2,6-bis-[(4*S*)-4-*tert*-butyl-4,5-dihydrooxazol-2-yl]pyridine}-(pyridine-2,6-dicarboxylate)ruthenium (1oa): From general procedure **B** by using **3o** (112 mg, 0.34 mmol), [{Ru(*p*-cymene)Cl_2}$_2$] (104 mg, 0.17 mmol), and disodium pyridine-2,6-dicarboxylate (72 mg, 0.34 mmol), a deep orange solid of **1oa** was obtained (46 mg, 23%). R_f=0.18 (CH_2Cl_2/MeOH 100:5); ^{1}H NMR (400 MHz, $CDCl_3$): δ=0.40 (s, 18H), 3.02 (dd, J=3.9, 9.6 Hz, 2H), 4.51–4.55 (unresolved dd, 2H), 4.73 (dd, J=3.9, 9.0 Hz, 2H), 7.69 (t, J=7.7 Hz, 1H), 7.90 (t, J=7.7 Hz, 2H), 8.02 (t, J=7.7 Hz, 1H), 8.29 ppm (d, J=7.7 Hz, 2H); ^{13}C NMR (100.61 MHz, $CDCl_3$): δ=24.9, 33.4, 71.7, 73.3, 124.7, 126.7, 126.9, 134.5, 135.5, 147.6, 152.0, 167.6, 172.1 ppm; FAB-MS: m/z: 596 $[M]^+$; UV/Vis (CH_2Cl_2): λ_{max} ($\log\varepsilon$)=379 (3.76), 484 nm (4.32); HRMS (ESI+): m/z calcd for $C_{26}H_{31}N_4O_6{}^{102}Ru+H^+$: 597.13052; found: 597.12872.

Synthesis of {2,6-bis-[(4*S*,5*S*)-4-methyl-5-phenyl-4,5-dihydrooxazol-2-yl]-pyridine}(pyridine-2,6-dicarboxylate)ruthenium (1pa): From general procedure **B** by using **3p** (135 mg, 0.34 mmol), [{Ru(*p*-cymene)Cl_2}$_2$] (104 mg, 0.17 mmol), and disodium pyridine-2,6-dicarboxylate (72 mg, 0.34 mmol), a deep green crystals of **1pa** was obtained (177 mg, 79%). R_f=0.16 (CH_2Cl_2/MeOH 100:5); ^{1}H NMR (400 MHz, CD_2Cl_2): δ=0.84 (d, J=6.7 Hz, 6H), 3.75 (dd, J=9.7, 6.7 Hz, 2H), 5.51 (d, J=9.7 Hz, 2H), 7.33–7.37 (m, 4H), 7.38–7.41 (m, 6H), 7.69 (t, J=7.9 Hz, 1H), 8.00 (d, J=7.9 Hz, 2H), 8.08 (dd, J=7.2, 8.2 Hz, 1H), 8.23 ppm (m, 2H); ^{13}C NMR (100.61 MHz, CD_2Cl_2): δ=18.2, 68.1, 92.5, 124.1, 126.5, 126.9, 129.1, 129.6, 135.1, 135.8, 136.7, 147.4, 151.3, 166.5, 171.4 ppm; FAB-MS: m/z: 664 $[M]^+$; UV/Vis (CH_2Cl_2): λ_{max} ($\log\varepsilon$)=382 (3.81), 482 nm (4.53); elemental analysis calcd (%) for $C_{32}H_{26}N_4O_6Ru$: C 57.91, H 3.95, N 8.44; found: C 57.86, H 3.84, N 8.27.

