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PAPER

A one pot three-step process for the synthesis of an array of arylated benzimidazoribosyl nucleosides†

Jolanta Hałuszczak,[a] Simon J. F. Macdonald[b] and Marie E. Migaud*[a]

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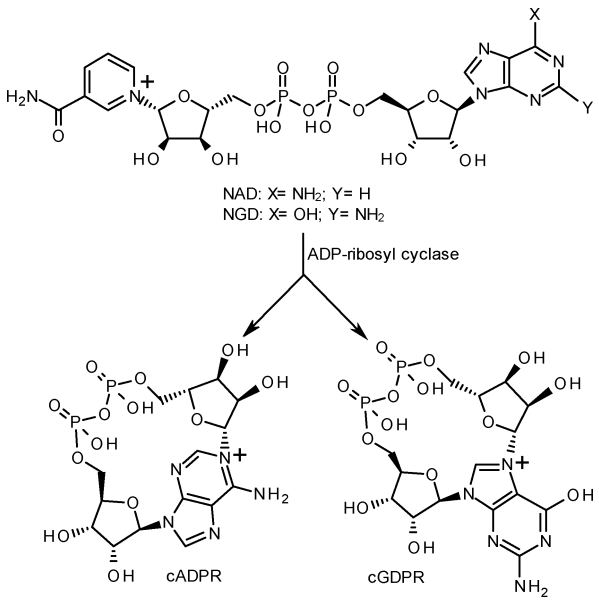
A three-step one pot reaction/purification protocol was developed to facilitate rapid access to benzimidazole-based nucleosides, for which benzoylated benzimidazoribosyl nucleosides incorporating boronic esters were key reaction intermediates.

Introduction

Since the discovery of nucleic acids, efforts in accessing natural and synthetic nucleosides have been continuous in order to supply biologists and biochemists with useful synthetic materials.[1] Much of the recent work has focused on expanding the pool of nucleoside-based antivirals[2] and on accessing nucleoside analogues with novel carbohydrate frameworks, such as locked nucleic acids (LNA) and bicyclic nucleic acids (BNA)[3] or nucleoside analogues with fluorescent properties. The latter analogues[4] have been employed to label genes[5] and to analyse DNA sequences,[6,7] and have also been used as building blocks in unnatural cofactors to explore enzyme activities.[8,9] Such activities include that of adenosine diphosphate ribosylcyclase which converts nicotinamide adenine dinucleotide (NAD) into the second messenger cyclic adenosine diphosphate ribose (cADPR) (Scheme 1). This cyclase is able to convert a wide range of substrates (*e.g.* nicotinamide guanine dinucleotide, NGD) (Scheme 1) into cyclic analogues (*e.g.* cyclic guanosine diphosphate ribose; cGDPR), which have been used to probe the physiological properties of cADPR and the catalytic properties of this enzyme.[10,11] We are particularly interested in nucleosides which, once converted to their dinucleotide parents, can be alkylated through cyclisation by this enzyme, to become fluorescent cyclised compounds. We postulated that benzimidazole-based nucleosides would provide such opportunity.[12–14] Surprisingly, this class of modified nucleosides is under-represented in the literature. Several methods have been developed over the last 90 years for the synthesis of nucleosides.[15] Amongst the most popular methods, glycosylations employing silver salts,[16] chloromercury salts[17] and fusion[18] sodium salts[19] or phase transfer reaction conditions[20] have been extensively used. However, the most versatile method remains the Lewis acid promoted approach developed by Vorbrüggen.[21] This method can be particularly effective in accessing a wide range of nucleoside analogues if the newly introduced nucleic base-mimic can be subsequently functionalised. Therefore, this work reports on the strategies adopted in the simple preparation of twenty three novel benzimidazole and azabenzimidazole nucleoside analogues.



Scheme 1 Cyclisation of dinucleotides by ADP-ribosylcyclase.

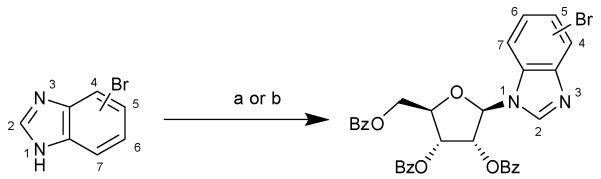
Results and discussion

As mentioned above, Vorbrüggen's glycosylation is known to be extremely versatile and usually proceeds in high yields.[22,23] Yet, for the simple introduction of the bromo-substituted benzimidazoles **1** and **2** on the 1-*O*-acetyl-2,3,5-tri-*O*-benzoyl-β-D-ribofuranoside **3**, the standard reaction conditions only gave poor to moderate yields. This limitation had to be overcome if a parallel synthetic program was to be developed from benzimidazole nucleoside

[a]*Queen's University Belfast, School of Pharmacy, Medical Biology Centre, 97 Lisburn Road, Belfast, U.K. BT9 7BL. E-mail: m.migaud@qub.ac.uk; Tel: +44 289097 2689*
[b]*GlaxoSmithKline, Stevenage Pharmaceuticals R&D facility, Gunnels Wood Road, Stevenage, Herts, U.K. SG1 2NY*

† Electronic supplementary information (ESI) available: Additional information on experimental details, more detailed tables and spectroscopic data for all new compounds. See DOI: 10.1039/c0ob00866d

Table 1 Comparison of reaction conditions for Vorbrüggen coupling



1 or **2** — **4-7**

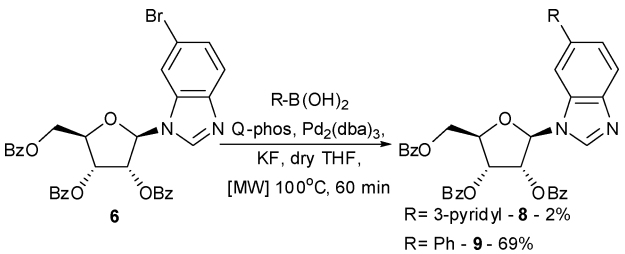
Substrates				Products		
Number	Br position n =	Conditions[a]	% yield	Compound number	Br position n =	Ratio[b]
1	5	a	53	**5/6**	5/6	45 : 55
1	5	b	97	**5/5**	5/6	63 : 37
2	4	b	80	**4/7**	4/7	79 : 21

[a] *Reaction conditions* a: i) HMDS; TMS-Cl, reflux, 24 h; ii) 1-*O*-acetyl-2,3,5-tri-*O*-benzoyl-β-D-ribofuranoside-**3**, TMSOTf, DCE, reflux, 2 h; b: 1-*O*-acetyl-2,3,5-tri-*O*-benzoyl-β-D-ribofuranoside-**3**, BSA, TMSOTf, DCE, reflux, 2 h. [b] Yields ratio of isolated regioisomers.

precursors such as **4**, **5**, **6** and **7** (Table 1). Screening of several reaction conditions ranging from solvent choice (*e.g.* MeCN, 1,2-dichloroethane (DCE)) to silylation methods (*e.g.* hexamethyldisilazane (HMDS) *vs. N*,*O*-bis (trimethylsilyl)acetamide (BSA)) allowed the identification of improved reaction conditions.[24,25] At first, 5-bromobenzimidazole **1**, which had been dried by co-evaporation with toluene, was silylated using HMDS as solvent and TMSCl as catalyst. After 24 h at reflux and removal of volatile materials, the silylated bromobenzimidazole was used in the TMSOTf-catalysed ribosylation of **3**. Extensive purification of the crude mixture led to the isolation of **5** and **6** in 53% overall yield (Table 1). When HMDS was replaced with BSA, the overall yields increased to 97% under similar glycosylation conditions, with regioisomer **5** obtained in 61% isolated yield and its regioisomer **6** obtained in 36%. Coupling of riboside **3** with 4-bromobenzimidazole **2** using the optimized conditions supplied benzimidazolide-ribosides **4** and **7** in 80% overall yields in a 4 : 1 ratio, respectively (Table 1). Moreover, no α bromobenzimidazoleribosides were isolated in any of the reactions. The four synthesised bromobenzimidazole nucleosides provided the framework to develop a library of modified nucleosides using the C–Br bond for further functionalisation.

Of the many methods available for C–C bond formation on aryl species, a Suzuki coupling was initially investigated.[26,27] The reaction between starting compound **6** and 3-pyridinylboronic acid was carried out in the presence of 1,2,3,4,5-pentaphenyl-1′-(di-*tert*-butylphosphino)ferrocene (Q-Phos), tris[dibenzylideneacetone]dipalladium(0) ($Pd_2(dba)_3$) and potassium fluoride under microwave reaction conditions (Scheme 2). These slightly basic conditions are known to allow for the use of less reactive aromatic halides and alkyl boronic acids in Suzuki cross-coupling reactions.[28,29]

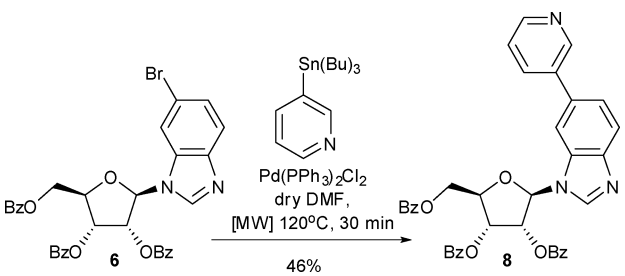
As our initial intentions were to perform the coupling while minimising sugar deprotection reaction, it was hoped that the potassium fluoride was sufficiently reactive to contribute to the coupling reaction and non-nucleophilic towards benzoates. Crude materials were then purified by reversed phase HPLC. Under these conditions, compound **8** could only be isolated in 2% yield from **6** and pyridylboronic acid, while compound **9** could be obtained in 69% yield from **6** and phenylboronic acid (Scheme 2). It must



Scheme 2 Cross-coupling of bromobenzimidazole nucleoside **6** with aryl and heteroarylboronic acids.

be noted that the stability of each boronic acid was found to be similar.

To broaden the scope of suitable reagents, the Stille-coupling methodology was therefore considered, as this strategy is known to work well under mild conditions and can be applied to various types of substrate.[30–32] The coupling of the bromobenzimidazolide **6** with 2-pyridyl tributylstannane in the presence of bis(triphenylphosphine)palladium(II) dichloride in dry DMF yielded product **8** in 46% yield (Scheme 3). While more successful than the previous method, this methodology was deemed unsuitable due to the limited commercial availability of reagents.



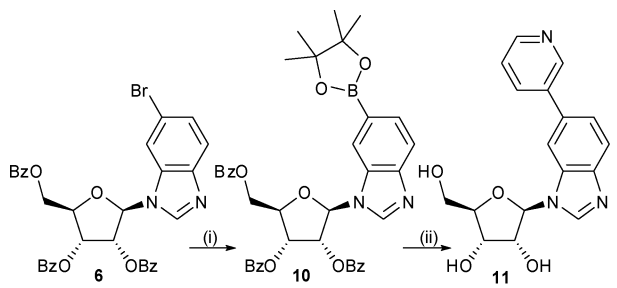
Scheme 3 Stille coupling between bromobenzimidazole nucleoside **6** and aryl stannane.

Given our desire to develop a versatile methodology which included the coupling of heteroaromatics to the benzimidazolide, we then considered inverting the bromo/boronate functionalities between the substrate and the reagent to facilitate the C–C bond formation and gain access to a greater range of commercial

reagents. It was anticipated that, stable boronate esters of protected benzimidazolides would undergo Pd(0)-catalysed Suzuki coupling reactions with a broad range of aryl halides. As such we developed a three-step one pot strategy for which the bromide on benzimidazolide **6** was exchanged for a boronic ester to form **10** which subsequently reacted with a range of aromatic and heteroaromatic bromides with the concomitant removal of the benzoyl protecting groups to yield a library of nucleoside analogues.

