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SULFONAMIDOACETAL CYCLIZATION-BASED SYNTHESIS OF A TETRAHYDROOXAZAPHENALENELACTONE RELATED TO THE ABC-RING SYSTEM OF THE STEPHAOXOCANES

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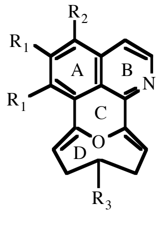
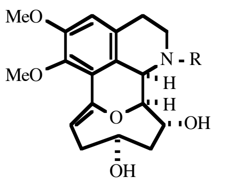
Abstract - *The elaboration of a tetrahydrooxazaphenalenelactone embodying the ABC-ring system of the stephaoxocanes, by means of Jackson's sulfonamidoacetal cyclization as the isoquinoline ring-forming strategy, is reported.*

Stephania cepharantha Hayata, *S. excentrica*, and *Cissampelos glaberrima* are Menispermaceae used as folk medicines in Taiwan, China and Brazil, respectively.[1a,b, 2a, 3] Their tuberous roots contain various alkaloids, such as bisbenzylisoquinolines, hasubanans, morphinans and aporphines.[1] Recently, however, the groups of Miao,[2] da-Cunha,[3] and Kashiwaba[4] reported the isolation of previously unknown alkaloids displaying a novel skeleton, for which the name stephaoxocane (**1a**)[4a] was coined.

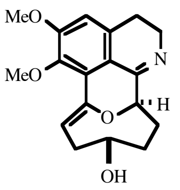
Figure



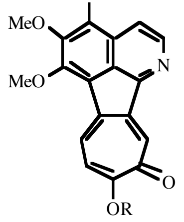
1a R_1=R_2=H, Stephaoxocane
1b R_1=OMe, R_2= H, R_3= OH, Stephaoxocanidine
1c R_1= R_2= OMe, R_3= OH Eletefine



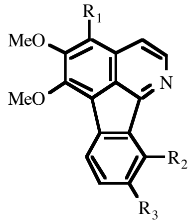
1d R= H, Excentricine
1e R = Me, 2-*N*-Methylexcentricine



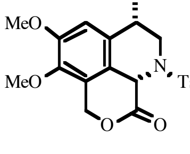
1f Stephaoxocanine



2a R= H Grandirubrine
2b R= Me Imerubrine



3a R_1= R_2=R_3= H Triclisine
3b R=R_1=H, R_2= OH Telitoxine
3c R_1= OMe, R_2= H, R_3= OMe Rufescine
3d R_1= OMe, R_2= H, R_3= OH Norrufescine
3e R_1=R_2=R_3= OMe Imeluteine



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To date, only 5 stephaoxocanes are known; they are stephaoxocanidine (**1b**)[4b] and stephaoxocanine (**1f**),[4a] obtained from *S. cepharantha*, eletefine[3] (**1c**), isolated from *C. glaberrima*, and excentricine (**1d**)[2a] and *N*-methylexcentricine (**1e**),[2b] from *S. excentrica.*

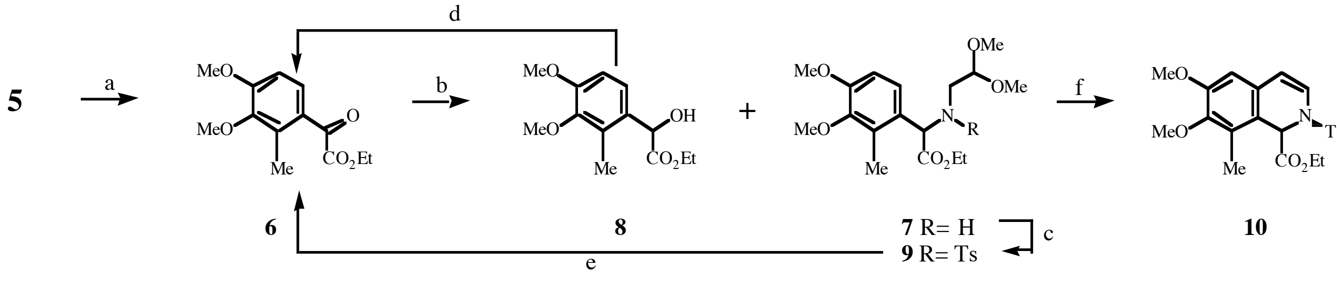
As shown in the Figure, the stephaoxocanes share a tetracyclic ring system composed of an isoquinoline moiety and an oxocane substructure joined together through a pyran ring, which conforms ring C. They are structurally reminiscent of tropoisoquinoline (**2a**,**b**) and azafluoranthene (**3a**-**e**) alkaloids,[5] which display an all carbon five-member C-ring system and were isolated from other Menispermaceae. This may be indicative of some biosynthetic relationship.[5b]

