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Regioselective, Unconventional Pictet–Spengler Cyclization Strategy Toward the Synthesis of Benzimidazole-Linked Imidazoquinoxalines on a Soluble Polymer Support

Chih-Hau Chen, Jaren Kuo, Gorakh S. Yellol, and Chung-Ming Sun*[a]

Abstract: A novel strategy for an unconventional Pictet–Spengler reaction has been developed for the regioselective cyclization of the imidazole ring system at the C2 position. The developed strategy was utilized to develop a diversity-oriented parallel synthesis for bis(heterocyclic) skeletal novel analogs of benzimidazole-linked imidazoquinoxalines on a soluble polymer support under microwave conditions. Condensation of polymer-immobilized *o*-phenylenediamines with 4-fluoro-3-nitrobenzoic acid followed by nucleophilic aromatic substitution with an imidazole motif affords bis(heterocyclic) skeletal precursors for the Pictet–Spengler reaction. The unconventional Pictet–Spengler cyclization with various aldehydes was achieved regioselectively at the C2 position of the imidazole ring to furnish rare imidazole-fused quinoxaline skeletons. During the Pictet–Spengler cyclization, aldehydes bearing electron-donating groups afford 4,5-dihydro-imidazoquinoxalines, which then auto-aromatize into benzimidazole-linked imidazo[1,2-*a*]quinoxalines. However, interestingly, aldehydes bearing electron-withdrawing groups directly provide aromatized imidazo[1,2-*a*]quinoxalines, which unexpectedly afford novel benzimidazole-linked 4-methoxy-4,5-dihydro-imidazo[1,2-*a*]quinoxalines after polymer cleavage.

Keywords: diversity-oriented synthesis · heterocycles · microwave chemistry · Pictet–Spengler cyclization · solid-phase synthesis

Introduction

Diversity-oriented combinatorial synthesis and high-throughput screening have had an enormous impact in the field of drug discovery over the last two decades.[1] These two revolutionary concepts provide the high-throughput pathway for drug optimization. Combinatorial chemistry is motorized by solid-phase synthesis, as it speeds up the library synthesis by fast purification.[2] Although solid-phase synthesis (SPS) shows its efficiency in organic synthesis, new generation liquid-phase organic synthesis (LPOS) has evolved to overcome the disadvantages associated with SPS.[3] In LPOS, soluble polymer supports are used to enable homogenous reaction conditions and monitor reaction progress by conventional proton NMR spectroscopy, without cleavage of the support, along with product purification by precipitation and filtration. This methodology integrates the advantages of SPS and traditional organic synthesis and provides a useful platform for the diversity-oriented synthesis of drug-like compound libraries. The application of microwave irradiation in solid-phase synthesis is an efficient tool for reaction optimization as it dramatically speeds up the rate of the reactions and improves product yields and purities.[4] With the aid of microwave irradiation, medicinal chemists can maximize the efficiency of library production to satisfy the demand of high-through screening.[5] Also, application of microwave irradiation often fit into green chemistry protocols. Consequently, multidisciplinary synergetic approaches integrating microwave synthesis and LPOS with newer methods can provide a high-speed path for diversity-oriented library synthesis.[6]

Since 1911, the Pictet–Spengler reaction has been widely used for C–C bond formation in intramolecular and intermolecular cyclizations.[7] However, despite being an attractive strategy, its application is limited to condensation of an aldehyde with an amine and final cyclization between a sufficiently reactive aromatic moiety.[8] Recently Kundu and co-workers have reported the unusual Pictet–Spengler reaction by switching the position of the amine functionality in the imidazole ring and by using an aromatic amine instead

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of an aliphatic amine.[9] This promoted us to develop another kind of unconventional Pictet–Spengler reaction that could be applied in the synthesis of a library of small biologically interesting molecules. A careful survey of the literature revealed that the Pictet–Spengler reaction has never been applied to cyclization at the C2 position of the imidazole ring. Moreover, there are very few other methods for direct cyclization at the C2 position of the imidazole ring system.[10] The typical Pictet–Spengler reaction involves cyclization of an imidazole and an activated imine nucleus at the C5 position (Figure 1).[11] Using two reactive sites, blocking either position with some substitution to promote cyclization at the desired position, is a commonly employed strategy. This prompted us to explore the Pictet–Spengler reaction for regioselective cyclization at the C2 position of the imidazole ring system (Figure 1). Progressively, this led us to believe that our regioselective strategy for the Pictet–Spengler reaction can be applied for the synthesis of a variety of imidazole-embedded heterosystems of medicinal significance.

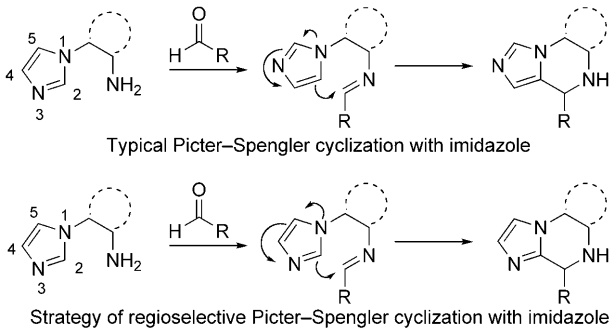


Figure 1. Regioselective strategy of the Pictet–Spengler cyclization with imidazole.

Imidazole-embedded benzimidazoles and imidazoquinoxalines are versatile pharmacophores in many drug candidates. Benzimidazoles are reported as potential bioactive motifs toward different targets such as hepatitis C virus NS5B RNA-dependent RNA polymerase inhibitors, transforming growth factor-β type I receptor inhibitors, anti-hepatitis B virus agents, and topoisomerase I inhibitors.[12] In contrast to benzimidazole, very few reports are associated with the synthesis of imidazo[1,2-*a*]quinoxalines. Bonnet and co-workers synthesized derivatives of compound **I**, elucidated SAR studies, and proposed some of these derivatives to exhibit cyclic nucleotide phosphordiesterase inhibitory activity.[13a] Imidazo[1,2-*a*]quinoxalin-4-amine **II** was synthesized by Ceccarelli and co-workers and they evaluated it as a non-xanthine A1-adenosine receptor antagonist.[13b] Similarly, imidazo[1,2-*a*]quinoxalines **III** and **IV** have been found to possess antiallergic and antimicrobial activities, respectively.[14] To the best of our knowledge, the synthesis of a bis(heteroaryl) system of benzimidazole-linked imidazoquinoxaline has not yet been reported, while the bioactivities of these bis(heteroaryl) analogs are interesting (Figure 2).

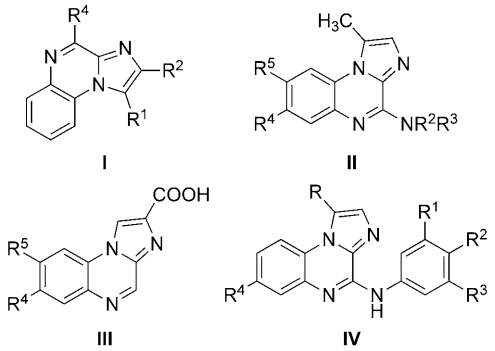


Figure 2. Bioactive imidazo[1,2-*a*]quinoxalines.

In continuation with our research interests that focus on the development of multifunctional heterocyclic molecules,[15] here we report the unconventional Pictet–Spengler reaction for the regioselective cyclization with an imidazole motif. This microwave-assisted high-speed path applied toward the combined bi-heterocyclic skeleton with imidazoquinoxalines and benzimidazole has a substantial intellectual appeal resembling drug-like molecules.

