J. Braz. Chem. Soc., Vol. 16, No. 6A, 1160-1173, 2005.
Printed in Brazil - ©2005 Sociedade Brasileira de Química
0103 - 5053 $6.00+0.00

Article

Thallium Trinitrate-Mediated Ring Contraction of 1,2-Dihydronaphthalenes: The Effect of Electron-donating and Electron-withdrawing Groups

Luiz F. Silva Jr., Raquel M. F. Sousa, Helena M. C. Ferraz* and Andrea M. Aguilar*

Instituto de Química, Universidade de São Paulo,CP 26077, 05513-970 São Paulo-SP, Brazil

A oxidação de uma série de 1,2-diidronaftalenos, substituídos no anel aromático, foi investigada com trinitrato de tálio (TTN) em metanol ou em trimetilortoformiato (TMOF) como solvente. Em todos os casos, indanos foram formados, embora o rendimento tenha variado de excelente a baixo, dependendo da estrutura do substrato. A presença de um grupo doador de elétrons no substrato favorece o rearranjo, enquanto que uma quantidade significativa de derivados glicólicos, bem como naftalenos, foi obtida na oxidação de 1,2-diidronaftalenos com um grupo retirador de elétrons, tais como Br e NO_2. Mecanismos para a formação de cada um destes produtos foram propostos.

The oxidation of a series of 1,2-dihydronaphthalenes substituted in the aromatic ring was investigated with thallium trinitrate (TTN) in methanol or in trimethylorthoformate (TMOF) as solvent. In all cases, indans are produced, although the yield varied from excellent to poor, depending on the structure of the substrate. The presence of an electron-donating group in the substrate favors the rearrangement, whereas significant amounts of glycolic derivatives, as well as naphthalenes, were obtained in the oxidation of 1,2-dihydronaphthalenes bearing electron-withdrawing groups, such as Br and NO_2. Mechanisms for the formation of each of these products are proposed.

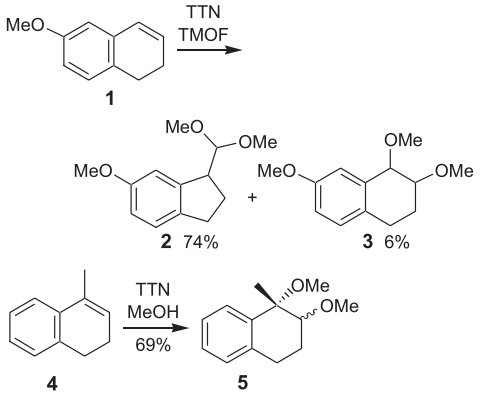
Keywords: ring contraction, oxidation, indans, thallium(III)

Introduction

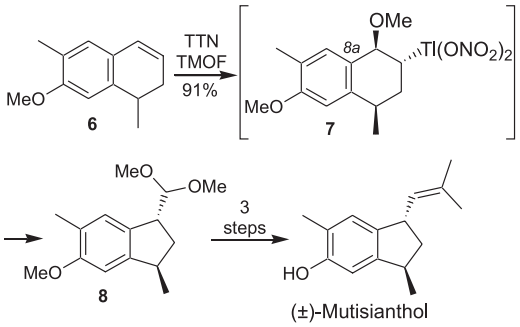
The indan moiety constitutes the core of several molecules with important biological activity.[1] Thus, a great effort has continuously been made toward the synthesis of such a class of compounds.[2] A typical approach to obtain functionalized indans is the selection of a suitable 1-indanone as starting material, which is then elaborated into the desired target molecule.[3] Considering that 1-tetralones are easily accessible and usually significantly cheaper than the corresponding 1-indanones, we initiated some years ago the development of short routes for the transformation of 1-tetralones into several types of functionalized indans, using a thallium(III)-promoted ring contraction as the key step.[4-9] One of these approaches is the thallium(III)-mediated rearrangement of 1,2-dihydronaphthalenes, which are easily obtained from 1-tetralones by a reduction/dehydration sequence.[6] Treatment of olefins, such as **1** (Scheme 1), with thallium trinitrate (TTN) in trimethylorthoformate (TMOF) gave indans in good yields, together with glycolic derivatives as minor components. However, trisubstituted alkenes, such as **4**, led only to the addition product **5** (Scheme 1). Remarkably, this ring contraction is diastereoselective, leading exclusively to *trans*-1,3-disubstituted indans, when a 1-methyl-1,2-dihydronaphthalene is used as starting material.[6] The efficiency of this selective reaction has recently been demonstrated in a short total synthesis of the sesquiterpene mutisianthol (Scheme 2).[9] Furthermore, during our studies toward the synthesis of this natural product, we found that olefins bearing a methoxy group in *para* to the migrating carbon, such as **6**, lead to the ring contraction product in nearly quantitative yield. This effect was rationalized considering that the methoxy group in *para* increases the migratory aptitude of the migrating carbon (8a in **7**) by mesomeric effect, favoring the rearrangement (Scheme 2).[8,9]

Although several aspects of the oxidation of 1,2-dihydronaphthalenes with thallium trinitrate have been disclosed, the substituents in the aromatic ring have been restricted to methyl and/or methoxy groups (**1** and **6**, for example).[6,8,9] Considering that indans substituted in the aromatic ring by groups such as halogens,[10-14] hydroxy,[15-17] nitro,[15,18] acetamido,[19] dimethyl,[20] and dimethoxy[14,17,20,21] are also important building blocks in organic synthesis, we decided to investigate further our approach based on the

* e-mail: luizfsjr@iq.usp.br; hmferraz@iq.usp.br



Scheme 1.



Scheme 2.

ring contraction reaction. The present article describes a detailed study of the TTN-mediated oxidation of 1,2-dihydronaphthalenes bearing different groups in the aromatic ring (Me, OMe, OH, NH_2, NHAc, Br and NO_2), better defining the scope of this reaction, which will facilitate future applications. In addition, a more clear picture of the mechanism of the thallium(III)-mediated oxidation of olefins could be drawn based on the new results.

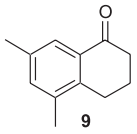
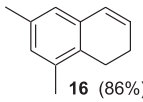
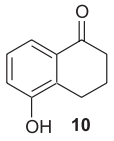
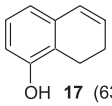
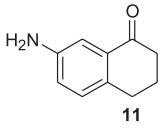
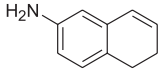
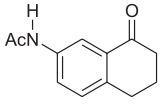
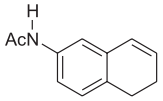
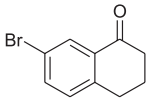
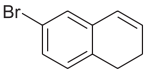
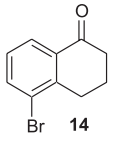
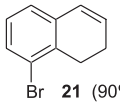
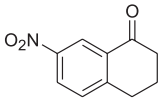
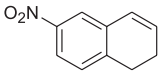
Results and Discussion

Preparation of 1,2-dihydronaphthalenes

The transformation of the 1-tetralones **9** to **15** into the corresponding 1-tetralols was performed using $NaBH_4$ (Table 1). The tetralols were then dehydrated under acidic conditions, for which two procedures were used. The first was the treatment of the alcohol with H_3PO_4 in THF, whereas the second was the use of a catalytic amount of *p*-TsOH in benzene or toluene. Table 1 summarizes the results obtained in the synthesis of 1,2-dihydronaphthalenes **16**-**22** from 1-tetralones **9**-**15**.

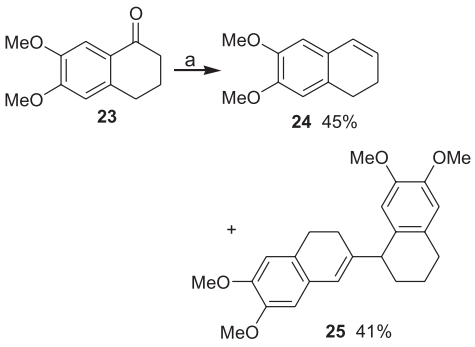
The transformation of a tetralol into the corresponding 1,2-dihydronaphthalene may be troublesome. The preparation of **24** exemplifies well this statement, because when the dehydration step was performed with H_3PO_4, the reaction was not reproducible, leading in some runs to the desired product **24** and in others to the dimer **25**.

Table 1. Preparation of 1,2-dihydronaphthalenes from 1-tetralones

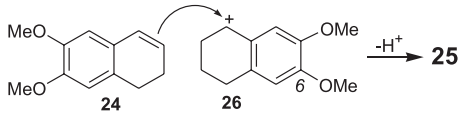
Entry	Substrate	Product (Yield)
1	 **9**	 **16** (86%)[a]
2	 OH **10**	 OH **17** (63%)[a]
3	 **11**	 **18** (82%)[b]
4	 **12**	 **19** (73%)[b]
5	 **13**	 **20** (89%)[b]
6	 Br **14**	 Br **21** (90%)[b]
7	 **15**	 **22** (86%)[b]

Conditions: [a] i) $NaBH_4$, MeOH, THF, rt, 1h; ii) THF, H_3PO_4, 80 °C, 10-60 min. [b] i) $NaBH_4$, MeOH, rt, 0.5-1.5 h; ii) *p*-TsOH, toluene (or benzene), reflux, 0.25-18 h.

Thus, to obtain the necessary amount of the required substrate, it was preferable to use *p*-TsOH, although under this condition the olefin **24** was obtained together with the dimer **25** (Scheme 3). The dimerization can be rationalized by the formation of the benzylic carbocation **26**, which then reacts with the formed olefin leading to the dimer **25**, after losing a proton (Scheme 4). The positive charge in **26** is stabilized by the methoxy group of the carbon 6 through a mesomeric effect. Presumably, this stabilization makes the dimerization easier in the formation of **24** than in the other 1,2-dihydronaphthalenes, where a similar mesomeric effect is not



Scheme 3. Reagents and Conditions: *i*) $NaBH_4$, EtOH, rt, 6 h; *ii*) TsOH, toluene, reflux, 30 min.



Scheme 4.

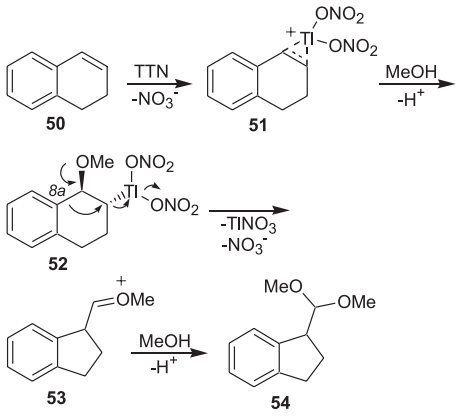
present. Nevertheless, this dimerization could be overcome in the preparation of other similar olefins.[8,9]

Oxidation of 1,2-dihydronaphthalenes with thallium trinitrate

With a representative number of differently substituted 1,2-dihydronaphthalenes in hands, we were in position to investigate their behavior toward the oxidation with thallium(III). As shown in Table 2, the reaction of the olefins with TTN led in all cases to the ring contraction product, although the yield varied from excellent to poor. Addition and aromatization products were also formed in some cases. The reason for this variation is discussed on the following paragraphs for each substrate, based on the mechanism of the rearrangement of olefins mediated by thallium(III),[22] which is exemplified for the 1,2-dihydronaphthalene (**50**) in Scheme 5. The first step in this mechanism is the formation of the thallonium ion **51**, which gives the *trans* oxythallated adduct **52**, after a ring-opening in a Markovnikov sense.[23] The rearrangement takes place in this intermediate, giving the acetal **54**, after addition of methanol to the oxonium **53**, followed by deprotonation.