Synthesis of {2,6-bis-[(4*S*)-4-benzyl-4,5-dihydrooxazol-2-yl]pyridine}(pyridine-2,6-dicarboxylate)ruthenium (1qa): From general procedure **B** by using **3q** (100 mg, 0.25 mmol), [{Ru(*p*-cymene)Cl_2}$_2$] (77 mg, 0.13 mmol), and disodium pyridine-2,6-dicarboxylate (53 mg, 0.25 mmol), a brown solid of **1qa** was obtained (141 mg, 85%). R_f=0.15 (CH_2Cl_2/MeOH 100:5); ^{1}H NMR (400 MHz, $CDCl_3$): δ=2.27–2.37 (m, 4H), 3.98–4.06 (m, 2H), 4.48 (unresolved dd, 2H), 4.65 (unresolved dd, 2H), 6.74 (d, J= 7.5 Hz, 4H), 7.14–7.18 (m, 6H), 7.62 (t, J=7.9 Hz, 1H), 7.86 (d, J= 7.9 Hz, 2H), 8.14 (t, J=7.7 Hz, 1H), 8.39 ppm (d, J=7.7 Hz, 2H); ^{13}C NMR (100.61 MHz, $CDCl_3$): δ=39.3, 65.2, 75.5, 124.0, 126.9, 127.0, 127.4, 128.6, 128.8, 135.1, 147.3, 151.1, 167.2, 171.5 ppm; FAB-MS: m/z: 664 $[M]^+$; UV/Vis (CH_2Cl_2): λ_{max} ($\log\varepsilon$)=382 (3.70), 481 nm (4.49); elemental analysis calcd (%) for $C_{32}H_{26}N_4O_6Ru$·*t*BuOMe: C 59.11, H 5.09, N 7.45; found: C 58.76, H 4.67, N 7.81.

Synthesis of {2,6-bis-[(4*R*)-4-hydroxymethyl-4,5-dihydrooxazol-2-yl]pyridine}(pyridine-2,6-dicarboxylate)ruthenium (1ra): From general procedure **B** by using **3r** (50 mg, 0.18 mmol), [{Ru(*p*-cymene)Cl_2}$_2$] (55 mg, 0.09 mmol), and disodium pyridine-2,6-dicarboxylate (38 mg, 0.18 mmol), a red crystalline solid of **1ra** was obtained (58 mg, 59%). R_f=0.21 (CH_2Cl_2/MeOH 100:5, neutral alumina); ^{1}H NMR (400 MHz, CD_3OD): δ=2.84 (dd, J=4.8, 11.3 Hz, 2H), 3.00 (dd, J=4.1, 11.3 Hz, 2H), 3.61–3.68 (m, 2H), 4.72 (dd, J=7.5, 8.7 Hz, 2H), 4.84–4.89 (unresolved dd, 2H), 7.82 (t, J=7.9 Hz, 1H), 8.07 (d, J=7.9 Hz, 2H), 8.18 (dd, J=6.8, 8.5 Hz, 1H), 8.26 (d, J=6.8 Hz, 1H), 8.26 ppm (d, J=8.5 Hz, 1H); ^{13}C NMR (100.61 MHz, CD_3OD): δ=63.0, 67.4, 80.4, 126.0, 129.2, 136.9, 137.4, 149.6, 152.6, 169.9, 174.6 ppm; FAB-MS: m/z: 544 $[M]^+$; UV/Vis (CH_2Cl_2): λ_{max} ($\log\varepsilon$)=383 (3.57), 476 nm (4.32); HRMS (ESI+): m/z calcd for $C_{20}H_{18}N_4O_8{}^{102}Ru$: 544.01827; found: 544.01678.

Synthesis of {2,6-bis-[(4*R*)-4-(*tert*-butyl-dimethylsilanyloxymethyl)-4,5-dihydrooxazol-2-yl]pyridine}(pyridine-2,6-dicarboxylate)ruthenium (1sa): From general procedure **B** by using **3s** (25 mg, 0.049 mmol), [{Ru(*p*-cymene)Cl_2}$_2$] (15 mg, 0.025 mmol), and disodium pyridine-2,6-dicarboxylate (10 mg, 0.049 mmol), a deep red solid of **1sa** was obtained (24 mg, 63%). R_f=0.17 (CH_2Cl_2/MeOH 100:5); ^{1}H NMR (400 MHz, $CDCl_3$): δ=−0.19 (s, 6H), −0.17 (s, 6H), 0.71 (s, 18H), 2.98–3.06 (m, 4H), 3.73–3.81 (m, 2H), 4.73–4.77 (unresolved dd, 2H), 4.80–4.85 (unresolved dd, 2H), 7.61 (t, J=7.9 Hz, 1H), 7.87 (d, J=7.9 Hz, 2H), 8.10 (t, J=7.7 Hz, 1H), 8.34 ppm (d, J=7.7 Hz, 2H); ^{13}C NMR (100.61 MHz, $CDCl_3$): δ=−5.8, −5.7, 17.9, 25.6, 63.0, 65.5, 75.0, 124.0, 126.7, 127.1, 134.8, 147.2, 151.0, 168.0, 171.1 ppm; FAB-MS: m/z: 772 $[M]^+$; UV/Vis (CH_2Cl_2): λ_{max} ($\log\varepsilon$) = 382 (3.68), 481 nm (4.26); HRMS (ESI+): m/z calcd for $C_{32}H_{46}N_4O_8{}^{102}RuSi_2$: 772.20908; found: 772.24414.