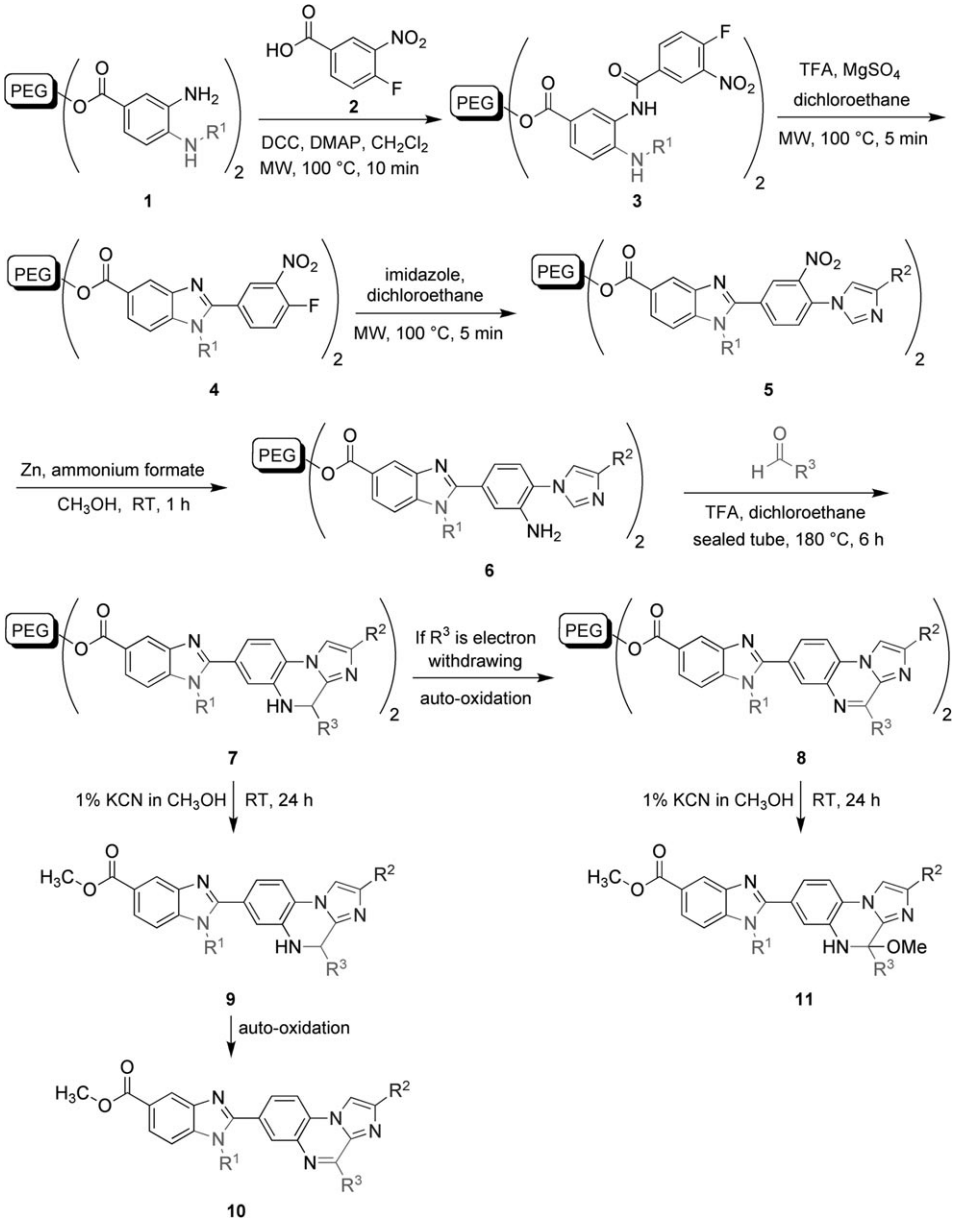
Results and Discussion

The polymer-immobilized *N*-alkylated *o*-phenylenediamine **1** was prepared through a three-step synthetic protocol installing the first diversity (R^1) in the growing skeleton.[3] PEG-supported diamine **1** was continuously treated with 4-fluoro-3-nitrobenzoic acid **2** in the presence of *N*,*N*′-dicyclohexylcabodimide (DCC) and *N*,*N*′-dimethylaniline pyridine (DMAP). The coupling reaction was completed in 10 minutes under microwave irradiation at 100 °C, however, it took 24 hours to convert **1** into polymer conjugate **3** under traditional refluxing conditions. The polymer-bound intermediate was separated by a simple precipitation method with low polarity solvents in each step of the current reaction sequence. The rate of functional group transformation was monitored directly on a polymer support by observing the change in the shift of the aromatic region in regular proton NMR spectrum. The amine–acid coupling reaction occurs regioselectivity with primary amines because an amide proton was observed at 9.1 ppm. The polymer-bound amide **3** was further cyclized into benzimidazole **4** in the presence of trifluoroacetic acid and magnesium sulfate under microwave irradiation after 5 minutes at 100 °C. However, it took 14 hours to complete cyclization under refluxing conditions. Mechanistically, nucleophilic attack by a secondary amine to the carbonyl group of the amide followed by dehydration furnishes the benzimidazole skeleton. The completion of the cyclization reaction was confirmed by the down-field shift of the aromatic protons in the NMR spectrum of compound **4**. The imidazole moiety is introduced to the immobilized *o*-fluoronitrobenzene **4** by a nucleophilic aromatic substitution reaction toward the targeted imidazole-fused quinoxaline skeleton. Accordingly, PEG conju-

gate **4** was treated with different imidazoles and was thus further diversified. This S_NAr reaction was completed in 5 minutes in a microwave cavity at 100 °C–usually takes 16 hours to complete under traditional reflux conditions–to afford polymer-bound *o*-imidazo-nitrobenzene **5**. It is noteworthy that the S_NAr reaction with imidazoles did not cleave the ester bond of the polymer linkage site even under harsh microwave conditions. The success of the S_NAr reaction as well as the structure of compound **5** was unambiguously confirmed by COSY and HMBC (2D NMR) experiments directly on a polymer support (see the Supporting Information). The nitro group of compound **5** was then reduced into an amine by using zinc and ammonium formate. The formation of the PEG-amine conjugate was observed from the expected change in the aromatic pattern of the proton NMR spectrum.

Scheme 1

As per our designed strategy, we decided to apply the Pictet–Spengler reaction for the cyclization at the C2 position of the imidazole ring system by using the *N*1-linked aromatic amine of the imidazole with aldehydes. The optimization of the Pictet–Spengler reaction, either at room temperature or refluxing temperature, failed to produce any coupling products. Screening of the Pictet–Spengler reaction under several microwave conditions also did not provide satisfactory results. During the optimization of the reaction conditions, we observed that when reactive aldehydes (*p*-nitrobenzaldehydes) are employed, the expected Pictet–Spengler cyclization product is afforded with low yields after prolonged refluxing conditions. However, electron-donating aldehydes (*p*-methoxybenzaldehyde) and aliphatic aldehydes remained unreacted under these conditions. Gratifyingly, in a sealed tube at 180 °C under high-pressure acidic conditions, the Pictet–Spengler reaction afforded the expected and regioselective results. Initial trials under sealed tube conditions revealed that the Pictet–Spengler reaction afforded the expected product in 40–50% yield within one hour. After few trials, the Pictet–Spengler cyclization reaction conditions were optimized to afford the desired regioselective product in good yield. According to the optimized conditions, immobilized *o*-imidazo-aniline **6** was treated with different kinds of aliphatic and aromatic aldehydes in a sealed tube in a mixture of trifluoroacetic acid and dichloroethane at 180 °C for 6 hours. The amine functionality of compound **6** reacted with an aldehyde to form an imine, followed by cyclization at the C2 carbon of the imidazole moiety to furnish the tricyclic imidazo[1,2-*a*]quinoxaline skeleton **7**. This immobilized benzimidazole-linked imidazoquinoxaline **7** was again separated and purified by simple precipitation in ether. It is noteworthy, that we obtained the regioselective cyclization at the C2 carbon of an imidazole from two possible reactive

