

Bentonitic Earth Catalyzed Rearrangement
of Aryl 1,1-Dimethylpropargyl Ethers.
Synthesis of 2,2-Dimethyl-2*H*-1-benzopyrans

Raymundo Cruz-Almanza*, Francisco Pérez-Flores and Leonardo Breña

Instituto de Química, UNAM, Circuito Exterior, Ciudad Universitaria, Coyoacán, 04510, México, D.F.

Eva Tapia, Reyna Ojeda and Aidee Fuentes

Facultad de Química, Universidad Autónoma del Estado de México,
Paseo Tollocán y Paseo Colón, Toluca, Edo. de México

Received July 15, 1994

Mexican Bentonitic earth (Tonsil) catalyzed the Claisen rearrangement of aryl 1,1-dimethylpropargyl ethers under mild conditions to provide 2,2-dimethyl-2*H*-1-benzopyrans. The synthesis of enecalinalin **2f** and desmethoxyenecalinalin **2i**, two biologically active products among other natural products (**2b**, **2e**) was performed by this procedure.

J. Heterocyclic Chem., **32**, 219 (1995).

The thermal Claisen rearrangement of aryl propargyl ethers is one of the most widely used methods for the synthesis of 2,2-disubstituted 2*H*-1-benzopyrans [1]. The [3,3] sigmatropic rearrangement takes place generally on heating in a high boiling point solvent *i.e.*, polyethylene glycol [2] and *N,N*-diethylaniline [3] for a period of time. On the other hand, clays have been widely used to bring about several kinds of chemical reactions involving acid catalysis [4]. This is probably due to ease of handling and work-up, mild experimental conditions, gain in yield and/or selectivity and low cost of the clay. However, few examples have been reported using clays for [3,3] sigmatropic rearrangements [5]. In the present paper, the [3,3] sigmatropic rearrangement of aryl 1,1-dimethylpropargyl ethers catalyzed with Mexican bentonitic earth (Tonsil) to provide good yield 2*H*-1-benzopyrans is reported (Scheme 1).

The last few years have seen considerable applications of the commercially available Mexican bentonitic earth (Tonsil) [6]. Such clay has been used for the oxidation of dihydropyridines [7], as a Lewis acid [8] and other chemical processes [9]. Now we have used it to carry out the [3,3] sigmatropic shift of the aryl propargyl ethers **1a-j**. So when the compounds **1a-j** were treated with Mexican bentonitic earth in 1:5 w/w ratio either in benzene or toluene at different temperatures, the corresponding 2,2-dimethyl-2*H*-1-benzopyrans **2a-j** were isolated in good yields. The results are summarized in Table 1.

From the rearrangement of ethers **1f**, **1h** and **1j**, a mix-

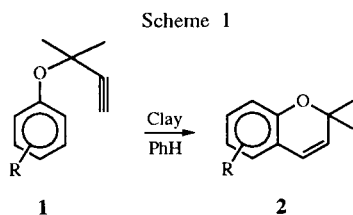


Table 1
Claisen Rearrangements of Aryl 1,1-Dimethylpropargyl Ethers **1** Catalyzed by Tonsil

Entry	Compound	R	Temp [°C]	time [hours]	yield of	
					2 [a]	2 [b]
1	1a	H	25	11	83	84
2	1b	4-MeO-	25	6	91	89
3	1c	4-Cl-	25	30	86	90
4	1d	4-Me-	50	20	85	83
5	1e	4-CH ₃ CO-, 3-HO-	75	8	77	82
6	1f	4-CH ₃ CO-, 3-MeO-	75	8	82 [c]	87 [c]
7	1g	4-CH=O	75	8	77	82
8	1h	3-CH=O	75	8	88 [d]	80 [d]
9	1i	4-CH ₃ CO-	75	30	76	85
10	1j	3-CH ₃ CO-	75	30	51 [d]	82 [d]

[a] Yields refer to pure isolated compounds. [b] Yields of benzopyrans **2** obtained by thermal rearrangements. [c] Overall yield of a mixture of enecalinalin **2f** and isoenecalinalin **2f'** separated by hplc. [d] Overall yield of a mixture of the two expected isomers separated by column chromatography.

ture of the two expected isomers was obtained; **2f** and **2f'** in a 3:2, **2h** and **2h'** in a 4:1, **2j** and **2j'** in a 3:2 ratio, respectively (Scheme 2). However, from the ether **1e** a single product **2e** was formed in agreement with the thermal rearrangement in a previous report [10].

The role of the solvent was pointed out when the reaction was carried out in polar coordinating solvents like acetone, tetrahydrofuran or acetonitrile, affording the 2*H*-benzopyrans in poor yield (15-27%). This effect had previously been observed for other clay catalyzed reactions [5].