Synthesis of {2,6-bis-{(4*R*)-4-[1-(*tert*-Butyldimethylsilanyloxy)ethyl]-4,5-dihydrooxazol-2-yl}pyridine}(pyridine-2,6-dicarboxylate)ruthenium (1ta): From general procedure **B** by using **3t** (30 mg, 0.060 mmol), [{Ru(*p*-cymene)Cl_2}$_2$] (18 mg, 0.030 mmol), and disodium pyridine-2,6-dicarboxylate (13 mg, 0.060 mmol), a deep orange solid of **1ta** was obtained (34 mg, 71%). R_f=0.10 (CH_2Cl_2/MeOH 100:5); ^{1}H NMR (400 MHz, $CDCl_3$): δ= −0.33 (s, 3H), −0.22 (s, 2H), 0.67 (d, J=5.7 Hz, 2H), 0.68 (s, 18H), 3.13–3.19 (m, 2H), 3.72–3.77 (m, 2H), 4.69 (unresolved dd, 2H), 4.93 (dd, J= 6.5, 9.4 Hz, 2H), 7.62 (t, J=7.9 Hz, 1H), 7.88 (d, J=7.9 Hz, 2H), 8.09 (t, J=7.7 Hz, 1H), 8.35 ppm (d, J=7.7 Hz, 2H); ^{13}C NMR (100.61 MHz, $CDCl_3$): δ=−5.5, −5.1, 15.6, 17.7, 25.5, 66.8, 68.3, 71.9, 124.2, 126.8, 127.1, 134.7, 147.1, 151.0, 167.6, 171.0 ppm; FAB-MS: m/z:800 $[M]^+$.

Synthesis of {2,6-bis-[(4*S*)-4-Methoxycarbonyl-4,5-dihydrooxazol-2-yl]pyridine}(pyridine-2,6-dicarboxylate) ruthenium (1ua): From general procedure **B** by using **3u** (100 mg, 0.30 mmol), [{Ru(*p*-cymene)Cl_2}$_2$] (92 mg, 0.15 mmol), and disodium pyridine-2,6-dicarboxylate (63 mg, 0.30 mmol), a deep green brown crystalline solid of **1ua** was obtained (32 mg, 18%). R_f=0.46 (CH_2Cl_2/MeOH 100:5, neutral alumina); ^{1}H NMR (400 MHz, $CDCl_3$): δ=3.49 (s, 6H), 4.17 (dd, J=7.2, 9.6 Hz, 2H), 4.94 (unresolved dd, 2H), 5.18 (unresolved dd, 2H), 7.66 (t, J=7.7 Hz, 1H), 7.96 (d, J= 7.7 Hz, 2H), 8.16 (t, J=7.7 Hz, 1H), 8.35 ppm (d, J=7.7 Hz, 2H); ^{13}C NMR (100.61 MHz, $CDCl_3$): δ=53.7, 64.4, 73.8, 125.3, 126.2, 126.6, 135.6, 146.6, 151.1, 167.4, 169.0, 171.7 ppm; FAB-MS: m/z: 600 $[M]^+$; UV/Vis (CH_2Cl_2): λ_{max} ($\log\varepsilon$)=371 (3.79), 488 nm (4.43); HRMS (ESI+): m/z calcd for $C_{22}H_{18}N_4O_{10}{}^{102}Ru$: 600.01109; found: 600.00665.