Treatment of the olefin **24**, which bears two methoxy groups, with TTN gave the ring contraction product **27**, as the only isolated product, in excellent yield (Table 2, entry 1). This result shows that the behavior of **24** is similar to **6**, as expected.

The reaction of the olefin **16** with TTN gave the indan **28**, in very good yield. However, in this case, the addition

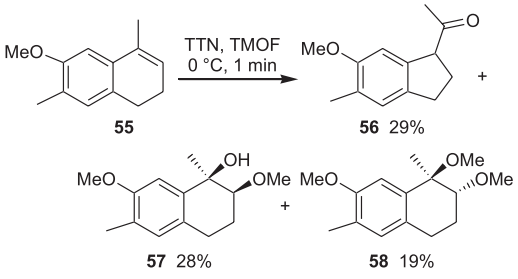


Scheme 5.

product **29** was also obtained as a minor component (entry 2). The high yield of the ring contraction can be explained considering the well-known hyperconjugative effect of the methyl groups, which increases the migratory aptitude of the migrating carbon.

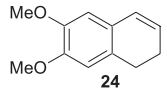
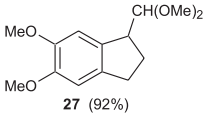
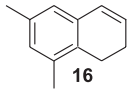
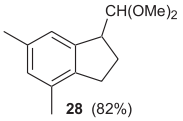
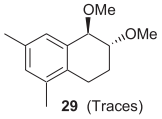
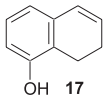
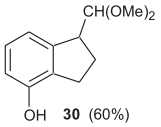
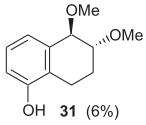
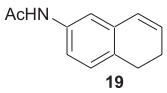
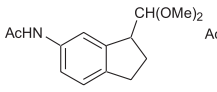
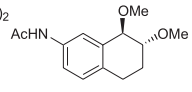
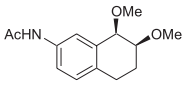
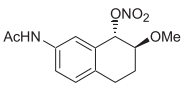
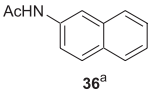
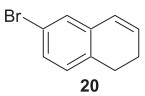
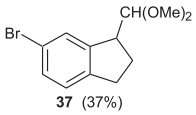
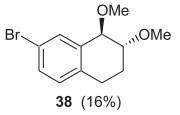
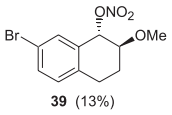
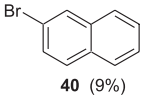
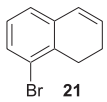
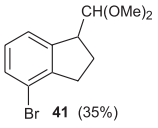
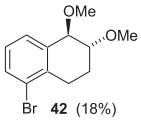
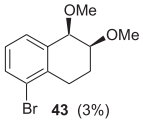
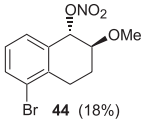
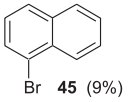
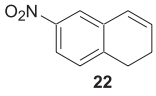
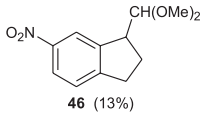
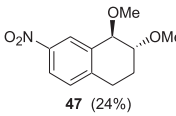
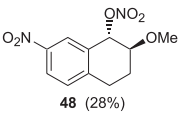
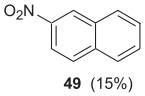
In our previous studies, when a trisubstituted olefin was treated with TTN in methanol, the formation of the ring contraction product has not been observed (see, for example, Scheme 1).[6] However, the reaction of the trisubstituted olefin **55** with TTN in TMOF led to the indan **56**, together with the addition products **57** and **58** (Scheme 6). This result shows that the presence of an electron-donating group indeed favors the rearrangement, partially changing the course of the oxidation of trisubstituted olefins by thallium(III). Another reason for the different behavior of **4** and **55** could be the modification of the solvent, because higher yields of the ring contraction products have been obtained for similar reactions in TMOF than in MeOH.[6] The relative configuration of the compound **58** was assigned by comparison with the NMR data of similar compounds.[24,25] The *cis* relationship of the hydroxy and the methoxy groups in **57** was analogously suggested.

The behavior of the 8-hydroxy-1,2-dihydronaphthalene **17** toward the oxidation with TTN in methanol (Table 2, entry 3) was somewhat similar to that of the olefins bearing a methoxy group in *meta* to the migrating carbon, such as **1**



Scheme 6.

Table 2. Oxidation of 1,2-dihydronaphthalenes with TTN.$3H_2O$

Entry	Substrate	Conditions	Product (Yield)		
			Ring Contraction	Addition	Aromatization
1	 **24**	TMOF, 0 °C, 1 min	 **27** (92%)	—	—
2	 **16**	TMOF, 0 °C, 1 min	 **28** (82%)	 **29** (Traces)	—
3	 OH **17**	MeOH, 0 °C, 1 min	 OH **30** (60%)	 OH **31** (6%)	—
4	 **19**	MeOH, rt, 1 h	 **32** (52%)	 **33** (11%)  **34** (2%)	 **35**[a]  **36**[a]
5	 **20**	MeOH, rt, 45 min	 **37** (37%)	 **38** (16%)  **39** (13%)	 **40** (9%)
6	 Br **21**	MeOH, rt, 1 h	 Br **41** (35%)	 Br **42** (18%)  Br **43** (3%)  Br **44** (18%)	 Br **45** (9%)
7	 **22**	MeOH, rt, 20.5 h	 **46** (13%)	 **47** (24%)  **48** (28%)	 **49** (15%)

[a] **35** and **36** were obtained as unseparable mixture.

(Scheme 1), because the indan **30** was obtained in good yield, together with the product of addition of methanol **31**. However, the yield of the ring contraction product was lower from **17**, probably due to the instability of **30**. An interesting aspect concerning the reaction of **17** with thallium(III) is that the oxidation of the phenol moiety, which has already been described,[26] was not observed. For olefin **17**, the ring contraction product was obtained in higher yield using methanol instead of TMOF. Thus, the oxidation of the following substrates was also examined in methanol.

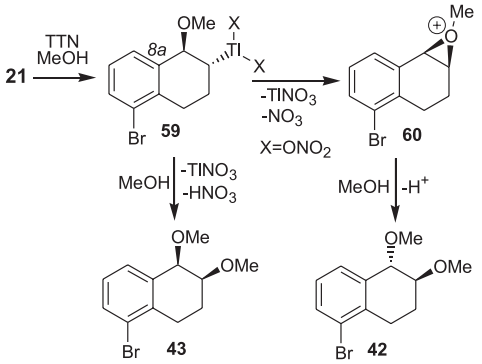
The reaction of the nitrogenated 1,2-dihydronaphthalenes **18** and **19** with thallium(III) was then investigated. Considering the studies of Michael and Nkwelo concerning the thallium(III)-promoted cyclization of unsaturated nitrogenated compounds,[27] we anticipated that difficulties would appear in the reaction of **18** and **19** with thallium(III). When TTN was added to the solution of **18** in methanol, the mixture immediately became black, which has never been observed in our long experience with thallium chemistry. TLC analysis showed a single spot corresponding to the starting material, even after more than 12 hours at room temperature. Later, NMR analysis

showed that the resulting black oil consisted of the starting amine **18** impure, contaminated with other products formed by the easily oxidated amine moiety. On the other hand, the corresponding acetyl amide **19** reacted with TTN giving the ring contraction product **32** in moderate yield, together with addition (**33** to **35**) and aromatization (**36**) products (Table 2, entry 4).

Next, the TTN-mediated oxidation of the bromo alkenes **20** and **21** (entries 5 and 6, respectively) was performed. For these substrates the ring contraction product was obtained in modest yields (35-37%). Using a substrate with a more powerful electron-withdrawing group, the nitro alkene **22**, the indan was obtained in even lower yield (entry 7). These results shows that the yield of the ring contraction products lowers as the electron-withdrawing power of the substituent in *meta* to the migrating carbon is increased, because its migratory aptitude is decreased.[28] Other products formed in the oxidation of olefins **20-22** were those of the addition of two molecules of methanol (**38**, **42**, **43** and **47**), of the addition of methanol and nitrate (**39**, **44** and **48**) and of aromatization (**40**, **45** and **49**).

The results shown in Table 2 allowed additional conclusions. First, comparing the reaction times and temperatures (see, for example, entries 1, 5 and 7), it is possible to conclude that the presence of an electron-withdrawing group in the aromatic ring makes the oxidation of the double bond by thallium(III) slower. Presumably, the electron density of the double bond is decreased by the electron-withdrawing group, which would decrease the rate of the electrophilic addition step. There is also a clear correlation between the rate of oxidation and the yield of the ring contraction product. In fast oxidations, the yields are usually high (compare, for example, entries 1 and 7). This trend has also been observed in previous works.[6,7]

Second, in the formation of the addition products of methanol the *trans* diastereomer was formed either as the major compound (entries 4 and 6) or exclusively (entries 2, 3, 5 and 7). A similar selectivity has also been observed in the oxidation of cyclohexene with thallium triacetate (TTA) in anhydrous AcOH,[23,29,30] whereas in the presence of water the *cis* diastereomer predominated.[22] Moreover, 3-*t*-butylcyclohexene gave exclusively a *trans* diol, when treated with thallium(III) sulfate.[31] The *cis* glycolic derivatives were obtained in the reaction of chromens with TTN[32] and of steroidal olefins with TTA.[33] In summary, the diastereoselectivity of the thallium(III)-mediated addition of nucleophilic species to cyclic olefins can not be easily predicted, because it depends on either the structure of the substrate or on the reaction conditions. Based on these previous



Scheme 7.

works, a mechanism for the formation of the *cis* and *trans* isomers was proposed, as exemplified for the olefin **21** in Scheme 7. In the formation of the *trans* isomer, the oxythallated aduct **59** would originate the oxonium ion **60**, by a reductive intramolecular displacement of the thallium(III). Addition of a second molecule of the solvent would give the *trans*-1,2-dimethoxylated isomer **42**, after deprotonation. The *cis* isomer **43** would be produced directly from **59** by an intermolecular displacement of the thallium(III) by the methanol, followed by deprotonation.

