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Efficient Synthesis of Maxonine Analogues from *N*-Substituted Benzyl-1-formyl-9*H*-β-carbolines[‡]

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Acid-catalyzed Pomeranz–Fritsch-type reaction between the acetal group at C-1 and the arene unit of the benzyl group at N-9 in 9-substituted benzyl-1-(dimethoxymethyl)-9*H*-β-carboline affords fused-β-carbolines that can be readily oxidized to furnish a maxonine-type framework. Mechanistically, the reaction proceeds via a protonated aldehyde as the intermediate, which undergoes attack by the activated arene subunit of the benzyl moiety. On the other hand, the Morita–Baylis–Hillman adducts of 1-formyl-*N*-substituted benzyl-9*H*-β-carbolines undergo an efficient P_2O_5-mediated intramolecular Friedel–Crafts reaction between the secondary hydroxy group and the activated phenyl group of the benzyl subunit to yield fused-β-carbolines. Investigations into the scope of the substrates reveal that the success of the methodology relies on the degree of activation of the phenyl ring. For substrates having less-activated phenyl groups, indolizinoindole derivatives were isolated in moderate yields only.

Introduction

Fused-β-carbolines are well represented in naturally occurring alkaloids[1] and are endowed with a variety of biological properties.[2] Given such importance, the synthesis of fused-β-carbolines has been and continues to be of significant interest to synthetic chemists.[3] In a project directed towards the formulation of strategies for the construction of fused-β-carbolines, we are engaged in the synthesis of mimics of fused-β-carboline-based natural products employing substituted 1-formyl-9*H*-β-carboline as the starting material.[4] Fortunately, we were able to harness this template for the synthesis of canthin-6-one, canthine, harmicine, and fascaplysin skeletons by using Morita–Baylis–Hillman (MBH) chemistry.[5] Additionally, from this aldehyde we could realize successfully the synthesis of a variety of fused-β-carboline-based heterocycles through cycloaddition, ene–carbonyl, and multicomponent reactions.[6] Maxonine, a pentacyclic alkaloid, is a fused-β-carboline derivative that was isolated from *Simira maxonii* and first reported in 1989 (Figure 1).[7] Kelly et al. in 1993 disclosed the correct structure of this alkaloid and successfully achieved its total synthesis.[8] Since then there has been a lack of literature pertaining to maxonine. Continuing with our efforts to prepare mimics of fused-β-carboline-based natural products, it occurred to us that we can achieve the synthesis of the maxonine-type framework by using the MBH derivatives of *N*-substituted benzyl-1-formyl-9*H*-β-carboline. As illustrated in the retrosynthetic plan, generation of a carbocation at the benzylic position in the presence of acid followed by intramolecular Friedel–Crafts (FC) alkylation (route A) would afford desired product **I** (Scheme 1). Alternatively, Lewis acid catalyzed generation of the carbocation at the allylic position followed by intramolecular FC alkylation (route B) would result in new fused-β-carboline system **II**. Intramolecular FC reactions in MBH adducts by both routes are widely reported.[9,10]

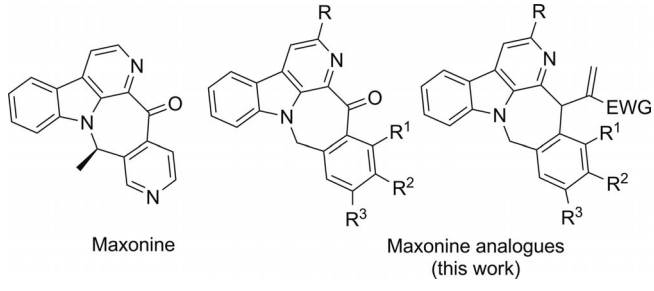

Figure 1. Maxonine, the pentacyclic β carboline-based alkaloid.

In addition, there are reports of several other cyclizations, wherein the benzylic alcohols served as substrates in intramolecular FC alkylation reactions under the influence of Lewis acids.[11] Even during the course of this work, Lautens et al. reported a novel Lewis acid mediated intramolecular FC alkylation involving the benzylic hydroxy group and phenyl group in tetralins.[12] Interestingly, during our study we discovered that treatment of *N*-substituted benzyl-9*H*-1-(dimethoxymethyl)-β-carbolines with acid for the preparation of *N*-substituted aldehydes for the MBH reac-

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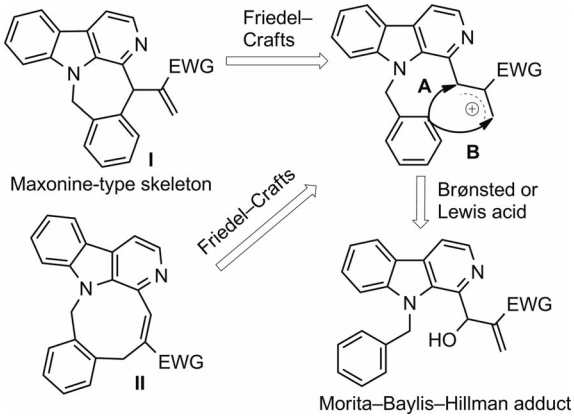
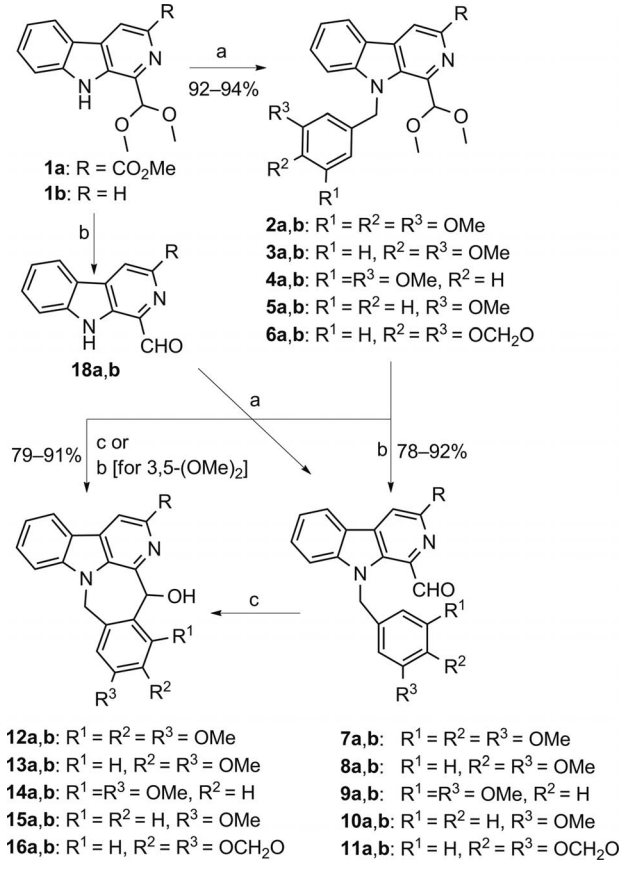


Scheme 1. Retrosynthetic scheme illustrating the two possibilities for the formation of fused β-carbolines from MBH derivatives by an intramolecular FC reaction.

tion results in the formation of fused-β-carbolines through a Pomeranz–Fritsch-type reaction in one pot. Further, we found that in our hands the Brønsted or Lewis acids were unsuccessful in executing the intramolecular FC alkylation, but P_2O_5 worked efficiently to promote the desired reaction to furnish the fused β-carbolines. The interesting results of this study are disclosed herein.

Results and Discussion

For performing the MBH reaction, the first objective was to prepare the required *N*-substituted benzyl-1-formyl-9*H*-β-carbolines. The present study therefore commenced with installing of the benzyl group containing an activated phenyl ring at the N-9 of C-1-(dimethoxymethyl)-9*H*-β-carbolines **1a** and **1b**, which in turn were prepared following the reported procedure.[5a,5b] Considering the fact that electronically rich arene units are more suited for the FC reaction, we decided to install benzyl groups at the N-9 position, wherein the phenyl ring bears methoxy or methylenedioxy groups as substituents. For the purpose of optimization, initially 3,4,5-trimethoxybenzyl bromide was prepared and treated with **1a** in the presence of Cs_2CO_3 in DMF at room temperature. The reaction was complete in 1 h and smoothly yielded 1-(dimethoxymethyl)-9-(3,4,5-trimethoxybenzyl)-9*H*-β-carboline (**2a**). In the next step, the acetal group of **2a** was hydrolyzed in the presence of AcOH/H_2O (2:3) as per the reported protocol.[5a] As expected, the reaction furnished required aldehyde **7a** in 90% yield (Scheme 2). With the optimized conditions in hand, we proceeded with the preparation of different starting materials. Several benzyl bromides containing electron-donating substituents in the phenyl ring were prepared and treated with **1a** and **1b** in the presence of Cs_2CO_3 in DMF to afford respective products **2a**–**6a** and **2b**–**6b** in excellent yields. Subsequently, compounds **2a**–**6a** and **2b**–**6b** were deprotected with AcOH/H_2O. Whereas compounds **2a**, **2b**, **3a**, **3b**, **5a**, **5b**, **6a**, and **6b** afforded the corresponding *N*-substituted benzyl-1-formyl-9*H*-β-carbolines **7a**, **7b**, **8a**, **8b**, **10a**, **10b**, **11a**, and **11b**, compounds **4a** and **4b** resulted in products that were different from expected aldehydes **9a** and **9b**. Spectroscopic analysis of products led us to establish them as fused β-carbolines **14a** and **14b**. This result may be rationalized on the basis of a Pomeranz–Fritsch-type reaction between the acetal group and the activated arene in the presence of acid.[13] However, in order to explain the synthesis of fused system **14a** and **14b** only in case of **4a** and **4b**, it is presumed that the reactive site in the phenyl ring of **4a** and **4b** is highly activated due to the +R effect of the two methoxy groups present at the *ortho* and *para* positions. Essentially, this facilitates attack of the arene ring to the oxonium ion generated in the presence of AcOH. Compared to this, amongst other analogues investigated, although **2a** and **2b** have similar effects, the presence of another methoxy group in the phenyl ring that is *meta* to the reactive site deactivates the arene unit because of its –I effect. Henceforth, we considered exploring stronger acids to achieve intramolecular cyclization in other substrates. Therefore, in a model study **2a** was treated with several acids under different conditions. We were delighted to note that treatment of **2a** with TFA/H_2O (100:1) at room temperature for 48 h resulted in product **12a**. Mechanistically, the Pomeranz–Fritsch-type intramolecular reaction was anticipated to proceed either through sequential partial hydrolysis of the acetal group and attack of the arene on the generated activated carbon, or through complete hydrolysis



Scheme 2. Reagents and conditions: (a) Substituted benzyl bromide, Cs_2CO_3, DMF, r.t., 1 h; (b) AcOH/H_2O (2:3), 90 °C, 45 min; (c) TFA/H_2O (100:1), r.t., 48–96 h.