Being their natural sources used in folk medicine, the pharmacological evaluation of compounds (**1b**-**f**) could be of interest; nevertheless, the results of such an evaluation have not been described, presumably due to the small amounts of isolated material. Thus, the synthesis of the stephaoxocanes could provide material for testing; however, no synthetic work on these natural products has been reported so far.

Therefore, as part of our research effort dedicated to the synthesis of structurally interesting isoquinoline-type natural products by the use of Jackson's sulfonamidoacetal cyclization,[6] we decided to study the elaboration of the tetrahydrooxazaphenalenelactone (**4**) from the commercially available 2,3-dimethoxytoluene (**5**). Lactone (**4**) embodies the unique ABC-ring system of the naturally occurring stephaoxocanes, and may be a potential key intermediate to their synthesis.

In the start of the synthesis, the pair of carbon atoms required to establish the lactone ring was cleanly introduced by an $AlCl_3$-mediated Friedel-Crafts acylation of **5** with ethyloxalyl chloride at room temperature.[7] This provided α-keto ester (**6**) in 94% yield, essentially uncontaminated with other regioisomers, as depicted in Scheme 1.

Scheme 1



Reagents and conditions: a. $ClOCCO_2Et$, $AlCl_3$, CH_2Cl_2, rt (94%); b. $NaCNBH_3$, $H_2NCH_2CH(OMe)_2$, AcOH (4.5 equiv), EtOH, reflux (**7**, 53%; **8**, 42%); c. TsCl, Et_3N, CH_2Cl_2, rt (82%); d. $(COCl)_2$, DMSO, CH_2Cl_2, -60°C, then Et_3N (89%); e. $PdCl_2$, $CuCl_2$, AcOH (92%); f. 6N HCl, dioxane, reflux (83%).

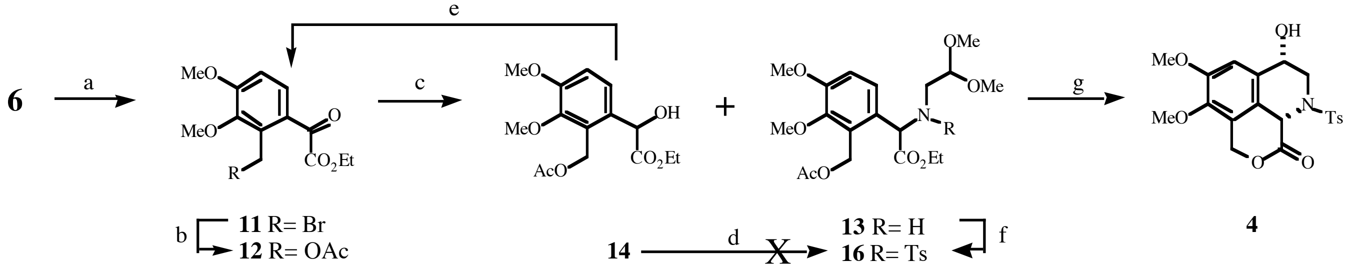
Next, reductive amination of glyoxylate (**6**) with aminoacetal and sodium cyanoborohydride in refluxing ethanol[8] furnished a mixture of the desired secondary amine (**7**) and α-hydroxy ester (**8**), the latter resulting from reduction of the starting ketone. Unfortunately, formation of side product (**8**) could not be avoided even by running the reaction at room temperature to improve selectivity, adding molecular sieves or calcined $MgSO_4$ to promote formation of the Schiff base intermediate, diminishing the amount of acetic acid to lower the reactivity of the cyanoborohydride towards carbonyl reduction, or allowing the mixture of ketone and amine to interact for 2 h before addition of the reducing agent. Therefore, synthesis continued by submitting amine (**7**) to conventional sulfonamidation with tosyl chloride and triethylamine; this smoothly afforded sulfonamide (**9**) in 82% yield, which was uneventfully cyclized to the 1,2-dihydroisoquinolinesulfonamide (**10**) upon reaction with 6N HCl under Jackson's conditions.