The indans and the dimethoxylated addition products have a quite similar ^{1}H NMR spectrum. However, these compounds can be easily distinguished by ^{13}C NMR, where the signal around 107 ppm indicates the presence of the acetal unit of the ring contraction product, whereas for the addition products, two signals between 75 and 80 ppm are present. During the development of this work and others,[6,8,9] a large number of indans, as well as *cis*- and *trans*-addition products, were obtained, which allowed us to find an easy way to differentiate this kind of compounds by ^{1}H NMR. This was achieved after tabulating the coupling constants corresponding to the doublets of the hydrogen of the benzylic C1 carbon for the addition products and of the acetal for the indans. The coupling constants of the mentioned hydrogens of all these compounds fall in a very restricted and characteristic range. The coupling constant of the hydrogen of the acetal moiety is the highest of the three kinds of products (7.5 Hz). A similar value was found by Antus et al. for structurally related acetals.[34] To assign the *cis* and *trans* isomers we considered that the coupling constant of the *trans* isomers should be higher than the *cis*, based on the well-established Karplus studies. Thus, for the hydrogen of the C1 carbon, the typical value for the *cis* isomer would be between 2.2 and 3.0 Hz, while for the *trans* isomer would be between 4.8 and 5.2 Hz (Figure 1). These values agree with that observed for the *cis*- and

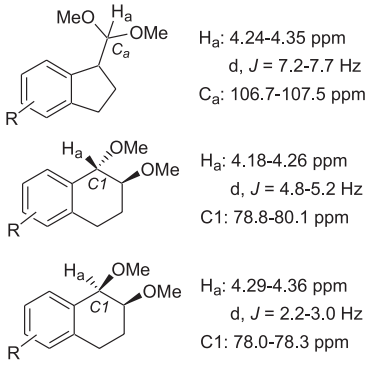


Figure 1. Selected chemical shifts for addition and ring contraction products.

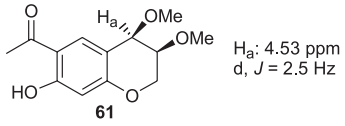
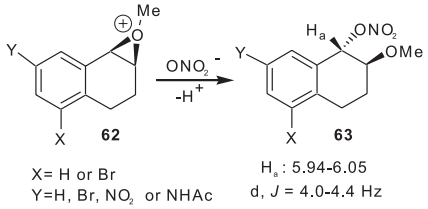


Figure 2. Selected chemical shift for a *cis*-1,2-dimethoxychroman.

trans-1,2-dihydroxy-1,2,3,4-tetrahydronaphthalene and other related *cis* isomers,[35] as well as with the *cis*-1,2-dimethoxychroman **61** (Figure 2).[32] However, the values are not in accord to that determined by Ogibin et al. for the *cis*- and *trans*-1,2-dimethoxy-1,2,3,4-tetrahydronaphthalenes.[36]

Nitrate derivatives are not usually produced in the oxidation of olefins with TTN, although a few papers reported the isolation of these compounds.[37] The somewhat unexpected formation of the *trans*-1-nitrate-2-methoxy derivatives **35**, **39**, **44** and **48** probably occurs from the oxonium ion **62**, which reacts with a nitrate anion. These nitrates have a very characteristic signal in the ^{1}H NMR spectrum. The hydrogen of the C1 carbon is deshielded when compared to the corresponding methoxy derivative, appearing as a doublet in *ca*. 6.0 ppm. The coupling constants, ranging from 4.0 to 4.4 Hz (Scheme 8), allowed us to suggest a *trans*-relationship between the two substituents (compare with Figure 1).

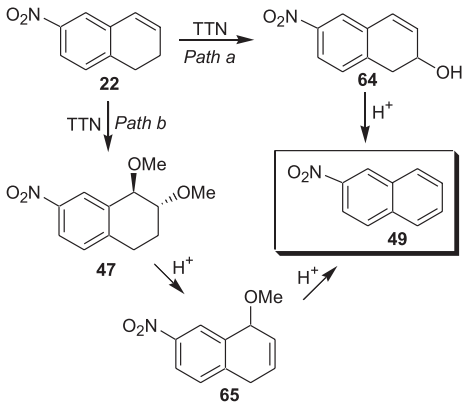
Naphthalene derivatives are usually produced in the oxidation of 1,2-dihydronaphthalenes with TTN, when the substrate has a low reactivity (entries 4 to 7, Table 2), as already observed in the oxidation of other 1,2-dihydronaphthalenes.[6,7] There are two possible mechanisms to explain the formation of this kind of product, as illustrated for the olefin **22** in Scheme 9. The first would be the allylic oxidation of the 1,2-dihydronaphthalene,[38] followed by the acid catalyzed dehydration of **64** (Path a), which is favored by the formation of an aromatic ring. The second possibility



Scheme 8.

would be two consecutives acid-catalyzed eliminations of MeOH in the addition product **47**, which would occur through the intermediate **65** (Path b).

In summary, the reaction of 1,2-dihydronaphthalenes with thallium trinitrate constitutes an efficient entry into indans, providing electron-withdrawing groups are not present in the aromatic ring. Moreover, these indans bear a masked aldehyde moiety, which could be useful for further transformations.



Scheme 9.

Experimental

General

Information concerning general experimental methods was recently published.[5] 6-Methoxy-4,7-dimethyl-1,2-dihydronaphthalene (**55**) was prepared according to the procedure described by Zubaidha *et al*.[39]

Preparation of 1-tetralones

*5-Hydroxy-1-tetralone (**10**).* Under nitrogen, NaH (0.30 g, 7.5 mmol, 60% in mineral oil) was washed with anhydrous hexanes (2 x 1 mL). After a few minutes under nitrogen, anhydrous DMF (3.5 mL) was added. To this mixture was slowly added a solution of EtSH (3.9 mL, 53 mmol) in anhydrous DMF (3.9 mL) at 0 °C and the resulting solution was stirred for 20 min at room temperature. The 5-methoxy-1-tetralone (0.881 g, 5.00 mmol) was then added and the

resulting mixture was stirred for 5 h at 140 °C, becoming light yellow. The mixture was cooled to the room temperature and a saturated solution of NH_4Cl was added. The mixture was extracted with Et_2O and the organic phase was washed with water, with brine, and dried over anhydrous $MgSO_4$. The solvent was removed under reduced pressure and the resulting brown solid was purified by flash chromatography (silica gel 200-400 mesh, 30% AcOEt in hexanes) giving starting material (0.103 g, 0.586 mmol, 12%) and **10**[40] (0.590 g, 3.64 mmol, 73%), as a yellow-brown solid (mp 208.1-208.2 °C).

*7-Amino-1-tetralone (**11**).* To stirred solution of **15** (1.00 g, 5.23 mmol) in MeOH (65 mL) was added 10% Pd/C (0.11 g). The mixture was subjected to 1.5 atm of H_2 for 2 h. The mixture was then filtered through a silica gel pad (200-400 Mesh, *ca.* 10 cm) and the filtrate was concentrated. The residue was purified by flash chromatography (silica gel 200-400 mesh, 50% EtOAc in hexanes) affording **11**[41] (0.708 g, 4.39 mmol, 84%), as a brown solid (mp: 137.7-137.8 °C), together with 7-amino-1,2,3,4-tetrahydronaphthalen-1-ol (0.0976 g, 0.598 mmol, 11%), also as a brown solid.

*7-Acetamido-1-tetralone (**12**).* In a solution of **11** (0.260 g, 1.61 mmol) and DMAP (0.0040 g) in Et_3N (4.0 mL) under nitrogen was added Ac_2O (0.5 mL). The mixture was stirred for 0.5 h at room temperature. MeOH was added and the solution was concentrated. The reaction was quenched with H_2O, extracted with AcOEt, washed with brine, and dried over anhydrous $MgSO_4$. The solvent was removed under reduced pressure giving **12**[41] (0.326 g, 1.60 mmol, 99%), as a yellow solid (mp 161.0-161.1 °C).

*7-Bromo-1-tetralone (**13**) and 5-bromo-1-tetralone (**14**).* To a three-necked flask equipped with a condenser, with a drying tube in a condenser and a mechanical stirrer terminating in a Teflon paddle, was added anhydrous $AlCl_3$ (7.0 g, 0.050 mol). While the catalyst was stirred, 1-tetralone (3.0 g, 20 mmol) was slowly added providing a viscous brown mixture that was difficult to stir. The mixture was heated at 60 °C and then cooled to 0 °C, becoming easier to stir. Bromine (1 mL; 0.02 mol) was added at 0 °C and the resulting mixture was stirred for 1 h at 80 °C. The mixture was cooled to the room temperature and the resulting brown solid was added in portions to a solution of crushed ice (200 mL) and concentrated HCl (3 mL). More crushed ice was added in portions until a total volume of 500 mL and then concentrated HCl (12 mL). The mixture was stirred for 1 h and extracted with Et_2O (four times). The organic phase was washed with water, saturated solution of $NaHCO_3$, with brine, and dried over anhydrous Na_2SO_4. The solvent was removed under reduced pressure and the resulting residue was purified by flash chromatography (silica gel 200-400 mesh, 15% AcOEt in hexanes) giving the bromo-1-tetralones contaminated with unreacted starting material. These mixtures were submitted to a bulb-to-bulb distillation affording **14**[42] (1.4 g, 6.2 mmol, 30%), as a brown solid (mp 43.7-43.8 °C), and **13**[43] (0.96 g, 4.3 mmol, 21%), as a yellow solid (mp 74.7-75.6 °C). The NMR data of the compound **13** have not been reported: ^{1}H NMR (200 MHz, $CDCl_3$) δ 2.14-2.19 (m, 2H), 2.65 (t, *J* 6.14 Hz, 1H), 2.91 (t, *J* 6.1 Hz, 2H), 7.14 (d, *J* 7.9 Hz, 1H), 7.56 (dd, *J* 2.2 and 7.9 Hz, 1H), 8.13 (d, *J* 2.2 Hz, 1H); ^{13}C NMR (50 MHz, $CDCl_3$) δ 22.9, 29.1, 38.7, 120.6, 129.9, 130.6, 134.0, 136.0, 143.1, 196.8.

*7-Nitro-1-tetralone (**15**).* The nitration was performed following the procedure described by Zhang and Schuster,[44] but the mixture of nitro-tetralones was separated by flash chromatography (silica gel 200-400 mesh, 30% AcOEt in hexanes) giving **15**[44] (1.51 g, 5.24 mmol, 34%), as pale yellow solid (mp 103.5-103.6 °C) and 5-nitro-1-tetralone[44] (0.95 g, 4.99 mmol, 21%), as a pale yellow solid (mp 98.8-98.9 °C). The ^{13}C NMR data of **15** and of 5-nitro-1-tetralone have not been reported. **(15)**: ^{13}C NMR (50 MHz, $CDCl_3$) δ 22.2, 29.7, 38.6, 122.5, 127.1, 130.2, 133.4, 147.1, 150.9, 195.9. 5-Nitro-1-tetralone: ^{13}C NMR (50 MHz, $CDCl_3$) δ 22.1, 26.3, 38.1, 127.0, 128.8, 132.1, 134.5, 138.4, 149.4, 199.3.