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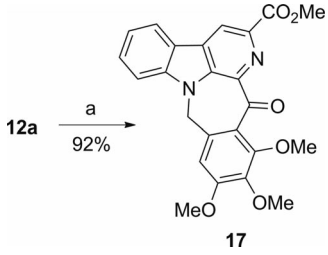
of the acetal to afford the aldehyde first, which then forms an oxonium ion that is attacked by the electron-rich arene system. To investigate the suggested possibilities experimentally, in a representative experiment **7a** was treated with TFA/H_2O. After 24 h, the reaction was complete and yielded product **12a**. The formation of **12a** from **7a** proved that the reaction proceeded through formation of a protonated aldehyde as the intermediate. Additionally, during careful monitoring of the reaction of **2a** with TFA/H_2O by TLC, initially the spot for aldehyde **7a** was present, but it slowly disappeared to afford product **12a**, which suggested that a cascade sequence was operating.

In view of these results we proceeded to test the scope of the substrates and therefore acetals **2b**, **3a**, **3b**, **5a**, **5b**, **6a**, and **6b** were treated with TFA/H_2O. It was pleasing to note that all substrates produced respective fused-β-carbolines **12b**, **13a**, **13b**, **15a**, **15b**, **16a**, and **16b** in 79–91% yield, though the time to reach completion of the reaction varied. We found that product **16b** afforded from **6b** started to disintegrate when subjected to column chromatography for purification, though no reason could be assigned for this unusual behavior. In order to ascertain that the intramolecular reaction is restricted to the phenyl ring carrying the electron-donating substituents, we investigated a similar reaction of 9-benzyl-1-(dimethoxymethyl)-9*H*-β-carboline with TFA/H_2O.[14] However this substrate failed to undergo a similar transformation and the corresponding aldehyde was the sole product.

To demonstrate the usefulness of compounds **12**–**16** for obtaining the maxonine-type product in a model reaction, **12a** was subjected to activated MnO_2-mediated oxidation in the presence of dichloromethane at room temperature. The reaction was complete in 2 h and afforded oxidized product **17** in 92% yield (Scheme 3).

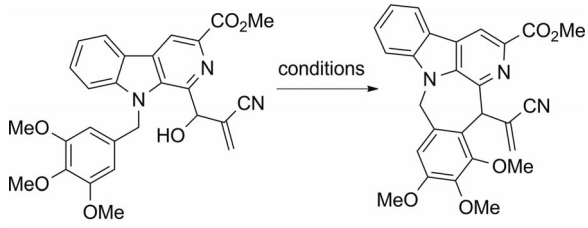


Scheme 3. Reagents and conditions: (a) MnO_2, CH_2Cl_2, r.t., 2 h.

Because the synthesis of aldehydes **9a** and **9b** could not be achieved by the general route, an alternate procedure was sought to synthesize them. Towards this goal, compounds **1a** and **1b** were initially transformed into aldehydes **18a** and **18b**, which were then treated with 3,5-dimethoxybenzyl bromide in the presence of Cs_2CO_3 in DMF to afford desired products **9a** and **9b**, respectively (Scheme 2).

With the required aldehydes in hand, in the next stage of the study we focused on our original objective of accomplishing the intramolecular FC alkylation in the MBH adducts. Accordingly, the MBH reactions of aldehydes **7a**, **7b**, **8a**, **8b**, **9a**, **9b**, **10a**, and **11a** with alkenes **A**–**D** in the presence of DABCO were performed. For the purpose of optimization, **7a** was treated with acrylonitrile (**A**) in the presence of DABCO to afford MBH adduct **7aA** in 88% yield. In order to accomplish the intramolecular FC alkylation in **7aA**, several reagents that have been reported in the literature for analogous reactions were evaluated, and the results of the study are compiled in Table 1.[15] We failed to achieve the desired cyclization under the influence of Brønsted or Lewis acids. Basavaiah et al. reported the P_2O_5-mediated intramolecular FC alkylation in MBH adducts for preparing indenes.[10a] Taking a cue from this report we evaluated the reaction of **7aA** with P_2O_5 in dichloromethane at room temperature. Fortunately, the reaction was complete in 1 h to yield a major product in 85% yield, which was delineated to be required fused-β-carboline **19aA**. Although Basavaiah et al. suggested the formation of indene through electrocyclic ring closure, we speculate that the formation of the product in our case proceeds through an S_N2-type reaction. As reported,[16] it is assumed that in the first step the phosphate ester is formed by the reaction of the *N*-substituted MBH adduct with P_2O_5 (exists as P_4O_{10}). Subsequently, this phosphate ester, which is a nice leaving group, can be eliminated by either route I, II, or III (Figure 2). To explain the formation of **19aA**, we presume that elimination by route I predominates.

Table 1. Optimization of the conditions for achieving the intramolecular FC alkylation in MBH adduct.[a]



7aA **19aA**

Entry	Catalyst	Solvent	Temp. [°C]	Time [h]	Yield [%]
1	PPA	–	r.t.	12	1
2	$MeSO_3H$	CH_2Cl_2	r.t.	3	2
3	H_2SO_4	CH_2Cl_2	r.t.	2	–
4	silica H_2SO_4	CH_2Cl_2	r.t.	3	–
5	$Yb(OTf)_3$	MeCN	90	3	–
6	PTSA	CH_2Cl_2	r.t.	6	–
7	$FeCl_3 \cdot 6H_2O$	CH_2Cl_2	r.t.	10	–
8	$BF_3 \cdot Et_2O$	CH_2Cl_2	r.t.	2	–
9	P_2O_5	CH_2Cl_2	r.t.	1	85

[a] All reactions were investigated by using 0.5 mmol of **7aA**.

Next, we decided to test the scope of our protocol with MBH adducts **7aA**–**D**; **7bA**,**C**; **8aA**,**B**; **8bB**; **9aA**–**C**; **9bA**,**B**; **10aA**–**C**; and **11aA**,**B** generated from the corresponding aldehydes and the appropriate alkenes, and the results of this study are presented in Table 2.

Substrates originating from tryptophan (**a** series) were fast reacting compared to those originating from tryptamine (**b** series). MBH adducts **7**–**9** and **11** afforded the

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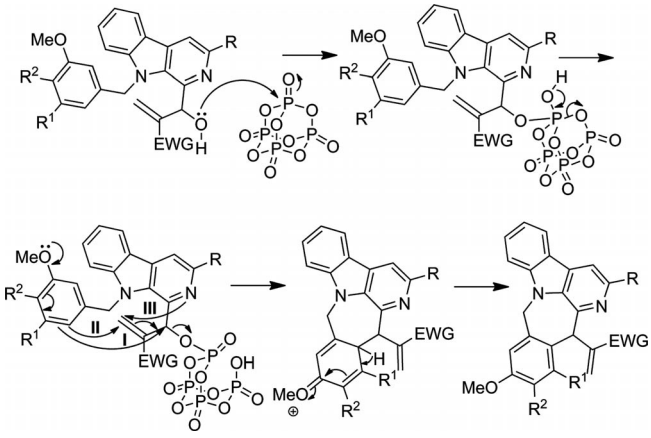
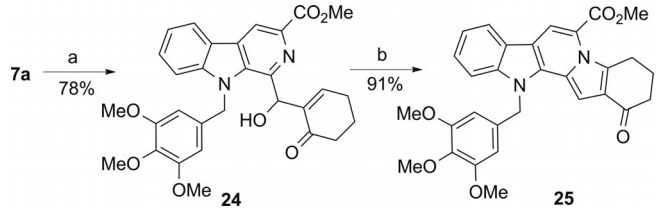


Figure 2. Plausible mechanism for the FC reaction in MBH derivatives.

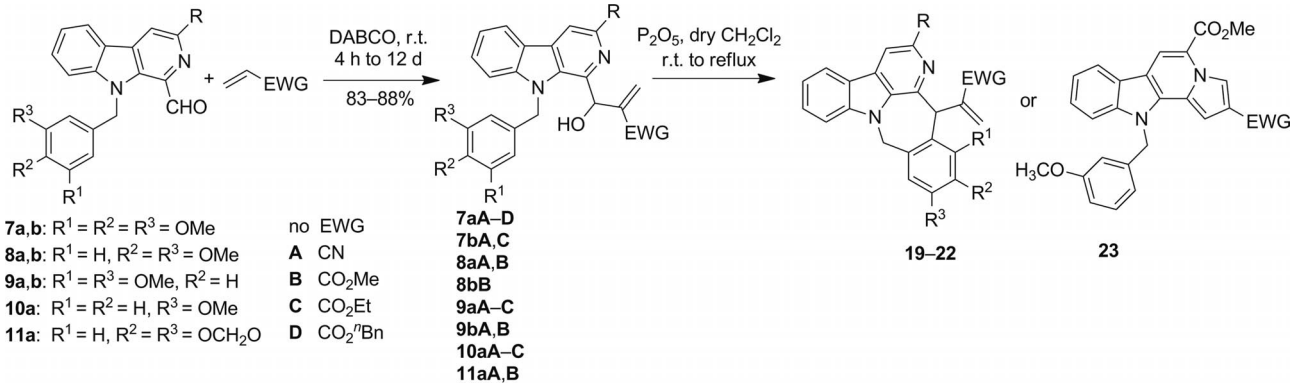
respective fused-β-carbolines **19**–**22**. Whereas reactions of substrates **11aA**,**B** incorporating a 3,4-methylenedioxy phenyl group were sluggish to afford products **22aA**,**B** in more than 48 h of heating, substrates **10aA**–**C** bearing only a 3-methoxy group in the phenyl ring yielded products **23aA**–**C**. The yields of compounds belonging to series **23** were moderate only. Formation of **23**, however, could be explained on the basis of a reaction proceeding through route III (Figure 2).

Mechanistic considerations provided a basis to investigate the fate of substrate **24** originating from the MBH reaction between **7a** and cyclohexene-2-one. It was found that the reaction of **24** with P_2O_5 under similar conditions resulted in the formation of product **25** in 91% yield (Scheme 4). The formation of **25** can again be explained by route III. In this case, due to the conjugation of the double bond with the keto group, the substrate becomes highly activated resulting in preferential attack of the lone pair of electrons on the nitrogen at this double bond.



Scheme 4. Reagents and conditions. (a) Cyclohex-2-enone, DABCO, r.t., 24 h; (b) P_2O_5, dry CH_2Cl_2, r.t., 5 h.