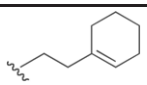
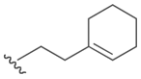
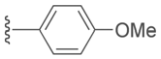
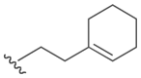
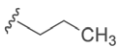
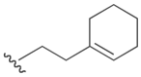
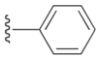
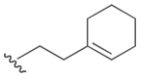
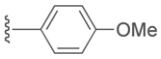
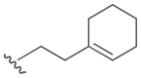
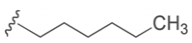
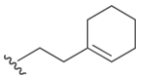
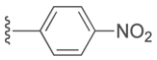
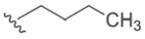
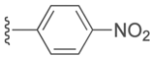
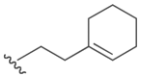
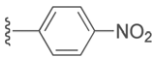
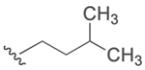
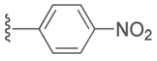
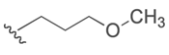
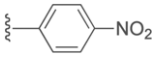
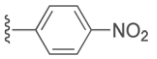
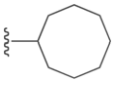
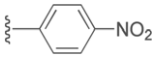
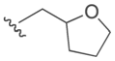


Scheme 1. Microwave-assisted synthesis of benzimidazole-linked imidazoquinoxalines. DCC = *N*,*N*′-dicyclohexylcabodimide; DMAP = *N*,*N*′-dimethylaniline pyridine; TFA = trifluoroacetic acid.

sites (C2 and C5) of cyclization. The regioselective cyclization was elucidated from the ^{1}H NMR spectrum of compound **7**, and this was later confirmed by COSY NMR relation studies after removal of the polymer support (Figure 4). In addition to this, herein we have observed interesting results, which depend upon the electronic nature of the aldehyde and the substituent present on the imidazole ring. In the case of the electron-rich aldehydes (Table 1, entries **10a**–**10f**), we observed the smooth formation of 4,5-dihydro-imidazo-quinoxaline **7**. Whereas, the Pictet–Spengler reaction with aldehydes bearing electron-withdrawing groups, such as *p*-nitrobenzaldehyde directly obtained imidazo-quinoxaline **8**, an aromatized derivative of compound **7**. The immediate auto-oxidation towards compound **8** is feasible owing to the high-acidic nature of the benzylic proton of the *p*-nitrobenzyl group in compound **7**.

The cleavage of the polymer support from compound **7** was carried out by using a 1% potassium cyanide solution in methanol. The polymer was precipitated out by addition of a cold ether solution and the filtrates were concentrated to obtain polymer-free benzimidazole-imidazo[1,2-*a*]quinoxaline **9**. Compound **9** was found to be unstable and it underwent auto-aromatization slowly at ambient temperature and converted completely into the benzimidazole-imidazo-[1,2-*a*]quinoxaline **10**. The auto-aromatization of compound **9** into product **10** was monitored by ^{1}H NMR spectroscopy. The comparable proton NMR spectra, after certain time intervals, are shown in Figure 3. Spectrum A shows the peaks corresponding to the benzylic proton (H^1) and the amine proton (H^2) at 5.51 and 5.08 ppm, respectively, for compound **9e**. Spectrum B was recorded after 10 days and it shows the gradual decrease in the integration of the H^1 and

Table 1. Synthesis of imidazo[1,2-*a*]quinoxaline **10** and **11** on a soluble support.

Entry	R^1	R^2	R^3	LRMS[a]	Yield[b]
10a				572	70%
10b				557	82%
10c				493	65%
10d				541	58%
10e				571	67%
10f				549	56%
10g				586	69%
10h				534	65%
11a				604	79%
11b				566	70%
11c				568	67%
11d				578	73%
11e				606	62%
11f				580	70%
11g				538	60%

[a] ESI mass, molecular peak recorded as [*M*+H]. [b] Yields were determined on the weight of purified samples.

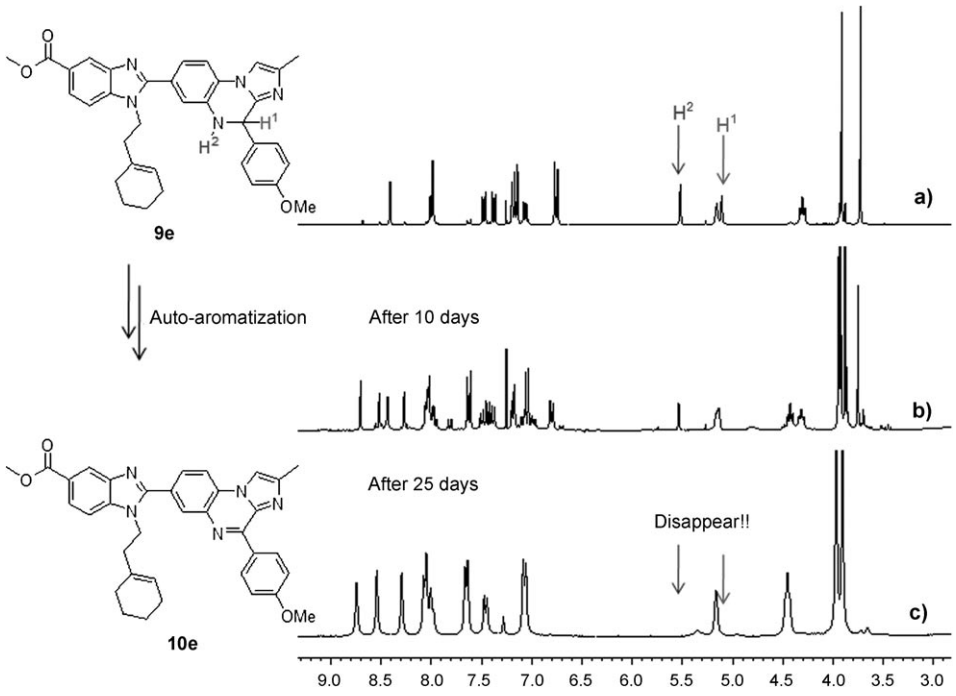


Figure 3. Proton NMR monitoring of auto-aromatization of compounds **9e**–**10e**.

H^2 proton peaks. This indicates that compound **9e** is progressively converted into the imidazoquinoxaline **10e** under air. Finally after 25 days, compound **9a** was completely aromatized into compound **10e** as shown from spectrum C, in which the peaks corresponding to the H^1 and H^2 protons have completely disappeared along with some shifting of relative peaks in the aromatic region. The rate of auto-aromatization depends on the substituent present on the aldehyde moiety. It is observed that the general reactivity trend is *p*-nitrobenzaldehyde > benzaldehyde≅*p*-methoxybenzaldehyde > aliphatic aldehydes.

Interestingly, in the removal of the polymer support from compound **8** using a 1% potassium cyanide solution in methanol at room temperature after 24 hours, we obtained the polymer-free methoxylated benzimidazole-imidazo[1,2-a]quinoxaline **11** as the only compound in good yield. The methoxy group attacks the carbon of the imine owing to the electron-withdrawing nitro group dispersing the electron density of the carbon of the imine. It should be noted that when compared with **11a**–**g**, the imidazoles of **10g** and **10h** were replaced by 4-methylimidazoles and the attack of methoxy group was not observed. This indicated that the additional weak electron-donating effect of the methyl group on the imidazole can increase the electron density of the carbon of the imine and prevent it from attack by the methoxy group.