Preparation of 1,2-dihydronaphthalenes

*6,8-Dimethyl-1,2-dihydronaphthalene (**16**).* To a stirred solution of 5,7-dimethyl-1-tetralone (0.348 g, 2.00 mmol) in a mixture of anhydrous THF (2 mL) and anhydrous MeOH (6 mL) under nitrogen, was added $NaBH_4$ (0.378 g, 10.0 mmol) in portions at 0 °C. The mixture was stirred for 1 h at room temperature. The reaction was quenched with H_2O (7 mL) and a 10% aqueous solution of HCl was added dropwise until pH around 7. The resulting solution was extracted with EtOAc, washed with brine, and dried over anhydrous $MgSO_4$. The solvent was removed under reduced pressure giving 5,7-dimethyl-1-tetralol[45] (0.331g, 1.90 mmol, 94%), as a white solid. To a stirred solution of the tetralol (2.19 g, 12.0 mmol) in anhydrous THF (18 mL), was added H_3PO_4 85% (10 mL). The mixture was heated for 10 min at 80 °C. $NaHCO_3$ was added in portions and then was added a 5% aqueous solution of $NaHCO_3$ until pH around 7. The resulting solution was extracted with EtOAc, washed with brine, and dried over anhydrous

$MgSO_4$. The solvent was removed under reduced pressure and the resulting oil was purified by flash chromatography (silica gel 200-400 mesh, 5% EtOAc in hexanes) affording **16**[46] (1.74 g; 11.0 mmol, 91%), as a pale yellow oil. The NMR data of **16** have not been reported: ^{1}H NMR (300 MHz, $CDCl_3$) δ 2.22 (s, 3H), 2.25 (s, 3H), 2.27-2.33 (m, 2H), 2.69 (t, *J* 8.3 Hz, 2H), 5.97 (dt, *J* 4.3 and 9.6 Hz, 1H), 6.39 (dt, *J* 1.8 and 9.6 Hz, 1H), 6.70 (s, 1H), 6.82 (s, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 19.1, 20.8, 23.1, 23.2, 124.8, 127.9, 128.2, 129.7, 130.5, 133.8, 134.8, 135.1.

*8-Hydroxy-1,2-dihydronaphthalene (**17**).* The reduction was performed following the procedure described for **16**, but using **10** (1.72 g, 10.6 mmol), anhydrous THF (11 mL), anhydrous MeOH (32 mL), $NaBH_4$ (2.0 g, 53 mmol) and reaction time of 1 h. The reaction was quenched with H_2O. The solvent was removed under reduced pressure giving 5-hydroxy-1-tetralol (1.71 g, 10.4 mmol, 98%), as a white solid. The tetralol (1.29 g, 7.84 mmol) was used without purification in the next step, which was performed using anhydrous THF (12 mL), H_3PO_4 85% (6.4 mL), and reaction time of 1 h at 80 °C. The resulting solid was purified by flash chromatography (silica gel 200-400 mesh, 40% EtOAc in hexanes) affording **17**[47] (0.732 g, 5.01 mol, 64%), as white needles (mp 53.3-54.6 °C). The NMR data of **17** have not been reported: ^{1}H NMR (200 MHz, $CDCl_3$) δ 2.26-2.37 (m, 2H), 2.75 (t, *J* 8.0 Hz, 2H), 4.92 (s, 1H), 6.01 (dt, *J* 4.0 and 9.6 Hz, 1H), 6.46 (dt, *J* 1.8 and 9.7 Hz, 1H), 6.64 (d, *J* 7.9 Hz, 2H), 7.01 (t, *J* 8.0 Hz, 1H); ^{13}C NMR (50 MHz, $CDCl_3$) δ 19.5, 22.5, 114.5, 119.2, 120.6, 126.7, 127.6, 128.5, 135.4, 152.1.

*6-Amino-1,2-dihydronaphthalene (**18**).* The reduction was performed following the procedure described for **16**, but using **11** (0.707 g, 4.38 mmol), anhydrous MeOH (62 mL), $NaBH_4$ (0.22 g, 5.7 mmol), and reaction time of 30 min at room temperature, giving the 7-amino-1-tetralol (0.679 g, 4.16 mmol, 95%) as red-brown solid (mp: 91.7-91.8 °C). The tetralol (0.391 g, 2.45 mmol) was used without purification in the next step, which was performed toluene (36 mL), a few crystals of *p*-TsOH, and reaction time of 18 h at 130 °C, using a Dean-Stark apparatus. The resulting oil was purified by flash chromatography (silica gel 200-400 mesh, 70% EtOAc in hexanes) affording **18** (0.307 g, 2.12 mmol, 86%), as a gray solid: mp: 43.7-44.5 ºC. IR (KBr) ν_{max}/cm^{-1}: 868, 1442, 1606, 1729; ^{1}H NMR (200 MHz, $CDCl_3$) δ 2.22-2.33 (m, 2H), 2.68 (t, *J* 8.1 Hz, 2H), 3.40-3.49 (m, 2H), 5.97-6.06 (m, 1H), 6.36 (d, *J* 9.7 Hz, 1H), 6.42 (s, 1H), 6.48 (dd, *J* 2.2 and 7.5 Hz, 1H), 6.90 (d, *J* 7.9 Hz, 1H); ^{13}C NMR (50 MHz, $CDCl_3$) δ 23.7, 26.6, 113.2, 113.4, 125.8, 127.8, 128.1, 129.1, 134.8, 144.8; *m/z* 145 (M^+, 80%), 144 (100). Anal. Calc. for $C_{10}H_{11}N$: C, 82.72; H, 7.64; N, 9.65. Found: C, 82.72; H, 7.59; N, 9.92.

*6-Acetamido-1,2-dihydronaphthalene (**19**).* The reduction was performed following the procedure above described for **16**, but using **12** (0.30 g, 1.48 mmol), anhydrous MeOH (21 mL), $NaBH_4$ (0.073 g, 1.92 mmol), and reaction time of 30 min at room temperature, giving 7-acetamido-1-tetralol (0.26, 1.29 mmol, 87%), as a brown solid: mp: 135.8-136.0 °C. IR (KBr) ν_{max}/cm^{-1}: 1497, 1665, 2938, 3285; ^{1}H NMR (200 MHz, $CDCl_3$) δ 1.49-1.99 (m, 5 H), 2.10 (s, 3H), 2.70 (d, *J* 5.7 Hz, 2H), 4.67 (s, 1H), 7.02 (d, *J* 8.3 Hz, 1H), 7.38 (d, *J* 8.34 Hz, 1H), 7.45 (s, 1H), 7.76 (s, 1H); ^{13}C NMR (50 MHz, $CDCl_3$) δ 19.0, 24.3, 28.7, 32.2, 68.0, 119.8, 120.0, 129.4, 133.2, 135.9, 139.4, 168.6; *m/z* 205 (M^+, 30%), 43 (100). Anal. Calc. for $C_{12}H_{15}NO_2$: C, 70.22; H, 7.37; N, 6.82. Found: C, 70.01; H, 7.50; N, 6.63.

The tetralol (0.250 g, 1.20 mmol) was dehydrated using toluene (18 mL), a few crystals of *p*-TsOH, and reaction time of 1 h at 130 °C, using a Dean-Stark apparatus. The resulting oil was purified by flash chromatography (silica gel 200-400 mesh, 50% EtOAc in hexanes) affording **19** (0.191 g, 1.02 mmol, 84%), as a brown solid: mp: 51.2-54.6 °C. IR (KBr) ν_{max}/cm^{-1}: 886, 1497, 1661, 2927, 3430; ^{1}H NMR (200 MHz, $CDCl_3$) δ 2.13 (s, 3H), 2.23-2.32 (m, 2H), 2.73 (t, *J* 8.1 Hz, 2H), 5.97-6.06 (m, 1H), 6.37 (d, *J* 9.7 Hz, 1H), 7.00 (d, *J* 7.5 Hz, 1H), 7.19 (s, 1H), 7.19-7.26 (m, 1H), 7.81 (s, 1H); ^{13}C NMR (50 MHz, $CDCl_3$) δ 22.3, 23.4, 25.9, 116.9, 117.5, 126.6, 126.7, 128.2, 130.5, 133.6, 135.3, 167.6; *m/z* 187 (M^+, 51%), 43 (100). Anal. Calc. for $C_{12}H_{13}NO$: C, 76.98; H, 7.00; N, 7.48. Found: C, 76.54; H, 6.93; N, 7.39.

*6-Bromo-1,2-dihydronaphthalene (**20**).* The reduction was performed following the procedure described for **16**, but using **13** (0.78 g, 3.5 mmol), anhydrous MeOH (25 mL), $NaBH_4$ (0.17 g, 4.5 mmol), and reaction time of 1 h at room temperature. The reaction was quenched with H_2O. The solvent was removed under reduced pressure giving 7-bromo-1-tetralol (0.77 g, 3.4 mmol, 98%) as a solid (mp 57.7-58.6 °C). The tetralol (0.62 g, 2.7 mmol) was used without purification in the next step, which was performed using toluene (12 mL), *p*-TsOH (0.05 g, 0.27 mmol), and reaction time of 15 min at 130 °C. The mixture was cooled to the room temperature and washed with 10% aqueous solution of $NaHCO_3$, with brine, and dried over anhydrous Na_2SO_4. The solvent was removed under reduced pressure giving **20**[42] (0.52 g, 2.5 mmol, 91%), as light brown oil. The ^{13}C NMR data of **20** have not been reported: (75 MHz, $CDCl_3$) δ 23.0, 26.9, 119.8, 126.7, 128.5, 129.0, 129.4, 130.1, 134.2, 136.0.

*8-Bromo-1,2-dihydronaphthalene (**21**).* The reduction was performed following the procedure described for **16**, but using **14** (0.30 g, 1.3 mmol), anhydrous MeOH (6.7 mL), and $NaBH_4$ (0.07 g, 1.7 mmol), giving 5-bromo-1-tetralol (0.10 g, 0.44 mmol, 98%), as white needles (mp: 64.7-65.9 °C). The tetralol (0.34 g, 1.5 mmol) was used without purification in the next step, which was performed using benzene (3.4 mL), *p*-TsOH (0.03 g, 0.15 mmol), and reaction time of 15 min at 80 °C. The mixture was cooled to the room temperature and washed with 10% aqueous solution of $NaHCO_3$, with brine, and dried over anhydrous $MgSO_4$. The solvent was removed under reduced pressure giving **21**[42] (0.29 g, 1.4 mmol, 92%), as yellow oil. The ^{13}C NMR data of **21** have not been reported: (75 MHz, $CDCl_3$) δ 23.1, 27.0, 124.3, 125.4, 127.6, 127.8, 129.6, 131.2, 134.9, 136.4.

*6-Nitro-1,2-dihydronaphthalene (**22**).* The reduction was performed following the procedure described for **16**, but using **15** (0.51 g, 2.7 mmol), anhydrous MeOH (25 mL), $NaBH_4$ (0.13 g, 3.5 mmol), and reaction time of 1.5 h at room temperature, giving 7-nitro-1-tetralol[48] (0.51 g, 2.6 mmol, 98%), as white solid (mp 109.0-109.1 °C). The ^{13}C NMR data of 7-nitro-1-tetralol have not been reported: (50 MHz, $CDCl_3$) δ 18.7, 29.4, 32.1, 67.9, 122.2, 123.7, 129.9, 140.6, 144.9, 146.6. The tetralol (0.203 g, 1.05 mmol) was used without purification in the next step, which was performed using toluene (22 mL), a few crystals of *p*-TsOH, and reaction time of 3.5 h at 130 °C, using a Dean-Stark apparatus. The resulting oil was purified by flash chromatography (silica gel 200-400 mesh, 30% EtOAc in hexanes) affording **22**[48] (0.161 g, 0.919 mmol, 88%), as solid (mp 33.3-33.7 °C). The ^{13}C NMR data of **22** have not been reported: (50 MHz, $CDCl_3$) δ 22.5, 27.4, 120.2, 121.7, 126.4, 128.1, 131.2, 135.2, 142.9, 146.9.