Table 2. Results of the FC reaction of several MBH adducts.



Reactant	R	R^1	R^2	R^3	EWG	Time [h]	Product	Yield [%]
7aA	CO_2Me	OMe	OMe	OMe	CN	1	**19aA**	85
7aB	CO_2Me	OMe	OMe	OMe	CO_2Me	1	**19aB**	80
7aC	CO_2Me	OMe	OMe	OMe	CO_2Et	1	**19aC**	81
7aD	CO_2Me	OMe	OMe	OMe	CO_2nBu	1	**19aD**	81
7bA	H	OMe	OMe	OMe	CN	2	**19bA**	83
7bC	H	OMe	OMe	OMe	CO_2Et	2	**19bC**	79
8aA	CO_2Me	H	OMe	OMe	CN	3	**20aA**	85
8aB	CO_2Me	H	OMe	OMe	CO_2Me	3	**20aB**	81
8bB	H	H	OMe	OMe	CO_2Me	4	**20bB**	79
9aA	CO_2Me	OMe	H	OMe	CN	3	**21aA**	81
9aB	CO_2Me	OMe	H	OMe	CO_2Me	3	**21aB**	82
9aC	CO_2Me	OMe	H	OMe	CO_2Et	3	**21aC**	80
9bA	H	OMe	H	OMe	CN	3	**21bA**	82
9bB	H	OMe	H	OMe	CO_2Me	4	**21bB**	78
11aA	CO_2Me	H	OCH_2O		CN	48	**22aA**	72
11aB	CO_2Me	H	OCH_2O		CO_2Me	96	**22aB**	78
10aA	CO_2Me	H	H	OMe	CN	8	**23aA**	45
10aB	CO_2Me	H	H	OMe	CO_2Me	19	**23aB**	47
10aC	CO_2Me	H	H	OMe	CO_2Et	17	**23aC**	52

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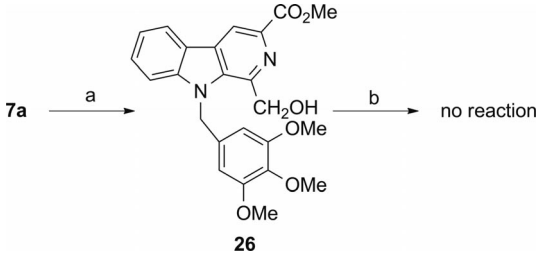
At this point of the study it was considered essential to investigate whether simple alcohols, which can be readily generated by the reduction of the formyl group, can participate in the FC alkylation under the influence of Lewis acids or P_2O_5. Accordingly, **7a** was treated with $NaBH_4$ in MeOH to successfully afford corresponding alcohol **26** (Scheme 5). Subsequently, FC reaction of **26** with several Lewis acids [$FeCl_3$, $In(OTf)_3$, $Sc(OTf)_3$, $ZnBr_2$, $BF_3{\cdot}Et_2O$] and P_2O_5 was investigated, but unfortunately the reaction was unsuccessful.



Scheme 5. Reagents and conditions (a) $NaBH_4$, MeOH, r.t., 20 min; (b) Lewis acid, CH_2Cl_2, reflux, 24 h.

Conclusions

In summary, we have demonstrated a new application of substituted 1-formyl-9*H*-β-carboline for the synthesis of maxonine analogues. The pentacyclic products could be achieved either directly from the *N*-substituted aldehyde by an acid-catalyzed Pomeranz–Fritsch-type process or from MBH adducts by using a P_2O_5-catalyzed FC reaction. Although the process works only with activated arenes, it may be considered to be an efficient route to maxonine variants. Further work on developing a library of new maxonine-based compounds for bioevaluation is underway in our laboratory.

Experimental Section

General Methods: Melting points were determined in capillary tubes with a Precision melting point apparatus containing silicon oil. IR spectra were recorded by using a Perkin–Elmer's RX I FTIR spectrophotometer. ^{1}H NMR and ^{13}C NMR spectra were recorded either with a Bruker DPX-200 or Bruker Avance DRX-300 FT spectrometer by using TMS as an internal standard. MS (ESI) were recorded with a Micromass Quadro-II LCMS system, whereas MS (EI) were recorded with a JEOL JMS600H mass spectrometer. HRMS (ESI) were recorded with an Agilent 6520 Q-TOF, LC–MS/MS mass spectrometer. Elemental analyses were performed with a Carlo Erba 108 or an Elementar Vario EL III microanalyzer. The room temperature varied between 20 and 35 °C. All the solvents and chemicals were used as procured from the suppliers. Compounds **7bA**, **8bB**, and **9bA** decomposed on standing so they were immediately subjected to reactions without any purification. Hence, the spectral characterization for these compounds was not performed. The spectroscopic data for compound **16** is of the crude product, as it disintegrated during purification.

General Procedure for the Synthesis of Compounds 2–6, as Exemplified by Compound 2a: To a stirred solution of compound **1a** (0.30 g, 1 mmol) in dry DMF (3 mL) was added Cs_2CO_3 (0.46 g, 1.4 mmol) at room temperature. After 15 min, 3,4,5-trimethoxybenzyl bromide (0.36 g, 1.4 mmol) was added dropwise, and the reaction mixture was stirred for an additional 1 h at the same temperature. Upon completion of the reaction as monitored by TLC, the contents were poured into water (25 mL) whilst stirring with a glass rod. The resulting suspension was filtered, and the solid residue was washed with hexane (10 mL) and dried in a desiccator over P_2O_5 under vacuum to obtain **2a** (0.45 g, 94%) as a yellowish white solid.

Methyl 1-(Dimethoxymethyl)-9-(3,4,5-trimethoxybenzyl)-9*H*-β-carboline-3-carboxylate (2a): M.p. 101–102 °C; R_f = 0.56 (hexanes/EtOAc, 60:40). IR (KBr): $\tilde{\nu}$ = 1718 (CO_2CH_3) cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 3.41 (s, 6 H, 2 OCH_3), 3.65 (s, 6 H, 2 OCH_3), 3.80 (s, 3 H, OCH_3), 4.06 (s, 3 H, CO_2CH_3), 5.74 (s, 1 H, CH), 6.04 (s, 2 H, NCH_2), 6.25 (s, 2 H, ArH), 7.34–7.38 (m, 2 H, ArH), 7.55 (t, J = 7.6 Hz, 1 H, ArH), 8.22 (d, J = 7.8 Hz, 1 H, ArH), 8.95 (s, 1 H, ArH) ppm. ^{13}C NMR (50 MHz, $CDCl_3$): δ = 50.2, 52.7, 55.5, 56.0, 60.8, 103.2, 109.3, 111.6, 118.4, 121.1, 121.2, 121.7, 129.1, 131.2, 133.9, 135.7, 136.2, 136.8, 141.1, 142.8, 153.3, 166.4 ppm. MS (ESI+): m/z = 481.1 [M + H]$^+$. HRMS (ESI): calcd. for $C_{26}H_{29}N_2O_7$ [M + H]$^+$ 481.1975; found 481.1978.

General Procedure for the Synthesis of 12,13, 15, and 16 By Using TFA and Water, as Exemplified by 12a: A mixture of **2a** (0.48 g, 1 mmol), trifluoroacetic acid (7.5 mL), and water (0.07 mL) was stirred at room temperature for 48 h. After completion of the reaction as monitored by TLC, TFA was removed under reduced pressure. After neutralization with a saturated solution of $NaHCO_3$, the contents were extracted with ethyl acetate (2 × 20 mL). Then the pooled organic layer was dried with anhydrous Na_2SO_4 and concentrated under reduced pressure to obtain a yellow oil as a crude product. The crude product was purified by column chromatography (silica gel hexanes/EtOAc, 70:30) to afford **12a** (0.37 g, 85%) as a yellow solid.

Methyl 3,4,5-Trimethoxy-6-hydroxy-1,6-dihydro-7,13b-diazabenzo-[5,6]cyclohepta[1,2,3-*jk*]fluorene-8-carboxylate (12a): M.p. 132–134 °C; R_f = 0.47 (hexanes/EtOAc, 55:45). IR (KBr): $\tilde{\nu}$ = 1734 (CO_2CH_3), 3286 (OH) cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 3.83–3.90 (m, 12 H, 3 OCH_3 and CO_2CH_3), 4.02 (br. s, 1 H, OH), 5.25 (d, J = 13.8 Hz, 1 H, NCH*H*), 6.36 (d, J = 13.7 Hz, 1 H, NC*H*H), 6.76 (s, 1 H, CH), 6.81 (s, 1 H, ArH), 7.33–7.38 (m, 1 H, ArH), 7.68–7.70 (m, 2 H, ArH), 8.17 (d, J = 7.8 Hz, 1 H, ArH), 8.75 (s, 1 H, ArH) ppm. ^{13}C NMR (50 MHz, $CDCl_3$/[D_6]DMSO): δ = 46.8, 51.6, 55.6, 60.2, 61.5, 69.0, 110.0, 110.3, 117.4, 120.0, 120.2, 121.4, 126.9, 128.2, 129.9, 135.0, 135.4, 140.5, 141.4, 145.1, 150.8, 152.4, 165.7 ppm. MS (ESI+): m/z = 435.1 [M + H]$^+$. HRMS (ESI): calcd. for $C_{24}H_{23}N_2O_6$ [M + H]$^+$ 435.1556; found 435.1561.

3,4,5-Trimethoxy-1,6-dihydro-7,13b-diazabenzo[5,6]cyclohepta-[1,2,3-*jk*]fluoren-6-ol (12b): Yield: 79%; white solid; m.p. 193–195 °C; R_f = 0.40 (hexanes/EtOAc, 60:40). IR (KBr): $\tilde{\nu}$ = 3428 (OH) cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 3.84 (s, 3 H, OCH_3), 3.87 (s, 3 H, OCH_3), 3.88 (s, 3 H, OCH_3), 5.24 (d, J = 13.8 Hz, 1 H, NCH*H*), 6.28 (d, J = 13.7 Hz, 1 H, NC*H*H), 6.68 (s, 1 H, CH), 6.76 (s, 1 H, ArH), 7.28–7.31 (m, 1 H, ArH), 7.64–7.66 (m, 2 H, ArH), 7.88 (d, J = 5.2 Hz, 1 H, ArH), 8.12 (d, J = 7.8 Hz, 1 H, ArH), 8.27 (d, J = 5.2 Hz, 1 H, ArH) ppm. ^{13}C NMR (75 MHz, $CDCl_3$/[D_6]DMSO): δ = 47.1, 55.7, 60.3, 61.6, 69.4, 108.9, 109.8, 114.3, 118.9, 120.1, 121.2, 127.2, 127.8, 128.5, 129.8, 133.5, 136.8, 140.0, 141.5, 145.1, 150.9, 152.3 ppm. MS (ESI+): m/z = 377.2 [M + H]$^+$. HRMS (ESI): calcd. for $C_{22}H_{21}N_2O_4$ [M + H]$^+$ 377.1501; found 377.1496.

