Ketone Transposition: 2(1*H*)-Tetralones from 1(2*H*)-Tetralones

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The conversion of 1(2*H*)-tetralones to 2(1*H*)-tetralones is a useful synthetic manipulation and several methods have been developed to accomplish the transposition[2-5]. The reported schemes use strong bases, aqueous acids, and frequently, heavy metal salts to prepare and manipulate intermediates.

We report here the development of a brief general method for converting 1(2*H*)-tetralones to 2(1*H*)-tetralones under very mild conditions and in high overall yield (Scheme).

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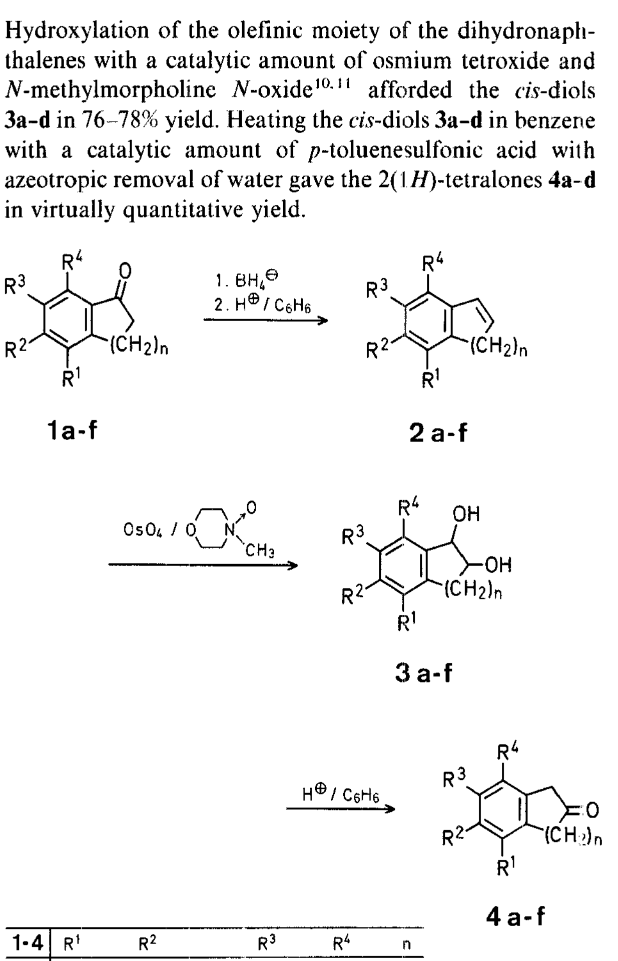
The reaction sequence exploits the enhanced propensity of benzylic alcohols, compared to their aliphatic counterparts, to undergo acid-catalyzed dehydration. Although this characteristic had been utilized in earlier ketone transpositions[5,6], they were limited in success[6], frequently resulting in low yields and complex product mixtures[5,7].

The first step in accomplishing the ketone transposition is the conversion of 1(2*H*)-tetralones **1a–d** to 3,4-dihydronaphthalenes **2a–d**. In the past, this conversion has been performed under rather harsh conditions[8,9]; however, we found the transformation can be straightforwardly accomplished by reducing the ketones **1a–d** to the alcohols with sodium borohydride and then dehydrating the alcohol intermediate in refluxing benzene with a catalytic amount of toluenesulfonic acid.

Hydroxylation of the olefinic moiety of the dihydronaphthalenes with a catalytic amount of osmium tetroxide and *N*-methylmorpholine *N*-oxide[10,11] afforded the *cis*-diols **3a–d** in 76–78% yield. Heating the *cis*-diols **3a–d** in benzene with a catalytic amount of *p*-toluenesulfonic acid with azeotropic removal of water gave the 2(1*H*)-tetralones **4a–d** in virtually quantitative yield.



1-4	R¹	R²	R³	R⁴	n
a	H	H	H	H	2
b	OCH₃	H	H	H	2
c	H	OCH₃	H	H	2
d	H	H	OCH₃	H	2
e	OCH₃	–CH=CH–CH=CH–		OCH₃	2
f	H	H	H	H	1

The generality of the methodology was further demonstrated by converting both 9,10-dimethoxy-3,4-dihydro-1(2*H*)-anthracenone (**1e**) and 1-indanone (**1f**) to their corresponding 2-ketones **4e**, **f** in high yield.

^{1}H-N.M.R. spectra were determined on a Varian HA 100 Spectrometer using tetramethylsilane as an internal standard. Column chromatography and thin layer analyses were performed on Merck silica gel 60. The purities of all compounds were ascertained by G.L.C. (silicone rubber) and T.L.C. analyses. The spectral (^{1}H-N.M.R. and I.R.) and chromatographic properties of 2(1*H*)-tetralones **4a–d** and 2-indanone **4f** were compared with commercially available samples.