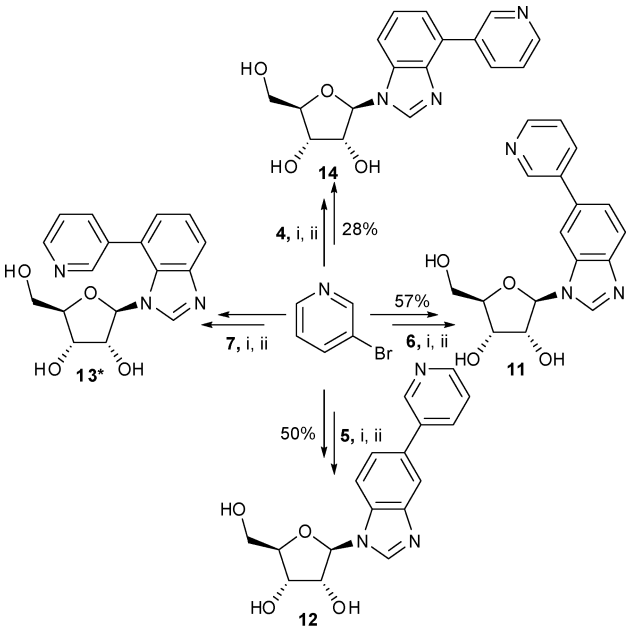
As proof of principle, 6-bromobenzimidazolide riboside **6** (Scheme 4) was coupled with bis(pinacolato)diboron in the presence of 2-(dicyclohexylphosphino)-2′,4′,6′-triisopropyl-1,1′-biphenyl (X-Phos), $Pd_2(dba)_3$ and potassium acetate in anhydrous dioxane.[33,34] Anhydrous conditions and a change of ligands were important for the formation of the boronic ester **10** and minimisation of side reactions, *e.g.* protodeboronation.[35] After heating, the aryl halide, potassium phosphate, ligand and palladium were added to the reaction mixture and heated at 140 °C for three hours. Conditions required for the activation of the boronic ester in the presence of aqueous base also cause the removal of the benzoyl protective groups, yielding the deprotected arylated benzimidazolide nucleoside analogue **11** (Scheme 4, 5). This one-pot procedure effectively eliminates the need for purification of the boronic ester **10** and that of the coupled protected product, thus leading directly to the new nucleoside derivative.

To show that this simple strategy could be applied to other benzimidazole-based bromides than **6**, 3-bromopyridine was reacted with the four different benzimidazolide derivatives **4**–**7** (Scheme 5). Coupling of the four different bromobenzimidazolides yielded compounds **11**, **12** and **14** in moderate to



(i) bis(pinacolato)diboron, X-phos, $Pd_2(dba)_3$, KOAc, dry dioxane, [MW] 110 °C, 15, 30, 60 min; (ii) 3-bromopyridine, K_3PO_4, X-Phos, $Pd_2(dba)_3$, H_2O, [MW] 140 °C, 3 h; 57% over 3 steps in one pot

Scheme 4 Three-step one pot synthetic strategy *via in situ* generation of the benzimidazoloborono ester nucleoside **10** and synthesis of **11**.



*mixture of products; (i) bis(pinacolato)diboron, X-phos, $Pd_2(dba)_3$, KOAc, dry dioxane, [MW] 110°C, 15, 30, 60 min; (ii) 3-bromopyridine, K_3PO_4, X-Phos, $Pd_2(dba)_3$, H_2O, [MW] 140°C, 3 h.

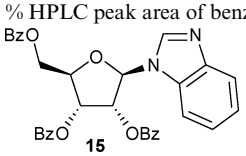
Scheme 5 Accessing different substitution patterns on the benzimidazole ring.

reasonable yields while 7-bromobenzimidazolide **7** gave a mixture of products which included regioisomers **13** and **14**. To investigate the boronylation yields, progress of the reaction was monitored by LCMS. The collected data suggested that all the substrates (**4**–**7**) were fully consumed with the yields of the boronylations summarised in Table 2.

The results indicated that boronylation of sterically hindered bromobenzimidazoleribosides **4** and **7** occurred with lower yields. Steric effects have previously been reported to influence boronic esters' syntheses and coupling of sterically hindered boronates.[36,37] This could explain low yields obtained for compound **14** and the mixture of products observed for **13**.

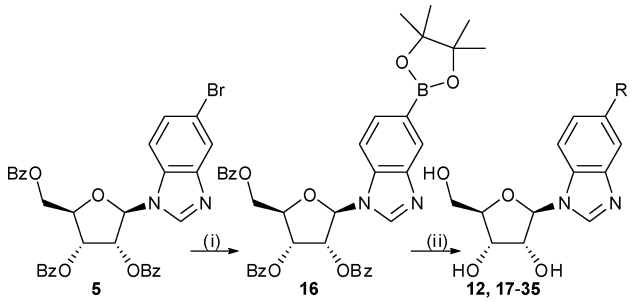
To expand efficiently on the range of modified benzimidazole nucleosides and establish the robustness of the strategy, boronic ester derivative **16** was reacted with a range of aromatic and heteroaromatic bromides, using a split-vial approach for which solutions of base (K_3PO_4) and catalysts (X-phos, Pd_2dba_3) were prepared and split equally between the vials containing **16** and

Table 2 Comparison of boronylation yields for the first step (i) in Scheme 5[a]

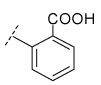
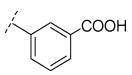
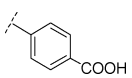
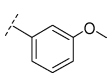
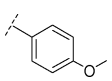
Reagent	Br position n =	% HPLC peak area of boronylation	% HPLC peak area of benzimidazolideriboside by-product[b] 
4	4	35	18
5	5	76	20
6	6	88	10
7	7	6	82

[a] Other products remained unidentified. [b] Protodeboronation product.

Table 3 Nucleosides from aryl bromides



(i) bis(pinacolato)diboron, X-phos, $Pd_2(dba)_3$, KOAc, dry dioxane, [MW] 110°C, 15, 30, 60 min; (ii) 3-bromopyridine, K_3PO_4, X-Phos, $Pd_2(dba)_3$, H_2O, [MW] 140°C,

Entry	Compound number	R	% isolated yield over 3 steps
1	**17**		45
2	**18**		18
3	**19**		15
4	**20**		23
5	**21**		22
6	**22**		20
7	**23**		19
8	**24**		48
9	**25**		17
10	**26**		31

its coupling partner. To ease product isolation and following a one-fit all reaction protocol, a simple operative procedure was developed where by the solvents were evaporated and the residue re-dissolved in a 1 : 1 H_2O/MeOH mixture. This mixture was filtered once through an SPE filter and purified by mass-directed reverse phase HPLC. While the yields of reactions (Table 3 and 4) with the aromatic and heteroaromatic bromides range from poor to average, the variability can be accounted for by a combination of different reaction rates according to the coupling partner and the one-fit-all purification protocol. However, good yields were

Table 4 Nucleosides from heteroaromatic bromides

Entry	Compound number	R	% isolated yield over 3 steps
1	**27**		31
2	**12**		40
3	**28**		61
4	**29**[a]		11
5	**30**[a]		12
5	**31**		12
6	**32**		23
7	**33**		32
8	**34**		16
9	**35**		20
10	**36**		No reaction

[a] 3-bromopyrazole was used in these syntheses (two separate runs).

achieved when partially optimised conditions were applied (*e.g.* **11**, **12**). Using this divergent strategy, nineteen novel benzimidazole nucleosides could be prepared and purified in a timely fashion. Even the pyridinyl and carboxylic acid derivatives (**12**, **27** and **28**) and (**21**–**23**), respectively, could be accessed under these automated conditions.

Preliminary investigation of the fluorogenicity of the novel compounds was examined to establish whether the fluorescence emission spectra of the synthesised nucleosides would red shift upon alkylation. As such compound **33** was reacted with methyl iodide in methanol and excitation-emission spectra of the crude mixture were collected. The alkylation mixture consisted mainly of compounds **33** and the methylated parent (**37**) as measured by mass spectroscopy and ^{1}H NMR. For compound **33** excitation maximum was observed at 290 nm while the emission maximum was found at 350 nm. As for the mixture of compounds **33** and the methylated parent (**37**), a second excitation maximum was detected at 300 nm and when the solution was excited at 300 nm a red shift to approximately 420 nm was observed (graph in supplementary material). These preliminary data suggest our

choice of benzimidazole derivatives could lead to fluorogenic dinucleotides, suitable substrates for the ADP-ribosylcyclase.

Conclusions

Herein, we have described a methodology which offers far-ranging opportunities for the synthesis and purification of benzimidazole-based nucleosides using boronate nucleosides as synthetic intermediates. Although some of the yields are low, the range of derivatives thus prepared demonstrates the breadth of this methodology, especially considering how under-represented in the literature this class of nucleoside analogues is. As such, it offers access to benzimidazole based nucleosides, which is time and cost effective.

Experimental Section

General

Chemicals and solvents were obtained from Aldrich, ALLICHEM LLC, Chemical block Ltd., ABCR Gelest Ltd. (UK), Priceton Bio, KairoKem and used without further purification.

A range of LC/MS purification protocols have been developed for this work:

System I consisted of a Waters ZQ platform with an Agilent/HP 1100 auto sampler. The HPLC analysis was conducted on a Sunfire C18 column (30 mm × 4.6 mm i.d. 3.5 μm packing diameter) at 30 °C with a flow rate of 3 ml min^{-1} and an injection volume of 5 μL. UV detection was in the range 210–350 nm. The mobile phase consisted of 0.1% formic acid in water (solvent A) against 0.1% formic acid in acetonitrile (solvent B) with a gradient of 97% A for 0.1 min changing to 100% B over 4.2 min, maintained for 0.6 min and then reverting to 97% A over 0.1 min.

System II consisted of a Waters ZQ platform with an Agilent/HP 1100 auto sampler. The HPLC analysis was conducted on a Sunfire C18 column (30 mm × 4.6 mm i.d. 3.5 μmpacking diameter) at 30 °C with a flow rate of 3 ml min^{-1} and an injection volume of 5 μL. UV detection was in the range 210–350 nm. The mobile phase consisted of 0.1% trifluoroacetic acid in water (solvent A) against 0.1% trifluoroacetic acid in acetonitrile (solvent B) with a gradient of 97% solvent 1 for 0.1 min changing to 100% B over 4.2 min, maintained for 0.6 min and then reverting to 97% A over 0.1 min. (TFA)

System III consisted of a Waters ZQ platform with an Agilent/HP 1100 auto sampler. The HPLC analysis was conducted on an XBridge C18 column (50 mm × 4.6 mm i.d. 3.5 μm packing diameter) at 30 °C with a flow rate of 3 ml min^{-1} and an injection volume of 5 μL. UV detection was in the range 210–350 nm. The mobile phase consisted of 10mM ammonium bicarbonate in water adjusted to pH 10 with ammonia solution (solvent A) against acetonitrile (solvent B) with a gradient of 99% A for 0.1 min changing to 97% B over 3.9 min, maintained for 1 min.