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Methyl 3,4-Dimethoxy-6-hydroxy-1,6-dihydro-7,13b-diazabenzo-[5,6]cyclohepta[1,2,3-*jk*]fluorene-8-carboxylate (13a): Yield: 88%; white solid; m.p. 205–207 °C; R_f = 0.41 (hexanes/EtOAc, 70:30). IR (KBr): $\tilde{\nu}$ = 1717 (CO_2CH_3), 3415 (OH) cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$/[D$_6$]DMSO): δ = 3.76 (s, 3 H, OCH_3), 3.78 (s, 3 H, OCH_3), 3.93 (s, 3 H, CO_2CH_3), 5.71 (d, J = 13.6 Hz, 1 H, NCH*H*), 5.98 (d, J = 13.8 Hz, 1 H, NC*H*H), 6.42 (s, 1 H, CH), 7.24 (s, 1 H, ArH), 7.30 (s, 1 H, ArH), 7.36 (t, J = 7.4 Hz, 1 H, ArH), 7.72 (t, J = 7.7 Hz, 1 H, ArH), 8.07 (d, J = 8.5 Hz, 1 H, ArH), 8.41 (d, J = 8.0 Hz, 1 H, ArH), 8.90 (s, 1 H, ArH) ppm. ^{13}C NMR (75 MHz, [D$_6$]DMSO): δ = 46.3, 52.2, 55.8, 55.9, 79.2, 110.8, 114.6, 117.9, 120.3, 120.6, 122.3, 125.9, 128.2, 128.9, 133.7, 134.7, 135.2, 140.8, 145.2, 148.1, 148.2, 166.0 ppm. MS (ESI+): m/z = 405.1 [M + H]$^+$. HRMS (ESI): calcd. for $C_{23}H_{21}N_2O_5$ [M + H]$^+$ 405.1450; found 405.1464.

3,4-Dimethoxy-1,6-dihydro-7,13b-diazabenzo[5,6]cyclohepta-[1,2,3-*jk*]fluoren-6-ol (13b): Yield: 81%; white solid; m.p. 188–189 °C; R_f = 0.43 (hexanes/EtOAc, 70:30). IR (KBr): $\tilde{\nu}$ = 3373 (OH) cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$): δ = 3.86 (s, 3 H, OCH_3), 3.92 (s, 3 H, OCH_3), 5.32 (d, J = 14.6 Hz, 1 H, NCH*H*), 5.72 (d, J = 14.5 Hz, 1 H, NC*H*H), 6.69 (s, 1 H, CH), 6.89 (s, 1 H, ArH), 7.28–7.31 (m, 1 H, ArH), 7.49 (s, 1 H, ArH), 7.63–7.65 (m, 2 H, ArH), 7.84 (d, J = 5.1 Hz, 1 H, ArH), 8.10 (d, J = 7.9 Hz, 1 H, ArH), 8.27 (d, J = 5.4 Hz, 1 H, ArH) ppm. ^{13}C NMR (50 MHz, [D$_6$]DMSO): δ = 45.2, 54.4, 54.6, 108.3, 108.9, 111.1, 112.7, 113.2, 118.1, 118.7, 120.4, 123.8, 126.9, 128.0, 131.5, 133.3, 134.8, 138.9, 142.9, 146.4, 147.1 ppm. MS (ESI+): m/z = 347.1 [M + H]$^+$. HRMS (ESI): calcd. for $C_{21}H_{19}N_2O_3$ [M + H]$^+$ 347.1396; found 347.1413.

Methyl 3,5-Dimethoxy-6-hydroxy-1,6-dihydro-7,13b-diazabenzo-[5,6]cyclohepta[1,2,3-*jk*]fluorene-8-carboxylate (14a): Yield: 91%; white solid; m.p. 234–236 °C; R_f = 0.41 (hexanes/EtOAc, 60:40). IR (KBr): $\tilde{\nu}$ = 1722 (CO_2CH_3), 3426 (OH) cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$): δ = 3.20 (br. s, 1 H, CHO*H*), 3.80 (s, 3 H, OCH_3), 3.83 (s, 3 H, OCH_3), 4.00 (s, 3 H, CO_2CH_3), 5.24 (d, J = 13.7 Hz, 1 H, NCH*H*), 6.30 (d, J = 13.8 Hz, 1 H, NC*H*H), 6.43 (d, J = 2.2 Hz, 1 H, ArH), 6.55 (d, J = 2.3 Hz, 1 H, ArH), 6.88 (s, 1 H, C*H*OH), 7.32–7.37 (m, 1 H, ArH), 7.67–7.69 (m, 2 H, ArH), 8.17 (d, J = 7.9 Hz, 1 H, ArH), 8.82 (s, 1 H, ArH) ppm. ^{13}C NMR (50 MHz, $CDCl_3$/[D$_6$]DMSO): δ = 45.3, 50.4, 53.7, 54.3, 66.2, 96.4, 106.0, 108.9, 116.0, 118.6, 118.8, 119.5, 120.4, 126.6, 127.1, 133.7, 134.8, 139.0, 143.9, 155.6, 158.4, 164.4 ppm. MS (ESI+): m/z = 405.0 [M + H]$^+$. HRMS (ESI): calcd. for $C_{23}H_{21}N_2O_5$ [M + H]$^+$ 405.1450; found 405.1455.

3,5-Dimethoxy-1,6-dihydro-7,13b-diazabenzo[5,6]cyclohepta-[1,2,3-*jk*]fluoren-6-ol (14b): Yield: 88%; white solid; m.p. 200–202 °C; R_f = 0.52 (hexanes/EtOAc, 55:45). IR (KBr): $\tilde{\nu}$ = 3321 (OH) cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$): δ = 3.80 (s, 3 H, OCH_3), 3.81 (s, 3 H, OCH_3), 5.22 (d, J = 13.7 Hz, 1 H, NC*H*H), 6.27 (d, J = 13.7 Hz, 1 H, NCH*H*), 6.43 (d, J = 2.2 Hz, 1 H, ArH), 6.56 (d, J = 2.3 Hz, 1 H, ArH), 6.77 (s, 1 H, CH), 7.27–7.30 (m, 1 H, ArH), 7.60–7.64 (m, 2 H, ArH), 7.88 (d, J = 5.3 Hz, 1 H, ArH), 8.11 (d, J = 7.8 Hz, 1 H, ArH), 8.29 (d, J = 5.3 Hz, 1 H, ArH) ppm. ^{13}C NMR (50 MHz, $CDCl_3$/[D$_6$]DMSO): δ = 46.4, 54.1, 54.7, 67.4, 96.8, 106.3, 108.3, 113.4, 118.2, 119.2, 120.4, 120.8, 126.9, 127.4, 132.8, 135.4, 136.0, 139.1, 144.8, 156.3, 159.0 ppm. MS (ESI+): m/z = 347.1 [M + H]$^+$. HRMS (ESI): calcd. for $C_{21}H_{19}N_2O_3$ [M + H]$^+$ 347.1396; found 347.1409.

Methyl 6-Hydroxy-3-methoxy-1,6-dihydro-7,13b-diazabenzo[5,6]cyclohepta[1,2,3-*jk*]fluorene-8-carboxylate (15a): Yield: 83%; white solid; m.p. 185–187 °C; R_f = 0.45 (hexanes/EtOAc, 55:45). IR (KBr): $\tilde{\nu}$ = 1709 (CO_2CH_3), 3341 (OH) cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$): δ = 3.78 (s, 3 H, OCH_3), 4.02 (s, 3 H, CO_2CH_3), 5.50 (d, J = 14.2 Hz, 1 H, NC*H*H), 5.67 (d, J = 14.4 Hz, 1 H, NCH*H*), 6.61 (s, 1 H, CH), 6.88–7.00 (m, 2 H, ArH), 7.35–7.38 (m, 1 H, ArH), 7.66–7.80 (m, 3 H, ArH), 8.14 (d, J = 7.7 Hz, 1 H, ArH), 8.74 (s, 1 H, ArH) ppm. ^{13}C NMR (50 MHz, $CDCl_3$): δ = 47.9, 52.6, 55.5, 74.1, 109.5, 113.3, 116.1, 118.0, 120.8, 121.0, 121.9, 122.2, 128.5, 129.0, 132.9, 133.5, 134.7, 141.0, 143.5, 159.3, 163.5, 166.2 ppm. MS (ESI+): m/z = 375.1 [M + H]$^+$. HRMS (ESI): calcd. for $C_{22}H_{19}N_2O_4$ [M + H]$^+$ 375.1345; found 375.1357.

3-Methoxy-1,6-dihydro-7,13b-diazabenzo[5,6]cyclohepta[1,2,3-*jk*]-fluoren-6-ol (15b): Yield: 81%; white solid; m.p. 182–184 °C; R_f = 0.44 (hexanes/EtOAc, 60:40). IR (KBr): $\tilde{\nu}$ = 3451 (OH) cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$): δ = 3.77 (s, 3 H, OCH_3), 5.37 (d, J = 14.4 Hz, 1 H, NC*H*H), 5.70 (d, J = 14.4 Hz, 1 H, NC*H*H), 6.66 (s, 1 H, CH), 6.88–6.93 (m, 2 H, ArH), 7.28–7.30 (m, 1 H, ArH), 7.62–7.66 (m, 2 H, ArH), 7.78–7.84 (m, 2 H, ArH), 8.09 (d, J = 7.8 Hz, 1 H, ArH), 8.27 (d, J = 5.3 Hz, 1 H, ArH) ppm. ^{13}C NMR (50 MHz, $CDCl_3$): δ = 47.8, 55.5, 70.1, 109.1, 113.2, 114.7, 115.9, 119.8, 120.8, 122.1, 126.5, 128.4, 133.0, 134.4, 136.4, 140.5, 143.4, 159.1 ppm. MS (ESI+): m/z = 317.2 [M + H]$^+$. HRMS (ESI): calcd. for $C_{20}H_{17}N_2O_2$ [M + H]$^+$ 317.1290; found 317.1293.