Synthesis of {2,6-bis-[(4*R*)-4-phenyl-5,6-dihydro-4*H*-[1,3]oxazinyl]pyridine}(pyridine-2,6-dicarboxylate)ruthenium ((*R*)-2aa): From general procedure **B** by using (*R*)-**4a** (199 mg, 0.50 mmol), [{Ru(*p*-cymene)Cl_2}$_2$] (153 mg, 0.25 mmol), and disodium pyridine-2,6-dicarboxylate (106 mg, 0.50 mmol), a green solid of (*R*)-**2aa** (132 mg, 40%) was obtained. R_f= 0.11 (CH_2Cl_2/MeOH 100:5); ^{1}H NMR (400 MHz, $CDCl_3$): δ=1.80–1.85 (m, 2H), 2.25–2.33, (m, 2H), 3.74–3.76 (m, 2H), 4.33–4.39 (m, 2H), 4.42–4.46 (m, 2H), 6.42 (d, J=7.3 Hz, 4H), 7.01 (unresolved dd, 4H), 7.11 (t, J=7.3 Hz, 2H), 7.44–7.50 (m, 3H), 7.62 (t, J=7.9 Hz, 1H), 7.97 ppm (d, J=7.9 Hz, 2H); ^{13}C NMR (100.61 MHz, $CDCl_3$): δ=30.4, 57.5, 62.7, 124.0, 125.4, 125.8, 126.0, 127.4, 128.6, 132.5, 139.3, 149.3, 151.8, 160.3, 171.4 ppm; FAB-MS: m/z: 664 $[M]^+$; UV/Vis (CH_2Cl_2): λ_{max} ($\log\varepsilon$)=384 (3.47), 482 nm (4.23); elemental analysis calcd (%) for $C_{32}H_{26}N_4O_6Ru$·H_2O: C 56.38, H 4.14, N 8.22; found: C 56.13, H 3.96, N 8.23.

Synthesis of {2,6-bis-[(4*S*)-4-phenyl-5,6-dihydro-4*H*-[1,3]oxazinyl]pyridine}(pyridine-2,6-dicarboxylate)ruthenium ((*S*)-2aa): From general procedure **B** by using (*S*)-**4a** (199 mg, 0.50 mmol), [{Ru(*p*-cymene)Cl_2}$_2$] (153 mg, 0.25 mmol) and disodium pyridine-2,6-dicarboxylate (106 mg,

0.50 mmol), a green solid of (*S*)-**2aa** (95 mg, 29%) was obtained. R_f= 0.13 (CH_2Cl_2/MeOH 100:5); ^{1}H NMR (400 MHz, $CDCl_3$): δ=1.80–1.84 (m, 2H), 2.24–2.32, (m, 2H), 3.73–3.75 (m, 2H), 4.32–4.38 (m, 2H), 4.41–4.45 (m, 2H), 6.41 (d, J=7.3 Hz, 4H), 7.00 (unresolved dd, 4H), 7.10 (t, J=7.3 Hz, 2H), 7.43–7.49 (m, 3H), 7.61 (t, J=7.9 Hz, 1H), 7.96 ppm (d, J=7.9 Hz, 2H); ^{13}C NMR (100.61 MHz, $CDCl_3$): δ=30.4, 57.5, 62.6, 123.9, 125.3, 125.8, 126.0, 127.4, 128.6, 132.5, 139.2, 149.3, 151.8, 160.3, 171.4 ppm; FAB-MS: *m*/*z*: 664 $[M]^+$; UV/Vis (CH_2Cl_2): λ_{max} ($\log\varepsilon$)=385 (3.47), 482 nm (4.26); elemental analysis calcd (%) for $C_{32}H_{26}N_4O_6Ru{\cdot}H_2O$: C 56.38, H 4.14, N 8.22; found: C 56.34, H 4.03, N 8.07.