For system IV, the UPLC analysis was conducted on an UPLC BEH C18 column (50 mm × 2.1 mm i.d. 1.7 μmpacking diameter) at 40 °C with a flow rate of 1 ml min^{-1} and an injection volume of 5 μL. UV detection was in the range 210–350 nm. The mobile phase consisted of 0.1% formic acid in water (solvent A) against 0.1% formic acid in acetonitrile (solvent B) with a gradient of 97% A changing to 100% B over 1.5 min, maintained for 0.4 min and then reverting to 97% A over 0.1 min.

Mass-directed autopreparation was carried out using a Waters Micromass ZQ platform in one of the following conditions:

Method A: Sunfire C18 column (150 mm × 30 mm i.d. 5 μm packing diameter) at ambient temperature with a flow rate of 40 ml min^{-1} and an injection volume of 1 ml. UV detection was in the range 210–350 nm. The mobile phase consisted of 0.1% formic acid in water (solvent 1) against 0.1% formic acid in acetonitrile (solvent 2) with a gradient of 95% solvent 1 for 1 min changing to 70% solvent 1 over 9 min, changing to 99% solvent 2 over 0.5 min and maintained for 4.5 min.

Method B: Sunfire C18 column (150 mm × 30 mm i.d. 5 μm packing diameter) at ambient temperature with a flow rate of 40 ml min^{-1} and an injection volume of 1 ml. UV detection was in the range 210–350 nm. The mobile phase consisted of 0.1% formic acid in water (solvent 1) against 0.1% formic acid in acetonitrile (solvent 2) with a gradient of 95% solvent 1 for 1 min changing to 70% solvent 1 over 19 min, changing to 99% solvent 2 over 0.5 min and maintained for 4.5 min.

Method C: XBridge C18 column (100 mm × 30 mm i.d. 5 μm packing diameter) at ambient temperature with a flow rate of 40 ml min^{-1} and an injection volume of 1 ml. UV detection was in the range 210–350 nm. The mobile phase consisted of 10 mm ammonium bicarbonate in water against acetonitrile (solvent 2) with a gradient of 95% solvent 1 for 1 min changing to 70% solvent 1 over 9 min, changing to 99% solvent 2 over 0.5 min and maintained for 4.5 min.

Method D: XBridge C18 column (100 mm × 30 mm i.d. 5 μm packing diameter) at ambient temperature with a flow rate of 40 ml min^{-1} and an injection volume of 1 ml. UV detection was in the range 210–350 nm. The mobile phase consisted of 10 mm ammonium bicarbonate in water (solvent 1) against acetonitrile (solvent 2) with a gradient of 70% solvent 1 for 1 min changing to 15% solvent 1 over 19 min, changing to 99% solvent 2 over 0.5 min and maintained for 4.5 min.

Experimental procedures

5-Bromo-1-(2′,3′,5′-tri-*O*-benzoyl-β-D-ribofuranosyl)benzimidazole (5) and 6-bromo-1-(2′,3′,5′-tri-*O*-benzoyl-β-D-ribofuranosyl)-benzimidazole (6). HMDS method. A solution of 5-bromobenzimidazole (2 g, 10.1 mmol, 1.15 equiv.) in HMDS (20 ml) with a catalytic amount of TMS-Cl (100 μl) was refluxed for 24 h. The excess of solvent was then removed by co-evaporation with toluene *in vacuo*. The residue was redissolved in DCE (20 ml) and combined with a previously prepared solution of 1-*O*-acetyl-2,3,5-tri-*O*-benzoyl-β-D-ribofuranose (4.45 g, 8.82 mmol, 1 equiv.) with TMSOTf (4.3 g, 19 mmol, 2.2 mmol) in DCE (20 ml). The reaction mixture was heated to reflux for 2 h and quenched by pouring onto a saturated potassium carbonate solution (30 ml). The organic layer was then diluted with DCM and washed with a saturated potassium carbonate solution (30 ml) and water (3x 30 ml) before it was dried over $MgSO_4$, filtered and concentrated *in vacuo*. The crude mixture was purified by silica column chromatography with a solvent gradient (5% AcOEt, 30% c-hex, 65% DCM to 10% AcOEt, 30% c-hex, 60% DCM) to yield 1.38 g (24%) of the 5-substituted product **5** and 1.63 g (29%) of the 6-substituted product **6**.

5-Bromo-1-(2′,3′,5′-tri-*O*-benzoyl-β-D-ribofuranosyl)benzimidazole (5) and 6-bromo-1-(2′,3′,5′-tri-*O*-benzoyl-β-D-ribofura-

nosyl)benzimidazole (6). BSA method. A solution of 5-bromobenzimidazole (3 g, 15.2 mmol, 1.5 equiv.), 1-*O*-acetyl-2,3,5-tri-*O*-benzoyl-β-D-ribofuranose (**3**; 5.12 g, 10.1 mmol, 1 equiv.) and TMSOTf (6.77 g, 30.5 mmol, 3 equiv.) in DCE (100 ml) including BSA (9.29 g, 45.1 mmol, 4.5 equiv.) was refluxed for 3 h and quenched by pouring onto a saturated potassium carbonate solution (50 ml). The organic layer was then diluted with DCM and washed again with a saturated potassium carbonate solution and then three times with water. The organic phase was then dried over $MgSO_4$ and concentrated. The crude was purified by silica column chromatography with a solvent gradient (5% AcOEt, 30% c-hex, 65% DCM to 10% AcOEt, 30% c-hex, 60% DCM) to yield 3.98 g (61%) of the 5-substituted product **5** and 2.33 g (36%) of the 6-substituted product **6**.

4-bromo-1-(2′,3′,5′-tri-*O*-benzoyl-β-D-ribofuranosyl)benzimidazole (4) and 7-bromo-1-(2′,3′,5′-tri-*O*-benzoyl-β-D-ribofuranosyl)-benzimidazole (7). BSA method. A solution of 4-bromobenzimidazole (0.5 g, 2.54 mmol, 1.5 equiv.), 1-*O*-acetyl-2,3,5-tri-*O*-benzoyl-β-D-ribofuranose (**3**; 0.854 g, 1.69 mmol, 1 equiv.) and TMSOTf (0.83 g, 5.08 mmol, 3 equiv.) in DCE (100 ml) including BSA (1.57 g, 7.62 mmol, 4.5 equiv.) was refluxed for 3 h and quenched by pouring onto a saturated potassium carbonate solution (50 ml). The organic layer was then diluted with DCM and washed again with the a saturated potassium carbonate solution and then three times with water. The organic phase was then dried over $MgSO_4$ and concentrated. The crude was purified by column chromatography with a solvent gradient (5% AcOEt, 30% c-hex, 65% DCM to 10% AcOEt, 30% c-hex, 60% DCM) to yield 0.689 g (63%) of the 4-substituted product **4** and 185 mg (17%) of the 7-substituted product **7**.

General procedure for cross - coupling with aryl boronic acids. A mixture of 6-bromo-1-(2′,3′,5′-tri-*O*-benzoyl-β-D-ribofuranosyl)benzimidazole (**6**; 108 mg, 0.17 mmol, 1 equiv.), boronic acid (0.202 mmol, 1.2 equiv), KF (0.336 mmol, 2 equiv.), Q-phos (4.8 mg, 6.7 μmol) and Pd_2dba_3 (1.54 mg, 1.68 μmol) in dry THF (200 μl) was prepared. The reaction mixture was then heated in 100 °C for one hour (Biotage Initiator 2.5) and purifiedby mass-directed autopreparation (*Method C*). The reaction yielded 2 mg (2%) for 6-(3′-pyridyl)-1-(2″,3″,5″-tri-*O*-benzoyl-β-D-ribofuranosyl)benzimidazole (**8**) and 74 mg (69%) 6-phenyl-1-(2″,3″,5″-tri-*O*-benzoyl-β-D-ribofuranosyl)benzimidazole (**9**).

Procedure for stannane coupling. 6-(3′-pyridyl)-1-(2″,3″,5″-tri-*O*-benzoyl-β-D-ribofuranosyl)benzimidazole (8). To a mixture of 6-bromo-1-(2′,3′,5′-tri-*O*-benzoyl-β-D-ribofuranosyl)benzimidazole (**6**) (50 mg, 0.078 mmol, 1 equiv.), 4-pyridyltributanestannane (43 mg, 0.117 mmol, 1.5 equiv) and bis(triphenylphosphine)palladium(II) dichloride (8.8 mg, 12.6 μmol, 0.16 equiv.) DMF (200 μl) was added. Then the reaction was performed at 120 °C for half an hour (Biotage Initiator 2.5) and purified by mass-directed autopreparation (*method D*). The reaction yielded 23 mg (46%) of purified nucleoside (**8**).

General procedure for one pot three-step synthesis. Starting materials (**4**, **5**, **6** or **7**, 192 mg, 0.3 mmol), bis(pinacolato)diboron (83.8 mg, 0.33 mmol), potassium acetate (71 mg, 0.75 mmol), Pd_2dba_3 (2.75 mg, 0.003 mmol) and X-phos (5.72 mg, 0.012 mmol) were dissolved in dry 1,4-dioxane (1.5 ml). The reaction mixture was placed in a microwave (Biotage Initiator 2.5) in a cycle consisting of five steps: (1) heating to 110 °C, hold time: 15 min, (2) cooling: 5 min, (3) heating to 110 °C, hold time: 30 min, (4) cooling: 5 min, (5) heating to 110 °C, hold time: 60 min. The reaction progress was checked by LCMS and when the peak for starting material had disappeared (MW = 639/641), and new peaks appeared (MW = 606 or 688) additional Pd_2dba_3 (2.75 mg, 0.003 mmol) and ligand – X-phos (5.72 mg, 0.012 mmol) were added. Then appropriate aromatic bromide (0.39 mmol, 1.3 equiv.) was dissolved in the suspension and finally K_3PO_4 (478 mg, 22.5 mmol) dissolved in 0.5 ml of water was added. Another microwave reaction was carried out 140 °C for 3 h (Biotage Initiator 2.5). After the reaction, solvents were removed, residues redissolved in 2 ml of MeOH and filtered through SPE filter. Purification of the final compound was done through mass-directed autopreparation, splitting the crude mixture into 3 samples of 1 ml each. Solvents were removed through freeze drying. Compounds were characterised.

In the case of the synthesis of compounds **12** and **17–36** the reaction of the first step of the coupling was carried out in one reaction vial containing the material for all 20 reactions (140 °C for 3 h Biotage Initiator 2.5). The reaction mixture was split into 20 vials and appropriate bromides were added. Palladium and ligand (for all 20 reactions) were mixed in 1 ml of dioxane and split equally into reactions, the same procedure was used in case of potassium phosphate. The resulting mixture was reacted at 126 °C for 3 h (Antonpaarsynthos 3000). After the reaction, solvents were removed, residues redissolved in 3 ml of MeOH/water (50 : 50) and filtered through SPE filter. Purification of the final compound was performed through mass-directed autopreparation, splitting the crude mixture into 3 samples of 1 ml each. Only 1 ml was purified[37] and the yield was calculated by multiplying the mass by three. Solvents were removed through freeze drying.