Methyl 8-Hydroxy-8,14-dihydro-10,12-dioxa-7,14a-diazaindeno-[5′,6′:5,6]cyclohepta[1,2,3-*jk*]fluorine-6-carboxylate (16a): Yield: 82%; white solid; m.p. >250 °C; R_f = 0.42 (hexanes/EtOAc, 60:40). IR (KBr): $\tilde{\nu}$ = 1703 (CO_2CH_3), 3472 (OH) cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$/[D$_6$]DMSO): δ = 3.93 (s, 3 H, CO_2CH_3), 5.69 (d, J = 14.5 Hz, 1 H, CH), 5.95 (s, 2 H, NCH_2), 6.01 (s, 2 H, OCH_2O), 7.23 (s, 1 H, ArH), 7.28 (s, 1 H, ArH), 7.36 (t, J = 7.1 Hz, 1 H, ArH), 7.72 (t, J = 7.5 Hz, 1 H, ArH), 8.06 (d, J = 7.6 Hz, 1 H, ArH), 8.41–8.47 (m, 1 H, ArH), 8.91 (s, 1 H, ArH) ppm. ^{13}C NMR (50 MHz, $CDCl_3$): insoluble. MS (ESI+): m/z = 389.2 [M + H]$^+$. HRMS (ESI): calcd. for $C_{22}H_{17}N_2O_5$ [M + H]$^+$ 389.1137; found 389.1132.

8,14-Dihydro-10,12-dioxa-7,14a-diazaindeno[5′,6′:5,6]cyclohepta-[1,2,3-*jk*]fluoren-8-ol (16b): Yield: 65%; brown solid; m.p. >250 °C; R_f = 0.46 (hexanes/EtOAc, 60:40). IR (KBr): $\tilde{\nu}$ = 3443 (OH) cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$/[D$_6$]DMSO): δ = 5.54–5.63 (m, 1 H, N*H*H), 5.79 (br. s, 1 H, NH*H*), 5.94 (s, 2 H, OCH_2O), 6.23 (s, 1 H, C*H*OH), 6.93 (s, 1 H, CHO*H*), 7.13 (s, 1 H, ArH), 7.15 (s, 1 H, ArH), 7.26 (t, J = 7.7 Hz, 1 H, ArH), 7.63 (t, J = 7.7 Hz, 1 H, ArH), 7.86 (d, J = 8.2 Hz, 1 H, ArH), 7.94 (d, J = 2.0 Hz, 1 H, ArH), 8.14 (d, J = 7.7 Hz, 1 H, ArH), 8.26 (d, J = 5.1 Hz, 1 H, ArH) ppm. MS (EI+): m/z = 330 [M]$^+$.

General Procedure for the Friedel–Crafts Reaction by using P_2O_5 as a Catalyst, as Exemplified by 19aA: To a stirred solution of **7aA** (0.49 g, 1.0 mmol) in dry dichloromethane (30 mL) in a round-bottomed flask was added P_2O_5 (0.2 g) at room temperature, and the reaction was continued for 1 h. Upon completion (TLC) of the reaction, the reaction mixture was poured into water and neutralized with a saturated solution of $NaHCO_3$. The contents were extracted with dichloromethane (2 × 30 mL). The combined organic layer was dried (Na_2SO_4) and concentrated to obtain a yellow residue, which was purified by column chromatography (silica gel; hexanes/EtOAc, 82:18) to furnish **19aA** (0.40 g, 85%) as a white solid.

2-(3,4,5-Trimethoxy-8-methoxycarbonyl-1,6-dihydro-7,13b-diazabenzo[5,6]cyclohepta[1,2,3-*jk*]fluoren-6-yl)acrylonitrile (19aA): White solid; m.p. 204–206 °C; R_f = 0.48 (hexanes/EtOAc, 60:40). IR (KBr): $\tilde{\nu}$ = 1718 (CO_2CH_3), 2226 (CN) cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$): δ = 3.84 (s, 3 H, OCH_3), 3.88 (s, 3 H, OCH_3), 4.04 (s, 3 H, OCH_3), 4.06 (s, 3 H, CO_2CH_3), 5.20–5.25 (m, 2 H, NC*H*H and CH), 5.62 (d, J = 14.6 Hz, 1 H, NCH*H*), 6.11–6.18 (m, 2 H, =CH_2), 6.71 (s, 1 H, ArH), 7.35–7.41 (m, 1 H, ArH),

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7.64–7.73 (m, 2 H, ArH), 8.19 (d, J = 7.8 Hz, 1 H, ArH), 8.85 (s, 1 H, ArH) ppm. ^{13}C NMR (50 MHz, $CDCl_3$): δ = 47.3, 47.5, 52.9, 56.2, 60.9, 61.9, 109.5, 109.7, 117.6, 118.1, 121.0, 121.2, 122.3, 123.1, 125.6, 129.2, 129.4, 129.7, 131.8, 136.3, 137.7, 140.4, 141.0, 143.0, 152.8, 153.5, 166.6 ppm. MS (ESI+): m/z = 470.2 $[M + H]^+$. HRMS (ESI): calcd. for $C_{27}H_{24}N_3O_5$ $[M + H]^+$ 470.1716; found 470.1728.

Methyl 2-(3,4,5-Trimethoxy-8-methoxycarbonyl-1,6-dihydro-7,13b-diazabenzo[5,6]cyclohepta[1,2,3-*jk*]fluoren-6-yl)acrylate (19aB): White solid; m.p. 215–216 °C; R_f = 0.45 (hexanes/EtOAc, 60:40). IR (KBr): $\tilde{\nu}$ = 1722 (CO_2CH_3) cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 3.65 (s, 3 H, OCH_3), 3.83 (s, 6 H, 2 OCH_3), 4.01 (s, 3 H, CO_2CH_3), 4.05 (s, 3 H, CO_2CH_3), 4.86 (d, J = 2.2 Hz, 1 H, CH), 5.12 (d, J = 14.6 Hz, 1 H, NCH*H*), 5.77 (d, J = 14.5 Hz, 1 H, NC*H*H), 6.29–6.31 (m, 2 H, =CH_2), 6.59 (s, 1 H, ArH), 7.33–7.38 (m, 1 H, ArH), 7.61–7.70 (m, 2 H, ArH), 8.19 (d, J = 7.8 Hz, 1 H, ArH), 8.83 (s, 1 H, ArH) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 46.1, 47.4, 51.9, 52.8, 56.0, 60.8, 61.6, 109.0, 109.5, 117.7, 120.6, 121.2, 122.1, 125.6, 126.9, 128.7, 129.3, 136.5, 137.4, 140.9, 142.2, 142.7, 143.2, 152.6, 152.9, 166.6, 166.9 ppm. MS (ESI+): m/z = 503.1 $[M + H]^+$. HRMS (ESI): calcd. for $C_{28}H_{27}N_2O_7$ $[M + H]^+$ 503.1818; found 503.1821.

Ethyl 2-(3,4,5-Trimethoxy-8-methoxycarbonyl-1,6-dihydro-7,13b-diazabenzo[5,6]cyclohepta[1,2,3-*jk*]fluoren-6-yl)acrylate (19aC): White solid; m.p. 170–171 °C; R_f = 0.51 (hexanes/EtOAc, 60:40). IR (KBr): $\tilde{\nu}$ = 1715 (CO_2CH_3 and $CO_2C_2H_5$) cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.65 (t, J = 7.1 Hz, 3 H, $CO_2CH_2CH_3$), 3.83 (s, 3 H, OCH_3), 3.84 (s, 3 H, OCH_3), 3.98 (s, 3 H, OCH_3), 4.09–4.14 (m, 5 H, CO_2CH_3 and $CO_2CH_2CH_3$), 4.83 (d, J = 1.9 Hz, 1 H, CH), 5.12 (d, J = 14.6 Hz, 1 H, NC*H*H), 5.79 (d, J = 14.5 Hz, 1 H, NCH*H*), 6.28 (s, 2 H, =CH_2), 6.59 (s, 1 H, ArH), 7.36 (t, J = 6.6 Hz, 1 H, ArH), 7.61–7.70 (m, 2 H, ArH), 8.18 (d, J = 7.7 Hz, 1 H, ArH), 8.83 (s, 1 H, ArH) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 14.2, 46.2, 47.5, 52.8, 56.1, 60.8, 61.7, 109.1, 109.5, 117.7, 120.7, 121.3, 122.2, 126.0, 126.5, 128.8, 129.4, 136.6, 137.5, 141.0, 142.7, 142.8, 143.4, 152.7, 152.9, 166.4, 167.0 ppm. MS (ESI+): m/z = 517.2 $[M + H]^+$. HRMS (ESI): calcd. for $C_{29}H_{29}F_6N_2O_7$ $[M + H]^+$ 517.1975; found 517.1971.

Butyl 2-(3,4,5-Trimethoxy-8-methoxycarbonyl-1,6-dihydro-7,13b-diazabenzo[5,6]cyclohepta[1,2,3-*jk*]fluoren-6-yl)acrylate (19aD): White solid; m.p. 155–156 °C; R_f = 0.53 (hexanes/EtOAc, 55:45). IR (KBr): $\tilde{\nu}$ = 1718 (CO_2CH_3 and $CO_2C_4H_9$) cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 0.88 (t, J = 7.3 Hz, 3 H, $CO_2CH_2CH_2CH_2CH_3$), 1.26–1.34 (m, 2 H, $CO_2CH_2CH_2CH_2CH_3$), 1.48–1.55 (m, 2 H, $CO_2CH_2CH_2CH_2CH_3$), 3.82 (s, 3 H, OCH_3), 3.84 (s, 3 H, OCH_3), 3.99 (s, 3 H, OCH_3), 4.03–4.07 (m, 5 H, $CO_2CH_2CH_2CH_2CH_3$ and CO_2CH_3), 4.83 (s, 1 H, CH), 5.12 (d, J = 14.5 Hz, 1 H, NC*H*H), 5.79 (d, J = 14.6 Hz, 1 H, NCH*H*), 6.27 (s, 2 H, =CH_2), 6.59 (s, 1 H, ArH), 7.35 (t, J = 6.5 Hz, 1 H, ArH), 7.61–7.70 (m, 2 H, ArH), 8.19 (d, J = 7.8 Hz, 1 H, ArH), 8.83 (s, 1 H, ArH) ppm. ^{13}C NMR (50 MHz, $CDCl_3$): δ = 13.8, 19.2, 29.8, 52.9, 56.1, 60.8, 61.7, 64.9, 109.0, 109.6, 117.7, 120.7, 121.3, 122.2, 125.7, 126.0, 126.6, 128.8, 129.3, 136.6, 137.4, 141.0, 142.6, 142.8, 143.5, 152.7, 152.9, 166.4, 167.0 ppm. MS (ESI+): m/z = 545.2 $[M + H]^+$. HRMS (ESI): calcd. for $C_{31}H_{33}N_2O_7$ $[M + H]^+$ 545.2288; found 545.2293.