Now, formation of the lactone ring by functionalization of the primary benzylic position was undertaken; however, the selenium dioxide-catalyzed benzylic oxidation of **10** furnished an unseparable mixture of uncharacterizable compounds in which the required product was not detected, while oxidation of its precursor (**9**) was unsuccessful and palladium(II)-mediated acyloxylation of **9**[9] furnished 92% of starting glyoxylate (**6**).

These results suggested the need of an early functionalization of the methyl group. Therefore, radical bromination of glyoxylate (**6**) with NBS in CCl_4, employing AIBN as radical initiator was explored; this cleanly gave benzyl bromide (**11**) as the only product, which was immediately transformed into the related acetate (**12**) with anhydrous sodium acetate in dry HMPA.[10]

Now the stage was set to perform Jackson's synthesis; therefore, α-keto ester (**12**) was subjected to the reductive amination protocol[8] providing, as anticipated, a mixture of amine (**13**) and alcohol (**14**). Unfortunately, attempts to transform alcohol (**14**) into tosylacetal (**16**) in one step by means of a Mitsunobu-type amination with *N*-tosylaminoacetal (**15**) failed under various conditions, as observed by almost quantitative recoveries of unchanged starting material, presumably due to steric congestion surrounding the hydroxyl group and poor acidity of sulfonamide (**15**).[11]

Scheme 2



Reagents and conditions: a. NBS, AIBN, CCl_4, reflux (91%); b. AcONa, Ac_2O, HMPA, (88%); c. $NaCNBH_3$, $H_2NCH_2CH(OMe)_2$ (5 equiv.), AcOH (4.5 equiv), EtOH, reflux (**13**, 52%; **14**, 41%); d. PPh_3, DEAD, $TsNHCH_2CH(OMe)_2$ (**15**), THF, reflux (no reaction); e. $(COCl)_2$, DMSO, CH_2Cl_2, -60°C, then Et_3N (91%); f. TsCl, Et_3N, $CHCl_3$, reflux (81%); g. 6N HCl, dioxane, reflux (49%).

In light of our previous experience, alcohol (**14**) was recycled by an efficient Swern oxidation to α-keto ester (**12**) and the key amine (**13**) was conveniently converted into the related tosylamide (**16**) with tosyl chloride and triethylamine in refluxing chloroform, as shown in Scheme 2.

With tosylacetal (**16**) in the hands, the next step consisting in its conversion into **4** was undertaken; however, in contrast to the easy formation of dihydroisoquinoline (**10**), cyclization of **16** proved to be difficult. After many trials it was observed that lactone formation occurred at an early stage; presumably, the strain and rigidity introduced by the lactone ring difficulted acetal cyclization. In addition, it was detected that increasing the concentration of acid or prolongued reflux periods caused diminished yields of the required product.

The conformation of the methoxy group *para* to the ring closure position could also contribute to the poor reactivity of **16** towards isoquinoline ring formation. Being flanked by two *ortho* substituents, the methyl group of the ether must adopt an out of plane conformation, as evidenced by its ^{13}C NMR chemical shift of δ 59.97 ppm, compared with δ 55.56 of its neighbouring methyl ether,[12] thus hindering the ability of the lone pairs of electrons of the oxygen to efficiently conjugate with the aromatic ring and thereby lowering the activation of the ring closure position. It has been reported that improper activation of the aromatic ring strongly disfavors or hinders cyclization causing diminished product yields due to undesirable side reactions.[13]

The best alternative was to cyclize **16** with 15 equivalents of HCl in refluxing dioxane during 2 h. This furnished a tetrahydroisoquinoline derivative in 49% yield, to which structure (**4**) was assigned on the grounds of its IR and NMR spectra. Interestingly, only one diastereoisomer was isolated, indicating that the rigid bicyclic lactone could be responsible for positioning the protonated intermediate in such a conformation that the attack of the aromatic ring would be possible only from one face of the carbonyl moiety.