4-Bromo-1-(2′,3′,5′-tri-*O*-benzoyl-β-D-ribofuranosyl)benzimidazole (4). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 8.23 (s, 1H, H2), 8.13-8.11 (m, 2H, H-Ph), 8.00–7.93 (m, 4H, H-Ph), 7.65–7.38 (m, 11H, H-Ph, H5, H7), 6.97 (t, J = 8.0, 8.0 Hz, 1H, H6), 6.37 (d, J = 6.1 Hz, 1H, H1′), 6.05 (t, J = 5.9, 5.9 Hz, 1H, H2′), 5.98 (dd, J = 4.1, 5.8 Hz, 1H, H3′), 4.92 (dd, J = 2.6, 12.3 Hz, 1H, H5′), 4.88–4.83 (m, 1H, H4′), 4.77 (dd, J = 3.3, 12.3 Hz, 1H, H5′); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 166.1 (C═O), 165.3 (C═O), 164.9 (C═O), 143.0 (C9), 141.2 (C2), 133.9 (C8), 133.9 (C-Ph), 133.7 (C-Ph), 132.9 (C-Ph), 129.9(C-Ph), 129.8 (C-Ph), 129.7 (C-Ph), 129.1 (C-Ph), 128.8 (C-Ph), 128.6 (C-Ph), 128.6 (C-Ph), 128.2 (C-Ph), 126.2 (C5), 124.6 (C6), 114.2 (C7), 110.2 (C4), 87.7 (C1′), 80.9 (C4′), 73.5 (C2′), 71.0 (C3′), 63.5 (C5′); LC/MS (system II): retention time: 3.60 min; UV_{max} = 280 nm; M.S. (ES) m s^{-1}: $C_{33}H_{25}BrN_2O_7$: calculated $[M+H]^+$- 641.0923, actual $[M+H]^+$- 641.0944.

5-Bromo-1-(2′,3′,5′-tri-*O*-benzoyl-β-D-ribofuranosyl)benzimidazole (5). ^{1}H NMR (600 MHz, $CDCl_3$): 8.16 (s, 1H, H2), 8.12-8.11 (m, 2H, H-Ph), 7.99–7.94 (m, 5H, H-Ph, H4), 7.65–7.39 (m, 10H, H-Ph, H7), 7.22 (dd, J = 1.7, 8.6 Hz, 1H, H6), 6.35 (d, J = 5.8 Hz, 1H, H1′), 6.02 (t, J = 5.8, 5.8 Hz, 1H, H2′), 5.96 (dd, J = 5.7, 4.6 Hz, 1H, H3′), 4.92 (dd, J = 2.7, 12.4 Hz, 1H, H5′), 4.86–4.85 (m, 1H, H4′), 4.76 (dd, J = 3.4, 12.4 Hz, 1H, H5′); ^{13}C NMR (125 MHz, $CDCl_3$) δ (ppm): 166.1 (C═O), 165.3 (C═O), 165.0 (C═O), 141.7 (C9), 141.7 (C2), 134.0 (C-Ph), 133.9 (C-Ph), 133.7 (C-Ph), 129.8 (C-Ph), 129.7 (C-Ph), 129.1 (C8), 128.8

(C-Ph), 128.6 (C-Ph), 128.6 (C-Ph), 128.6 (C-Ph), 128.2 (C-Ph), 126.8 (C-Ph), 123.7 (C-Ph), 123.6 (C6), 116.2 (C4), 112.0 (C5), 110.0 (C7), 87.6 (C1′), 80.7 (C4′), 73.6 (C2′), 71.0 (C3′), 63.4 (C5′); IR: 3062(w), 2926 (w), 1725 (s), 1602 (w), 1584 (w), 1493 (w), 1452 (m); LC/MS (system II): retention time: 3.41 min; UV_{max} = 280 nm; M.S. (ES) m s^{-1}:$C_{33}H_{25}BrN_2O_7$: calculated $[M+H]^+$- 641.0923, actual $[M+H]^+$- 641.0936.

6-Bromo-1-(2′,3′,5′-tri-*O*-benzoyl-β-D-ribofuranosyl)benzimidazole (6). ^1H NMR (600 MHz, $CDCl_3$): 8.16 (s, 1 H, H2), 8.12-8.14 (m, 2 H, H-Ph), 8.01–7.95 (m, 4 H, H-Ph), 7.84 (d, *J* = 1.6 Hz, 1 H, H7), 7.66 (d, *J* = 8.6 Hz, 1 H, H4), 7.63–7.39 (m, 10 H, H-Ph,H5), 6.35 (d, *J* = 6.1 Hz, 1 H, H1′), 6.00 (t, *J* = 5.9, 5.9 Hz, 1 H, H2′), 5.97 (dd, *J* = 3.7, 5.6 Hz, 1 H, H3′), 4.89 (dd, *J* = 2.6, 12.2 Hz, 1 H, H5′), 4.87–4.86 (m, 1 H, H4′), 4.78 (dd, *J* = 3.2, 12.2 Hz, 1 H, H5′); ^{13}C NMR (125 MHz, $CDCl_3$) δ (ppm): 166.2 (C═O), 165.3 (C═O), 165.0 (C═O), 141.0 (C9), 141.0 (C2), 134.0 (C-Ph), 133.9 (C-Ph), 133.7 (C-Ph), 133.7 (C8), 129.9 (C-Ph), 129.8 (C-Ph), 129.8 (C-Ph), 129.8 (C-Ph), 129.8 (C-Ph), 129.7 (C-Ph), 129.1 (C-Ph), 128.8 (C-Ph), 128.8 (C-Ph), 128.6 (C-Ph), 128.6 (C-Ph), 128.6 (C-Ph), 128.2 (C-Ph), 126.6 (C-Ph), 126.6 (C-Ph), 122.0 (C5), 117.2 (C4), 113.9 (C6), 110.0 (C7), 87.2 (C1′), 81.0 (C4′), 73.9 (C2′), 71.26 (C3′), 63.7 (C5′); IR: 3065 (w), 2924 (w), 1722 (s), 1602 (w), 1583 (w), 1493 (w), 1451 (m); LC/MS (system II): retention time: 3.33 min; UV_{max} = 278 nm, M.S. (ES) m s^{-1}:$C_{33}H_{25}BrN_2O_7$: calculated $[M+H]^+$- 641.0923, actual $[M+H]^+$- 641.0931.

7-Bromo-1-(2′,3′,5′-tri-*O*-benzoyl-β-D-ribofuranosyl)benzimidazole (7). ^1H NMR (400 MHz, $CDCl_3$) δ (ppm): 8.36 (s, 1 H, H2), 8.16–8.14 (m, 2 H, H-Ph), 8.01–7.93 (m, 4 H, H-Ph), 7.77 (dd, *J* = 0.7, 8.1 Hz, 1 H, H4), 7.64–7.37 (m, 11 H, H-Ph,H6,H1′), 7.17 (t, *J* = 8.0, 8.0 Hz, 1 H, H5), 6.06 (t, *J* = 5.4, 5.4 Hz, 1 H, H2′), 5.98 (t, *J* = 5.1, 5.1 Hz, 1 H, H3′), 4.89 (dd, *J* = 2.8, 12.2 Hz, 1 H, H5′), 4.85–4.83 (m, 1 H, H4′), 4.74 (dd, *J* = 3.4, 12.2 Hz, 1 H, H5′); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 166.2 (C═O), 165.2 (C═O), 164.9 (C═O), 146.1 (C9), 141.1 (C2), 133.9 (C-Ph), 133.8 (C-Ph), 133.7 (C-Ph), 133.6 (C-Ph), 130.9 (C8), 129.9 (C-Ph), 129.8 (C-Ph), 129.7 (C-Ph), 129.7 (C-Ph), 129.2 (C-Ph), 128.8 (C-Ph), 128.8 (C-Ph), 128.7 (C-Ph), 128.6 (C-Ph), 128.6 (C-Ph), 128.5 (C-Ph), 128.4 (C-Ph), 124.0 (C5), 120.3 (C4), 102.4 (C7), 86.1 (C1′), 80.0 (C4′), 75.2 (C2′), 70.8 (C3′), 63.5 (C5′); LC/MS (system II): retention time: 3.59 min; UV_{max} = 278 nm; M.S. (ES) m s^{-1}: $C_{33}H_{25}BrN_2O_7$: calculated $[M+H]^+$- 641.0923, actual $[M+H]^+$- 641.0955.

6-(3′-Pyridyl)-1-(2″,3″,5″-tri-*O*-benzoyl-β-D-ribofuranosyl)benzimidazole (8). ^1H NMR (600 MHz, $CDCl_3$) δ (ppm): 8.85 (s, 1 H, H2′), 8.57 (d, *J* = 3.9 Hz, 1 H, H6′), 8.26 (s, 1 H, H2), 8.07–7.96 (m, 6 H, H-Ph), 7.90 (d, *J* = 8.4 Hz, 1 H, H4), 7.87 (d, *J* = 0.8 Hz, 1 H, H7), 7.81 (td, *J* = 1.8, 1.8, 7.7 Hz, 1 H, H4′), 7.61–7.37 (m, 10 H, H-Ph, H5), 7.30–7.27 (m, 1 H, H5′), 6.47 (d, *J* = 5.8 Hz, 1 H, H1″), 6.08 (t, *J* = 5.7, 5.7 Hz, 1 H, H2″), 5.96 (t, *J* = 4.9, 4.9 Hz, 1 H, H3″), 4.93–4.90 (m, 2 H, H5″,H4″), 4.80 (dd, *J* = 3.8, 12.6 Hz, 1 H, H5″);^{13}C NMR (150 MHz, $CDCl_3$) δ (ppm): 166.1 (C═O), 165.3 (C═O), 165 (C═O), 148.6 (C2′), 148.6 (C6′), 148.3 (C9), 141.1 (C2), 134.7 (C3′), 134.0 (C-Ph), 133.9 (C-Ph), 133.6 (C-Ph), 129.9 (C4′), 129.8 (C6), 129.8 (C-Ph), 129.6 (C-Ph), 129 (C8), 129.0 (C-Ph), 128.7 (C-Ph), 128.7 (C-Ph), 128.7 (C-Ph), 128.6 (C-Ph), 128.6 (C-Ph), 128.6 (C-Ph), 128.6 (C-Ph), 128.3 (C-Ph), 128.3(C-Ph), 123.5 (C5′), 122.9 (C5), 121.3 (C4), 109.3 (C7), 87.4 (C1″), 80.9 (C4″), 74.1 (C2″), 71.3 (C3″), 63.7 (C5″); LC/MS (system I): retention time: 2.82 min; UV_{max} = 294 nm; M.S. (ES) m s^{-1}:$C_{38}H_{29}N_3O_7$: calculated $[M+H]^+$- 640.2084, actual $[M+H]^+$- 640.2089.

6-Phenyl-1-(2″,3″,5″-tri-*O*-benzoyl-β-D-ribofuranosyl)-benzimidazole (9). ^1H NMR (400 MHz, $CDCl_3$) δ (ppm): 8.26 (s, 1 H, H2), 8.08–8.06 (m, 2 H, H-Ph), 8.01–7.96 (s, 4 H, H-Ph), 7.87 (d, *J* = 6.0 Hz, 1 H, H4), 7.85 (s, 1 H, H7), 7.62–7.29 (m, 15 H, H-Ph, H2′-H6′, H5), 6.47 (d, *J* = 6.0 Hz, 1 H, H1″), 6.09 (t, *J* = 5.8, 5.8 Hz, 1 H, H2″), 5.98 (dd, *J* = 4.0, 5.6 Hz, 1 H, H3″), 4.92–4.88 (m, 2 H, H5″,H4″), 4.80 (dd, *J* = 4.3, 12.9 Hz, 1 H, H5″);^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 166.2 (C═O), 165.3 (C═O), 164.9 (C═O), 143.3 (C8), 141.4 (C1′), 140.6 (C2), 137.8 (C9), 133.9 (C-Ph), 133.8 (C-Ph), 133.5 (C-Ph), 133.2 (C-Ph), 129.8 (C-Ph), 129.8 (C-Ph), 129.6 (C-Ph), 129.0 (C-Ph), 128.7 (C-Ph), 128.7 (C-Ph), 128.6 (C-Ph), 128.6 (C-Ph), 128.3 (C-Ph), 127.5 (C-Ph), 127.1 (C-Ph), 123.2 (C5), 120.7 (C4), 119.6 (C6), 109.1 (C7), 87.4 (C1″), 80.9 (C4″), 74.2 (C2″), 71.4 (C3″), 63.8 (C5″); IR: 3067 (w), 2957 (w), 1721 (s), 1600 (w), 1584 (w), 1476 (w), 1452 (m); LC/MS (system III): retention time: 3.77 min; UV_{max} = 274 nm; M.S. (ES) m s^{-1}:$C_{38}H_{30}N_2O_7$: calculated $[M+H]^+$- 639.2131, actual $[M+H]^+$- 639.2142.