2-(3,4,5-Trimethyl-1,6-dihydro-7,13b-diazabenzo[5,6]cyclohepta-[1,2,3-*jk*]fluoren-6-yl)acrylonitrile (19bA): White solid; m.p. 134–136 °C; R_f = 0.52 (hexanes/EtOAc, 60:40). IR (KBr): $\tilde{\nu}$ = 2225 (CN) cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 3.86 (s, 3 H, OCH_3), 3.88 (s, 3 H, OCH_3), 4.01 (s, 3 H, OCH_3), 5.17–5.26 (m, 2 H, CH and NC*H*H), 5.59 (d, J = 14.6 Hz, 1 H, NCH*H*), 6.00 (d, J = 2.5 Hz, 1 H, =C*H*H), 6.10 (d, J = 2.7 Hz, 1 H, =CH*H*), 6.72 (s, 1 H, ArH), 7.26–7.33 (m, 1 H, ArH), 7.59–7.68 (m, 2 H, ArH), 7.91 (d, J = 5.2 Hz, 1 H, ArH), 8.14 (d, J = 7.8 Hz, 1 H, ArH), 8.41 (d, J = 5.2 Hz, 1 H, ArH) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 47.3, 47.4, 56.2, 60.9, 61.9, 109.1, 109.8, 114.8, 117.7, 119.9, 120.8, 122.1, 123.5, 125.9, 128.6, 129.5, 130.0, 131.6, 134.8, 138.9, 140.4, 140.6, 142.8, 152.6, 153.4 ppm. MS (ESI+): m/z = 412.2 $[M + H]^+$. HRMS (ESI): calcd. for $C_{25}H_{22}N_3O_3$ $[M + H]^+$ 412.1661; found 412.1665.

Ethyl 2-(3,4,5-Trimethoxy-1,6-dihydro-7,13b-diazabenzo[5,6]cyclohepta[1,2,3-*jk*]fluoren-6-yl)acrylate (19bC): White solid; m.p. 162–164 °C; R_f = 0.53 (hexanes/EtOAc, 60:40). IR (KBr): $\tilde{\nu}$ = 1716 ($CO_2C_2H_5$) cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.17 (t, J = 7.1 Hz, 3 H, $CO_2CH_2CH_3$), 3.83 (s, 3 H, OCH_3), 3.85 (s, 3 H, OCH_3), 3.96 (s, 3 H, OCH_3), 4.08–4.16 (m, 2 H, $CO_2CH_2CH_3$), 4.86 (d, J = 2.1 Hz, 1 H, CH), 5.10 (d, J = 14.5 Hz, 1 H, NC*H*H), 5.75 (d, J = 14.4 Hz, 1 H, NCH*H*), 6.13 (t, J = 2.2 Hz, 1 H, =C*H*H), 6.27 (d, J = 2.1 Hz, 1 H, =CH*H*), 6.60 (s, 1 H, ArH), 7.26–7.30 (m, 1 H, ArH), 7.56–7.65 (m, 2 H, ArH), 7.87 (d, J = 5.3 Hz, 1 H, ArH), 8.13 (d, J = 7.8 Hz, 1 H, ArH), 8.38 (d, J = 5.3 Hz, 1 H, ArH) ppm. ^{13}C NMR (50 MHz, $CDCl_3$): δ = 14.0, 46.0, 47.2, 53.5, 56.0, 60.8, 61.6, 109.0, 109.1, 114.1, 119.5, 120.8, 121.9, 126.1, 126.2, 128.2, 128.7, 129.5, 134.8, 138.6, 140.4, 142.5, 142.9, 143.4, 152.4, 152.6, 166.4 ppm. MS (ESI+): m/z = 459.2 $[M + H]^+$. HRMS (ESI): calcd. for $C_{27}H_{27}N_2O_5$ $[M + H]^+$ 459.1920; found 459.1930.

2-(3,4-Dimethoxy-8-methoxycarbonyl-1,6-dihydro-7,13b-diazabenzo[5,6]cyclohepta[1,2,3-*jk*]fluoren-6-yl)acrylonitrile (20aA): White solid; m.p. 213-215 °C; R_f = 0.46 (hexanes/EtOAc, 60:40). IR (KBr): $\tilde{\nu}$ = 1726 (CO_2CH_3), 2216 (CN) cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 3.89 (s, 3 H, OCH_3), 3.92 (s, 3 H, OCH_3), 4.07 (s, 3 H, CO_2CH_3), 5.23–5.34 (m, 3 H, CH, =CH*H* and NCH*H*), 5.60 (d, J = 14.8 Hz, 1 H, NC*H*H), 6.11 (d, J = 2.5 Hz, 1 H, =C*H*H), 6.90 (s, 1 H, ArH), 7.07 (s, 1 H, ArH), 7.39 (t, J = 6.4 Hz, 1 H, ArH), 7.66–7.74 (m, 2 H, ArH), 8.21 (d, J = 7.8 Hz, 1 H, ArH), 8.86 (s, 1 H, ArH) ppm. ^{13}C NMR (50 MHz, $CDCl_3$): δ = 47.2, 53.0, 56.19, 56.24, 56.8, 109.6, 114.0, 115.0, 117.3, 118.2, 121.0, 122.3, 125.0, 126.0, 129.0, 129.2, 129.6, 132.0, 136.1, 137.2, 140.2, 141.1, 149.0, 149.5, 166.5 ppm. MS (ESI+): m/z = 440.1 $[M + H]^+$. HRMS (ESI): calcd. for $C_{26}H_{22}N_3O_4$ $[M + H]^+$ 440.1610; found 440.1601.

Methyl 2-(3,4-Dimethoxy-8-methoxycarbonyl-1,6-dihydro-7,13b-diazabenzo[5,6]cyclohepta[1,2,3-*jk*]fluoren-6-yl)acrylate (20aB): White solid; m.p. 198–200 °C; R_f = 0.46 (hexanes/EtOAc, 60:40). IR (KBr): $\tilde{\nu}$ = 1719 (CO_2CH_3) cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 3.69 (s, 3 H, OCH_3), 3.85 (s, 3 H, OCH_3), 3.91 (s, 3 H, CO_2CH_3), 4.06 (s, 3 H, CO_2CH_3), 4.92 (d, J = 1.6 Hz, 1 H, CH), 5.18 (d, J = 14.6 Hz, 1 H, NCH*H*), 5.66–5.73 (m, 2 H, =C*H*H and NC*H*H), 6.30 (d, J = 1.3 Hz, 1 H, =CH*H*), 6.78 (s, 1 H, ArH), 7.21 (s, 1 H, ArH), 7.33–7.38 (m, 1 H, ArH), 7.66 (br. s, 2 H, ArH), 8.19 (d, J = 7.8 Hz, 1 H, ArH), 8.84 (s, 1 H, ArH) ppm. ^{13}C NMR (50 MHz, $CDCl_3$): δ = 46.8, 51.9, 52.8, 55.3, 56.1, 109.6, 113.2, 116.3, 117.7, 120.7, 121.1, 122.1, 126.1, 128.8, 130.6, 136.6, 137.2, 141.0, 141.6, 142.7, 148.1, 148.8, 166.4, 166.7 ppm. MS (ESI+): m/z = 473.2 $[M + H]^+$. HRMS (ESI): calcd. for $C_{27}H_{25}N_2O_6$ $[M + H]^+$ 473.1713; found 473.1716.

Methyl 2-(3,4-Dimethoxy-1,6-dihydro-7,13b-diazabenzo[5,6]cyclohepta[1,2,3-*jk*]fluoren-6-yl)acrylate (20bB): White solid; m.p. 185–187 °C; R_f = 0.54 (hexanes/EtOAc, 60:40). IR (KBr): $\tilde{\nu}$ = 1714 (CO_2CH_3) cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 3.71 (s, 3 H, OCH_3), 3.85 (s, 3 H, OCH_3), 3.91 (s, 3 H, CO_2CH_3), 4.98 (d, J = 1.6 Hz, 1 H, CH), 5.14 (d, J = 14.5 Hz, 1 H, NCH*H*), 5.51 (s, 1 H,

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=C*H*H), 5.67 (d, *J* = 14.5 Hz, 1 H, NCH*H*), 6.30 (d, *J* = 1.1 Hz, 1 H, =CH*H*), 6.78 (s, 1 H, ArH), 7.16 (s, 1 H, ArH), 7.29–7.32 (m, 1 H, ArH), 7.60–7.67 (m, 2 H, ArH), 7.90 (d, *J* = 5.3 Hz, 1 H, ArH), 8.14 (d, *J* = 7.8 Hz, 1 H, ArH), 8.38 (d, *J* = 5.3 Hz, 1 H, ArH) ppm. ^{13}C NMR (50 MHz, $CDCl_3$): δ = 46.7, 52.0, 55.7, 56.2, 109.1, 113.4, 114.3, 116.3, 119.7, 120.9, 122.0, 126.0, 126.5, 128.4, 129.1, 131.0, 135.1, 138.7, 140.5, 142.2, 142.7, 148.2, 148.8, 166.7 ppm. MS (ESI+): *m*/*z* = 415.2 $[M + H]^+$. HRMS (ESI): calcd. for $C_{25}H_{23}N_2O_4$ $[M + H]^+$ 415.1658; found 415.1653.

2-(3,5-Dimethoxy-8-methoxycarbonyl-1,6-dihydro-7,13b-diazabenzo[5,6]cyclohepta[1,2,3-*jk*]fluoren-6-yl)acrylonitrile (21aA): White solid; m.p. 140–142 °C; R_f = 0.42 (hexanes/EtOAc, 60:40). IR (KBr): $\tilde{\nu}$ = 1721 (CO_2CH_3), 2223 (CN) cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 3.83 (s, 3 H, OCH_3), 3.92 (s, 3 H, OCH_3), 4.08 (s, 3 H, CO_2CH_3), 5.22–5.27 (m, 2 H, NC*H*H and C*H*OH), 5.63 (d, *J* = 14.7 Hz, 1 H, NCH*H*), 6.08 (d, *J* = 2.8 Hz, 1 H, =C*H*H), 6.30 (t, *J* = 2.6 Hz, 1 H, =CH*H*), 6.56 (d, *J* = 1.2 Hz, 2 H, ArH), 7.36–7.42 (m, 1 H, ArH), 7.66–7.74 (m, 2 H, ArH), 8.21 (d, *J* = 7.8 Hz, 1 H, ArH), 8.86 (s, 1 H, ArH) ppm. ^{13}C NMR (50 MHz, [D$_6$]DMSO): δ = 45.3, 46.2, 52.1, 55.3, 56.3, 98.8, 107.9, 110.7, 116.5, 117.4, 117.8, 120.2, 120.7, 122.4, 123.9, 128.6, 128.9, 132.8, 135.8, 136.5, 139.9, 140.7, 158.1, 160.2, 165.7 ppm. MS (ESI+): *m*/*z* = 440.1 $[M + H]^+$. HRMS (ESI): calcd. for $C_{26}H_{22}N_3O_4$ $[M + H]^+$ 440.1610; found 440.1599.