Table. Yields and Physical Constants of Products **2a–f**, **3a–f**, and **4a–f**

Product	Yield [%]	m.p. [°C] or b.p. [°C]/torr	Molecular formula[a] or Lit. m.p. [°C] or b.p. [°C]/torr
2a	97	71–72°/3	70–73°/3[9]
2b	96	70–71°/0.04	70°/0.04[12]
2c	96	60–61°/0.1	63°/0.1[12]
2d	95	69–71°/0.1	71°/0.1[12]
2e	96	149–150°	$C_{16}H_{16}O_2$ (240.2)
2f	97	179–181°/160	C_9H_8 (116.2)
3a	79	101–102°	102°[7]
3b	78	150–151°	$C_{11}H_{14}O_3$ (194.2)
3c	76	120–121°	117.5–118.5°[7]
3d	77	126–127°	$C_{11}H_{14}O_3$ (194.2)
3e	86	181–182°	$C_{16}H_{18}O_4$ (274.3)
3f	74	98–99°	99–101°[6]
4a	98	115–117°/5 2,4-DNP: 162–165°	114–116°/4.5[13]
4b	97	35–37° 2,4-DNP: 198–200°	36–37°[14] 2,4-DNP: 187–189°[15]
4c	98	123–125°/0.4 2,4-DNP: 137–138°	114–116°/0.2[16] 2,4-DNP: 136°[17]
4d	98	123–126°/1.5 2,4-DNP: 179–183°	123–126°/1.5[18] 2,4-DNP: 177–181°[18]
4e	97	88–89° 2,4-DNP: 204–207°	$C_{16}H_{16}O_3$ (256.3)
4f	95	58–59° 2,4-DNP: 199–201°	58–59°[6] 2,4-DNP: 198–199.5°[6]

[a] The microanalyses were in satisfactory agreement with the calculated values (C ±0.3, H ±0.2).

1,2-Dihydronaphthalenes (2a–d) and 9,10-Dimethoxy-1,2-dihydroanthracene (2e); General Procedure:

Sodium borohydride (0.38 g, 10 mmol) is added in small portions to a magnetically stirred solution of ketone **1a–e** (20 mmol) in 95% ethanol (50 ml). When the addition is completed, the reaction is heated under reflux for 15 min and then cooled. Water (50 ml) is added to the reaction and the ethanol is removed under reduced pressure. The alcohol product is extracted into benzene (2 × 75 ml) and the benzene is dried with sodium sulfate, filtered, and concentrated to 100 ml. *p*-Toluenesulfonic acid (10–20 mg) is added to the benzene solution and the solution is heated under reflux with azeotropic removal of water until T.L.C. analysis shows complete dehydration of the alcohol intermediate to the olefinic product **2a–e**. The benzene solution of the olefinic product is washed with 5% sodium hydrogen carbonate solution (2 × 25 ml), dried with sodium sulfate, filtered, and evaporated at reduced pressure. Final purification is accomplished either by distillation or chromatography (silica, 10 g, benzene).

***cis*-1,2-Dihydroxy-1,2,3,4-tetrahydronaphthalenes (3a–d), *cis*-1,2-Dihydroxy-9,10-dimethoxy-1,2,3,4-tetrahydroanthracene (3e), *cis*-1,2-Indanediol (3f):**

To a magnetically stirred solution of *N*-methylmorpholine *N*-oxide (18 mmol) in water (10 ml), acetone (6 ml), and *t*-butanol (6 ml) is added osmium tetroxide (20 mg) in tetrachloromethane (2 ml) and olefins **2a–f** (16 mmol) in acetone (10 ml). The mixture is stirred overnight, then diluted with water (50 ml), and extracted with ethyl acetate (2 × 75 ml). The combined ethyl acetate extracts are washed with 1% sodium hydrogen sulfite solution (50 ml), 5% sodium hydrogen carbonate (50 ml), and water, then dried with sodium sulfate, filtered, and evaporated at reduced pressure to give the *cis*-

diol products **3a–f** as solids. Recrystallization of the impure products from dichloromethane/hexane affords pure *cis*-diols **3a–f**; yield: 76–78%. In some cases, chromatography on silica (10 g, dichloromethane) is necessary to remove colored impurities.

3,4-Dihydro-2(1*H*)-naphthalenones (4a–d), 9,10-Dimethoxy-3,4-dihydro-2(1*H*)-anthracenone (4e) and 2-Indanone (4f):

A solution of the *cis*-diol **3a–f** (5.0 mmol) and *p*-toluenesulfonic acid (0.2 g) in benzene (30 ml) is heated under reflux for 15 min with azeotropic removal of water and then cooled. The benzene solution is washed with sodium hydrogen carbonate solution (25 ml) and water (25 ml), dried with sodium sulfate, filtered, and evaporated under reduced pressure to afford nearly pure **4a–f**. Final purification is accomplished either by distillation or chromatography (silica, 10 g, benzene).

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