6-(3′-Pyridyl)-1-(β-D-ribofuranosyl)benzimidazole (11). ^1H NMR (400 MHz, CD_3OD) δ (ppm): 8.87 (br. s, 1 H, H2′), 8.54 (s, 1 H, H2), 8.50 (d, *J* = 4.5 Hz, 1 H, H6′), 8.18–8.16 (m, 2 H, H7, H4′), 7.79 (d, *J* = 8.4 Hz, 1 H, H4), 7.61 (dd, *J* = 1.6, 8.4 Hz, 1 H, H5), 7.52 (dd, *J* = 4.9, 7.9 Hz, 1 H, H5′), 6.06 (d, *J* = 5.9 Hz, 1 H, H1″), 4.54 (t, *J* = 5.7, 5.7 Hz, 1 H, H2″), 4.33 (dd, *J* = 3.7, 5.2 Hz, 1 H, H3″), 4.19–4.16 (m, 1 H, H4″), 3.91 (dd, *J* = 2.8, 12.2 Hz, 1 H, H5″), 3.83 (dd, *J* = 3.1, 12.2 Hz, 1 H, H5″); ^{13}C NMR (100 MHz, CD_3OD) δ (ppm): 148.6 (C2′), 148.4 (C6′), 144.6 (C9), 144.2 (C2), 138.9 (C3′), 136.9 (C4′), 134,8 (C6), 134.2 (C8), 125.5 (C5′), 123.4 (C5), 120.9 (C4), 111.6 (C7), 91.1 (C1″), 87.2 (C4″), 75.8 (C2″), 71.8 (C3″), 62.6 (C5″); IR: 3192 (br), 2926 (w), 1579 (m), 1452 (m), 1417 (w); LC/MS (system I): retention time: 0.57 min; M.S. (ES) m s^{-1}: $C_{17}H_{17}N_3O_4$: calculated $[M+H]^+$- 328.1297, actual $[M+H]^+$- 328.1293.

5-(3′-Pyridyl)-1-(β-D-ribofuranosyl)benzimidazole (12). ^1H NMR (600 MHz, CD_3OD) δ (ppm): 8.84 (d, *J* = 2.0 Hz, 1 H, H2′), 8.51 (dd, *J* = 1.3, 4.8 Hz, 1 H, H6′), 8.38 (s, 1 H, H2), 8.15–8.13 (m, 1 H, H4′), 7.95 (d, *J* = 1.3 Hz, 1 H, H4), 7.89 (d, *J* = 8.5 Hz, 1 H, H7), 7.63 (dd, *J* = 1.7, 8.5 Hz, 1 H, H6), 7.53 (dd, *J* = 4.9, 7.8 Hz, 1 H, H5′), 6.01 (d, *J* = 5.9 Hz, 1 H, H1″), 4.49 (t, *J* = 5.6, 5.6 Hz, 1 H, H2″), 4.30 (dd, *J* = 3.8, 5.3 Hz, 1 H, H3″), 4.15 (q, *J* = 3.3, 3.3, 3.4 Hz, 1 H, H4″), 3.89 (dd, *J* = 3.0, 12.1 Hz, 1 H, H5″), 3.81 (dd, *J* = 3.4, 12.1 Hz, 1 H, H5″); ^{13}C NMR (150 MHz, CD_3OD) δ (ppm): 148.6 (C-Ar), 148.4 (C-Ar), 145.2 (C-Ar), 144.1 (C-Ar), 139.0 (C-Ar), 136.8 (C-Ar), 134.4 (C-Ar), 133.9 (C-Ar), 125.5 (C-Ar), 124.0 (C-Ar), 118.8 (C-Ar), 113.4 (C-Ar), 91.0 (C1″), 87.1 (C4″), 76.0 (C2″), 71.8 (C3″), 62.7 (C5″); LC/MS (system I[37]): retention time: 0.47 min; M.S. (ES) m s^{-1}: $C_{17}H_{17}N_3O_4$: calculated $[M+H]^+$- 328.1297, actual $[M+H]^+$- 328.1291.

7-(3′-Pyridyl)-1-(β-D-ribofuranosyl)benzimidazole (13) in a mixture. ^1H NMR (600 MHz, CD_3OD) and ^{13}C NMR (125 MHz, CD_3OD) are shown in the Support Information; LC/MS (system I): retention time: 0.76 min; UV_{max} = 264 nm; M.S. (ES) m

s^{-1}:$C_{17}H_{17}N_3O_4$: calculated $[M+H]^+$- 328.1297, actual $[M+H]^+$- 328.1288.

4-(3′-Pyridyl)-1-(β-D-ribofuranosyl)benzimidazole (14). ^1H NMR (400 MHz, CD_3OD) δ (ppm): 9.03 (d, J = 1.2 Hz, 1 H, H2′), 8.54 (d, J = 3.9 Hz, 1 H, H6′), 8.34 (td, J = 1.5, 1.5, 9.9 Hz, 1 H, H4′), 8.26 (s, 1 H, H2), 7.81 (dd, J = 2.1, 7.0 Hz, 1 H, H7), 7.56 (dd, J = 4.9, 7.9 Hz, 1 H, H5′), 7.47–7.42 (m, 1 H, H5 and H6), 6.02 (d, J = 5.7 Hz, 1 H, H1″), 4.49 (t, J = 5.5, 5.5 Hz, 1 H, H2″), 4.30 (dd, J = 4.0, 5.2 Hz, 1 H, H3″), 4.15 (q, J = 3.3, 3.3, 3.3 Hz, 1 H, H4″), 3.89 (dd, J = 3.0, 12.1 Hz, 1 H, H5″), 3.80 (dd, J = 3.4, 12.2 Hz, 1 H, H5″); ^{13}C NMR (100 MHz, *CD_3OD*) δ (ppm): 150.1 (C-Ar), 148.6 (C-Ar), 143.6 (C-Ar), 142.3 (C-Ar), 138.7 (C-Ar), 135.2 (C-Ar), 129.8 (C-Ar), 125.2 (C-Ar), 125.0 (C-Ar), 123.6 (C-Ar), 121.0 (C-Ar), 112.8 (C-Ar), 90.9 (C1″), 87.0 (C4″), 76.1 (C2″), 71.7 (C3″), 62.6 (C5″); LC/MS (system I): retention time: 0.90 min; UV_{max} = 314 nm; M.S. (ES) m s^{-1}: $C_{17}H_{17}N_3O_4$: calculated $[M+H]^+$- 328.1297, actual $[M+H]^+$- 328.1284.

5-(4,4,5,5-Tetramethyl-1,3,2-dioxaborolan-2-yl)-1-(2′,3′,5′-tri-*O*-benzoyl-β-D-ribofuranosyl)benzimidazole (16). ^1H NMR (400 MHz, $CDCl_3$) δ (ppm): 8.28 (s, 1 H, H4), 8.22 (s, 1 H, H2), 8.13–8.11 (m, 2 H, H-Ph), 7.99–7.93 (m, 4 H, H-Ph), 7.68–7.37 (m, 11 H, H-Ph, H6, H7), 6.42 (d, J = 6.0 Hz, 1 H, H1′), 6.04 (t, J = 5.9, 5.9 Hz, 1 H, H2′), 5.98 (dd, J = 4.1, 5.7 Hz, 1 H, H3′), 4.91–4.83 (m, 2 H, H5′, H4′), 4.77 (dd, J = 3.3, 12.0 Hz, 1 H, H5′), 1.36 (s, 12 H, CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 166.2 (C═O), 165.3 (C═O), 164.9 (C═O), 143.7 (C9), 140.7 (C2), 134.8 (C8), 133.9 (C-Ph), 133.8 (C-7), 133.6 (C-Ph), 130.0 (C-Ph), 129.9 (C-Ph), 129.8 (C-Ph), 129.7 (C-Ph), 129.1 (C-Ph), 128.8 (C-Ph), 128.6 (C-Ph), 128.6 (C-Ph), 128.3 (C-Ph), 127.8 (C4), 119.6 (C5), 109.9 (C6), 87.2 (C1′), 83.8 ($C(CH_3)_2$), 80.8 (C4′), 73.9 (C2′), 71.2 (C3′), 63.7 (C5′), 24.9 (CH_3); IR: 2978 (w), 1728 (s), 1602 (w), 1493 (w), 1452 (w); LC/MS (system I): retention time: 3.78 min; M.S. (ES) m s^{-1}: $C_{39}H_{37}BN_2O_9$: calculated $[M+H]^+$- 689.2670, actual $[M+H]^+$- 689.2689.

5-(2′-Methylphenyl)-1-(β-D-ribofuranosyl)benzimidazole (17). ^1H NMR (400 MHz, CD_3OD) δ (ppm): 8.52 (s, 1 H, H2), 7.79 (d, J = 8.4 Hz, 1 H, H7), 7.57 (d, J = 0.9 Hz, 1 H, H4), 7.28-7.21 (m, 5 H, H6, H3′, H4′, H5′, H6′), 6.01 (d, J = 5.8 Hz, 1 H, H1″), 4.50 (t, J = 5.6, 5.6 Hz, 1 H, H2″), 4.30 (dd, J = 3.8, 5.3 Hz, 1 H, H3″), 4.14 (dd, J = 3.4, 6.9 Hz, 1 H, H4″), 3.89 (dd, J = 3.1, 12.2 Hz, 1 H, H5″), 3.81 (dd, J = 3.5, 12.2 Hz, 1 H, H5″), 2.24 (s, 3 H, CH_3); ^{13}C NMR (100 MHz, CD_3OD) δ (ppm):143.6 (C1′), 138.8 (C9), 136.7 (C2), 131.5, 131.2, 130.8, 129.5, 128.5, 127.0, 126.4 (C-Ph, C5, C8), 121.2 (C7), 120.7 (C6), 112.3 (C4), 91.1 (C1″), 87.2 (C4″), 76.1 (C2″), 72.0 (C3″), 62.9 (C5″), 20.9 (CH_3); LC/MS (system I[37]): retention time: 1.62 min; UV_{max} = 282 nm; M.S. (ES) m s^{-1}: $C_{19}H_{20}N_2O_4$: calculated $[M+H]^+$- 341.1501, actual $[M+H]^+$- 341.1493.