It has been previously observed [11] that electrodonating groups in the meta position to the ethereal linkage increased the yield of the cyclization products, while electron withdrawing groups gave lower yields. No appreciable effects were observed with the *para*-substituents. Our data in Table 1 are in general agreement with such results.

On the other hand, the presence of the α,α -dimethyl

Table 2
Spectral Properties of Aryl Propargyl Ethers (Entry 1-10) and 2*H*-1-Benzopyrans (Entry 11-15)

Entry	Compound	IR (cm ⁻¹) Film	¹ H-NMR (CDCl ₃ , TMS, δ ppm)	MS m/z (%)
1	1a	3292, 2987, 2929, 1593, 1491, 1221, 1139	1.62 (s, 6H), 2.51 (s, 1H), 7.20 (s, 5H)	160 (M ⁺ , 5), 94 (100)
2	1b	3287, 2988, 2936, 1504, 1464, 1232, 1212, 1138	1.61 (s, 6H), 2.53 (s, 1H), 3.75 (s, 3H), 6.75 (d, 2H, J = 8 Hz) 7.15 (d, 2H, J = 8 Hz)	190 (M ⁺ , 6), 124 (100)
3	1c	3297, 2989, 1592, 1486, 1237, 1137, 707	1.60 (s, 6H), 2.65 (s, 1H), 7.23 (m, 4H)	196 (M ⁺ , 2) 194 (M ⁺ , 6), 41 (100)
4	1d	3290, 2988, 2935, 1611, 1506, 1232, 1139	1.65 (s, 6H), 2.25 (s, 3H), 2.55 (s, 1H), 7.10 (s, 4H)	174 (M ⁺ , 5), 108 (100)
5	1e	3288, 3073, 2990, 2938, 1690, 1253, 1129	1.69 (s, 6H), 2.51 (s, 3H), 2.61 (s, 1H), 6.55 (dd, 1H, J = 8 Hz, J = 3 Hz), 6.82 (d, 1H, J = 3 Hz), 7.54 (d, H, J = 8 Hz), 9.81 (s, 1H)	218 (M ⁺ , 3), 147 (100)
6	1f	3287, 2990, 2938, 1666, 1264, 1029	1.68 (s, 6H), 2.55 (s, 3H), 2.60 (s, 1H), 3.85 (s, 3H), 6.75 (dd, 1H, J = 8 Hz, J = 2 Hz), 6.90 (d, 1H, J = 2 Hz), 7.66 (d, 1H, J = 8 Hz)	232 (M ⁺ , 4), 151 (100)
7	1g	3290, 2990, 2938, 1696, 1600, 1504, 1248, 1137	1.70 (s, 6H), 2.65 (s, 1H), 7.25 (d, 2H, J = 8 Hz), 6.82 (d, 1H, J = 3 Hz), 7.54 (d, H, J = 8 Hz), 9.85 (s, 1H)	188 (M ⁺ , 5), 41 (100)
8	1h	3271, 2990, 2827, 1720, 1599, 1502, 1245, 1135	1.67 (s, 6H), 2.63 (s, H), 7.32 (m, 4H), 9.87 (s, 1H)	188 (M ⁺ , 38), 39 (100)
9	1i	3303, 2987, 1675, 1598, 1504, 1270, 1137	1.72 (s, 6H), 2.55 (s, 3H), 2.65 (s, 1H), 7.21 (d, 2H, J = 8 Hz), 7.91 (d, 2H, J = 8 Hz)	202 (M ⁺ , 2), 121 (100)
10	1j	3289, 2988, 2936, 1682, 1582, 11482, 1272, 1139	1.70 (s, 6H), 2.55 (s, 3H), 2.60 (s, 1H), 7.35 (m, 3H), 7.55 (m, 1H)	202 (M ⁺ , 3), 121 (100)
11	2c	3042, 2977, 2932, 1637, 1593, 1483, 1265, 1136	1.40 (s, 6H), 5.65 (d, 1H, J = 10 Hz), 6.25 (d, 1H, J = 10 Hz) 6.71 (d, 1H, J = 8 Hz), 6.92 (d, 1H, J = 3 Hz), 7.10 (dd, 1H, J = 8 Hz, J = 3 Hz)	196 (M ⁺ , 0.8), 39 (100) 194 (M ⁺ , 2.5)
12	2h	2980, 2872, 2740, 1700, 1575, 1370, 1280, 1210	1.44 (s, 6H), 5.72 (d, 1H, J = 10 Hz), 6.32 (d, 1H, J = 10 Hz), 7.05 (d, 1H, J = 10 Hz), 7.21 (d, 1H, J = 3 Hz), 7.30 (dd, 1H, J = 10 Hz, J = 3 Hz)	188 (M ⁺ , 0.8), 43 (100)
13	2h'	2995, 2840, 1740, 1610, 1590, 1370, 1230, 1050	1.45 (s, 6H), 5.75 (d, 1H, J = 10 Hz), 7.05 (d, 1H, J = 10 Hz, 7.25 (m, 2H), 7.35 (dd, 1H, J = 10 Hz, J = 1 Hz)	188 (M ⁺ , 3), 43 (100)
14	2j	2985, 2837, 1705, 1575, 1368, 1220, 1105	1.44 (s, 6H), 2.53 (s, 3H), 5.72 (d, 1H, J = 10 Hz), 6.32 (d, 1H, J = 10 Hz), 7.10 (d, 1H, J = 10 Hz), 7.31 (m, 2H)	202 (M ⁺ , 5), 187 (100)
15	2j'	2960, 2940, 1730, 1560, 1460, 1270, 1120	1.47 (s, 6H), 2.55 (s, 3H), 5.75 (d, 1H, J = 10 Hz), 7.05 (d, 1H, J = 10 Hz), 7.10 (m, 2H), 7.35 (dd, 1H, J = 10 Hz, J = 1 Hz)	202 (M ⁺ , 2), 187 (100)