Methyl 2-(3,5-Dimethoxy-8-methoxycarbonyl-1,6-dihydro-7,13b-diazabenzo[5,6]cyclohepta[1,2,3-*jk*]fluoren-6-yl)acrylate (21aB): White solid; m.p. 209–211 °C; R_f = 0.42 (hexanes/EtOAc, 55:45). IR (KBr): $\tilde{\nu}$ = 1719 (CO_2CH_3) cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 3.62 (s, 3 H, OCH_3), 3.77 (s, 3 H, OCH_3), 3.91 (s, 3 H, CO_2CH_3), 4.05 (s, 3 H, CO_2CH_3), 4.84 (d, *J* = 2.2 Hz, 1 H, C*H*OH), 5.13 (d, *J* = 14.5 Hz, 1 H, NCH*H*), 5.77 (d, *J* = 14.4 Hz, 1 H, NC*H*H), 6.27 (d, *J* = 2.2 Hz, 1 H, =C*H*H), 6.39–6.42 (m, 2 H, =CH*H* and ArH), 6.48 (d, *J* = 2.3 Hz, 1 H, ArH), 7.32–7.37 (m, 1 H, ArH), 7.61–7.69 (m, 2 H, ArH), 8.18 (d, *J* = 7.8 Hz, 1 H, ArH), 8.82 (s, 1 H, ArH) ppm. ^{13}C NMR (50 MHz, $CDCl_3$): δ = 44.9, 47.5, 51.8, 52.7, 55.3, 56.3, 98.9, 106.6, 109.5, 117.6, 120.2, 120.6, 121.2, 122.1, 126.4, 128. 7, 135.6, 136.8, 137.3, 140.9, 142.7, 143.3, 159.1, 159.7, 166.7, 166.9 ppm. MS (ESI+): *m*/*z* = 473.2 $[M + H]^+$. HRMS (ESI): calcd. for $C_{27}H_{25}N_2O_6$ $[M + H]^+$ 473.1713; found 473.1716.

Ethyl 2-(3,5-Dimethoxy-8-methoxycarbonyl-1,6-dihydro-7,13b-diazabenzo[5,6]cyclohepta[1,2,3-*jk*]fluoren-6-yl)acrylate (21aC): White solid; m.p. 229–231 °C; R_f = 0.44 (hexanes/EtOAc, 70:30). IR (KBr): $\tilde{\nu}$ = 1716 (CO_2CH_3 and $CO_2C_2H_5$) cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.14 (t, *J* = 7.1 Hz, 3 H, $COCH_2CH_3$), 3.77 (s, 3 H, OCH_3), 3.89 (s, 3 H, OCH_3), 4.05–4.10 (m, 5 H, CO_2CH_3 and $CO_2CH_2CH_3$), 4.79 (d, *J* = 2.1 Hz, 1 H, CH), 5.13 (d, *J* = 14.5 Hz, 1 H, NC*H*H), 5.79 (d, *J* = 14.5 Hz, 1 H, NCH*H*), 6.27 (d, *J* = 2.1 Hz, 1 H, =C*H*H), 6.37–6.46 (m, 3 H, =CH*H* and ArH), 7.32–7.37 (m, 1 H, ArH), 7.61–7.69 (m, 2 H, ArH), 8.18 (d, *J* = 7.8 Hz, 1 H, ArH), 8.82 (s, 1 H, ArH) ppm. ^{13}C NMR (50 MHz, $CDCl_3$): δ = 14.0, 44.8, 47.6, 52.7, 55.3, 56.0, 60.7, 98.7, 106.4, 109.5, 117.6, 120.2, 120.6, 121.2, 122.0, 126.2, 128.6, 135.6, 137.2, 140.9, 143.0, 143.5, 159.1, 159.8, 166.5 ppm. MS (ESI+): *m*/*z* = 487.2 $[M + H]^+$. HRMS (ESI): calcd. for $C_{28}H_{27}N_2O_6$ $[M + H]^+$ 487.1869; found 487.1875.

2-(3,5-Dimethyl-1,6-dihydro-7,13b-diazabenzo[5,6]cyclohepta-[1,2,3-*jk*]fluoren-6-yl)acrylonitrile (21bA): White solid; m.p. 183–185 °C; R_f = 0.41 (hexanes/EtOAc, 60:40). IR (KBr): $\tilde{\nu}$ = 2224 (CN) cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 3.81 (s, 3 H, OCH_3), 3.90 (s, 3 H, OCH_3), 5.17–5.25 (m, 2 H, NC*H*H and C*H*OH), 5.58 (d, *J* = 14.6 Hz, 1 H, NCH*H*), 6.06 (d, *J* = 2.6 Hz, 1 H, =C*H*H), 6.12 (d, *J* = 2.4 Hz, 1 H, =CH*H*), 6.54 (d, *J* = 3.0 Hz, 2 H, ArH), 7.26–7.32 (m, 1 H, ArH), 7.58–7.67 (m, 2 H, ArH), 7.90 (d, *J* = 5.2 Hz, 1 H, ArH), 8.13 (d, *J* = 7.8 Hz, 1 H, ArH), 8.41 (d, *J* = 5.2 Hz, 1 H, ArH) ppm. ^{13}C NMR (50 MHz, $CDCl_3$): δ = 46.0, 47.6, 55.5, 56.3, 98.7, 107.4, 109.1, 114.7, 117.7, 117.9, 119.8, 120.8, 122.1, 126.3, 128.6, 129.4, 131.1, 135.0, 136.3, 138.8, 140.5, 140.8, 158.8, 160.6 ppm. MS (ESI+): *m*/*z* = 382.2 $[M + H]^+$. HRMS (ESI): calcd. for $C_{24}H_{20}N_3O_2$ $[M + H]^+$ 382.1556; found 382.1557.

Methyl 2-(3,5-Dimethoxy-1,6-dihydro-7,13b-diazabenzo[5,6]cyclohepta[1,2,3-*jk*]fluoren-6-yl)acrylate (21bB): White solid; m.p. 187–189 °C; R_f = 0.42 (hexanes/EtOAc, 70:30). IR (KBr): $\tilde{\nu}$ = 1710 (CO_2CH_3) cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 3.64 (s, 3 H, OCH_3), 3.77 (s, 3 H, OCH_3), 3.91 (s, 3 H, CO_2CH_3), 4.88 (d, *J* = 1.7 Hz, 1 H, C*H*OH), 5.10 (d, *J* = 14.5 Hz, 1 H, NCH*H*), 5.74 (d, *J* = 14.2 Hz, 1 H, NC*H*H), 6.26 (br. s, 2 H, =CH_2), 6.43 (s, 1 H, ArH), 6.49 (d, *J* = 2.3 Hz, 1 H, ArH), 7.26–7.29 (m, 1 H, ArH), 7.56–7.62 (m, 2 H, ArH), 7.86 (d, *J* = 5.3 Hz, 1 H, ArH), 8.12 (d, *J* = 7.9 Hz, 1 H, ArH), 8.38 (d, *J* = 5.3 Hz, 1 H, ArH) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 44.9, 47.5, 51.9, 55.4, 56.4, 98.9, 106.7, 109.1, 114.1, 119.6, 120.6, 121.0, 126.2, 128.2, 128.8, 135.2, 135.9, 138.7, 140.5, 143.2, 143.5, 159.0, 159.7, 167.0 ppm. MS (ESI+): *m*/*z* = 415.3 $[M + H]^+$. HRMS (ESI): calcd. for $C_{25}H_{23}N_2O_4$ $[M + H]^+$ 415.1658; found 415.1661.

2-(6-Carboxymethyl-8,14-dihydro-10,12-dioxa-7,14a-diazaindeno-[5′,6′:5,6]cyclohepta[1,2,3-*jk*]fluorine-8-yl)acrylonitrile (22aA): White solid; m.p. 203–205 °C; R_f = 0.43 (hexanes/EtOAc, 60:40). IR (KBr): $\tilde{\nu}$ = 1713 (CO_2CH_3), 2225 (CN) cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 4.07 (s, 3 H, CO_2CH_3), 5.18–5.23 (m, 2 H, CH and NCH*H*), 5.32 (s, 1 H, =CH*H*), 5.56 (d, *J* = 14.8 Hz, 1 H, NC*H*H), 5.95 (s, 1 H, =C*H*H), 6.01 (d, *J* = 1.0 Hz, 1 H, OCH*H*O), 6.12 (d, *J* = 2.5 Hz, 1 H, OC*H*HO), 6.89 (s, 1 H ArH), 7.04 (s, 1 H, ArH), 7.38 (t, *J* = 6.9 Hz, 1 H, ArH), 7.62–7.73 (m, 2 H, ArH), 8.20 (d, *J* = 7.9 Hz, 1 H, ArH), 8.86 (s, 1 H, ArH) ppm. ^{13}C NMR (50 MHz, $CDCl_3$): δ = 47.0, 53.1, 56.9, 101.8, 109.5, 110.9, 112.1, 117.2, 118.3, 121.2, 122.3, 125.1, 127.4, 129.3, 130.4, 132.1, 136.1, 137.5, 140.0, 141.0, 148.5, 166.6 ppm. MS (ESI+): *m*/*z* = 424.1 $[M + H]^+$. HRMS (ESI): calcd. for $C_{25}H_{18}N_3O_4$ $[M + H]^+$ 424.1297; found 424.1294.