5-(3′-Methylphenyl)-1-(β-D-ribofuranosyl)benzimidazole (18). ^1H NMR (600 MHz, CD_3OD) δ (ppm): 8.51 (s, 1 H, H2), 7.86 (d, J = 1.1 Hz, 1 H, H4), 7.79 (d, J = 8.5 Hz, 1 H, H7), 7.58 (dd, J = 1.5, 8.5 Hz, 1 H, H6), 7.46 (s, 1 H, H2′), 7.42 (d, J = 7.7 Hz, 1 H, H6′), 7.31 (t, J = 7.6, 7.6 Hz, 1 H, H5′), 7.14 (d, J = 7.5 Hz, 1 H, H4′), 5.99 (d, J = 5.8 Hz, 1 H, H1″), 4.49 (t, J = 5.6, 5.6 Hz, 1 H, H2″), 4.30 (dd, J = 4.0, 5.2 Hz, 1 H, H3″), 4.14 (ddd, J = 3.5, 3.5, 3.5 Hz, 1 H, H4″), 3.89 (dd, J = 3.1, 12.1 Hz, 1 H, H5″), 3.81 (dd, J = 3.5, 12.2 Hz, 1 H, H5″), 2.41 (s, 3 H, CH_3); ^{13}C NMR (150 MHz, CD_3OD) δ (ppm): 144.9 (C-Ar), 143.6 (C-Ar), 142.7 (C-Ar), 139.6 (C-Ar), 139.6 (C-Ar), 138.2 (C-Ar), 133.6 (C-Ar), 129.8 (C-Ar), 129.0 (C-Ar), 128.7 (C-Ar), 125.4 (C-Ar), 124.3 (C-Ar), 118.3 (C-Ar), 112.7 (C-Ar), 91.0 (C1″), 87.0 (C4″), 75.9 (C2″), 71.7 (C3″), 62.7 (C5″), 21.6 (CH_3); LC/MS (system I): retention time: 1.68 min; UV_{max} = 298 nm; M.S. (ES) m s^{-1}: $C_{19}H_{20}N_2O_4$: calculated $[M+H]^+$- 341.1501, actual $[M+H]^+$- 341.1497.

5-(4′-Methylphenyl)-1-(β-D-ribofuranosyl)benzimidazole (19). ^1H NMR (600 MHz, CD_3OD) δ (ppm): 8.50 (s, 1 H, H2), 7.85 (d, J = 0.8 Hz, 1 H, H4), 7.78 (d, J = 8.5 Hz, 1 H, H7), 7.58 (d, J = 8.5 Hz, 1 H, H6), 7.53 (d, J = 8.0 Hz, 2 H, H2′, H6′), 7.25 (d, J = 7.9 Hz, 2 H, H3′, H5′), 5.99 (d, J = 5.8 Hz, 1 H, H1″), 4.48 (t, J = 5.6, 5.6 Hz, 1 H, H2″), 4.29 (dd, J = 4.1, 5.2 Hz, 1 H, H3″), 4.14 (ddd, J = 3.5, 3.5, 3.5 Hz, 1 H, H4″), 3.88 (dd, J = 3.1, 12.1 Hz, 1 H, H5″), 3.81 (dd, J = 3.5, 12.1 Hz, 1 H, H5″); ^{13}C NMR (150 MHz, CD_3OD) δ (ppm): 143.6 (C-Ar), 139.9 (C-Ar), 138.0 (C-Ar), 137.9 (C-Ar), 133.5 (C-Ar), 130.5 (C-Ar), 130.5 (C-Ar), 128.1 (C-Ar), 128.1 (C-Ar), 124.1 (C-Ar), 118.1 (C-Ar), 112.7 (C-Ar), 111.4 (C-Ar), 91.0 (C1″), 87.0 (C4″), 75.9 (C2″), 71.7 (C3″), 62.7 (C5″), 21.1 (CH3); LC/MS (system I): retention time: 1.65 min; UV_{max} = 288 nm; M.S. (ES) m s^{-1}: $C_{19}H_{20}N_2O_4$: calculated $[M+H]^+$- 341.1501, actual $[M+H]^+$- 341.1504.

5-(2′,6′-Dimethylphenyl)-1-(β-D-ribofuranosyl)benzimidazole (20). ^1H NMR (400 MHz, CD_3OD) δ (ppm): 8.53 (s, 1 H, H2), 7.83 (d, J = 8.3 Hz, 1 H, H7), 7.40 (d, J = 0.5 Hz, 1 H, H4), 7.15–7.07 (s, 4 H, H6, H3′, H4′, H5′), 6.02 (d, J = 5.9 Hz, 1 H, H1″), 4.53 (t, J = 5.6, 5.6 Hz, 1 H, H2″), 4.31 (dd, J = 3.8, 5.3 Hz, 1 H, H3″), 4.15 (ddd, J = 3.4, 3.4, 3.4 Hz, 1 H, H4″), 3.89 (dd, J = 3.1, 12.2 Hz, 1 H, H5″), 3.82 (dd, J = 3.6, 12.2 Hz, 1 H, H5″), 1.98 (s, 1 H, CH3, CH3); ^{13}C NMR (150 MHz, CD_3OD) δ (ppm): 144.7 (C-Ar), 143.1 (C-Ar), 139.9 (C-Ar), 137.5 (C-Ar), 137.2 (C-Ar), 137.2 (C-Ar), 133.1 (C-Ar), 128.4 (C-Ar), 128.2 (C-Ar), 126.0 (C-Ar), 120.4 (C-Ar), 112.8 (C-Ar), 111.4 (C-Ar), 91.0 (C1″), 87.1 (C4″), 75.8 (C2″), 71.8 (C3″), 62.7 (C5″), 21.1 (CH3), 21.1 (CH3); LC/MS (system I): retention time: 1.75 min; UV_{max} = 276 nm; M.S. (ES) m s^{-1}: $C_{20}H_{22}N_2O_4$: calculated $[M+H]^+$- 355.1658, actual $[M+H]^+$- 355.1649.

5-(2′-Carboxyphenyl)-1-(β-D-ribofuranosyl)benzimidazole (21). ^1H NMR (600 MHz, CD_3OD) δ (ppm): 8.85 (s, 1H, H2), 7.77–7.73 (m, 2 H, H7, H3′), 7.68 (d, J = 1.0 Hz, 1 H, H4), 7.51 (dt, J = 1.3, 7.6, 7.6 Hz, 1 H, H5′), 7.45–7.39 (m, 2 H, H4′, H6′), 7.37 (dd, J = 1.5, 8.4 Hz, 1 H, H6), 5.99 (d, J = 5.7 Hz, 1 H, H1″), 4.48 (t, J = 5.5, 5.5 Hz, 1 H, H2″), 4.29 (dd, J = 4.1, 5.3 Hz, 1 H, H3″), 4.13 (ddd, J = 3.4, 3.4, 3.4 Hz, 1 H, H4″), 3.88 (dd, J = 3.1, 12.1 Hz, 1 H, H5″), 3.80 (dd, J = 3.5, 12.1 Hz, 1 H, H5″); ^{13}C NMR (150 MHz, CD_3OD) δ (ppm): 169.8 (C═O), 148.0 (C-Ar), 145.1 (C-Ar), 143.6 (C-Ar), 139.9 (C-Ar), 138.0 (C-Ar), 137.9 (C-Ar), 133.5 (C-Ar), 130.5 (C-Ar), 128.1 (C-Ar), 124.1 (C-Ar), 118.1 (C-Ar), 112.7 (C-Ar), 111.4 (C-Ar), 91.0 (C1″), 87.0 (C4″), 75.9 (C2″), 71.7 (C3″), 62.7 (C5″); LC/MS (system I): retention time: 1.21 min; UV_{max} = 286 nm; M.S. (ES) m s^{-1}: $C_{19}H_{18}N_2O_6$: calculated $[M+H]^+$- 371.1243, actual $[M+H]^+$- 371.1229.

5-(3′-Carboxyphenyl)-1-(β-D-ribofuranosyl)benzimidazole (22). ^1H NMR (600 MHz, CD_3OD) δ (ppm): 8.53 (s, 1 H, H2), 8.30 (t, J = 1.6, 1.6 Hz, 1 H, H2′), 7.99 (dt, J = 1.1, 1.2, 7.8 Hz, 1 H, H4′), 7.94 (d, J = 1.2 Hz, 1 H, H4), 7.88 (ddd, J = 1.1, 1.6, 7.7 Hz, 1 H,

H6′), 7.85 (d, J = 8.5 Hz, 1 H, H7), 7.64 (dd, J = 1.6, 8.5 Hz, 1 H, H6), 7.55 (t, J = 7.7, 7.7 Hz, 1 H, H5′), 6.01 (d, J = 5.8 Hz, 1 H, H1″), 4.49 (t, J = 5.6, 5.6 Hz, 1 H, H2″), 4.30 (dd, J = 4.0, 5.3 Hz, 1 H, H3″), 4.15 (ddd, J = 3.4, 3.4, 3.4 Hz, 1 H, H4″), 3.89 (dd, J = 3.1, 12.2 Hz, 1 HH5″), 3.81 (dd, J = 3.5, 12.1 Hz, 1 H, H5″); ^{13}C NMR (150 MHz, CD_3OD) δ (ppm): 170.54 (C═O), 145.09 (C-Ar), 143.85 (C-Ar), 143.00 (C-Ar), 137.10 (C-Ar), 133.96 (C-Ar), 133.58 (C-Ar), 132.44 (C-Ar), 130.04 (C-Ar), 129.39 (C-Ar), 129.23 (C-Ar), 124.14 (C-Ar), 118.53 (C-Ar), 113.04 (C-Ar), 91.01 (C1″), 87.03 (C4″), 75.97 (C2″), 71.77 (C3″), 62.69 (C5″); LC/MS (system I): retention time: 1.32 min; UV_{max} = 286 nm; M.S. (ES) m s^{-1}: $C_{19}H_{18}N_2O_6$: calculated $[M+H]^+$- 371.1243, actual $[M+H]^+$- 371.1242.

5-(4′-Carboxyphenyl)-1-(β-D-ribofuranosyl)benzimidazole (23). ^{1}H NMR (600 MHz, CD_3OD) δ (ppm): 8.53 (s, 1 H, H2′), 8.09 (d, J = 8.4 Hz, 1 H, H3′, H5′), 7.96 (d, J = 1.3 Hz, 1 H, H4), 7.84 (d, J = 8.5 Hz, 1 H, H7), 7.75 (d, J = 8.4 Hz, 1 H, H2′, H6′), 7.67 (dd, J = 1.6, 8.5 Hz, 1 H, H6), 6.00 (d, J = 5.8 Hz, 1 H, H1″), 4.49 (t, J = 5.6, 5.6 Hz, 1 H, H2″), 4.30 (dd, J = 3.9, 5.3 Hz, 1 H, H3″), 4.15 (ddd, J = 3.4, 3.4, 3.4 Hz, 1 H, H4″), 3.89 (dd, J = 3.1, 12.1 Hz, 1 H, H5″), 3.81 (dd, J = 3.5, 12.1 Hz, 1 H, H5″); ^{13}C NMR (150 MHz, CD_3OD) δ (ppm): 171.1 (C═O), 146.6 (C-Ar), 145.1 (C-Ar), 143.9 (C-Ar), 136.9 (C-Ar), 134.2 (C-Ar), 132.2 (C-Ar), 131.3 (C-Ar), 131.3 (C-Ar), 128.1 (C-Ar), 128.1 (C-Ar), 124.2 (C-Ar), 118.7 (C-Ar), 113.0 (C-Ar), 91.0 (C1″), 87.1 (C4″), 76.0 (C2″), 71.8 (C3″), 62.7 (C5″); LC/MS (system I): retention time: 1.25 min; UV_{max} = 298 nm; M.S. (ES) m s^{-1}: $C_{19}H_{18}N_2O_6$: calculated $[M+H]^+$- 371.1243, actual $[M+H]^+$- 371.1242.