The spectral properties for compounds **2a** [13], **2b** [14], **2d** [15], **2e** [16], **2f** and **2f'** [10], **2g** [17] and **2i** [18] were found to be identical with those reported for these compounds.

group in the propargyl ethers (the gem-dimethyl effect which increases the rate of cyclization) [12], was pointed out when some propargyl phenyl ethers (R = H, Me,

OMe) were treated with Tonsil under the same conditions described above and the rearrangement did not occur.

In order to compare the results obtained by tonsil cat-

alyzed reaction vs the classic thermal rearrangement, we heated compounds **1a-j** in a sealed tube at 175-180° for 8

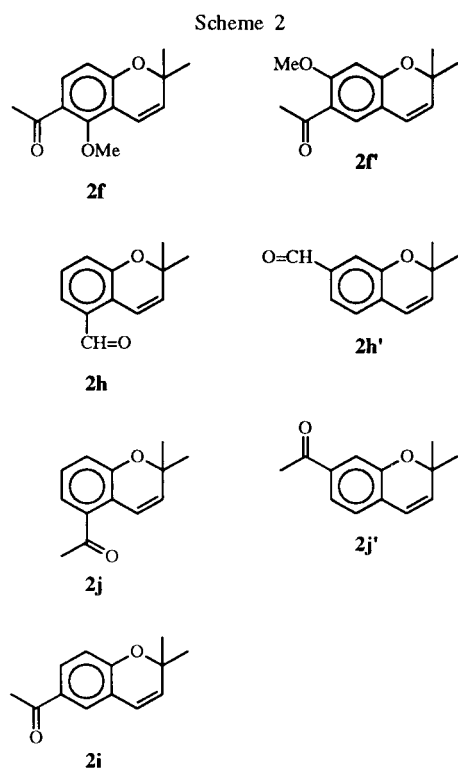


Table 3

Analytical Data for all New Compounds

Entry	Compound	Formula	Calcd./Found (%)	
			C	H
2	1b	C ₁₂ H ₁₄ O ₂	75.76	7.42
			75.52	7.31
3	1c	C ₁₁ H ₁₁ ClO	67.90	5.66
			67.78	5.53
5	1e	C ₁₃ H ₁₄ O ₃	71.54	6.47
			71.69	6.58
6	1f	C ₁₄ H ₁₆ O ₃	70.89	7.32
			70.71	7.53
7	1g	C ₁₂ H ₁₂ O ₂	76.57	6.43
			76.32	6.21
8	1h	C ₁₂ H ₁₂ O ₂	76.57	6.43
			76.47	6.67
9	1i	C ₁₃ H ₁₄ O ₂	77.20	6.98
			76.89	7.22
10	1j	C ₁₃ H ₁₄ O ₂	77.20	6.98
			77.42	7.15
11	2c	C ₁₁ H ₁₁ ClO	67.90	5.66
			67.68	5.43
12	2h	C ₁₂ H ₁₂ O ₂	76.57	6.43
			76.63	6.57
13	2h'	C ₁₂ H ₁₂ O ₂	76.57	6.43
			76.55	6.52
14	2j	C ₁₃ H ₁₄ O ₂	77.20	6.98
			77.43	7.27
15	2j'	C ₁₃ H ₁₄ O ₂	77.20	6.98
			77.37	7.09

hours and used *N,N*-dimethylaniline as the solvent. The results are shown in Table 1.