Curiously, benzylic alcohols are not the usual products of Jackson's cyclization. Under conventional reaction conditions, these intermediates are protonated and dehydrate to furnish the related 1,2-dihydroisoquinolinesulfonamides, as observed with **10**. We have shown[14] that the dehydration step involves an *anti* elimination, being the benzylic alcohol the reaction product in cases where a *trans* H-3 is absent. Examination of the ^{1}H NMR spectrum of **4** evidenced that H_a-3 has a large coupling constant (10.3 Hz) with the adjacent H-4, indicating that the benzylic alcohol adopts a pseudoequatorial conformation in which its dihedral angle with H_e-3 is small. Furthermore, in addition to the poor availability of H-3 to engage in the required β-elimination, it is likely that dehydration of **4** might be disfavored because of the additional strain that it would introduce into the product.

In conclusion, it has been shown that Jackson's protocol successfully led to the elaboration of **4**, a polysubstituted tetrahydrooxazaphenalene lactone embodying the ABC-ring system of the natural stephaoxocanes, and a potential key intermediate for their synthesis.

EXPERIMENTAL

Mps were measured on an Ernst Leitz hot-stage microscope apparatus and are uncorrected. IR spectra were taken on a Bruker IFS 25 spectrophotometer with solid samples as KBr pellets and liquid samples as films. ^{1}H and ^{13}C NMR spectra were recorded in deuteriochloroform, on a Bruker AC-200E instrument at

200.13 and 50.33 MHz respectively, with tetramethylsilane as the internal standard; *J* values are given in Hz. High resolution MS were obtained from LANAIS-EMAR (Buenos Aires) and microanalytical data were provided by Atlantic Microlab (Norcross, GA, USA). All reactions were carried out in dry oxygen-free nitrogen or argon atmospheres. Reactions were monitored by thin layer chromatography on Merck's pre-coated silica gel 60 F_{254} TLC plates and detected by examination under UV light and by spraying with 2% *p*-anisaldehyde-sulfuric acid reagent in 95% ethanol. Careful heating improved the selectivity of the detection. All new compunds gave a single and homogeneous spot by TLC. Flash chromatography was carried out on Merck Kieselgel 60 (0.04-0.063 mm), packed in hexane; elution was with mixtures of hexane-EtOAc, using gradient techniques. Compounds were pre-adsorbed from CH_2Cl_2 solutions onto the adsorbent before column chromatography.

Ethyl (2-acetoxymethyl-3,4-dimethoxyphenyl)glyoxylate (**12**).- A solution of 2,3-dimethoxytoluene (**5**, 1000 mg, 6.57 mmol) and ethyloxalyl chloride (0.845 mg, 7.56 mmol) in dry CH_2Cl_2 (4 mL) was dropwise added to a suspension of anhydrous $AlCl_3$ (1926 mg, 14.44 mmol) in CH_2Cl_2 (5 mL), cooled in an ice-bath. The deep-red colored reaction mixture was stirred under argon until completion, then it was poured over saturated NH_4Cl (10 mL) and the reaction product was extracted with EtOAc (5 x 20 mL). The combined organic fractions were washed with brine (10 mL), dried (Na_2SO_4), concentrated *in vacuo* and chromatographed through a short pad of silica, furnishing glyoxylate (**6**) (1559 mg, 94%), as a clear oil; IR (film): 2980, 2860, 1740, 1680, 1600, 1520, 1470, 1330, 1260, 1160, 1040, 900 and 770 cm^{-1}; ^{1}H NMR (δ): 1.40 (t, 3H, *J*= 7.2, OCH_2*Me*), 2.54 (s, 3H, ArMe), 3.78 (s, 3H, OMe), 3.93 (s, 3H, OMe), 3.41 (q, 2H, *J*= 7.2, O*CH_2*Me), 6.82 (d, 2H, *J*= 8.7, ArH) and 7.49 (d, 2H, *J*= 8.7, ArH); ^{13}C NMR (δ): 12,87, 13.92, 55.72, 60.21, 61.93, 108.55, 122.62, 130.38, 135.88, 147.80, 157.38, 164.94 and 187.43.