5-(2′-Methoxyphenyl)-1-(β-D-ribofuranosyl)benzimidazole (24). ^{1}H NMR (600 MHz, CD_3OD) δ (ppm): 8.48 (s, 1 H, H2), 7.77 (d, J = 1.0 Hz, 1 H, H4), 7.73 (d, J = 8.4 Hz, 1 H, H7), 7.45 (dd, J = 1.5, 8.4 Hz, 1 H, H6), 7.32–7.30 (m, 2 H, H4′, H6′), 7.07 (dd, J = 0.8, 8.8 Hz, 1 H, H3′), 7.02 (dt, J = 1.0, 7.4, 7.4 Hz, 1 H, H5′), 5.99 (d, J = 5.7 Hz, 1 H, H1″), 4.48 (t, J = 5.5, 5.5 Hz, 1 H, H2″), 4.29 (dd, J = 4.1, 5.2 Hz, 1 H, H3″), 4.14 (ddd, J = 3.5, 3.5, 3.5 Hz, 1 H, H4″), 3.89 (dd, J = 3.1, 12.2 Hz, 1 H, H5″), 3.81 (dd, J = 3.2, 12.5 Hz, 1 H, H5″), 3.78 (s, 3 H, OCH_3); ^{13}C NMR (150 MHz, CD_3OD) δ (ppm): 158.0 (C2′), 144.3 (C-Ar), 143.2 (C-Ar), 135.3 (C-Ar), 133.1 (C-Ar), 132.2 (C-Ar), 132.0 (C-Ar), 129.7 (C-Ar), 126.6 (C-Ar), 122.0 (C-Ar), 121.0 (C-Ar), 112.7 (C-Ar), 111.7 (C-Ar), 91.0 (C1″), 86.9 (C4″), 75.9 (C2″), 71.7 (C3″), 62.7 (C5″), 56.1 (OCH_3); LC/MS (system I): retention time: 1.49 min; UV_{max} = 298 nm; M.S. (ES) m s^{-1}: $C_{19}H_{20}N_2O_5$: calculated $[M+H]^+$- 357.1450, actual $[M+H]^+$- 357.1451.

5-(3′-Methoxyphenyl)-1-(β-D-ribofuranosyl)benzimidazole (25). ^{1}H NMR (600 MHz, CD_3OD) δ (ppm): 8.51 (s, 1 H, H2), 7.88 (d, J = 1.2 Hz, 1 H, H4), 7.80 (d, J = 8.5 Hz, 1 H, H7), 7.59 (dd, J = 1.6, 8.5 Hz, 1 H, H6), 7.35 (t, J = 7.9, 7.9 Hz, 1 H, H5′), 7.22–7.21 (m, 1 H, H6′), 7.17 (s, 1 H, H2′), 6.90 (ddd, J = 0.6, 2.5, 8.2 Hz, 1 H, H4′), 5.99 (d, J = 5.8 Hz, 1 H, H1″), 4.48 (t, J = 5.6, 5.6 Hz, 1 H, H2″), 4.29 (dd, J = 3.9, 5.3 Hz, 1 H, H3″), 4.14 (ddd, J = 3.4, 3.4, 3.4 Hz, 1 H, H4″), 3.88 (dd, J = 3.1, 12.1 Hz, 1 H, H5″), 3.85 (s, 3 H, OCH_3), 3.81 (dd, J = 3.5, 12.1 Hz, 1 H, H5″); ^{13}C NMR (150 MHz, CD_3OD) δ (ppm): 161.6 (C2′), 145.0 (C-Ar), 144.2 (C-Ar), 143.6 (C-Ar), 138.0 (C-Ar), 133.8 (C-Ar), 130.9 (C-Ar), 124.2 (C-Ar), 120.8 (C-Ar), 118.4 (C-Ar), 114.0 (C-Ar), 113.4 (C-Ar), 112.7 (C-Ar), 91.0 (C1″), 87.0 (C4″), 76.0 (C2″), 71.8 (C3″), 62.7 (C5″), 55.8 (OCH_3); LC/MS (system I): retention time: 1.56 min; UV_{max} = 303 nm; M.S. (ES) m s^{-1}: $C_{19}H_{20}N_2O_5$: calculated $[M+H]^+$- 357.1450, actual $[M+H]^+$- 357.1459.

5-(4′-Methoxyphenyl)-1-(β-D-ribofuranosyl)benzimidazole (26). ^{1}H NMR (600 MHz, CD_3OD) δ (ppm): 8.48 (s, 1 H, H2), 7.82 (d, J = 1.2 Hz, 1 H, H4), 7.76 (d, J = 8.5 Hz, 1 H, H7), 7.58–7.54 (m, 3 H, H6, H2′, H6′), 7.00 (d, J = 8.8 Hz, 2 H, H3′, H5′), 5.98 (d, J = 5.8 Hz, 1 H, H1″), 4.48 (t, J = 5.6, 5.6 Hz, 1 H, H2″), 4.29 (dd, J = 4.0, 5.3 Hz, 1 H, H3″), 4.13 (ddd, J = 3.5, 3.5, 3.5 Hz, 1 H, H4″), 3.88 (dd, J = 3.1, 12.1 Hz, 1 H, H5″), 3.83 (s, 3 H, OCH_3), 3.80 (dd, J = 3.5, 12.1 Hz, 1 H, H5″); ^{13}C NMR (150 MHz, CD_3OD) δ (ppm): 160.6 (C2′), 145.0 (C-Ar), 143.5 (C-Ar), 137.8 (C-Ar), 135.2 (C-Ar), 133.2 (C-Ar), 129.3 (C-Ar), 129.3 (C-Ar), 123.9 (C-Ar), 117.8 (C-Ar), 115.3 (C-Ar), 115.3 (C-Ar), 112.6 (C-Ar), 90.9 (C1″), 86.9(C4″), 75.9 (C2″), 71.7 (C3″), 62.7 (C5″), 55.8 (OCH_3); LC/MS (system I): retention time: 1.49 min; UV_{max} = 310 nm; M.S. (ES) m s^{-1}: $C_{19}H_{20}N_2O_5$: calculated $[M+H]^+$- 357.1450, actual $[M+H]^+$- 357.1442.

5-(2′-Pyridyl)-1-(β-D-ribofuranosyl)benzimidazole (27). ^{1}H NMR (600 MHz, CD_3OD) δ (ppm): 8.61 (td, J = 1.2, 1.2, 4.9 Hz, 1 H, H6′), 8.51–8.50 (m, 2 H, H2+H4′), 8.26 (d, J = 1.4 Hz, 1 H, H4), 7.95 (dd, J = 1.6, 8.5 Hz, 1 H, H6), 7.91–7.90 (m, 1 H, H3′), 7.86 (d, J = 8.5 Hz, 1 H, H7), 7.35 (dd, J = 4.5, 8.9 Hz, 1 H, H5′), 6.01 (d, J = 5.8 Hz, 1 H, H1″), 4.49 (t, J = 5.5, 5.5 Hz, 1 H, H2″), 4.30 (dd, J = 3.8, 5.3 Hz, 1 H, H3″), 4.15 (q, J = 3.4, 3.4, 3.4 Hz, 1 H, H4″), 3.89 (dd, J = 3.1, 12.1 Hz, 1 H, H5″), 3.81 (dd, J = 3.3, 12.1 Hz, 1 H, H5″); ^{13}C NMR (150 MHz, CD_3OD) δ (ppm): 158.7 (C-Ar), 149.7 (C-Ar), 142.4 (C-Ar), 143.6 (C-Ar), 138.4 (C-Ar), 135.3 (C-Ar), 134.4 (C-Ar), 123.4 (C-Ar), 122.8 (C-Ar), 122.1 (C-Ar), 118.5 (C-Ar), 112.3 (C-Ar), 90.4 (C1″), 86.5 (C4″), 75.4 (C2″), 71.2 (C3″), 62.1 (C5″); LC/MS (system I): retention time: 0.87 min; UV_{max} = 316 nm; M.S. (ES) m s^{-1}: $C_{17}H_{17}N_3O_4$: calculated $[M+H]^+$- 328.1297, actual $[M+H]^+$- 328.1302.

5-(4′-Pyridyl)-1-(β-D-ribofuranosyl)benzimidazole (28). ^{1}H NMR (600 MHz, CD_3OD) δ (ppm): 8.57 (d, J = 5.9 Hz, 2 H, H2′, H6′), 8.42 (s, 1 H, H2), 8.07 (d, J = 1.2 Hz, 1 H, H4), 7.90 (d, J = 8.5 Hz, 1 H, H7), 7.77 (dd, J = 1.5, 4.7 Hz, 2 H, H3′, H5′), 7.74 (dd, J = 1.6, 8.5 Hz, 1 H, H6), 6.01 (d, J = 5.9 Hz, 1 H, H1″), 4.49 (t, J = 5.6, 5.6 Hz, 1 H, H2″), 4.30 (dd, J = 3.8, 5.2 Hz, 1 H, H3″), 4.15 (ddd, J = 3.3, 3.3, 3.3 Hz, 1 H, H4″), 3.89 (dd, J = 3.0, 12.1 Hz, 1 H, H5″), 3.81 (dd, J = 3.4, 12.2 Hz, 1 H, H5″); ^{13}C NMR (150 MHz, CD_3OD) δ (ppm): 151.1 (C-Ar), 150.5 (C-Ar), 150.5 (C-Ar), 145.1 (C-Ar), 144.4 (C-Ar), 135.1 (C-Ar), 134.0 (C-Ar), 123.8 (C-Ar), 123.3 (C-Ar), 123.3 (C-Ar), 118.9 (C-Ar), 113.5 (C-Ar), 91.0 (C1″), 87.2 (C4″), 76.1 (C2″), 71.8 (C3″), 62.7 (C5″); LC/MS (system I): retention time: 0.43 min; UV_{max} = 312 nm; M.S. (ES) m s^{-1}: $C_{17}H_{17}N_3O_4$: calculated $[M+H]^+$- 328.1297, actual $[M+H]^+$- 328.1287.

5-(1′-Pyrazolyl)-1-(β-D-ribofuranosyl)benzimidazole (29). ^{1}H NMR (600 MHz, CD_3OD) δ (ppm): 8.43 (s, 1 H, H2), 7.89 (s, 1 H, H3′), 7.82 (d, J = 1.0 Hz, 1 H, H5′), 7.73 (d, J = 8.5 Hz, 1 H, H7), 7.55–7.53(m, 2 H, H6 and H4), 6.83 (dd, J = 0.8, 1.7 Hz, 1 H, H4′), 5.96 (d, J = 5.8 Hz, 1 H, H1″), 4.47 (t, J = 5.6, 5.6 Hz, 1 H, H2″), 4.28 (dd, J = 4.0, 5.3 Hz, 1 H, H3″), 4.13 (q, J = 3.4, 3.4, 3.4 Hz, 1 H, H4″), 3.87 (dd, J = 3.1, 12.2 Hz, 1H, H5″), 3.80 (dd, J = 3.5, 12.1 Hz, 1 H, H5″); ^{13}C NMR (150 MHz, CD_3OD) δ (ppm): 145.0 (C-Ar), 143.4 (C-Ar), 139.7 (C-Ar), 133.3

(C-Ar), 129.3 (C-Ar), 128.0 (C-Ar), 123.0 (C-Ar), 117.0 (C-Ar), 112.8 (C-Ar), 109.9 (C-Ar), 90.9 (C1″), 87.0 (C4″), 75.9 (C2″), 71.7 (C3″), 62.7 (C5″); LC/MS (system I): retention time: 0.99 min; UV_{max} = 292 nm; M.S. (ES) m s^{-1}: $C_{15}H_{16}N_4O_4$: calculated $[M+H]^+$- 317.1250, actual $[M+H]^+$- 317.1253.