Methyl 2-(6-Carboxymethyl-8,14-dihydro-10,12-dioxa-7,14a-diazaindeno[5′,6′:5,6]cyclohepta[1,2,3-*jk*]fluorine-8-yl)acrylate (22aB): White solid; m.p. 164–165 °C; R_f = 0.49 (hexanes/EtOAc, 70:30). IR (KBr): $\tilde{\nu}$ = 1717 (CO_2CH_3) cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 3.45 (d, *J* = 14.8 Hz, 1 H, NC*H*H), 3.75 (s, 1 H, CH), 3.79 (s, 3 H, CO_2CH_3), 4.07 (s, 3 H, CO_2CH_3), 4.76 (d, *J* = 16.0 Hz, 1 H, NCH*H*), 5.99 (s, 2 H, OCH_2O), 6.41 (d, *J* = 15.4 Hz, 1 H, =CH*H*), 6.80 (s, 1 H, =C*H*H), 7.02 (s, 1 H, ArH), 7.38 (t, *J* = 7.0 Hz, 1 H, ArH), 7.51 (d, *J* = 8.4 Hz, 1 H, ArH), 7.61 (t, *J* = 7.5 Hz, 1 H, ArH), 8.20 (d, *J* = 7.6 Hz, 1 H, ArH), 8.28 (s, 1 H, ArH), 8.82 (s, 1 H, ArH) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 46.8, 52.1, 52.9, 55.5, 101.5, 109.5, 110.2, 113.5, 117.8, 120.8, 121.2, 122.2, 126.6, 127.3, 129.0, 132.1, 136.6, 137.4, 141.0, 141.6, 142.5, 147.1, 147.8, 166.4, 166.8 ppm. MS (ESI+): *m*/*z* = 457.1 $[M + H]^+$. HRMS (ESI): calcd. for $C_{26}H_{21}N_2O_6$ $[M + H]^+$ 457.1400; found 457.1397.

Methyl 2-Cyano-11-(3-methoxybenzyl)-11*H*-indolizino[8,7-*b*]indole-5-carboxylate (23aA): Yellow solid; m.p. 207–208 °C; R_f = 0.39 (hexanes/EtOAc, 90:10). IR (KBr): $\tilde{\nu}$ = 1709 (CO_2CH_3), 2230 (CN) cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 3.71 (s, 3 H, OCH_3), 4.03 (s, 3 H, CO_2CH_3), 5.68 (s, 2 H, NCH_2), 6.60 (s, 1 H, ArH), 6.67 (d, *J* = 7.2 Hz, 1 H, ArH), 6.80 (d, *J* = 6.7 Hz, 1 H, ArH), 6.92 (s, 1 H, ArH), 7.20–7.26 (m, 1 H, ArH), 7.38–7.43 (m, 3 H, ArH), 8.00 (d, *J* = 7.4 Hz, 1 H, ArH), 8.45 (s, 1 H, ArH), 9.33 (s, 1 H, ArH) ppm. ^{13}C NMR (50 MHz, $CDCl_3$): δ = 48.2, 52.6, 55.9, 97.0, 102.2, 110.0, 110.1, 116.4, 116.6, 117.8, 119.5, 122.0, 123.3,

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125.4, 125.9, 129.3, 135.8, 140.0, 160.2, 162.9 ppm. MS (ESI+): *m*/*z* = 410.2 [M + H]$^+$. HRMS (ESI): calcd. for $C_{25}H_{20}N_3O_3$ [M + H]$^+$ 410.1505; found 410.1511.

Dimethyl 11-(3-Methoxybenzyl)-11*H*-indolizino[8,7-*b*]indole-2,5-dicarboxylate (23aB): Yellow solid; m.p. 211–212 °C; R_f = 0.41 (hexanes/EtOAc, 90:10). IR (KBr): $\tilde{\nu}$ = 1717 (CO_2CH_3) cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 3.70 (s, 3 H, OCH_3), 3.88 (s, 3 H, CO_2CH_3), 4.03 (s, 3 H, CO_2CH_3), 5.75 (s, 2 H, NCH_2), 6.67–6.78 (m, 3 H, ArH), 7.16–7.21 (m, 2 H, ArH), 7.26–7.39 (m, 3 H, ArH), 7.98 (d, *J* = 7.0 Hz, 1 H, ArH), 8.42 (s, 1 H, ArH), 9.40 (s, 1 H, ArH) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 48.3, 51.6, 52.3, 55.3, 100.7, 109.3, 110.1, 112.4, 112.8, 116.5, 118.1, 118.5, 119.1, 119.3, 121.6, 121.7, 123.7, 124.2, 124.8, 130.3, 134.1, 137.9, 139.9, 160.3, 163.2, 165.5 ppm. MS (ESI+): *m*/*z* = 443.1 [M + H]$^+$. HRMS (ESI): calcd. for $C_{26}H_{23}N_2O_5$ [M + H]$^+$ 443.1607; found 443.1603.

2-Ethyl 5-Methyl-11-(3-methoxybenzyl)-11*H*-indolizino[8,7-*b*]-indole-2,5-dicarboxylate (23aC): Yellow solid; m.p. 171–173 °C; R_f = 0.42 (hexanes/EtOAc, 90:10). IR (KBr): $\tilde{\nu}$ = 1718 (CO_2CH_3 and $CO_2C_2H_5$) cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.41 (t, *J* = 7.1 Hz, 3 H, $CO_2CH_2CH_3$), 3.71 (s, 3 H, OCH_3), 4.05 (s, 3 H, CO_2CH_3), 4.37 (q, *J* = 7.1 Hz, 2 H, $CO_2CH_2CH_3$), 5.77 (s, 2 H, NCH_2), 6.70–6.81 (m, 3 H, ArH), 7.19–7.24 (m, 2 H, ArH), 7.32–7.41 (m, 3 H, ArH), 7.99 (d, *J* = 6.8 Hz, 1 H, ArH), 8.43 (s, 1 H, ArH), 9.41 (s, 1 H, ArH) ppm. ^{13}C NMR (50 MHz, $CDCl_3$): δ = 14.6, 48.3, 52.3, 55.3, 60.4, 100.8, 109.2, 110.1, 112.4, 112.8, 116.5, 118.1, 118.5, 119.3, 119.5, 121.5, 121.6, 123.8, 124.1, 124.8, 130.2, 134.1, 137.9, 140.0, 160.2, 163.2, 165.1 ppm. MS (ESI+): *m*/*z* = 457.4 [M + H]$^+$. HRMS (ESI): calcd. for $C_{27}H_{25}N_2O_5$ [M + H]$^+$ 457.1763; found 457.1758.

Methyl 12-(3,4,5-Trimethoxybenzyl)-1-oxo-2,3,4,12-tetrahydro-1*H*-benzo[2,3]indolizino[8,7-*b*]indole-6-carboxylate (25): Yield: 91%; yellow solid; m.p. 174–176 °C; R_f = 0.47 (hexanes/EtOAc, 90:10). IR (KBr): $\tilde{\nu}$ = 1673 (CO), 1710 (CO_2CH_3) cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 2.15–2.19 (m, 2 H, CH_2), 2.66 (t, *J* = 6.7 Hz, 2 H, CH_2), 2.87 (t, *J* = 6.0 Hz, 2 H, CH_2) 3.68 (s, 6 H, 2 OCH_3), 3.79 (s, 3 H, OCH_3), 4.05 (s, 3 H, CO_2CH_3), 5.73 (s, 2 H, NCH_2), 6.36 (s, 2 H, ArH), 7.30–7.44 (m, 4 H, ArH), 7.96 (d, *J* = 7.3 Hz, 1 H, ArH), 8.12 (s, 1 H, ArH) ppm. ^{13}C NMR (50 MHz, $CDCl_3$): δ = 25.0, 26.7, 38.4, 46.9, 52.6, 56.2, 60.9, 97.0, 108.8, 109.9, 117.0, 117.3, 119.2, 119.8, 121.5, 123.6, 123.7, 124.6, 124.8, 133.7, 138.4, 139.5, 153.5, 163.5, 196.5 ppm. MS (ESI+): *m*/*z* = 513.2 [M + H]$^+$. HRMS (ESI): calcd. for $C_{30}H_{29}N_2O_6$ [M + H]$^+$ 513.2026; found 513.2033.

Typical Procedure for the Synthesis of Compound 17 By Using MnO_2: To a stirred solution of **12a** (0.22 g, 0.5 mmol) in dichloromethane (15 mL) was added activated MnO_2 (0.4 g, 5 mmol), and the mixture was stirred for 2 h. Upon completion of the reaction, the reaction mixture was filtered through a bed of Celite, and the filtrate was concentrated to afford a residue. Triturating the residue with hexanes/EtOAc (80:20) [R_f = 0.44 (hexanes/EtOAc, 55:45)] afforded pure **17** (0.20 g, 92%) as a white solid.

Methyl 6-Oxo-3,4,5-trimethoxy-1,6-dihydro-7,13b-diazabenzo[5,6]-cyclohepta[1,2,3-*jk*]fluorene-8-carboxylate (17): M.p. >250 °C; R_f = 0.44 (hexanes/EtOAc, 55:45). IR (KBr): $\tilde{\nu}$ = 1708 (CO and CO_2CH_3) cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 3.83 (s, 3 H, OCH_3), 3.97 (s, 3 H, OCH_3), 4.01 (s, 3 H, OCH_3), 4.05 (s, 3 H, CO_2CH_3), 5.39 (s, 2 H, NCH_2), 6.78 (s, 1 H, ArH), 7.41 (t, *J* = 6.0 Hz, 1 H, ArH), 7.71 (s, 2 H, ArH), 8.22 (d, *J* = 7.8 Hz, 1 H, ArH), 8.96 (s, 1 H, ArH) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 48.7, 52.8, 56.4, 61.0, 62.8, 108.0, 109.7, 120.0, 121.2, 121.6, 122.6, 129.0, 129.4, 129.8, 131.7, 137.0, 138.9, 139.0, 141.2, 143.2, 153.5, 155.8, 166.5, 190.8 ppm. MS (ESI+): *m*/*z* = 433.1 [M + H]$^+$. HRMS (ESI): calcd. for $C_{24}H_{21}N_2O_6$ [M + H]$^+$ 433.1400; found 433.1404.

Procedure for the Synthesis of Compound 26: To a stirred suspension of **7a** (0.43 g, 1 mmol) in dry methanol (25 mL) was added $NaBH_4$ (0.04 g, 1 mmol) at room temperature. The reaction mixture was stirred for 20 min, and upon completion of the reaction, methanol was removed under reduced pressure. The reaction was neutralized with 5% aq. HCl and extracted with chloroform (2 × 20 mL). The organic layers were pooled, washed with brine, dried (Na_2SO_4), and concentrated to afford **26** (0.41 g, 94%) as a yellow solid.

Supporting Information (see footnote on the first page of this article): Remaining spectroscopic data and copies of the ^{1}H NMR and ^{13}C NMR spectra of all compounds.

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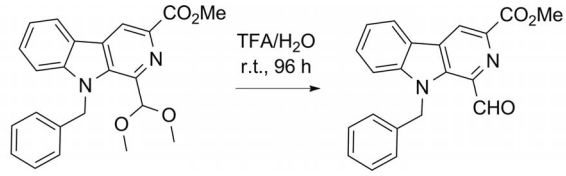

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