Without delay, the α-keto ester (**6**) (750 mg, 2.976 mmol) was dissolved in CCl_4 (17 mL) and successively treated with NBS (636 mg, 3.57 mmol) and AIBN (1 mg), and refluxed in an argon atmosphere for 90 min. When the reaction was completed, it was diluted with brine (10 mL) and extracted with EtOAc (4 x 30 mL). The organic extracts were dried (Na_2SO_4), concentrated and chromatographed, affording benzyl bromide (**11**) (897 mg, 91 %) as a yellowish and slightly unstable solid, mp 67-67.5°C (hexane/EtOAc); IR (KBr): 3000, 2860, 1740, 1680, 1580, 1470, 1310, 1260, 1100, 1030, 910, 830 and 720 cm^{-1}; ^{1}H NMR (δ): 1.41 (t, 3H, *J*= 7.3, OCH_2*Me*), 3.97 (s, 3H, OMe), 3.99 (s, 3H, OMe), 4.43 (q, 2H, *J*= 7.3, O*CH_2*Me), 5.08 (s, 2H, Ar*CH_2*Br), 6.94 (d, 2H, *J*= 8.7, ArH) and 7.56 (d, 1H, *J*= 8.7, ArH); ^{13}C NMR (δ): 13.84, 23.13, 55.66, 60.86, 62.01, 110.89, 122.68, 131.02, 134.48, 148.35, 157.38, 164.12 and 186.52; HRMS for $C_{13}H_{15}O_5Br$. Calcd: 330.0102. Found: 330.0111.

Without further purification, anhydrous sodium acetate (100 mg, 1.22 mmol) and acetic anhydride (0.025 mL) were successively added to a solution of bromide (**11**) (100 mg, 0.30 mmol) in dry HMPA (1.5 mL). The reaction mixture was stirred under argon at rt for 24 h; then, it was diluted with 1N HCl (5 mL) and extracted with ether (3 x 30 mL). The combined organic extracts were washed with brine (5 mL), dried (Na_2SO_4) and concentrated *in vacuo* to furnish benzylic acetate (**12**) (82.5 mg, 88%), as an oil; IR (film): 2980, 2860, 1750, 1730, 1660, 1600, 1500, 1460, 1300, 1250, 1110, 1030 and 820 cm^{-1}; ^{1}H NMR (δ): 1.41 (t, 3H, *J*= 7.1, OCH$_2$*Me*), 2.05 (s, 3H, MeCO$_2$), 3.86 (s, 3H, OMe), 3.96 (s, 3H, OMe), 4.41 (q, 2H, *J*= 7.1, OC*H*$_2$Me), 5.45 (s, 2H, ArC*H*$_2$O), 6.97 (d, 1H, *J*= 8.7, ArH) and 7.54 (d, 1H, *J*= 8.7, ArH); ^{13}C NMR (δ): 13.91, 20.58, 55.91, 55.99, 61.29, 62.19, 111.31, 125.23, 130.11, 149.16, 157.30, 160.43, 163.77, 170.46 and 186.23; Anal. Calcd for $C_{15}H_{18}O_7$: C, 58.06; H, 5.85. Found: C, 58.16; H, 5.88.