5-(3′Pyrazolyl)-1-(β-D-ribofuranosyl)benzimidazole (30). ^1H NMR (500 MHz, CD_3OD) δ (ppm): 8.56 (s, 1H, H2), 8.50 (s, 1H, H1′), 8.10 (s, 1H, H4), 7.85–7.80 (m, 2H, H6 and H7), 7.70 (d, J = 1.9, 1H, H5′), 6.73 (d, J = 2.2, 1H, H4′), 6.03 (d, J = 5.7, 1H, H1″), 4.52 (t, J = 5.6, 1H, H2″), 4.33 (dd, J = 4.0, 5.0, 1H, H3″), 4.19–4.17 (m, 1H, H4″), 3.93 (dd, J = 2.8, 12.3, 1H. H5″), 3.84 (dd, J = 12.1, 3.4, 1H, H5″); ^{13}C NMR (125 MHz, CD_3OD) δ (ppm): 143.9 (C-Ar), 142.7 (C-Ar), 134.8 (C-Ar), 133.0 (C-Ar), 126.3 (C-Ar), 121.9 (C-Ar), 116.3 (C-Ar), 112.9 (C-Ar), 102.3 (C-Ar), 102.3 (C-Ar), 89.9 (C1″), 86.0 (C4″), 74.9 (C2″), 70.7 (C3″), 61.6 (C5″); LC/MS (system IV): retention time: 0.39 min; UV_{max} = 299 nm; M.S. (ES) m s^{-1}:$C_{15}H_{16}N_4O_4$: calculated $[M+H]^+$- 317.1250, actual $[M+H]^+$- 317.1241.

5-(4′-Isothiazolyl)-1-(β-D-ribofuranosyl)benzimidazole (31). ^1H NMR (400 MHz, CD_3OD) δ (ppm): 9.10 (s, 1 H, H5′), 8.92 (s, 1 H, H3′), 8.54 (s, 1 H, H2), 8.01 (d, J = 1.1 Hz, 1 H, H4), 7.84 (d, J = 8.5 Hz, 1 H, H7), 7.70 (dd, J = 1.6, 8.5 Hz, 1 H, H6), 5.99 (d, J = 5.9 Hz, 1 H, H1″), 4.48 (t, J = 5.6, 5.6 Hz, 1 H, H2″), 4.29 (dd, J = 3.8, 5.3 Hz, 1 H, H3″), 4.14 (dd, J = 3.4, 6.8 Hz, 1 H, H4″), 3.88 (dd, J = 3.0, 12.2 Hz, 1 H, H5″), 3.80 (dd, J = 3.4, 12.2 Hz, 1 H, H5″); ^{13}C NMR (150 MHz, CD_3OD) δ (ppm): 157.6 (C-Ar), 145.2 (C-Ar), 144.2 (C-Ar), 144.1 (C-Ar), 141.7 (C-Ar), 134.2 (C-Ar), 129.3 (C-Ar), 129.3(C-Ar), 124.1 (C-Ar), 118.5 (C-Ar), 113.4 (C-Ar), 91.1 (C1″), 87.3 (C4″), 76.1 (C2″), 71.9 (C3″), 62.8 (C5″); LC/MS (system I): retention time: 1.15 min; UV_{max} = 290 nm; M.S. (ES) m s^{-1}: $C_{15}H_{15}N_3O_4S$: calculated $[M+H]^+$- 334.0862, actual $[M+H]^+$- 334.0858.

5-(2′-Thiophenyl)-1-(β-D-ribofuranosyl)benzimidazole (32). ^1H NMR (600 MHz, CD_3OD) δ (ppm): 8.50 (s, 1 H, H2), 7.90 (d, J = 1.3 Hz, 1 H, H4), 7.76 (d, J = 8.5 Hz, 1 H, H7), 7.63 (dd, J = 1.7, 8.5 Hz, 1 H, H6), 7.38 (dd, J = 1.1, 3.6 Hz, 1 H, H3′), 7.34 (dd, J = 1.1, 5.1 Hz, 1 H, H5′), 7.08 (dd, J = 3.6, 5.1 Hz, 1 H, H4′), 5.97 (d, J = 5.8 Hz, 1 H, H1″), 4.47 (t, J = 5.6, 5.6 Hz, 1 H, H2″), 4.29 (dd, J = 3.9, 5.3 Hz, 1 H, H3″), 4.14 (ddd, J = 3.4, 3.4, 3.4 Hz, 1 H, H4″), 3.88 (dd, J = 3.1, 12.1 Hz, 1 H, H5″), 3.80 (dd, J = 3.5, 12.1 Hz, 1 H, H5″);^{13}C NMR (150 MHz, CD_3OD) δ (ppm): 145.8 (C-Ar), 144.9 (C-Ar), 143.9 (C-Ar), 133.7 (C-Ar), 131.4 (C-Ar), 129.1 (C-Ar), 125.5 (C-Ar), 124.0 (C-Ar), 123.2 (C-Ar), 117.1 (C-Ar), 113.0 (C-Ar), 90.9 (C1″), 87.0 (C4″), 75.9 (C2″), 71.7 (C3″), 62.7 (C5″); LC/MS (system I): retention time: 1.48 min; UV_{max} = 325 nm; M.S. (ES) m s^{-1}: $C_{16}H_{16}N_2O_4S$: calculated $[M+H]^+$- 333.0909, actual $[M+H]^+$- 333.0906.

5-(3′-Thiophenyl)-1-(β-D-ribofuranosyl)benzimidazole (33). ^1H NMR (600 MHz, CD_3OD) δ (ppm): 9.09 (s, 1 H, H2′), 8.92 (s, 1 H, H5′), 8.49 (s, 2 H, H2, H4′), 8.01 (d, J = 1.7 Hz, 1 H, H4), 7.83 (d, J = 8.5 Hz, 1 H, H7), 7.70 (dd, J = 1.6, 8.5 Hz, 1 H, H6), 5.99 (d, J = 5.9 Hz, 1 H, H1″), 4.48 (t, J = 5.6, 5.6 Hz, 1 H, H2″), 4.29 (dd, J = 3.8, 5.3 Hz, 1 H, H3″), 4.14 (ddd, J = 3.4, 3.4, 3.4 Hz, 1 H, H4″), 3.88 (dd, J = 3.1, 12.1 Hz, 1 H, H5″), 3.81 (dd, J = 3.5, 12.1 Hz, 1 H, H5″); ^{13}C NMR (150 MHz, CD_3OD) δ (ppm): 157.5 (C-Ar), 145.1 (C-Ar), 144.1 (C-Ar), 144.0 (C-Ar), 142.5 (C-Ar), 134.1 (C-Ar), 129.2 (C-Ar), 123.9 (C-Ar), 118.4 (C-Ar), 118.4 (C-Ar), 113.3 (C-Ar), 90.9 (C1″), 87.1 (C4″), 76.0 (C2″), 71.8 (C3″), 62.7 (C5″); LC/MS (system I): retention time: 1.41 min; UV_{max} = 308 nm; M.S. (ES) m s^{-1}: $C_{16}H_{16}N_2O_4S$: calculated $[M+H]^+$- 333.0909, actual $[M+H]^+$- 333.0911.

5-(2′-Furanyl)-1-(β-D-ribofuranosyl)benzimidazole (34). ^1H NMR (600 MHz, CD_3OD) δ (ppm): 8.47 (s, 1 H, H2), 7.97 (d, J = 0.9 Hz, 1 H, H4), 7.76 (d, J = 8.5 Hz, 1 H, H7), 7.69 (dd, J = 1.5, 8.5 Hz, 1 H, H6), 7.55 (d, J = 1.2 Hz, 1 H, H5′), 6.75 (d, J = 3.3 Hz, 1 H, H3′), 6.51 (dd, J = 1.8, 3.3 Hz, 1 H, H4′), 5.97 (d, J = 5.8 Hz, 1 H, H1″), 4.46 (t, J = 5.6, 5.6 Hz, 1 H, H2″), 4.28 (dd, J = 3.9, 5.3 Hz, 1 H, H3″), 4.13 (ddd, J = 3.4, 3.4, 3.4 Hz, 1 H, H4″), 3.87 (dd, J = 3.1, 12.2 Hz, 1 H, H5″), 3.80 (dd, J = 3.5, 12.1 Hz, 1 H, H5″); ^{13}C NMR (150 MHz, CD_3OD) δ (ppm): 155.5 (C-Ar), 144.8 (C-Ar), 143.8 (C-Ar), 143.2 (C-Ar), 133.6 (C-Ar), 128.0 (C-Ar), 121.1 (C-Ar), 115.1 (C-Ar), 112.9 (C-Ar), 112.7 (C-Ar), 105.5 (C-Ar), 90.9 (C1″), 87.0 (C4″), 75.9 (C2″), 71.7 (C3″), 62.7 (C5″); LC/MS (system I): retention time: 1.32 min; UV_{max} = 316 nm; M.S. (ES) m s^{-1}: $C_{16}H_{16}N_2O_5$: calculated $[M+H]^+$- 317.1137, actual $[M+H]^+$- 317.1147.

5-(3′-Furanyl)-1-(β-D-ribofuranosyl)benzimidazole (35). ^1H NMR (600 MHz, CD_3OD) δ (ppm): 8.48 (s, 1 H, H2), 7.92 (d, J = 1.0 Hz, 1 H, H4), 7.75 (d, J = 8.5 Hz, 1 H, H7), 7.65 (dd, J = 1.6, 8.5 Hz, 1 H, H6), 7.60 (dd, J = 1.7, 2.6 Hz, 1 H, H4′), 7.49–7.47 (m, 2 H, H2′, H5′), 5.97 (d, J = 5.8 Hz, 1 H), 4.47 (t, J = 5.6, 5.6 Hz, 1 H), 4.29 (dd, J = 4.0, 5.3 Hz, 1 H), 4.13 (ddd, J = 3.4, 3.4, 3.4 Hz, 1 H), 3.88 (dd, J = 3.1, 12.2 Hz, 1 H), 3.80 (dd, J = 3.5, 12.1 Hz, 1 H); ^{13}C NMR (150 MHz, CD_3OD) δ (ppm): 144.9 (C-Ar), 143.7 (C-Ar), 143.6 (C-Ar), 133.4 (C-Ar), 132.8 (C-Ar), 127.4 (C-Ar), 127.3 (C-Ar), 123.6 (C-Ar), 120.8 (C-Ar), 117.6 (C-Ar), 112.8 (C-Ar), 90.9 (C1″), 87.0 (C4″), 75.9 (C2″), 71.7 (C3″), 62.7 (C5″); LC/MS (system I): retention time: 1.24 min; UV_{max} = 298 nm; M.S. (ES) m s^{-1}: $C_{16}H_{16}N_2O_5$: calculated $[M+H]^+$- 317.1137, actual $[M+H]^+$- 317.1141.

3-(Methyl)-5-(3′-thiophenyl)-1-(β-D-ribofuranosyl)benzimidazole (37) in a mixture. ^1H NMR (300 MHz, CD_3OD) is shown in the Supporting Information; UV_{max} = 300 nm; M.S. (ES) m s^{-1}:$C_{17}H_{19}N_2O_4S$: calculated $[M+H]^+$- 347.1066, actual $[M+H]^+$- 347.0965.

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