Synthesis of {2,6-bis-[(4*R*)-4-phenyl-5,6-dihydro-4*H*-[1,3]oxazinyl]pyridine}(4-chloropyridine-2,6-dicarboxylate)ruthenium ((*R*)-2ac): From general procedure **B** by using (*R*)-**4a** (197 mg, 0.50 mmol), [{Ru(*p*-cymene)Cl_2}$_2$] (152 mg, 0.25 mmol), **5c** (100 mg, 0.50 mmol), and NaOH (40 mg, 1.0 mmol), a green solid of (*R*)-**2ac** (132 mg, 38%) was obtained. R_f=0.16 (CH_2Cl_2/MeOH 100:5); ^{1}H NMR (400 MHz, $CDCl_3$): δ=1.85–1.89 (m, 2H), 2.23–2.32, (m, 2H), 3.71–3.73 (m, 2H), 4.35–4.41 (m, 2H), 4.44–4.49 (m, 2H), 6.44 (d, J=7.2 Hz, 4H), 7.05 (unresolved dd, 4H), 7.16 (t, J=7.3 Hz, 2H), 7.40 (s, 2H), 7.64 (t, J=7.9 Hz, 1H), 7.98 ppm (d, J=7.9 Hz, 2H); ^{13}C NMR (100.61 MHz, $CDCl_3$): δ=30.5, 57.8, 63.1, 124.1, 126.0, 126.0, 127.6, 128.7, 139.2, 140.3, 150.1, 152.0, 160.4, 170.4 ppm; FAB-MS: *m*/*z*: 698 $[M]^+$; UV/Vis (CH_2Cl_2): λ_{max} ($\log\varepsilon$)=393 (3.53), 485 nm (4.32); elemental analysis calcd (%) for $C_{32}H_{25}ClN_4O_6Ru{\cdot}0.5H_2O$: C 54.36, H 3.71, N 7.92; found: C 54.37, H 3.66, N 8.00.

Synthesis of {2,6-bis-[(4*R*)-4-(1-naphthyl)-5,6-dihydro-4*H*-[1,3]oxazinyl]-pyridine}(pyridine-2,6-dicarboxylate)ruthenium ((*R*)-2ba): From general procedure **B** by using (*R*)-**4b** (650 mg, 1.3 mmol), [{Ru(*p*-cymene)Cl_2}$_2$] (400 mg, 0.65 mmol) and disodium pyridine-2,6-dicarboxylate (276 mg, 1.3 mmol), a green solid of (*R*)-**2ba** (488 mg, 49%) was obtained. R_f= 0.11 (CH_2Cl_2/MeOH 100:5); ^{1}H NMR (400 MHz, $CDCl_3$): δ=1.90 (d, J= 13.7 Hz, 2H), 2.39–2.45, (m, 2H), 4.40–4.54 (m, 6H), 6.20 (t, J=7.6 Hz, 1H), 6.60–6.62 (m, 4H), 7.12–7.16 (m, 2H), 7.21–7.29 (m, 6H), 7.55 (d, J=8.3 Hz, 2H), 7.60 (d, J=8.3 Hz, 2H), 7.63 (t, J=7.9 Hz, 1H), 7.98 ppm (d, J=7.9 Hz, 2H); ^{13}C NMR (100.61 MHz, $CDCl_3$): δ=29.0, 53.2, 62.8, 121.1, 123.9, 124.7, 125.1, 125.3, 125.8, 125.9, 126.0, 127.9, 128.3, 128.7, 130.7, 133.2, 134.3, 148.1, 151.9, 161.0, 171.1 ppm; FAB-MS: *m*/*z*: 765 $[M+H]^+$; UV/Vis (CH_2Cl_2): λ_{max} ($\log\varepsilon$)=383 (3.39), 481 nm (4.25); HRMS (ESI+): *m*/*z* calcd for $C_{40}H_{30}N_4O_6{}^{102}Ru$: 764.12091; found: 764.14739.