Ethyl (2-acetoxymethyl-3,4-dimethoxyphenyl)-[N-(2,2-dimethoxyethyl)-N-(4-toluenesulfonyl)-amino]-acetate (**16**).- Aminoacetal (0.123 mL, 1.13 mmol) and glacial acetic acid (0.052 mL, 0.903 mmol) were added to a solution of keto ester (**12**) (70 mg, 0.226 mmol) in absolute ethanol (1.5 mL). The reaction mixture was left to stand for 1 h at rt, then it was treated with sodium cyanoborohydride (14 mg, 0.226 mmol) at rt overnight. The reaction was quenched with 1N NaOH (5 mL) and extracted with EtOAc (4 x 20 mL); the organic extracts were washed with brine (5 mL), dried (Na$_2$SO$_4$), concentrated and chromatographed, providing mandelate (**14**) (29 mg, 41 %) as an oil; IR (film): 3460, 2980, 2850, 1730, 1740, 1600, 1500, 1460, 1280, 1090 and 810 cm^{-1}; ^{1}H NMR (δ): 1.22 (s, 3H, *J*= 8.6, OCH$_2$*Me*), 2.07 (s, 2H, MeCO$_2$), 3.84 (s, 3H, OMe), 3.86 (s, 3H, OMe), 4.20 (dq, *J*= 1, 8.6, OC*H*$_2$Me), 5.35 (s, 2H, ArC*H*$_2$O), 5.40 (s, 1H, ArC*H*OH), 6.92 (d, 1H, *J*= 8.6, ArH) and 7.10 (d, 1H, *J*= 8.6, ArH); ^{13}C NMR (δ): 13.88, 20.86, 55.56, 57.60, 61.20, 61.97, 69.77, 112.71, 122.97, 128.03, 130.88, 148.46, 142.65, 170.73 and 173.60. Increasing the polarity furnished the desired secondary amine (**13**) (47 mg, 52%), as an oil; IR (film): 3550-2700, 2960, 2840, 1740, 1280, 1090 and 820 cm^{-1}; ^{1}H NMR (δ): 1.20 (t, 3H, *J*= 7.1, OCH$_2$*Me*), 2.05 (s, 3H, MeCO$_2$), 2.59 (dd, 1H, *J*= 5.5, 13, NC*H*$_2$), 2.74 (dd, 1H, *J*= 5.5, 13, NC*H*$_2$), 3.34 (s, 3H, OMe), 3.36 (s, 3H, OMe), 3.85 (s, 3H, OMe), 3.86 (s, 3H, OMe), 4.13 (dq, 2H, *J*= 1.0, 7.1, OC*H*$_2$Me), 4.46 [t, 1H, *J*= 5.5, C*H*(OMe)$_2$], 4.61 (s, 1H, NH), 2.60 (2H, s, ArC*H*$_2$OAc), 6.92 (t, 1H, *J*= 8.6, ArH), 7.12 (d, 1H, *J*= 8.6, ArH) and 7.75 (d, 1H, *J*= 8.6, ArH); ^{13}C NMR (δ): 13.95, 20.86, 48.82, 53.46, 53.73, 55.59, 57.59, 60.76, 60.99, 61.22, 103.72, 112.78, 122.53, 128.38, 130.67, 148.42, 152.23, 170.65 and 172.72; HRMS for $C_{19}H_{29}NO_8$. Calcd: 399.1893. Found: 399.1904

Tosyl chloride (38 mg, 0.2 mmol) was added at once to a solution of amine (**13**) (39 mg, 0.094 mmol) in chloroform (1 mL) and triethylamine (0.048 mL, 0.35 mmol). The reaction was stirred 24 h at rt and next refluxed for 4 h; then, it was diluted with brine (5 mL) and the reaction product was extracted with EtOAc (4 x 20 mL). The combined organic extracts were dried (Na$_2$SO$_4$), concentrated under reduced pressure and chromatographed, affording sulfonamide (**16**) (41.6 mg, 81%) as a solid mp 88.5-90°C (hexane/EtOAc); IR (film): 2940, 2840, 1740, 1600, 1500, 1460, 1350, 1290, 1170, 1090, 1080, 830 and 670 cm^{-1}; ^{1}H NMR (δ): 1.14 (t, 3H, *J*= 7.2, OCH$_2$*Me*), 2.11 (s, 3H, MeCO$_2$), 2.44 (s, 3H, Ar*Me*), 3.01 (s, 3H, OMe), 3.21 (s, 3H, OMe), 3.26 (dd, 1H, *J*= 6.9, 15.7, NC*H*$_2$), 3.49 (dd, 1H, *J*= 4, 15.7, NC*H*$_2$), 3.85 (s, 3H, OMe), 3.86 (s, 3H, OMe), 3.82-4.10 (m, 3H, NCH$_2$C*H* and OC*H*$_2$Me), 5.13 (d, 1H, *J*= 11.9, ArC*H*$_2$O), 5.40 (d, 1H, *J*= 11.9, ArC*H*$_2$O), 6.07 (s, 1H, ArC*H*NTs), 6.77 (d, 1H, *J*= 8.6, ArH), 6.85 (d, 1H, *J*= 8.6, ArH), 7.29 (d, 2H, *J*= 8.3, ArH of Tosyl) and 7.72 (d, 2H, *J*= 8.3, ArH of Tosyl); ^{13}C NMR (δ): 13.75, 20.92, 21.94, 47.44, 54.48, 54.93, 55.56, 57.50, 59.97, 61.15, 61.20, 104.37, 111.83, 124.70, 125.91, 127.65 (2 x C), 129.26 (2 x C), 130.41, 135.78, 143.55, 146.91, 153.32, 170.11 and 170.52; Anal. Calcd for $C_{26}H_{35}NO_{10}S$: C, 56.41; H, 6.37; N, 2.53; S, 5.79. Found: C, 56.53; H, 6.34; N, 2.55; S, 5.83.