Attempts to extend the clay catalyzed reaction to allyl phenyl ether under several conditions and different solvents were futile, recovering the unreacted starting materials.

The compounds synthesized through this approach include encecaine **2f** and desmethoxyenecaine **2i**, two biologically active compounds which are potentially useful as insecticides. The spectral and analytical data necessary for the identification of the products are summarized in Tables 2 and 3 respectively.

In conclusion, the use of Mexican bentonitic earth (Tonsil) provides a very mild procedure to carry out the [3,3] sigmatropic rearrangement of aryl 1,1-dimethylpropargyl ethers, which is remarkably simple and easy to perform, giving 2,2-dimethyl-2*H*-1-benzopyrans.

EXPERIMENTAL

The ir spectra were recorded on a Nicolet FT-55X Spectrophotometer, the ¹H nmr spectra were obtained on a Varian-Gemini 200 instrument with TMS as the internal standard. Mass spectra were measured with a Hewlett-Packard 5985-B spectrometer with a gc/ms system; compounds were introduced through the direct reaction probe.

The required aryl 1,1-dimethylpropargyl ethers were prepared following a method previously described [11].

Rearrangement with Tonsil. General Procedure.

In a round bottom flask equipped with a magnetic stirrer and reflux condenser, a solution of 2.0 g of the appropriate aryl 1,1-dimethylpropargyl ether in 25 ml of benzene and 10 g of tonsil was vigorously stirred and heated at the indicated temperature. The progress of the reaction was followed by thin layer chromatography (silica gel, hexane-ethyl acetate). After the reaction was completed the mixture was filtered and the tonsil washed with dichloromethane. The filtrate was dried over anhydrous magnesium sulphate and the solvent evaporated under reduced pressure and, if necessary, purified by column chromatography.

Acknowledgments.

The authors gratefully acknowledge partial financial support from CONACyT. We thank Messrs. R. Gaviño, R. Patiño and R. Velasco for their technical assistance.

REFERENCES AND NOTES

- [1] E. E. Schweizer and D. Meeder-Nycz, in *Chromenes, Chromenones and Chromones*, G. P. Ellis, ed, John Wiley and Sons, 1977, pp 57-58 and references cited therein.
- [2] U. Rao and K. K. Balasubramanian, *Tetrahedron Letters*, **24**, 5023 (1983).
- [3] J. Hlubucek, E. Ritche and W. C. Taylor, *Tetrahedron Letters*, 1369 (1969), F. Bohlmann and U. Bühmann, *Chem. Ber.*, **105**, 863 (1972).

- [4] P. Diddams, in *Solid Supports and Catalyst in Organic Synthesis*, K. Smith, ed, Prentice Hall, N.Y., 1992, pp 3-39.
- [5] W. G. Dauben, J. M. Cogen and U. Behar, *Tetrahedron Letters*, **23**, 3241 (1990).
- [6] For recent application, commercial source and structural composition of the Mexican bentonitic earth see: A. Cabrera, N. Rosas, C. Márquez, M. Salmón, E. Angeles, R. Miranda and R. Lozano, *Gazz. Chem. Ital.*, **121**, 127 (1991); R. Cruz-Almanza, J. Pérez-Flores and C. Lemini, *Heterocycles*, **37**, 759 (1994).
- [7] A. Cano, F. Delgado, A. Córdoba, C. Márquez and C. Alvarez, *Synth. Commun.*, **18**, 2051 (1988).
- [8] A. Ortega and E. Maldonado, *Heterocycles*, **29**, 635 (1989).
- [9] M. Salmón, E. Angeles and R. Miranda, *Chem. Commun.*, 118 (1990).
- [10] S. K. Mukerjee, S. C. Sarkar and T. R. Seshadri, *Indian J. Chem.*, **8**, 861 (1970).
- [11] I. Iwai and J. Ide, *Chem. Pharm. Bull.*, **11**, 1042 (1963).
- [12] M. Harfenist and E. Thom, *J. Org. Chem.*, **37**, 841 (1972).
- [13] A. Pawa, A. Au, G. A. Lee and W. Owens, *J. Org. Chem.*, **40**, 1142 (1975).
- [14] F. Bohlmann, P. Zitzkowski, A. Suwita and L. Fielder, *Phytochemistry*, **17**, 2101 (1978).
- [15] A. Bougini, G. Cardillo, M. Orena, G. Parzi and S. Sandri, *Tetrahedron Letters*, 2545 (1979).
- [16] W. M. Bandaranayake, L. Crombie and D. A. Whiting, *J. Chem. Soc. C*, 811 (1971).
- [17] V. M. Naidu and G. S. K. Rao, *Synthesis*, 144 (1979).
- [18] F. Bohlmann and M. Grenz, *Chem. Ber.*, **110**, 295 (1977).