*6,7-Dimethoxy-1,2-dihydronaphthalene (**24**).* To a stirred solution of 6,7-dimethoxy-1-tetralone (0.207 g, 1.00 mmol) in anhydrous EtOH (2 mL) under nitrogen, was added $NaBH_4$ (0.0504 g, 1.20 mmol) in small portions during 10 min at room temperature. The resulting mixture was stirred for 6 h at room temperature. The solvent was removed under reduced pressure. To the residue was added H_2O (2 mL) and a 10% aqueous solution of HCl until pH around 7. The resulting solution was extracted with Et_2O, washed with brine, and dried over anhydrous $MgSO_4$. The solvent was removed under reduced pressure affording a yellow oil that was diluted in toluene (2 mL). A few crystals of *p*-TsOH were added to this solution and the mixture was heated under reflux for 30 min. The mixture was cooled to the room temperature and hexane was added. The resulting solution was washed with saturated aqueous solution of $NaHCO_3$ (twice), with brine, and dried over anhydrous Na_2SO_4. The solvent was removed under reduced pressure giving a oil, which was purified by flash chromatography (silica gel 200-400 mesh, 30% EtOAc in hexanes) affording the olefin **24**[49] (0.0844 g, 0.444 mmol, 45%) as a white solid (mp 56.7-56.7 °C), together with the dimer **25** (0.0703 g, 0.185 mmol, 41%).

*1,2-dihydro-3-(1,2,3,4-tetrahydro-6,7-dimethoxy-naphthalen-4-yl)-6,7-dimethoxynaphthalene (**25**).*[49] Pale brown solid. The analytical data of this compound has not been reported: mp: 54.8-55.0 °C. IR (film) ν_{max}/cm^{-1}: 1511, 2931; ^1H NMR (300 MHz, $CDCl_3$) δ 1.63-1.83 (m, 2H), 1.85-1.94 (m, 2H), 2.04-2.24 (m, 2H), 2.68-2.73 (m, 4H), 3.58-3.62 (m, 1H), 3.76 (s, 3H), 3.85 (s, 3H), 3.86 (s, 6H), 6.10 (s, 1H), 6.59 (d, *J* 5.7 Hz, 2H), 6.68 (d, *J* 2.2 Hz, 2H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 21.3, 25.4, 28.4, 28.6, 29.4, 46.7, 55.8, 55.9, 56.0, 56.1, 109.7, 111.4, 111.6, 112.1, 124.4, 127.1, 127.7, 129.7, 129.9, 143.7, 147.1, 147.3, 147.4, 147.5; *m/z* 380 (M^+, 42%), 190 (100).

Oxidation of 1,2-dihydronaphthalenes with TTN. General procedure for the thallium(III) mediated oxidation of 1,2-dihydronaphthalenes

*Oxidation of **16** with TTN.* To a stirred solution of **16** (0.166 g, 1.05 mmol) in TMOF (5.2 mL), was added $TTN.3H_2O$ (0.518 g, 1.20 mmol) at 0 °C, which promptly dissolved. The mixture was stirred for 1 minute at room temperature and an abundant precipitation was observed. The resulting suspension was filtered through a silica gel pad (200-400 Mesh, *ca.* 10 cm), using CH_2Cl_2 as eluent. The filtrate was washed with H_2O (twice), with brine, and dried over anhydrous $MgSO_4$. The solvent was concentrated under reduced pressure giving a yellow solid. The residue was purified by flash chromatography (silica gel 200-400 mesh, 5% EtOAc in hexanes) immediately after concentration of the solvent, affording **28** (0.181 g, 0.860 mmol, 82%), together with traces of impure **29**.

*1-(Dimethoxymethyl)-4,6-dimethyl-indan (**28**).* White neddles. mp: 37.1-37.3 °C. IR (KBr) ν_{max}/cm^{-1}: 1052, 2831; ^1H NMR (300 MHz, $CDCl_3$) δ 1.90-2.02 (m, 1H), 2.14-2.25 (m, 1H), 2.21 (s, 3H), 2.30 (s, 3H), 2.64-2.86 (m, 2H), 3.37 (s, 3H), 3.43 (s, 3H), 3.42-3.43 (m, 1H), 4.33 (d, *J* 7.4 Hz, 1H), 6.83 (s, 1H), 7.07 (s, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 19.0, 21.2, 27.1, 29.5, 47.6, 53.0, 54.1, 107.4, 123.4, 128.7, 133.3, 135.9, 140.6, 142.7; *m/z* 220 (M^+, 1%), 75 (100). HRMS calc. for $C_{14}H_{20}O_2$: 220.14633, found 220.13807.

*trans-1,2-Dimethoxy-5,7dimethyl-tetrahydronaphthalene (**29**).* The compound **29** was obtained in low yield and purity which precluded its characterization. The characteristic signal of the hydrogen of the C1 carbon appears as a dublet in 4.20 ppm (*J* 4.9 Hz).

*Oxidation of **17** with TTN.* The reaction was performed following the general procedure, but using **17** (0.074 g, 0.51 mmol), MeOH (2.5 mL), TTN.3H_2O (0.25 g, 0.56 mmol), and reaction time of 1 min at 0 °C. The resulting brown solid was purified by flash chromatography (silica gel 200-400 mesh, 20-40% EtOAc in hexanes) affording the unstable indan **30** (0.063 g, 0.30 mmol, 60%) and **31** (0.01 g, 0.07 mmol, 6%).

*1-(Dimethoxymethyl)-indan-4-ol (**30**).* Viscous colorless oil. IR (film) ν_{max}/cm^{-1}: 1591, 1709, 2942; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.97-2.09 (m, 1H), 2.18-2.30 (m, 1H), 2.71-2.95 (m, 2H), 3.37 (s; 3H), 3.42-3.52 (m, 1H), 3.43 (s; 3H), 4.34 (d, *J* 7.5 Hz, 1H), 6.66 (d, *J* 7.8 Hz, 1H), 7.00-7.10 (m, 2H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 27.1, 27.3, 48.1, 53.1, 54.3, 107.2, 113.3, 118.0, 127.8, 130.1, 145.2, 151.8; *m/z* 208 (M^+, 8%), 150 (100). The analyses were performed as soon as the compound **30** was isolated. The instability of this phenol precluded to obtain elemental analysis.

*trans-5,6,7,8-Tetrahydro-5,6-dimethoxynaphthalen-1-ol (**31**).* Viscous colorless oil. ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.96-2.02 (m, 1H), 2.10-2.16 (m, 1H), 2.60-2.73 (m, 2H), 3.46 (s, 3H), 3.73-3.75 (m, 1H), 3.51 (s, 3H), 4.25 (d, *J* 4.8 Hz, 1H), 6.67 (d, *J* 7.8 Hz, 1H), 6.96 (d, *J* 7.6 Hz, 1H), 7.08 (t, *J* 7.8 Hz, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 19.0, 22.1, 56.6, 57.5, 77.0, 79.1, 114.0, 122.4, 123.3, 126.6, 135.8, 153.0; *m/z* 208 (M^+, 8%), 150 (100). HRMS Calc. for: $C_{12}H_{16}O_3$ 208.10994, found 208.10865.

*Oxidation of **19** with TTN.* The reaction was performed following the general procedure, but using **19** (0.190 g, 1.02 mmol), MeOH (5.1 mL) and TTN.3H_2O (0.50 g, 1.0 mmol), which was added at 0 °C. The mixture was stirred for 1 h at room temperature. The resulting oil was purified by flash chromatography (silica gel 200-400 mesh, eluent: EtOAc (90%) and hexanes (10%)) affording the indan **32** (0.148 g, 0.527 mmol, 52%), **33** (0.0322 g, 0.115 mmol, 11%), **34** (0.0050 g, 0.018 mmol, 2%) and a mixture of the **35** and **36**.

*1-(Dimethoxymethyl)-6-amide-indan (**32**).* Pale yellow solid. mp: 81.8-81.9 °C. IR (KBr) ν_{max}/cm^{-1}: 1052, 1112, 1498, 1662, 2984, 3292; ^{1}H NMR (200 MHz, $CDCl_3$) δ: 1.88-2.02 (m, 2H), 2.05-2.24 (m, 1H), 2.14 (s, 3H), 2.70-3.01 (m, 2H), 3.37 (s, 3H), 3.43 (s, 3H), 4.32 (d, *J* 7.0 Hz, 1H), 7.13 (d, *J* 7.9 Hz, 1H), 7.38 (dd, *J* 1.5 and 8.1 Hz, 1H), 7.45 (s, 1H), 7.51 (s, 1H); ^{13}C NMR (50 MHz, $CDCl_3$) δ 24.4, 27.5, 30.9, 47.6, 53.2, 54.3, 107.2, 117.5, 119.3, 124.4, 136.1, 140.9, 143.6, 168.3; *m/z* 217 (M^+-32, 17%), 43 (100). Anal. Calc. for $C_{14}H_{19}NO_3$: C, 67.45; H, 7.68; N, 5.62. Found: C, 67.22; H, 7.59; N, 5.57.

*trans-1,2,3,4-Tetrahydro-1,2-dimethoxy-7-amide-naphthalene (**33**).* Yellow solid. mp: 90.7-92.3 °C. IR (KBr) ν_{max}/cm^{-1}: 1089, 1123, 1498, 1658, 2931, 3291; ^{1}H NMR (200 MHz, $CDCl_3$) δ: 1.80-1.93 (m, 1H), 2.04-2.19 (m, 1H), 2.14 (s, 3H), 2.61-2.89 (m, 2H), 3.45 (s, 3H), 3.52 (s, 3H), 3.66-3.73 (m, 1H), 4.23 (d, *J* 4.8 Hz, 1H), 7.05 (d, *J* 8.3 Hz, 1H), 7.32 (s, 1H), 7.38 (dd, *J* 2.0 and 8.1 Hz, 1H), 7.45 (s, 1H); ^{13}C NMR (50 MHz, $CDCl_3$) δ 23.7, 24.5, 25.0, 56.6, 57.6, 76.4, 79.7, 119.7, 120.9, 129.0, 133.0, 135.4, 135.8, 168.2; *m/z* 249 (M^+, 19%), 191 (100). HRMS Calc. for $C_{14}H_{19}NO_3$: 249.13649, found 249.13649.

*cis-1,2,3,4-Tetrahydro-1,2-dimethoxy-7-amide-naphthalene (**34**).* Yellow solid. ^{1}H NMR (200 MHz, $CDCl_3$) δ 1.91-1.99 (m, 1H), 2.16 (s, 3H), 2.16 (m, 1H), 2.65-2.82 (m, 1H), 2.91-3.05 (m, 1H), 3.47 (s, 3 H), 3.49 (s, 3H), 3.61-3.69 (m, 1H), 4.33 (d, *J* 2.6 Hz, 1H), 7.08 (d, *J* 7.9 Hz, 1H), 7.22 (s, 1H), 7.32 (dd, *J* 2.4 and 8.1 Hz, 1H), 7.50 (d, *J* 2.2 Hz, 1H); ^{13}C NMR (50 MHz, $CDCl_3$) δ 22.5, 24.5, 26.4, 56.5, 57.4, 77.2, 78.0, 120.1, 121.1, 129.3, 132.7, 135.4, 168.2. The compound **34** was obtained in low yield and purity which precluded its full characterization.