The illustrated strategy was generalized by using various substitutions on the benzimidazole motif (R^1), by taking substituted imidazole (R^2), and by using various aldehydes (R^3). The corresponding benzimidazole-imidazo[1,2-*a*]quinoxaline **10** and methoxylated benzimidazole-imidazo[1,2-*a*]quinoxaline **11** were obtained in good yields as depicted in Table 1. The regioselective outcome of the Pictet–Spengler reaction was confirmed by COSY analysis studies after the removal of the polymer support. The COSY spectrum and correlation of the respective proton peaks for compound **10h** are depicted in Figure 4. In the COSY spectrum of **10h**, the peaks corresponding to the H_a proton show a strong correlation with the H_b proton peak. The H_d proton also shows strong correlation with the H_c proton; this suggests that the H_d and H_c protons are adjacent to each other. In the case of the other regioisomer (compound **10h**–**a**), the H_d proton is not

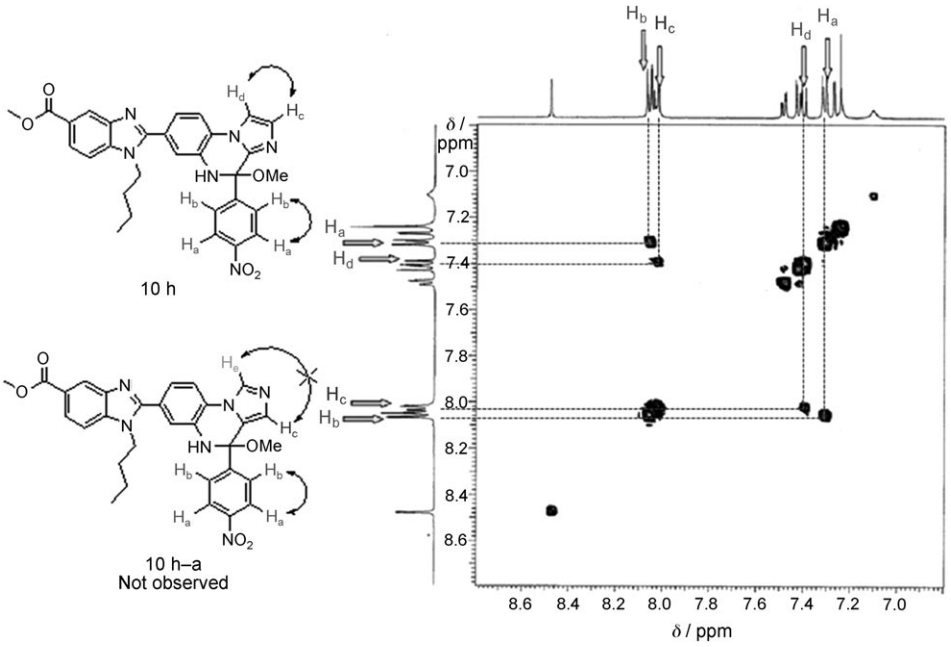


Figure 4. COSY NMR spectrum of compound **10h**.

supposed to correlate with any proton. These observations clearly confirm the regioselective cyclization through an unconventional Pictet–Spengler reaction.

Conclusions

In summary, we have achieved an alternative application of an unconventional Pictet–Spengler reaction for the regioselective cyclization at the C2 position of the imidazole ring system. The developed strategy was utilized for the efficient synthesis of biologically promising novel bis(heteroaryl) skeletal benzimidazole-imidazo[1,2-*a*]quinoxalines with three points of diversity on a soluble polymer support under microwave conditions. The Pictet–Spengler reaction, bearing aldehydes with electron-donating groups provides benzimidazole-dihydroimidazo[1,2-*a*]quinoxaline **7,** which further auto-aromatized into benzimidazole-linked imidazo[1,2-*a*]quinoxaline **10**. While, aldehydes bearing electron-withdrawing groups directly produce aromatized benzimidazole-imidazo[1,2-*a*]quinoxaline **8** in the Pictet–Spengler reaction. These electron-withdrawing aldehydes subsequently deliver novel analogs of benzimidazole-linked 4-methoxy-dihydroimidazo[1,2-*a*]quinoxaline **11**. This multidisciplinary synergetic approach integrating microwave synthesis, soluble polymer-supported synthesis with an unconventional Pictet–Spengler reaction illustrates a new process for the efficient synthesis of biologically promising molecules.

Experimental Section

General Methods

Dichloroethane and methanol were distilled before use. All reactions were performed under an inert atmosphere with unpurified reagents and dry solvents. Analytical thin-layer chromatography (TLC) was performed using 0.25 mm silica gel coated Kieselgel 60 F254 plates. Flash chromatography was performed using the indicated solvent and silica gel 60 (Merck, 230–400 mesh). ^{1}H NMR (300 MHz) and ^{13}C NMR (75 MHz) spectra were recorded on a Bruker DX-300 spectrometer. Chemical shifts are reported in parts per million (ppm) on the scale from an internal standard. High-resolution mass spectra (HRMS) were recorded on a JEOL TMS-HX 110 mass spectrometer. Normal phase HPLC was performed on a Shimadzu LC-10AT series machine with a Hypersil (250× 4.6 mm) analytical column. PEG was purchased from SHOWA (Tokyo, Japan). A monomode CEM Discover microwave reactor with standard configuration operating at a maximum power of 300 W and equipped with an infrared pyrometer for the control of temperature and a compressed air system for cooling was used. All the microwave experiments were performed under optimized reaction conditions of power and temperature in a closed vessel. To monitor the progression of reaction on a polymer support, a small portion of the reaction mixture was extracted, the compound was precipitated and washed with cold ether, subsequently dried, and a proton NMR spectrum was recorded.

General procedure for the synthesis of 1-alkyl-2-(4-phenyl-imidazo[1,2-a] quinoxalin-7-yl)-1H-benzoimidazole-5-carboxylic acid methyl ester

The polymer support **1** (PEG 4000; 1.00 g, 1.0 equiv, 0.25 mmol) in dichloromethane (5 mL) was treated with 4-fluoro-3-nitrobenzoic acid **2** (0.11 g, 2.4 equiv, 0.60 mmol) in dichloromethane (5 mL) and this was treated with DCC (0.144 g, 2.8 equiv, 0.70 mmol) in the presence of catalytic 4-dimethylaminopyridine (DMAP) (0.003 g) under MW (150 W) irradiation for 20 min to afford amide **3**. The separated dicyclohexyl urea (DCU) was filtered off and the reaction mixture was diluted with slow addition of excess cold ether (50 mL). The precipitated amide conjugate was filtered through a fritted funnel, washed with ether, and then dried. Trifluoroacetic acid (0.5 mL) and $MgSO_4$ (0.5 g) were added to a solution of **3** in dichloroethane. The reaction mixture was refluxed for 15 h and after completion, the reaction mixture was passed through a thin layer of celite to remove $MgSO_4$. The solution was concentrated by rotary evaporation and diluted with slow addition of an excess of cold ether. The precipitated benzimidazole conjugate was filtered through a fritted funnel and washed with ether to afford **4**. Compound **4** was then treated with imidazole (0.12 g, 7 equiv, 1.75 mmol) in dichloroethane under MW (150W) irradiation for 40 min. After completion of the reaction, the reaction mixture was washed with ether and dried to yield **5**. Zinc (0.5 g, 30.0 equiv, 7.5 mmol) and ammonium formate (0.24 g, 15.0 equiv, 3.75 mmol) were added to a solution of **5** in methanol (10 mL). The reaction mixture was allowed to stir for 1 hour at room temperature. The mixture was then centrifuged to remove zinc and concentrated by rotary evaporation to remove methanol. Then dichloromethane was added to salt out the ammonium formate. The mixture was passed through a thin layer of celite to remove ammonium formate to afford amine **6**. TFA (1 mL) and the aldehyde (0.27 g, 10.0 equiv, 2.5 mmol) were added to a solution of **6** in dichloroethane (10 mL). The reaction mixture was refluxed in a sealed tube for six hours. After completion, the reaction mixture was washed with ether and a mixture of **7/8** was obtained. To a solution of **7/8** in methanol (10 mL), KCN (0.1 g) was added and stirred for 1 day. After the quenching procedure, the crude products **9** or **11** were obtained. The crude product was purified by column chloromatography (ethyl acetate/acetone = 7:1), then compound **9** was further exposed to air for auto-aromatization and finally compounds **10** and **11** were obtained in a total yield of 56~82%.