Attempted synthesis of (**16**) *by Mitsunobu amination of* (**14**).- A THF solution (1 mL) of alcohol (**14**) (40 mg, 0.12 mmol) was successively treated with tosylamidoacetal (**15**, 65 mg, 0.25 mmol), PPh_3 (65.6 mg, 0.25 mmol) and DEAD (0.046 mL, 0.25 mmol). The reaction was stirred at 60°C for 30 min, when TLC showed absence of DEAD; then the volatiles were evaporated *in vacuo* and the oily residue was chromatographed, allowing the recovery of **14** (37.8 mg, 94.5%).

Recycling of alcohol (**14**) *to glyoxylate* (***12***) *by Swern oxidation*.- Dry DMSO (434 mg, 5.55 mmol) was dropwise added to a stirred solution of trifluoroacetic anhydride (777 mg, 3.70 mmol) in CH_2Cl_2 (7 mL) cooled to -60°C. After 5 min at -60°C, a solution of alcohol (**14**) (470 mg, 1.85 mmol) in CH_2Cl_2 (3 mL) was slowly dropped in *via* canula and the mixture was left to react for 15 min. Then, TEA (0.91 mL, 6.47 mmol) was added and after another 15 min period the reaction was warmed to rt, when it was diluted with brine (5 mL) and extracted with EtOAc (4 x 20 mL). Drying (Na_2SO_4), concentration and chromatography of the organic extracts furnished α-keto ester (**12**) (427 mg, 91%).

3-Hydroxy-5,6-dimethoxy-1-(4-toluenesulfonyl)-2,3,7,9a-tetrahydro-1H-8-oxa-1-azaphenalen-9-one (**4**).- A stirred solution of tosylacetal (**16**) (54 mg, 0.1 mmol) in peroxide-free dioxane (1 mL) was treated with 6N HCl (0.166 mL, 10 equiv.) and refluxed under nitrogen during 1 h; then, more 6N HCl (0.083 mL, 5 equiv.) was added and the mixture was left to react for another 1 h period. After cooling to rt, brine (5 mL) was added and the product was extracted with EtOAc. Drying (Na_2SO_4), concentration and chromatography of the extract finally provided compound (**4**) (24.2 mg, 49%) as a pale yellow solid, mp 172-173.5°C (hexane-EtOAc); IR (KBr): 3488, 2924, 2852, 1764, 1496, 1342, 1268, 1160, 1018, 968, 848, 730 and 666 cm^{-1}; ^{1}H NMR (δ): 1.67 (br s, 1H, OH), 2.44 (s, 3H, ArMe), 2.74 (dd, 1H, *J*= 10.3, 13.3, H_a-3), 3.87 (s, 3H, OMe), 3.89 (s, 3H, OMe), 3.97 (dd, 1H, *J*= 4.9, 13.3, H_e-3), 4.85 (br dd, 1H, *J*= 4.9, 10.3, H-4), 5.26 (d, 1H, *J*= 14.1, $ArC\mathit{H}_2O$), 5.56 (br s, 1H, O*H*), 5.59 (d, 1H, *J*= 14.1, $ArC\mathit{H}_2O$), 7.20 (s, 1H, ArH), 7.33 (d, 2H, *J*= 8.0, ArH of Tosyl) and 7.94 (d, 2H, *J*= 8.0, ArH of Tosyl); ^{13}C NMR (δ): 21,47, 46,96, 53,42, 55,92, 61,29, 64,27, 64,84, 109,32, 118,65, 124,51, 127,87 (2 x C), 129,54 (2 x C), 133,46, 136,43, 143,93, 144,38, 152,14 and 169,03; Anal. Calcd for $C_{20}H_{21}NO_7S$: C, 57.27; H, 5.05; N, 3.34; S, 7.64. Found: C, 57.51; H, 5.00; N, 3.26; S, 7.66.

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REFERENCES AND NOTES

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