*Oxidation of **20** with TTN.* The reaction was performed following the general procedure, but using **20** (0.16 g, 0.72 mmol), MeOH (4.6 mL) and TTN.3H_2O (0.35 g, 0.79 mmol), which was added at 0 °C. The mixture was stirred for 45 min at room temperature. The resulting light brown oil was purified by flash chromatography (silica gel 200-400 mesh, 10% AcOEt and 10% CH_2Cl_2 in hexanes) affording the indan **37** (0.072 g, 0.27 mmol, 37%), **39** (0.028 g, 0.094 mmol, 13%), **38** (0.032 g, 0.12 mmol, 16%), and **40** (0.014 g, 0.065 mmol, 9%).

*6-Bromo-1-(dimethoxymethyl)-indan (**37**).* Colorless oil. IR (film) ν_{max}/cm^{-1}: 1061, 1122, 1469, 2039; ^{1}H NMR (200 MHz, $CDCl_3$) δ 1.87-2.02 (m, 1H), 2.05-2.29 (m, 1H), 2.68-2.96 (m, 2H), 3.37-3.49 (m, 1H), 3.37 (s, 3H), 3.43 (s, 3H), 4.30 (d, *J* 7.5 Hz, 1H), 7.06 (d, *J* 7.9 Hz, 1H), 7.28 (dd, *J* 1.5 and 8.1 Hz, 1H), 7.54 (s, 1H); ^{13}C NMR (50 MHz; $CDCl_3$) δ 27.5, 30.9, 47.5, 52.9, 54.3, 106.8, 119.8, 125.7, 128.6, 129.8, 143.7, 145.3; *m/z* 241 (M^+ -OCH_2,

3%), 75 (100). Anal. Calc. for $C_{12}H_{15}BrO_2$: C, 53.15; H, 5.58. Found: C, 53.20; H, 5.52.

*trans-7-Bromo-1,2,3,4-tetrahydro-1,2-dimethoxynaphthalene (**38**).* Colorless oil. IR (film) ν_{max}/cm^{-1}: 855, 1097, 1481, 2931; ^{1}H NMR (200 MHz, $CDCl_3$) δ 1.83-2.17 (m, 2H), 2.59-2.88 (m, 2H), 3.44 (s, 3H), 3.53 (s, 3H), 3.66-3.74 (m, 1H), 4.18 (d, *J* 4.8 Hz, 1H), 6.97 (d, *J* 8.3 Hz, 1H), 7.30 (dd, *J* 2.0 and 8.1 Hz, 1H), 7.48 (d, *J* 2.2 Hz, 1H); ^{13}C NMR (50 MHz, $CDCl_3$) δ 23.2, 24.9, 56.6, 57.9, 77.6, 79.3, 119.4, 130.2, 130.7, 132.5, 135.9, 137.0; *m/z* 270 (M^+-H, 3%), 212 (100). Anal. Calc. for $C_{12}H_{15}BrO_2$: C, 53.15; H, 5.58. Found: C, 53.10; H, 5.43.

*trans-7-Bromo-2-methoxy-1-nitrate-1,2,3,4-tetrahydro-naphthtalene (**39**).* White solid. mp: 53.1-53.2 °C; IR (KBr) ν_{max}/cm^{-1}: 855, 1081, 1270, 1621, 2932; ^{1}H NMR (200 MHz, $CDCl_3$) δ 2.01-2.09 (m, 2H), 2.63-2.95 (m, 2H), 3.46 (s, 3H), 3.76-3.83 (m, 1H), 5.97 (d, *J* 4.4 Hz, 1H), 7.04 (d, *J* 8.3 Hz, 1H), 7.40 (dd, *J* 2.0 and 8.1 Hz, 1H), 7.45 (d, *J* 1.8 Hz, 1H); ^{13}C NMR (50 MHz; $CDCl_3$) δ 23.3, 24.1, 57.1, 75.6, 79.4, 119.9, 130.6, 131.0, 132.3, 133.0, 137.1; *m/z* 256 (M^+-46, 5%), 115 (100). Anal. Calc. for $C_{11}H_{12}BrNO_4$: C, 43.73; H, 4.00. Found: C, 43.82; H, 3.93.

*2-Bromonaphthalene (**40**).*[50] Yellow solid. mp 49.2-51.0 °C. The NMR data of the compound **40** have not been reported: ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.46-7.51 (m, 2H), 7.54 (dd, *J* 2.0 and 8.8 Hz, 1H), 7.72-7.82 (m, 2H), 7.73 (d, *J* 2.3 Hz, 1H), 8.00 (d, *J* 1.0 Hz, 1H); ^{13}C NMR (75 MHz; $CDCl_3$) δ 119.8, 126.3, 126.9, 127.0, 127.8, 129.2, 129.6, 129.9, 131.8, 134.5.

*Oxidation of **21** with TTN.* The reaction was performed following the general procedure, but using **21** (0.305 g, 1.46 mmol), MeOH (7.3 mL), TTN.3H_2O (0.71 g, 1.60 mmol), and reaction time of 1 h at room temperature. The resulting brown oil was purified by flash chromatography (silica gel 200-400 mesh, 5% EtOAc and 5% Et_2O in hexanes) affording the indan **41** (0.139 g, 0.512 mmol, 35%), **42** (0.073 g, 0.269 mmol, 18%), **43** (0.010 g, 0.037 mmol, 3%), **44** (0.0796 g, 0.264 mmol, 18%) and **45** (0.0264 g, 0.128 mmol, 9%).

*4-Bromo-1-(dimethoxymethyl)-indan (**41**).* Colorless oil. IR (film) ν_{max}/cm^{-1}: 1059, 1113, 1451, 2940; ^{1}H NMR (200 MHz, $CDCl_3$) δ 1.91-2.09 (m, 1H), 2.13-2.31 (m, 1H), 2.77-3.07 (m, 2H), 3.37 (s, 3H), 3.42 (s, 3H), 3.46-3.60 (m, 1H), 4.31 (d, *J* 7.0 Hz, 1H), 7.03 (t, *J* 7.7 Hz, 1H), 7.32 (s, 1H), 7.36 (s, 1H); ^{13}C NMR (50 MHz, $CDCl_3$) δ 26.1, 32.9, 48.8, 53.0, 54.4, 107.1, 119.8, 124.4, 128.0, 130.0, 144.8, 145.1; *m/z* 241 (M^+ -OCH_2, 3%), 75 (100). Anal. Calc. for $C_{12}H_{15}BrO_2$: C, 53.15; H, 5.58. Found: C, 53.12; H, 5.54.

*trans-5-Bromo-1,2,3,4-tetrahydro-1,2-dimethoxynaphthalene (**42**).* Yellow oil. IR (film) ν_{max}/cm^{-1}: 1094, 1446, 2932; ^{1}H NMR (200 MHz, $CDCl_3$) δ 1.91-2.20 (m, 2H), 2.77 (t, *J* 6.8 Hz, 2H), 3.43 (s, 3H), 3.49 (s, 3H), 3.69-3.76 (m, 1H), 4.20 (d, *J* 4.8 Hz, 1H), 7.06 (t, *J* 7.9 Hz, 1H), 7.30 (d, *J* 7.5 Hz, 1H), 7.48 (dd, *J* 1.1 and 7.7 Hz, 1H); ^{13}C NMR (50 MHz, $CDCl_3$) δ 22.9, 26.5, 56.9, 57.8, 76.7, 79.6, 125.4, 127.4, 129.6, 132.2, 136.8, 137.1; *m/z* 270 (M^+ -H, 2%), 212 (100). Anal. Calc. for $C_{12}H_{15}BrO_2$: C, 53.15; H, 5.58. Found: C, 53.48; H, 5.46.

*cis-5-Bromo-1,2,3,4-tetrahydro-1,2-dimethoxynaphthalene (**43**).* Yellow oil. The compound **43** was obtained in low yield and purity which precluded its characterization. The characteristic signal of the hydrogen of the C1 carbon appears as a dublet at 4.33 ppm (*J* 2.6 Hz).

*trans-5-Bromo-2-methoxy-1-nitrate-1,2,3,4-tetrahydro-naphthalene (**44**).* White solid. mp: 57.2-57.3 °C. IR (KBr) ν_{max}/cm^{-1}: 855, 1110, 1273, 1445, 1635, 2936; ^{1}H NMR (200 MHz, $CDCl_3$) δ 1.96-2.23 (m, 2H), 2.82 (t, *J* 6.6 Hz, 2H), 3.46 (s, 3H), 3.78-3.85 (m, 1H), 6.01 (d, *J* 4.0 Hz, 1H), 7.12 (t, *J* 7.7 Hz, 1H), 7.30 (d, *J* 7.5 Hz, 1H), 7.58 (dd, *J* 1.3 and 7.2 Hz, 1H); ^{13}C NMR (50 MHz, $CDCl_3$) δ 23.0, 25.6, 57.0, 75.1, 80.2, 125.3, 127.7, 129.8, 131.2, 133.5, 137.7; m/z 254 (M^+ – 48, 7%), 115 (100). Anal. Calc. for $C_{11}H_{12}BrNO_4$: C, 43.73; H, 4.00; N, 4.64. Found: C, 44.17; H, 4.10; N, 4.29.

*Bromonaphthalene (**45**).* Yellow oil. Commercially available.

*Oxidation of **22** with TTN.* The reaction was performed following the general procedure, but using **22** (0.161 g, 0.922 mmol), MeOH (4.6 mL) and TTN.3H_2O (0.451 g, 1.01 mmol), which was added at room temperature. The mixture was stirred for 20.5 h at room temperature. The resulting oil was purified by flash chromatography (silica gel 200-400 mesh, 10% AcOEt and 10% CH_2Cl_2 in hexanes) affording the indan **46** (0.0294 g, 0.124 mmol, 13%), **48** (0.0663 g, 0.261 mmol, 28%), **47** (0.0534 g, 0.225 mmol, 24%), and **49** (0.0236 g, 0.136 mmol, 15%).

*1-(Dimethoxymethyl)-6-nitro-indan (**46**).* Pale yelllow solid. mp: 42.6-42.7 °C. IR (KBr) ν_{max}/cm^{-1}: 1060, 1122, 1347, 1519, 1471, 2940; ^{1}H NMR (200 MHz, $CDCl_3$) δ 1.99-2.16 (m, 1H), 2.21-2.39 (m, 1H), 2.83-3.13 (m, 2H), 3.40 (s, 3H), 3.46 (s, 3H), 3.50-3.58 (m, 1H), 4.35 (d, *J* 7.0 Hz, 1H), 7.32 (d, *J* 8.3 Hz, 1H), 8.06 (dd, *J* 2.2 and 8.3 Hz, 1H), 8.24

(s, 1H); ^{13}C NMR (50 MHz, $CDCl_3$) δ 27.4, 31.6, 47.4, 53.2, 54.8, 106.7, 120.9, 122.7, 124.6, 144.7, 147.3, 152.7; *m/z* 206 (M^+ -OCH_3, 6%); 75 (100). Anal. Calc. for $C_{12}H_{15}NO_4$: C, 60.75; H, 6.37; N, 5.90. Found: C, 60.59; H, 6.25; N, 6.04.