*1-(2-Cyclohex-1-enyl-ethyl)-2-(4-phenyl-imidazo[1,2-a]quinoxalin-7-yl)-1 H-benzoimidazole-5-carboxylic acid methyl ester (**10a**)*

^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.84 (s, 1H, ArH), 8.56 (s, 1H, ArH), 8.42 (s, 1H, ArH), 8.30–7.70 (m, 6H, ArH), 7.55–7.65 (m, 3H, ArH), 7.48 (d, 1H, J = 8.5 Hz, ArH), 5.22 (s, 1H, cyclohexeneyl-C=C*H*), 4.47 (t, 2H, J = 7.0 Hz, NCH_2CH$_2$), 3.97 (s, 3H, CO_2CH_3), 2.42 (t, J = 7.0 Hz, 2H, NCH$_2$CH_2), 1.89–1.72 (m, 4H, cyclohenexyl), 1.53–1.35 ppm (m, 4H, cyclohenexyl); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 167.5 (C_q), 154.9 (C_q), 153.9 (C_q), 142.6 (C_q), 138.9 (C_q), 136.9 (C_q), 136.4 (C_q), 132.8 (C_q), 132.8 (C_q), 131.0 (CH), 130.6 (CH), 129.5 (CH), 129.1 (C_q), 128.9 (CH), 128.3 (CH), 125.0 (CH), 125.0 (CH), 124.7 (C_q), 124.7 (C_q), 124.5 (CH), 122.4 (CH), 115.0 (CH), 110.1 (CH), 110.1 (CH), 52.1(CH_3), 44.0 (CH_2), 37.8 (CH_2), 28.2 (CH_2), 25.0 (CH_2), 22.5 (CH_2), 21.8 ppm (CH_2); IR (KBr): $\tilde{\nu}$ = 2924, 1709, 1305 cm^{-1}; EI-MS m/z 527 [M^+]; HRMS: m/z calcd for $C_{33}H_{29}N_5O_2$: 527.2321; found: 527.2319.

*1-(2-Cyclohex-1-enyl-ethyl)-2-[4-(4-methoxy-phenyl)-imidazo[1,2-a]quinoxalin-7-yl]-1H-benzoimidazole-5-carboxylic acid methyl ester (**10b**)*

^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.82 (s, 1H, ArH), 8.56 (d, 1H, J = 1.1 Hz, ArH), 8.39 (d, 1H, J = 1.6 Hz, ArH), 8.15–8.00 (m, 6H, ArH), 7.48 (d, 1H, J = 8.6 Hz, ArH), 7.11 (d, 2H, J = 8.8 Hz, ArH), 5.22 (s, 1H, cyclohexeneyl-C=C*H*), 4.47 (t, 2H, J = 7.1 Hz, NCH_2CH$_2$), 3.98 (s, 3H, CO_2CH_3), 3.93 (s, 3H, OCH_3), 2.42 (t, 2H, J = 7.1 Hz, NCH$_2$CH_2), 1.92–1.75 (m, 4H, cyclohenexyl), 1.53–1.37 ppm (m, 4H, cyclohenexyl); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 167.6 (C_q), 162.0 (C_q), 154.2 (C_q), 154.0 (C_q), 142.6 (C_q), 138.9 (C_q), 136.5 (C_q), 132.8 (C_q), 132.8 (C_q), 131.6 (C_q), 130.4 (CH), 129.9 (CH), 129.5 (C_q), 129.1 (CH), 129.0 (C_q), 125.1 (CH), 125.1 (CH), 124.7 (C_q), 124.5 (CH), 122.4 (CH), 114.9 (CH), 114.3 (CH), 110.1 (CH), 110.1 (CH), 55.5 (CH_3), 52.1(CH_3), 44.0 (CH_2), 37.8 (CH_2), 28.2 (CH_2), 25.1 (CH_2), 22.5 (CH_2), 21.8 ppm (CH_2); IR (KBr): $\tilde{\nu}$ = 2924, 1715, 1305 cm^{-1}; EI-MS m/z 557 [M^+]; HRMS m/z calcd for $C_{34}H_{31}N_5O_3$: 557.2427; found: 557.2433.

*1-(2-Cyclohex-1-enyl-ethyl)-2-(4-propyl-imidazo[1,2-a]quinoxalin-7-yl)-1H-benzoimidazole-5-carboxylic acid methyl ester (**10c**)*

^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.73 (s, 1H, ArH), 8.51 (s, 1H, ArH), 8.27 (s, 1H, ArH), 8.09–7.91 (m, 3H, ArH), 7.85 (s, 1H, ArH), 7.44 (d, 1H, J = 8.5 Hz, ArH), 5.18 (s, 1H, cyclohexeneyl-C=C*H*), 4.41 (t, 2H, J = 7.0 Hz, NCH_2CH$_2$), 3.94 (s, 3H, CO_2CH_3), 3.01 (t, 2H, J = 7.3 Hz, CH_2CH$_2$CH$_3$), 2.38 (t, 2H, J = 6.6 Hz, NCH$_2$CH_2), 2.00–1.90 (m, 2H, CH$_2$CH_2CH$_3$), 1.84–1.67 (m, 4H, cyclohexenyl), 1.47–1.35 (m, 4H, cyclohexenyl), 1.07 ppm (t, 3H, J = 7.3 Hz, CH_2CH$_2$CH_3); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 167.5 (C_q), 158.4 (C_q), 153.9 (C_q), 142.5 (C_q), 138.8 (C_q), 136.1 (C_q), 132.7 (C_q), 132.7 (C_q), 130.1 (CH), 130.1 (CH), 128.9 (CH), 128.8 (C_q), 125.0 (CH), 124.7 (C_q), 124.7 (C_q), 124.4 (CH), 122.3 (CH), 114.9 (CH), 110.0 (CH), 110.0 (CH), 52.0 (CH_3), 44.0 (CH_2), 37.8 (CH_2), 37.6 (CH_2), 28.1 (CH_2), 25.0 (CH_2), 22.4 (CH_2), 21.8 (CH_2), 21.1 (CH_2), 14.0 ppm (CH_3); IR (KBr): $\tilde{\nu}$ = 2928, 1715, 1303 cm^{-1}; EI-MS m/z 493 [M^+]; HRMS m/z calcd for $C_{30}H_{31}N_5O_2$: 493.2478; found: 493.2477.

*1-(2-Cyclohex-1-enyl-ethyl)-2-(2-methyl-4-phenyl-imidazo[1,2-a]quinoxalin-7-yl)-1H-benzoimidazole-5-carboxylic acid methyl ester (**10d**)*

^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.75 (s, 1H, ArH), 8.55 (d, 1H, J = 1.2 Hz, ArH), 8.32 (d, 1H, J = 1.7 Hz, ArH), 8.13–8.00 (m, 3H, ArH), 7.70–7.65 (m, 2H, ArH), 7.60–7.50 (m, 3H, ArH), 7.47 (d, 1H, J = 8.5 Hz, ArH), 5.16 (s, 1H, cyclohexeneyl-C=C*H*), 4.46 (t, 2H, J = 7.0 Hz, NCH_2CH$_2$), 3.97 (s, 3H, CO_2CH_3), 2.37 (t, 2H, J = 7.0 Hz, NCH$_2$CH_2), 2.24 (s, 3H, CH_3), 1.85–1.65 (m, 4H, cyclohexenyl), 1.45–1.37 ppm (m, 4H, cyclohexenyl); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 167.6 (C_q), 157.0 (C_q), 154.0 (C_q), 142.6 (C_q), 138.9 (C_q), 138.5 (C_q), 137.5 (C_q), 136.0 (C_q), 132.7 (C_q), 130.2 (CH), 130.1 (CH), 129.4 (CH), 128.8 (C_q), 128.6 (CH), 128.5 (CH), 128.4 (CH), 125.7 (C_q), 125.0 (CH), 124.7 (C_q), 124.4 (CH), 122.4 (CH), 120.1 (C_q), 114.7 (CH), 110.1 (CH), 52.1 (CH_3), 43.9 (CH_2), 37.7 (CH_2), 28.2 (CH_2), 25.0 (CH_2), 22.5 (CH_2), 21.8(CH_2), 16.2 ppm (CH_3); IR (KBr): $\tilde{\nu}$ = 2925, 1715, 1301 cm^{-1}; EI-MS m/z 541 [M^+]; HRMS m/z calcd for $C_{34}H_{31}N_5O_2$: 541.2478; found: 541.2481.