Synthesis of {2,6-bis-[(4*S*)-4-(1-naphthyl)-5,6-dihydro-4*H*-[1,3]oxazinyl]-pyridine}(pyridine-2,6-dicarboxylate)ruthenium ((*S*)-2ba): By using (*S*)-**4b** (400 mg, 0.80 mmol), [{Ru(*p*-cymene)Cl_2}$_2$] (246 mg, 0.40 mmol) and disodium pyridine-2,6-dicarboxylate (170 mg, 0.80 mmol), a green solid of (*S*)-**2ba** (293 mg, 48%) was obtained. R_f=0.11 (CH_2Cl_2/MeOH 100:5); ^{1}H NMR (400 MHz, $CDCl_3$): δ=1.89 (d, J=13.7 Hz, 2H), 2.37–2.45, (m, 2H), 4.38–4.53 (m, 6H), 6.20 (t, J=7.7 Hz, 1H), 6.59–6.62 (m, 4H), 7.12–7.16 (m, 2H), 7.20–7.29 (m, 6H), 7.56 (d, J=8.1 Hz, 2H), 7.60 (d, J= 8.3 Hz, 2H), 7.64 (t, J=7.9 Hz, 1H), 7.99 ppm (d, J=7.9 Hz, 2H); ^{13}C NMR (100.61 MHz, $CDCl_3$): δ=29.0, 53.2, 62.8, 121.0, 123.9, 124.7, 125.1, 125.3, 125.7, 125.9, 126.0, 127.9, 128.3, 128.6, 130.6, 133.1, 134.3, 148.2, 151.9, 160.9, 171.2 ppm; FAB-MS: *m*/*z*: 765 $[M+H]^+$; UV/Vis (CH_2Cl_2): λ_{max} ($\log\varepsilon$)=383 (3.37), 482 nm (4.25); HRMS (ESI+): *m*/*z* calcd for ($C_{40}H_{30}N_4O_6{}^{102}Ru$): 764.12091; found: 764.14165.

Synthesis of {2,6-bis-[(4*S*)-4-(4-chlorophenyl)-5,6-dihydro-4*H*-[1,3]oxazinyl]pyridine}(pyridine-2,6-dicarboxylate)ruthenium ((*S*)-2da): From general procedure **B** by using (*S*)-**4d** (200 mg, 0.43 mmol), [{Ru(*p*-cymene)Cl_2}$_2$] (131 mg, 0.21 mmol) and disodium pyridine-2,6-dicarboxylate (91 mg, 0.43 mmol), a green solid of (*S*)-**2da** (171 mg, 54%) was obtained. R_f=0.25 (CH_2Cl_2/MeOH 100:5); ^{1}H NMR (400 MHz, $CDCl_3$): δ=1.80–1.85 (m, 2H), 2.22–2.30, (m, 2H), 3.70–3.73 (m, 2H), 4.28–4.34 (m, 2H), 4.43–4.48 (m, 2H), 6.36 (d, J=8.4 Hz, 4H), 6.96 (d, J=8.4 Hz, 4H), 7.62 (t, J=7.9 Hz, 1H), 7.97 ppm (d, J=7.9 Hz, 2H); ^{13}C NMR (100.61 MHz, $CDCl_3$): δ=30.4, 57.0, 63.0, 124.3, 125.6, 125.7, 127.3, 128.8, 132.7, 133.3, 137.7, 149.4, 151.8, 160.6, 171.3 ppm; FAB-MS: *m*/*z*: 732 $[M]^+$, 734 $[M+2]^+$; UV/Vis (CH_2Cl_2): λ_{max} ($\log\varepsilon$)=386 (3.46), 483 nm (4.27); HRMS (ESI+): *m*/*z* calcd for $C_{32}H_{25}{}^{35}Cl_2N_4O_6{}^{102}Ru$: 733.01947; found: 733.01749.

Synthesis of {2,6-bis-[(4*S*)-4-(4-methoxyphenyl)-5,6-dihydro-4*H*-[1,3]oxazinyl]pyridine}(pyridine-2,6-dicarboxylate)ruthenium ((*S*)-2ea): From general procedure **B** by using (*S*)-**4e** (97 mg, 0.21 mmol), [{Ru(*p*-cymene)Cl_2}$_2$] (65 mg, 0.11 mmol) and disodium pyridine-2,6-dicarboxylate (45 mg, 0.21 mmol), a green solid of (*S*)-**2ea** (80 mg, 53%) was obtained. R_f=0.19 (CH_2Cl_2/MeOH 100:5); ^{1}H NMR (400 MHz, $CDCl_3$): δ=1.81–1.84 (m, 2H), 2.22–2.28, (m, 2H), 3.67–3.69 (m, 2H), 3.75 (s, 6H), 4.33–4.37 (m, 2H), 4.43–4.46 (m, 2H), 6.32 (d, J=8.5 Hz, 4H), 6.51 (d, J= 8.5 Hz, 4H), 7.45–7.53 (m, 3H), 7.60 (t, J=7.8 Hz, 1H), 7.95 ppm (d, J= 7.8 Hz, 2H); ^{13}C NMR (100.61 MHz, $CDCl_3$): δ=30.7, 55.5, 57.0, 63.0, 114.2, 123.9, 125.3, 125.6, 127.2, 131.5, 132.5, 149.4, 152.0, 158.6, 160.1, 171.5 ppm; FAB-MS: *m*/*z*: 724 $[M]^+$; UV/Vis (CH_2Cl_2): λ_{max} ($\log\varepsilon$)=387 (3.45), 482 nm (4.28); HRMS (ESI+): *m*/*z* calcd for $C_{34}H_{31}N_4O_8{}^{102}Ru$: 725.11853; found: 725.11740.