*trans-1,2,3,4-Tetrahydro-1,2-dimethoxy-7-nitronaphthalene (**47**).* Yellow solid. mp: 28.8-29.0 °C. IR (KBr) ν_{max}/cm^{-1}: 1089, 1187, 1460, 1347, 1519, 2935; ^{1}H NMR (200 MHz; $CDCl_3$) δ 1.92-2.21 (m, 2H), 2.74-3.03 (m, 2H), 3.45 (s, 3H), 3.57 (s, 3H), 3.74-3.81 (m, 1H), 4.25 (d, J 4.4 Hz, 1H), 7.26 (d, J 8.8 Hz; 1H), 8.05 (dd, J 2.6 and 8.3 Hz, 1H), 8.22 (d, J 2.2 Hz, 1H); ^{13}C NMR (50 MHz; $CDCl_3$) δ 22.5, 25.3, 56.7, 58.2, 76.8, 78.8, 122.5, 125.3, 129.5, 136.4, 144.9, 146.4; m/z 206 (M^+ -OCH_3, 9%), 115 (100). Anal. Calc. for $C_{12}H_{15}NO_4$: C, 60.75; H, 6.37; N, 5.90. Found: C, 60.72; H, 6.23; N, 6.10.

*trans-7-Nitro-2-methoxy-1-nitrate-1,2,3,4-tetrahydronaphthtalene (**48**).* Yellow oil. IR (film) ν_{max}/cm^{-1}: 849, 1094, 1173, 1273, 1347, 1460, 1528, 1543, 2938; ^{1}H NMR (200 MHz, $CDCl_3$) δ 1.98-2.25 (m, 2H), 2.79-3.12 (m, 2H), 3.48 (s, 3H), 3.83-3.90 (m, 1H), 6.05 (d, *J* 4.0 Hz, 1H), 7.35 (d, *J* 8.8 Hz, 1H), 8.14 (dd, *J* 2.4 and 8.6 Hz, 1H), 8.23 (d, *J* 2.2 Hz, 1H); ^{13}C NMR (50 MHz, $CDCl_3$) δ 22.8, 24.6, 57.1, 74.9, 78.5, 123.9, 125.9, 130.1, 130.5, 145.9, 146.6; *m/z* 191 (M^+ -ONO_2 – CH_3), 115 (100). Anal. Calc. for $C_{11}H_{12}NO_6$: C, 49.26; H, 4.51; N, 10.44. Found: C, 49.21; H, 4.53; N, 10.22.

*2-Nitronaphthalene (**49**).*[50] Yellow needles. mp 76.1-77.9 °C. The NMR data of **49** have not been reported: ^{1}H NMR (200 MHz; $CDCl_3$) δ 7.60-7.74 (m, 2H), 7.94-8.06 (m, 3H), 8.24 (dd, *J* 2.2 and 9.2 Hz, 1H), 8.80 (d, *J* 1.7 Hz, 1H). ^{13}C NMR (50 MHz; $CDCl_3$) δ 119.3, 124.6, 127.9, 128.0, 129.5, 129.7, 130.0, 132.0, 135.8, 145.6.

*Oxidation of **24** with TTN.* The reaction was performed following the general procedure, but using **24** (0.101 g, 0.533 mmol), TMOF (2.7 mL), TTN.3H_2O (0.259 g, 0.583 mmol), and reaction time of 1 min at 0 °C. The resulting oil was purified by flash chromatography (silica gel 200-400 mesh, 20% EtOAc in hexanes) affording **27** (0.118 g, 0.47 mmol, 92%).

*5,6-Dimethoxy-1-(dimethoxymethyl)-indan (**27**).* Light yellow oil. IR (film) ν_{max}/cm^{-1}: 2830, 2859; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.91-2.03 (m, 1H), 2.16-2.27 (m,1H), 2.74-2.94 (m, 2H), 3.38 (s, 3H), 3.39-3.42 (m, 1H), 3.44 (s, 3H), 3.85 (s, 3H), 3.87 (s, 3H), 4.28 (d, *J* 7.6 Hz, 1H), 6.75 (s, 1H), 6.99 (s, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 27.7, 31.2, 47.4, 52.7, 54.3, 55.9, 56.0, 107.5, 107.5, 109.0, 134.4, 136.4, 147.8, 148.5; *m/z* 252 (M^+, 9%), 75 (100). HRMS Calc. for: $C_{14}H_{20}O_4$ 252.13616, found 252.13301.

*Oxidation of **55** with TTN.* The reaction was performed following the general procedure, but using **55** (0.152 g, 0.806 mmol), TMOF (4.0 mL), TTN.3H_2O (0.394 g, 0.887 mmol), and reaction time of 1 min at 0 °C. The resulting oil was purified by flash chromatography (silica gel 200-400 mesh, 10% EtOAc and 10% CH_2Cl_2 in hexanes) affording the indan **56** (0.0477 g, 0.234 mmol, 29%), **58** (0.0388 g, 0.155 mmol, 19%), and **57** (0.0535 g, 0.226 mmol, 28%).

*1-(6-Methoxy-5-methyl-indan-1-yl)-ethanone (**56**).* Colorless oil. IR (film) ν_{max}/cm^{-1}: 1707; ^{1}H RMN (300 MHz, $CDCl_3$) δ 2.15 (s, 3H), 2.19 (s, 3H), 2.22-2.43 (m, 2H), 2.82-3.06 (m, 2H), 3.80 (s, 3H), 4.03 (dd, *J* 8.3 and 5.9 Hz, 1H), 6.71 (s, 1H); 7.03 (s, 1H); ^{13}C RMN (75 MHz, $CDCl_3$) δ 16.4, 27.3, 29.2, 31.2, 55.6, 59.4, 106.6, 126.4, 126.7, 135.8, 139.2, 157.0, 209.5; *m/z* 204 (M^+, 37%), 161 (100). Anal. Calc. for $C_{13}H_{16}O_2$: C, 76.44, H, 7.90. Found C, 76.25, H, 7.88.

*cis-2,7-Dimethoxy-1,6-dimethyl-1,2,3,4-tetrahydronaphthalen-1-ol (**57**).* Colorless oil. IR (film) ν_{max}/cm^{-1}: 3549, 1099, 1250; ^{1}H RMN (300 MHz, $CDCl_3$) δ 1.46 (s, 3H), 1.95 (dddd, *J* 1.8, 6.6, 11.7, and 14.7 Hz, 1H), 2.15 (s, 3H), 2.16-2.28 (m, 1H), 2.52-2.61 (m, 1H), 2.74-2.88 (m, 1H), 3.31 (sl, 1H), 3.44 (s, 3H), 3.45-3.47 (m, 1H), 3.83 (s, 3H), 6.82 (s, 1H), 7.10 (s, 1H); ^{13}C RMN (75 MHz, $CDCl_3$) δ 15.7, 22.1, 23.3, 29.4, 55.5, 56.8, 82.7, 108.2, 125.7, 126.3, 130.1, 140.6, 156.6; *m/z* 236 (M^+, 19%), 163 (100). HRMS Calc. for $C_{14}H_{20}O_3$ 236.14124, Found 236.14143.

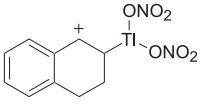
*trans-1,2,7-Trimethoxy-1,6-dimethyl-1,2,3,4-tetrahydronaphthalene (**58**).* Colorless oil. IR (film) ν_{max}/cm^{-1}: 1252, 1104, 1075; ^{1}H RMN (300 MHz, $CDCl_3$) δ: 1.46 (s, 3H), 1.68-1.82 (m, 1H), 2.15-2.24 (m, 1H), 2.17 (s, 3H), 2.77 (dd, *J* 4.2 and 8.8 Hz, 2H), 3.08 (s, 3H), 3.53 (s, 3H), 3.72 (dd, *J* 3.5 and 11.5 Hz, 1H), 3.82 (s, 3H), 6.83 (s, 1H), 6.87 (s, 1H); ^{13}C RMN (75 MHz, $CDCl_3$) δ 15.8, 24.8, 25.2, 27.4, 50.3, 55.6, 57.2, 77.6, 80.5, 107.7, 126.1, 128.3, 130.3, 138.3, 156.7; *m/z* 250 (M^+, 18%), 177 (100). HRMS calc. for $C_{15}H_{22}O_3$ 250.15689, Found 250.15646.

Acknowledgments

We are grateful for the financial support provided by FAPESP, CNPq and CAPES.