*1-(2-Cyclohex-1-enyl-ethyl)-2-[4-(4-methoxy-phenyl)-2-methyl-imidazo[1,2-a]quinoxalin-7-yl]-1H-benzoimidazole-5-carboxylic acid methyl ester (**10e**)*

^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.74 (s, 1H, ArH), 8.54 (s, 1H, ArH), 8.29 (s, 1H, ArH), 8.13–7.95 (m, 3H, ArH), 7.65 (d, 2H, J = 8.0 Hz, ArH), 7.46 (d, 1H, J = 8.4 Hz, ArH), 7.07 (d, 2H, J = 8.0 Hz, ArH), 5.16 (s, 1H, cyclohexeneyl-C=C*H*), 4.45 (t, 2H, J = 7.2 Hz, NCH_2CH$_2$), 3.97 (s, 3H, CO_2CH_3), 3.91 (s, 3H, OC*H3*), 2.37 (t, 2H, J = 7.2 Hz, NCH$_2$CH_2), 2.31 (s, 3H, CH_3), 1.88–1.70 (m, 4H, cyclohexenyl), 1.48–1.35 ppm (m, 4H, cyclohexenyl); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 167.5 (C_q), 161.1 (C_q), 156.6 (C_q), 154.0 (C_q), 142.5 (C_q), 138.9 (C_q), 138.2 (C_q), 136.1 (C_q), 132.7 (C_q), 130.2 (CH), 130.0 (CH), 129.9 (C_q), 129.1 (CH), 128.7 (C_q), 128.4 (CH), 125.6 (C_q), 124.9 (CH), 124.6 (C_q), 124.4 (CH), 124.4 (CH), 122.3 (CH), 120.2 (C_q), 114.6 (CH), 113.8(CH), 110.1 (CH), 55.4 (CH_3), 52.1(CH_3), 43.9 (CH_2), 37.7 (CH_2), 28.1 (CH_2), 25.0 (CH_2), 22.5 (CH_2), 21.8 (CH_2), 16.5 ppm (CH_3); IR (KBr): $\tilde{\nu}$ = 2926, 1713, 1305 cm^{-1}; EI-MS m/z 571 [M^+]; HRMS m/z calcd for $C_{35}H_{33}N_5O_3$: 571.2583; found: 571.2581.

*1-(2-Cyclohex-1-enyl-ethyl)-2-[2-methyl-4-(4-nitro-phenyl)-imidazo[1,2-a]quinoxalin-7-yl]-1H-benzoimidazole-5-carboxylic acid methyl ester (**10f**)*

^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.79 (s, 1H, ArH), 8.54 (d, 1H, J = 1.1 Hz, ArH), 8.45 (d, 2H, J = 8.7 Hz, ArH), 8.34 (d, 1H, J = 1.6 Hz, ArH), 8.15–8.05 (m, 3H, ArH), 7.90 (d, 2H, J = 8.7 Hz, ArH), 7.48 (d, 1H, J = 8.6 Hz, ArH), 5.19 (s, 1H, cyclohexeneyl-C=C*H*), 4.46 (t, 2H, J = 7.1 Hz, NCH_2CH$_2$), 3.97 (s, 3H, CO_2CH_3), 2.40 (t, 2H, J = 7.1 Hz, NCH$_2$CH_2), 2.27 (s, 3H, CH_3), 1.88–1.72 (m, 4H, cyclohexenyl), 1.50–1.35 ppm (m, 4H, cyclohexenyl); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 167.5 (C_q), 154.5 (C_q), 153.7 (C_q), 148.8 (C_q), 143.5 (C_q), 142.6 (C_q), 138.9 (C_q), 138.1 (C_q), 135.7 (C_q), 132.7 (C_q), 130.5 (CH), 130.1 (CH), 129.9 (CH), 129.2 (C_q), 128.9 (CH), 125.7 (C_q), 125.1 (CH), 124.8 (C_q), 124.6 (CH), 123.7 (CH), 122.4 (CH), 119.7 (C_q), 114.8 (CH), 110.1 (CH), 52.1 (CH_3), 44.0 (CH_2), 37.8 (CH_2), 29.3 (CH_2), 25.0 (CH_2), 22.5 (CH_2), 21.8 (CH_2), 16.4 ppm (CH_3); IR (KBr): $\tilde{\nu}$ = 2925, 1714, 1522, 1347, 1302, 1286 cm^{-1}; EI-MS m/z 586 [M^+]; HRMS m/z calcd for $C_{34}H_{30}N_6O_4$: 586.2329; found: 586.2322.

*1-(2-Cyclohex-1-enyl-ethyl)-2-(4-hexyl-2-methyl-imidazo[1,2-a]quinoxalin-7-yl)-1H-benzoimidazole-5-carboxylic acid methyl ester (**10g**)*

^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.56 (s, 1H, ArH), 8.47 (s, 1H, ArH), 8.16 (s, 1H, ArH), 8.00 (d, 1H, J = 8.4 Hz, ArH), 7.97–7.85 (m, 2H, ArH), 7.40 (d, 1H, J = 8.4 Hz, ArH), 5.13 (s, 1H, cyclohexeneyl-C=C*H*), 4.37 (t, 2H, J = 6.9 Hz, NCH_2CH$_2$), 3.90 (s, 3H, CO_2CH_3), 3.04 (t, 2H, J = 7.7 Hz, CH_2(CH$_2$)$_4$CH$_3$), 2.72 (s, 3H, CH_3), 2.31 (t, 2H, J = 6.9 Hz, , NCH$_2$CH_2), 1.85–1.65 (m, 6H, cyclohexenyl and CH$_2$CH_2(CH$_2$)$_3$CH_3), 1.40–1.10 (m, 10H, cyclohexenyl and CH$_2$CH$_2$(CH_2)$_3$CH_3)), 0.84 ppm (t, 3H, J = 6.4 Hz, CH$_2$(CH$_2$)$_4$CH_3); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 167.6 (C_q), 159.3 (C_q), 154.2 (C_q), 142.6 (C_q), 138.9 (C_q), 136.7 (C_q), 136.0 (C_q), 132.8 (C_q), 129.8 (CH), 128.7 (CH), 128.6 (C_q), 127.8 (CH), 125.9 (C_q), 125.0 (CH), 124.7 (C_q), 124.4 (CH), 122.4 (CH), 120.6 (C_q), 114.5 (CH), 110.0 (CH), 52.1 (CH_3), 44.0 (CH_2), 37.8 (CH_2), 36.6 (CH_2), 31.7 (CH_2), 29.7 (CH_2), 29.2 (CH_2), 28.2 (CH_2), 25.1 (CH_2), 22.6 (CH_2), 22.5 (CH_2), 21.8 (CH_2), 16.1 (CH_3), 14.0 ppm (CH_3); IR (KBr): $\tilde{\nu}$ = 2927, 1716, 1301 cm^{-1}; EI-MS m/z 549 [M^+]; HRMS m/z calcd for $C_{34}H_{39}N_5O_2$: 549.3104; found: 549.3111.