Synthesis of {2,6-bis-[(4*R*)-4-isopropyl-5,6-dihydro-4*H*-[1,3]oxazinyl]pyridine}(pyridine-2,6-dicarboxylate)ruthenium ((*R*)-2fa): From general procedure **B** by using (*R*)-**4f** (329 mg, 1.0 mmol), [{Ru(*p*-cymene)Cl_2}$_2$] (306 mg, 0.50 mmol) and disodium pyridine-2,6-dicarboxylate (211 mg, 1.0 mmol), a deep green crystalline solid of (*R*)-**2fa** (166 mg, 28%) was obtained. R_f=0.05 (CH_2Cl_2/MeOH 100:5); ^{1}H NMR (400 MHz, CD_2Cl_2): δ=0.46 (d, J=7.1 Hz, 6H), 0.49 (d, J=6.9 Hz, 6H), 1.17–1.25 (m, 2H), 1.85–1.98 (m, 4H), 2.51 (dd, J=4.3, 6.8 Hz, 2H), 4.46 (m, 4H), 7.65 (t, J=7.7 Hz, 1H), 7.97 (d, J=7.7 Hz, 2H), 8.04 (t, J=7.7 Hz, 1H), 8.26 ppm (d, J=7.7 Hz, 2H); ^{13}C NMR (100.61 MHz, CD_2Cl_2): δ=16.4, 19.0, 21.8, 30.8, 58.3, 64.9, 124.0, 126.4, 126.8, 133.4, 151.8, 152.5, 159.5, 171.6 ppm; FAB-MS: *m*/*z*: 597 $[M+H]^+$; UV/Vis (CH_2Cl_2): λ_{max} ($\log\varepsilon$)= 395 (3.59), 481 nm (4.38); elemental analysis calcd (%) for $C_{26}H_{30}N_4O_6Ru{\cdot}H_2O$: C 50.89, H 5.26, N 9.13; found: C 50.90, H 5.00, N 9.08.

X-ray crystallographic studies of the complexes: Data were collected with a STOE-IPDS diffractometer using graphite-monochromated $Mo_{K\alpha}$ radiation. The structures were solved by direct methods (SHELXS-97: G. M. Sheldrick, University of Göttingen, Germany, **1997**) and refined by full-matrix least-squares techniques against F^2 (SHELXL-97: G. M. Sheldrick, University of Göttingen, Germany, **1997**). XP (BRUKER AXS) was used for structure representations. CCDC-279900–279903 (**1ia**, **1ja**, **1na**, and **(*S*)-2aa**, respectively) contain the supplementary crystallographic data for this paper. These data can be obtained free of charge from The Cambridge Crystallographic Data Centre via www.ccdc.cam.ac.uk/data_request/cif.

Computational methods: All calculations were carried out by using the Gaussian 98 program.[54] All structures were optimized at B3LYP density functional level of theory with the LANL2DZ[55] basis set, and characterized as energy minimum structures without imaginary number of frequencies at the same level of theory (B3LYP/LANL2DZ).[56] The B3LYP/LANL2DZ structures were further refined at the B3LYP DFT level of theory with the LANL2DZ basis set by adding a set of polarization function (LANL2DZ(d)). The B3LYP/LANLDZ(d) optimized structures are used for comparison with the available X-ray data. To assign the observed UV-visible adsorption spectra, we carried out time-dependent DFT calculations at the B3P86/LANL2DZ(d) DFT level with the B3LYP/LANL2DZ(d) optimized structures.

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