References

1. For examples, see: Dorsey, B.D.; Levin, R.B.; McDaniel, S.L.; Vacca, J.P.; Guare, J.P.; Darke, P.L.; Zugay, J.A.; Emini, E.A.; Schleif, W.A.; Quintero, J.C.; Lin, J.H.; Chen, I.-W.; Holloway, M.K.; Fitzgerald, P.M.D.; Axel, M.G.; Ostovic, D.; Anderson, P.S.; Huff, J.R.; *J. Med. Chem.* **1994**, *37*, 3443; Sugimoto, H.; Iimura, Y.; Yamanishi, Y.; Yamatsu, K.; *J. Med. Chem.* **1995**, *38*, 4821; Matasi, J.J.; Caldwell, J.P.; Hao, J.; Neustadt, B.; Arik, L.; Foster, C.J.; Lachowicz, J.; Tulshian, D.B.; *Bioorg. Med. Chem. Lett.* **2005**, *15*, 1333; Waldmann, H.; Karaguni, I.-M.; Carpintero, M.; Gourzoulidou, E.; Herrmann, C.; Brockmann, C.; Oschkinat, H.; Müller, O.; *Angew. Chem., Int. Ed.* **2004**, *43*, 454; Bogeso, K.P.; Chirstensen, A.V.; Hyttel, J.; Liljefors, T.; *J. Med. Chem.* **1985**, *28*, 1817; Jenwitheesuk, E.; Samudrala, R.; *Bioorg. Med. Chem. Lett.* **2003**, *13*, 3989.
2. For some recent examples, see: Gagnier, S.V.; Larock, R.C.; *J. Am. Chem. Soc.* **2003**, *125*, 4804; Püschl, A.; Rudbeck, H.C.; Faldt, A.; Confante, A.; Kehler, J.; *Synthesis* **2005**, 291; Arefalk, A.; Larhed, M.; Hallberg, A.; *J. Org. Chem.* **2005**, *70*, 938; Obora, Y.; Kimura, M.; Tokunaga, M.; Tsuji, Y.; *Chem. Commun.* **2005**, 901; Ozaki, S.; Adachi, M.; Sekiya, S.; Kamikawa, R.; *J. Org. Chem.* **2003**, *68*, 4586; Yao, S.-W.; Lopes, V.H.C.; Fernández, F.; Garcia-Mera, X.; Morales, M.; Rodríguez-Borges, J.E.; Cordeiro, M.N.D.S.; *Bioorg. Med. Chem.* **2003**, *11*, 4999; Shintani, R.; Okamoto, K.; Hayashi, T.; *J. Am. Chem. Soc.* **2005**, *127*, 2872. For an account concerning the synthesis of indans, see: Ferraz, H.M.C.; Aguilar, A.M.; Silva, L.F, Jr; Craveiro, M.V.; *Quim. Nova* **2005**, *28*, 703.
3. For some interesting examples, see: Ho, T.-L.; Lee, K.-Y.; Chen, C.-K.; *J. Org. Chem.* **1997**, *62*, 3365; Hashimi, A.S.K.; Ding, L.; Bats, J.W.; Fischer, P.; Frey, W.; *Chem. Eur. J.* **2003**, *9*, 4339; Gu, X.-H.; Yu, H.; Jacobson, A.E.; Rothman, R.B.; Dersch, C.M.; George, C.; Flippen-Anderson, J.L.; Rice, K.C.; *J. Med. Chem.* **2000**, *43*, 4868; Mattson, R.J.; Catt, J.D.; Keavy, D.; Sloan, C.P.; Epperson, J.; Gao, Q.; Hodges, D.B.; Iben, L.; Mahle, C.D.; Ryan, E.; Yocca, F.D.; *Bioorg. Med. Chem. Lett.* **2003**, *13*, 1199; Watanabe, N.; Ikeno, A.; Minato, H.; Nakagawa, H.; Kohayakawa, C.; Tsuji, J.-i.; *J. Med. Chem.* **2003**, *46*, 3961; Torisawa, Y.; Nishi, T.; Minamikawa, J.-i.; *Bioorg. Med. Chem.* **2003**, *11*, 2205.
4. Ferraz, H.M.C.; Silva Jr., L.F. ; Aguilar, A.M.; Vieira, T.O.; *J. Braz. Chem. Soc.* **2001**, *12*, 680. Available free of charge at http://jbcs.sbq.org.br.
5. Ferraz, H.M.C.; Silva Jr, L.F.; *Tetrahedron* **2001**, *57*, 9939.
6. Ferraz, H.M.C.; Silva Jr., L.F.; Vieira, T.O.; *Tetrahedron* **2001**, *57*, 1709.
7. Ferraz, H.M.C.; Silva Jr., L.F.; *Synthesis* **2002**, 1033.
8. Ferraz, H.M.C.; Aguilar, A.M.; Silva Jr., L.F.; *Synthesis* **2003**, 1031.
9. Ferraz, H.M.C.; Aguilar, A.M.; Silva Jr., L.F.; *Tetrahedron* **2003**, *59*, 5817.
10. Musso, D.L.; Orr, G.F.; Cochran, F.R.; Kelley, J.L.; Selph, J.L.; Rigdon, G.C.; Cooper, B.R.; Jones, M.L.; *J. Med. Chem.* **2003**, *46*, 409.
11. Dalton, A.M.; Zhang, Y.; Davie, C.P.; Danheiser, R.L.; *Org. Lett.* **2002**, *4*, 2465.
12. Nguyen, P.; Corpuz, E.; Heidelbaugh, T.M.; Chow, K.; Garst, M.E.; *J. Org. Chem.* **2003**, *68*, 10195.
13. Cui, D.-M.; Zhang, C.; Kawamura, M.; Shimada, S.; *Tetrahedron Lett.* **2004**, *45*, 1741.
14. Wu, X.; Nilsson, P.; Larhed, M.; *J. Org. Chem.* **2005**, *70*, 346.
15. Uchikawa, O.; Fukatsu, K.; Tokunoh, R.; Kawada, M.; Matsumoto, K.; Imai, Y.; Hinuma, S.; Kato, K.; Nishikawa, H.; Hirai, K.; Miyamoto, M.; Ohkawa, S.; *J. Med. Chem.* **2002**, *45*, 4222.
16. Bell, I.M.; Gallichio, S.N.; Abrams, M.; Beese, L.S.; Beshore, D.C.; Bhimnathwala, H.; Bogusky, M. J.; Buser, C.A.; Culberson, J.C.; Davide, J.; Ellis-Hutchings, M.; Fernandes, C.; Gibbs, J.B.; Graham, S.L.; Hamilton, K.A.; Hartman, G.D.; Heimbrook, D.C.; Homnick, C.F.; Huber, H.E.; Huff, J.R.; Kassahun, K.; Koblan, K.S.; Kohl, N.E.; Lobell, R.B.; Lynch, J.J., Jr.; Robinson, R.; Rodrigues, A.D.; Taylor, J.S.; Walsh, E.S.; Williams, T.M.; Zartman, C.B.; *J. Med. Chem.* **2002**, *45*, 2388.
17. Jereb, M.; Stavber, S.; Zupan, M.; *Tetrahedron* **2003**, *59*, 5935.
18. Pletnev, A.A.; Larock, R.C.; *J. Org. Chem.* **2002**, *67*, 9428.
19. Bavetsias, V.; Clauss, R.; Henderson, E.A.; *Org. Biomol. Chem.* **2003**, *1*, 1943.
20. Fillion, E.; Fishlock, D.; *Org. Lett.* **2003**, *5*, 4653.
21. Ohno, H.; Wakayama, R.; Maeda, S.-i.; Iwasaki, H.; Okumura, M.; Iwata, C.; Mikamiyama, H.; Tanaka, T.; *J. Org. Chem.* **2003**, *68*, 5909.
22. For reviews concerning thallium(III) in organic synthesis, see: McKillop, A.; Taylor, E.C. In *Comprehensive Organometallic Chemestry*; Wilkinson, G., ed., Pergamon Press: New York, 1982; Vol. 7, p 465; Ferraz, H.M.C.; Silva Jr., L.F.; Vieira, T. de O.; *Synthesis* **1999**, 2001. For articles where the mechanism of the ring contraction of olefins is discussed, see: Anderson, C. B.; Winstein, S.; *J. Org. Chem.* **1963**, *28*, 605; Abley, P.; Byrd, J.E.; Halpern, J.; *J. Am. Chem. Soc.* **1973**, *95*, 2591.
23. Another possibility, as suggested by one of the referees, would be the formation of the oxythallated adduct **52** from the thallonium ion **51** through the benzylic carbocation shown below. This pathway would be favored by the presence of electron-donating groups in the aromatic ring.



24. Chini, M.; Crotti, P.; Macchia, F.; *Gazz. Chim. Ital.* **1988**, *118*, 827.
25. Crotti, P.; Di Bussolo, V.; Favero, L.; Pineschi, M.; Sergiampietri, D.; Renzi, G.; Ricciutelli, M.; Roselli, G.; *Tetrahedron* **1997**, *53*, 5515.
26. For examples, see: McKillop, A.; Swann, B.P.; Zelesko, M.J.; Taylor, E.C.; *Angew. Chem., Int. Ed.* **1970**, *9*, 74; McKillop, A.; Perry, D.H.; Edwards, M.; Antus, S.; Farkas, L.; Nógradi, M.; Taylor, E. C.; *J. Org. Chem.* **1976**, *41*, 282; articles cited in the reference 22.
27. Michael, J.P.; Nkwelo, M.M.; *Tetrahedron* **1990**, *46*, 2549.
28. For examples of other rearrangements where this effect have been observed, see: Adejare, A.; Shen, J.; Ogunbadeniyi, A.M.; *J. Fluor. Chem.* **2000**, *105*, 107; Bachmann, W.E.; Ferguson, J.W.; *J. Am. Chem. Soc.* **1934**, *56*, 2081.
29. Kabbe, H.-J.; *Ann.* **1962**, *656*, 204.
30. Lee, J.B.; Price, M.J.; *Tetrahedron* **1964**, *20*, 1017.
31. Freppel, C.; Favier, R.; Richer, J.-C.; Zador, M.; *Can. J. Chem.* **1971**, *49*, 2586.
32. Begley, M.J.; Mohamed, S.E.; Whiting, D.A.; D'Souza, F.; Hatam, N. A. R.; *J. Chem. Soc., Perkin Trans. 1* **1983**, 883.
33. Glotter, E.; Schwartz, A.; *J. Chem. Soc., Perkin Trans. 1* **1976**, 1660.
34. Antus, S.; Gottsegen, A.; Nógrádi, M.; Gergely, A.; *Chem. Ber.* **1979**, *112*, 3879.
35. Naemura, K.; Wakebe, T.; Hirose, K.; Tobe, Y.; *Tetrahedron: Asymmetry* **1997**, *8*, 2585.
36. Ogibin, Y.N.; Ilovaisky, A.I.; Nikishin, G.I.; *J. Org. Chem.* **1996**, *61*, 3256.
37. For examples, see: Ouellette, R.J.; Bertsch, R.J.; *J. Org. Chem.* **1976**, *41*, 2782; Bertsch, R.J.; Ouellette, R.J.; *J. Org. Chem.* **1974**, *39*, 2755; Layton, W.J.; Brock, C.P.; Crooks, P.A.; Smith, S.L.; Burn, P.; *J. Org. Chem.* **1985**, *50*, 5372.
38. For examples, see: Sekizaki, H.; Ito, M.; Inoue, S.; *Bull. Chem. Soc. Jpn.* **1978**, *51*, 2439; references 23 and 30.
39. Zubaidha, P.K.; Chavan, S.P.; Racherla, U.S.; Ayyangar, N.R.; *Tetrahedron* **1991**, *47*, 5759.
40. Papa, D.; Schwenk, E.; Breiger, H.; *J. Org. Chem.* **1949**, *14*, 366.
41. Biggs, D.F.; Casy, A.F.; Chu, I.; Coutts, R.T.; *J. Med. Chem.* **1976**, *19*, 472.
42. Adamczyk, M.; Watt, D.S.; Netzel, D.A.; *J. Org. Chem.* **1984**, *49*, 4226.
43. Fieser, L.F.; Seligman, A.M.; *J. Am. Chem. Soc.* **1938**, *60*, 170.
44. Zhang, M.B.; Schuster, G.B.; *J. Am. Chem. Soc.* **1994**, *116*, 4852.
45. Zhang, X.; Taketomi, T.; Yoshizumi, T.; Kumobayashi, H.; Akutagawa, S.; Mashima, K.; Takaya, H.; *J. Am. Chem. Soc.* **1993**, *115*, 3318.
46. Heimgartner, H.; Zsindely, J.; Hansen, H.J.; Schmid, H.; *Helv. Chim. Acta* **1973**, *56*, 2924.
47. Eastham, J.F.; Larkin, D.R.; *J. Am. Chem. Soc.* **1958**, *80*, 2887.
48. Nichols, D.E.; Cassady, J.M.; Persons, P.E.; Yeung, M.C.; Clemens, J.A.; Smalstig, E.B.; *J. Med. Chem.* **1989**, *32*, 2128.
49. Rastogi, S.N.; Anand, N.; Bindra, J.S.; *Ind. J. Chem.* **1971**, *9*, 1175.
50. Danish, A.A.; Silverman, M.; Tajima, Y.A.; *J. Am. Chem. Soc.* **1954**, *76*, 6144.

Received: May 21, 2005
Published on the web: September 15, 2005

FAPESP helped in meeting the publication costs of this article.