*1-Butyl-2-[2-methyl-4-(4-nitro-phenyl)-imidazo[1,2-a]quinoxalin-7-yl]-1H-benzoimidazole-5-carboxylic acid methyl ester (**10h**)*

^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.79 (s, 1H, ArH), 8.55 (s, 1H, ArH), 8.44 (d, 2H, J = 8.4 Hz, ArH), 8.31 (s, 1H, ArH), 8.15–8.04 (m, 3H, ArH), 7.90 (d, 2H, J = 8.4 Hz, ArH), 7.48 (d, 1H, J = 8.5 Hz, ArH), 4.38 (t, 2H, J = 7.4 Hz, NCH_2CH$_2$CH$_2$CH$_3$), 3.97 (s, 3H, CO_2CH_3), 2.26 (s, 3H, CH_3), 1.87–1.76 (m, 2H, NCH$_2$CH_2CH$_2$CH$_3$), 1.33–1.20 (m, 2H, NCH$_2$CH$_2$CH_2CH$_3$), 0.86 ppm (t, 3H, J = 7.3 Hz, NCH$_2$CH$_2$CH$_2$CH_3); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 167.5 (C_q), 154.5 (C_q), 153.6 (C_q), 148.7 (C_q), 143.5 (C_q), 142.6 (C_q), 138.8 (C_q), 138.1 (C_q), 135.7 (C_q), 130.5 (CH), 130.2 (CH), 129.9 (CH), 129.1 (C_q), 128.9 (CH), 125.7 (C_q), 124.8 (C_q), 123.8 (CH), 122.4 (CH), 119.6 (C_q), 115.3 (CH), 110.4 (CH), 110.0 (CH), 52.6 (CH_3), 45.3 (CH_2), 32.2 (CH_2), 20.3 (CH_2), 16.8 (CH_3), 13.9 ppm (CH_3); IR (KBr): $\tilde{\nu}$ = 2927, 1714, 1521, 1348, 1302, 1287 cm^{-1}; EI-MS m/z 534 [M^+]; HRMS m/z calcd for $C_{30}H_{26}N_6O_4$: 534.2016; found: 534.2017.

*1-(2-Cyclohex-1-enyl-ethyl)-2-[4-methoxy-4-(4-nitro-phenyl)-4,5-dihydro-imidazo[1,2-a]quinoxalin-7-yl]-1H-benzoimidazole-5-carboxylic acid methyl ester (**11a**)*

^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.51 (s, 1H, N*H*), 8.09–8.01 (m, 3H, ArH), 7.55–7.47 (m, 2H, ArH), 7.42 (d, 1H, J = 8.7 Hz, ArH), 7.36 (dd, 2H, J = 4.8 Hz, J = 3.2 Hz, ArH), 7.26 (d, 2H, J = 8.7 Hz, ArH), 7.13 (s, 1H, ArH), 6.98 (s, 1H, ArH), 5.09 (s, 1H, cyclohexeneyl-C=C*H*), 4.30 (t, 2H, J = 7.0 Hz, NCH_2CH$_2$), 4.02 (s, 3H, OCH_3), 3.96 (s, 3H, CO_2CH_3), 2.28 (t, 2H, J = 7.0 Hz, NCH$_2$CH_2), 1.85–1.75 (m, 4H, cyclohexenyl), 1.55–1.35 ppm (m, 4H, cyclohexenyl); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 167.3 (C_q), 159.0 (C_q), 153.4 (C_q), 148.3 (C_q), 142.2 (C_q), 142.1 (C_q), 138.8 (C_q), 135.6 (C_q), 132.5 (C_q), 132.5 (C_q), 130.7 (C_q), 129.4 (CH), 129.3 (C_q), 129.1 (CH), 125.8 (CH), 124.9 (CH), 124.7 (CH), 124.6 (C_q), 124.5 (CH), 124.4 (CH), 123.2 (CH), 122.2 (CH), 119.2 (CH), 109.9 (CH), 55.0 (CH_3), 54.1 (CH_3), 43.7 (CH_2), 37.7 (CH_2), 28.1 (CH_2), 24.9 (CH_2), 22.4 (CH_2), 21.6 ppm (CH_2); IR (KBr): $\tilde{\nu}$ = 2927, 1716, 1622, 1524, 1303, 1288 cm^{-1}; EI-MS m/z 604 [M^+]; HRMS m/z calcd for $C_{34}H_{32}N_6O_5$: 604.2434; found: 604.2441.

*2-[4-Methoxy-4-(4-nitro-phenyl)-4,5-dihydro-imidazo[1,2-a]quinoxalin-7-yl]-1-(3-methyl-butyl)-1H-benzoimidazole-5-carboxylic acid methyl ester (**11b**)*

^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.51 (s, 1H, N*H*), 8.08–8.02 (m, 3H, ArH), 7.54–7.33 (m, 5H, ArH,), 7.27 (d, 2H, J = 7.6 Hz, ArH), 7.13 (s, 1H, ArH), 6.97 (s, 1H, ArH), 4.25 (t, 2H, J = 7.5 Hz, NCH_2CH$_2$CH-(CH$_3$)$_2$), 4.01 (s, 3H, OCH_3), 3.96 (s, 3H, CO_2CH_3), 1.74–1.65 (m, 2H, NCH$_2$CH_2CH(CH$_3$)$_2$), 1.60–1.50 (m, 1H, , NCH$_2$CH$_2$CH(CH$_3$)$_2$), 0.92 ppm (d, 6H, J = 6.5 Hz, , NCH_2CH$_2$CH(CH_3)$_2$); ^{13}C NMR (75 MHz,

$CDCl_3$): δ = 167.4 (C_q), 159.0 (C_q), 153.3 (C_q), 148.5 (C_q), 142.4 (C_q), 142.2 (C_q), 138.7 (C_q), 136.7 (CH), 135.7 (C_q), 130.7 (C_q), 130.7 (C_q), 129.3 (C_q), 129.2 (CH), 126.0 (CH), 124.8 (CH), 124.8 (C), 124.6 (CH), 124.6 (CH), 123.4 (CH), 122.3 (CH), 119.3 (CH), 109.8 (CH), 55.1 (CH_3), 52.1 (CH_3), 43.5 (CH_2), 38.5 (CH_2), 25.9 (CH), 22.3 ppm (CH_3); IR (KBr): $\tilde{\nu}$ = 2954, 1714, 1523, 1303, 1290 cm^{-1}; EI-MS *m*/*z* 566 [M^+]; HRMS *m*/*z* calcd for $C_{31}H_{30}N_6O_5$: 566.2278; found: 566.2282.

*2-[4-Methoxy-4-(4-nitro-phenyl)-4,5-dihydro-imidazo[1,2-a]quinoxalin-7-yl]-1-(3-methoxy-propyl)-1H-benzoimidazole-5-carboxylic acid methyl ester (**11c**)*

^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.51 (s, 1H, N*H*), 8.05 (d, 2H, *J* = 8.0 Hz, ArH), 8.05 (m, 1H, ArH), 7.58–7.42 (m, 3H, ArH), 7.40–7.31 (m, 2H, ArH), 7.28 (d, 2H, *J* = 8.0 Hz, ArH), 7.14 (s, 1H, ArH), 6.99 (s, 1H, ArH), 4.36 (t, 2H, *J* = 6.3 Hz, $CH_2CH_2CH_2OCH_3$), 4.01 (s, 3H, OCH_3), 3.96 (s, 3H, CO_2CH_3), 3.38–3.05 (m, 5H, $CH_2CH_2CH_2OCH_3$), 1.97 ppm (m, 2H, $CH_2CH_2CH_2OCH_3$); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 167.4 (C_q), 159.0 (C_q), 153.5 (C_q), 148.5 (C_q), 142.3 (C_q), 142.1 (C_q), 138.9 (C_q), 136.8 (CH), 135.7 (C_q), 130.6 (C_q), 129.3 (C_q), 129.3 (C_q), 129.3 (CH), 126.0 (CH), 125.0 (CH), 124.8 (C), 124.6 (CH), 124.4 (CH), 123.3 (CH), 122.2 (CH), 119.3 (CH), 109.9 (CH), 68.4 (CH_2), 58.6 (CH_3), 55.1 (CH_3), 52.1 (CH_3), 41.8 (CH), 29.9 ppm (CH_2); IR (KBr): $\tilde{\nu}$ = 2926, 1715, 1303, 1285 cm^{-1}; EI-MS *m*/*z* 568 [M^+]; HRMS *m*/*z* calcd for $C_{30}H_{28}N_6O_6$: 568.2070; found: 568.2072.

*1-Cyclohexyl-2-[4-methoxy-4-(4-nitro-phenyl)-4,5-dihydro-imidazo[1,2-a]quinoxalin-7-yl]-1H-benzoimidazole-5-carboxylic acid methyl ester (**11d**)*

^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.50 (s, 1H, N*H*), 8.07 (d, 2H, *J* = 8.8 Hz, ArH), 8.00 (dd, 1H, *J* = 8.6 Hz, *J* = 1.4 Hz, ArH), 7.70 (s, 1H, ArH), 7.66 (d, 1H, *J* = 8.6 Hz, ArH), 7.37 (s, 2H, ArH), 7.31 (d, 2H, *J* = 8.8 Hz, ArH), 7.24 (s, 1H, ArH), 7.19 (s, 1H, ArH), 7.02 (s, 1H, ArH), 4.26 (m, 1H, cyclohexyl), 4.00 (s, 3H, OCH_3), 3.96 (s, 3H, CO_2CH_3), 2.40–1.70 ppm (m, 10H, cyclohexyl); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 167.4 (C_q), 158.9 (C_q), 153.6 (C_q), 148.6 (C_q), 143.1 (C_q), 142.3 (C_q), 137.1 (C_q), 135.7 (C_q), 131.2 (C_q), 129.5 (CH), 129.4 (CH), 129.3 (C_q), 126.0 (CH), 125.1 (CH), 124.8 (CH), 124.4 (C_q), 124.4 (C_q), 124.0 (CH), 123.4 (CH), 122.5 (CH), 119.3 (CH), 112.3 (CH), 57.4 (CH), 55.1 (CH_3), 52.1 (CH_3), 31.4 (CH_2), 29.7 (CH_2), 25.8 ppm (CH_2); IR (KBr): $\tilde{\nu}$ = 2926, 1717, 1304, 1286 cm^{-1}; EI-MS *m*/*z* 578 [M^+]; HRMS *m*/*z* calcd for $C_{32}H_{30}N_6O_5$: 578.2278; found: 578.2278.

*1-Cyclooctyl-2-[4-methoxy-4-(4-nitro-phenyl)-4,5-dihydro-imidazo[1,2-a]quinoxalin-7-yl]-1H-benzoimidazole-5-carboxylic acid methyl ester (**11e**)*

^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.50 (s, 1H, N*H*), 8.05 (d, 2H, *J* = 8.0 Hz, ArH), 7.99 (d, 1H, *J* = 8.4 Hz, ArH), 7.60 (s, 1H, ArH), 7.54 (d, 1H, *J* = 8.4 Hz, ArH), 7.38–7.25 (m, 5H, ArH), 7.16 (s, 1H, ArH), 6.98 (s, 1H, ArH), 4.66 (m, 1H, cyclooctyl), 4.01 (s, 3H, OCH_3), 3.96 (s, 3H, CO_2CH_3), 2.43 (m, 2H, cyclooctyl), 2.01–1.48 ppm (m, 12H, cyclooctyl); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 167.5 (C_q), 159.0 (C_q), 153.1 (C_q), 148.6 (C_q), 143.1 (C_q), 142.3 (C_q), 136.8 (C_q), 135.7 (C_q), 131.2 (C_q), 129.3 (CH), 129.3 (C_q), 125.7 (CH), 125.7 (CH), 125.1 (C_q), 125.0 (CH), 125.0 (CH), 124.6 (C_q), 124.1 (CH), 123.4 (CH), 122.6 (CH), 123.4 (CH), 112.1 (CH), 57.6 (CH), 55.1(CH_3), 52.1 (CH_3), 33.7 (CH_2), 26.4 (CH_2), 25.9 (CH_2), 25.3 ppm (CH_2); IR (KBr): $\tilde{\nu}$ = 2924, 1716, 1304, 1285 cm^{-1}; EI-MS *m*/*z* 606 [M^+]; HRMS *m*/*z* calcd for $C_{34}H_{34}N_6O_5$: 606.2591; found: 606.2587.

*2-[4-Methoxy-4-(4-nitro-phenyl)-4,5-dihydro-imidazo[1,2-a]quinoxalin-7-yl]-1-(tetrahydro-furan-2-ylmethyl)-1H-benzoimidazole-5-carboxylic acid methyl ester (**11f**)*

^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.51 (s, 1H, N*H*), 8.10–8.02 (m, 3H, ArH), 7.82 (s, 1H, ArH), 7.62 (d, 1H, *J* = 8.1 Hz, ArH), 7.49 (d, 1H, *J* = 8.5 Hz, ArH), 7.43 (s, 1H, ArH), 7.39 (d, 1H, *J* = 8.1 Hz, ArH), 7.31 (d, 2H, *J* = 8.5 Hz, ArH), 7.22 (s, 1H, ArH), 7.06 (s, 1H, ArH), 4.29–4.13 (m, 3H, NCH_2 and tetrahydrofuranyl), 4.00 (s, 3H, OCH_3), 3.96 (s, 3H, CO_2CH_3), 3.79–3.63 (m, 2H, tetrahydrofuranyl), 2.01–1.72 (m, 3H, tetrahydrofuranyl), 1.51–1.38 ppm (m 1H, tetrahydrofuranyl); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 167.5 (C_q), 159.0 (C_q), 154.0 (C_q), 148.5 (C_q), 142.4 (C_q), 142.0 (C_q), 139.1 (C_q), 136.8 (CH), 135.8 (C_q), 130.8 (C_q), 129.5 (C_q), 129.3 (C_q), 129.3 (CH), 125.9 (CH), 125.5 (CH), 125.0 (CH), 124.9 (C_q), 124.6 (CH), 123.4 (CH), 122.3 (CH), 119.3 (CH), 110.4 (CH), 77.3 (CH), 68.1 (CH_2), 55.1(CH_3), 52.1 (CH_3), 49.0 (CH_2), 29.3 (CH_2), 25.5 ppm (CH_2); IR (KBr): $\tilde{\nu}$ = 2924, 1714, 1304, 1286 cm^{-1}; EI-MS *m*/*z* 580 [M^+]; HRMS *m*/*z* calcd for $C_{31}H_{28}N_6O_6$: 580.2070; found: 580.2073.

*1-Isopropyl-2-[4-methoxy-4-(4-nitro-phenyl)-4,5-dihydro-imidazo[1,2-a]quinoxalin-7-yl]-1H-benzoimidazole-5-carboxylic acid methyl ester (**11g**)*

^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.50 (s, 1H, N*H*), 8.08 (d, 2H, *J* = 8.5 Hz, ArH), 8.01 (d, 1H, *J* = 8.5 Hz, ArH), 7.62 (d, 1H, *J* = 8.7 Hz, ArH), 7.54 (s, 1H, ArH), 7.43–7.35 (m, 2H, ArH), 7.30 (d, 2H, *J* = 8.7 Hz, ArH), 7.17 (s, 1H, ArH), 7.14 (s, 1H, ArH), 7.01 (s, 1H, ArH), 4.62 (m, 1H, $CH(CH_3)_2$), 4.01 (s, 3H, OCH_3), 3.96 (s, 3H CO_2CH_3), 1.58 ppm (d, 6H, *J* = 6.9 Hz, $CH(CH_3)_2$); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 167.4 (C_q), 159.0 (C_q), 153.4 (C_q), 148.5 (C_q), 143.1 (C_q), 142.1 (C_q), 136.8 (CH), 136.6 (C_q), 135.7 (C_q), 131.0 (C_q), 130.6 (C_q), 129.5 (C_q), 129.4 (CH), 126.0 (CH), 125.4 (CH), 124.5 (C_q), 124.5 (CH), 124.1 (CH), 123.4 (CH), 122.5 (CH), 119.3 (CH), 111.9 (CH), 55.1 (CH_3), 52.1 (CH_3), 49.2 (CH), 21.4 ppm (CH_3); IR (KBr): $\tilde{\nu}$ = 2924, 1716, 1304, 1285 cm^{-1}; EI-MS *m*/*z* 538 [M^+]; HRMS *m*/*z* calcd for $C_{29}H_{26}N_6O_5$: 538.1965; found: 538.1969.

See the Supporting Information for ^{1}H and ^{13}C NMR spectra of compounds **10a**–**10h** and **11a**–**11g**. COSY spectra for compounds **3**, **4**, **5**, and **10h** are also available. This information is available free of charge via the Internet.

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