CHEMISTRY LETTERS, pp. 1459-1460, 1983. © The Chemical Society of Japan 1983

MERCURY(II) TRIFLATE—AMINE COMPLEX-INDUCED CYCLIZATION OF GERANYLGERANYL *p*-NITROBENZOATE: SYNTHESIS OF SPONDIAN AND LABDANE DITERPENOIDS1)

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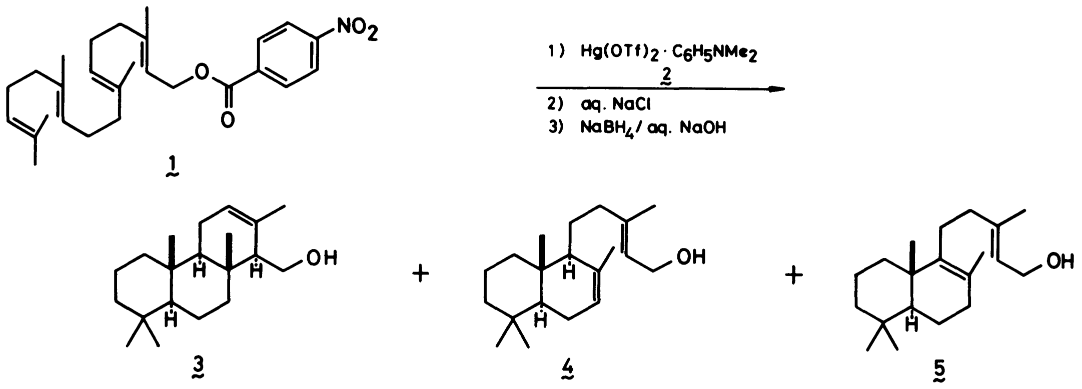
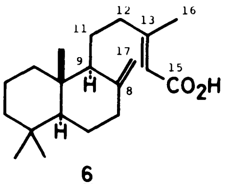
Biomimetic cyclization of geranylgeranyl *p*-nitrobenzoate by the mercury(II) triflate—*N*,*N*-dimethylaniline complex and subsequent reductive demercuration provide a tricyclic and two bicyclic diterpenoids in moderate yields. This is the first example of the cyclization of geranylgeraniol to the tricyclic diterpene.

Biomimetic olefin cyclization reaction to give carbocycles has been intensively studied with geraniol or farnesol derivatives as acyclic polyolefin.2) However, so many cyclizations of geranylgeraniol derivatives have never been recorded,3) probably due to the lack of product selectivity in any known procedures. Recently, we have developed a new highly efficient olefin cyclization agent, mercury(II) trifluoromethanesulfonate (hereafter triflate)—amine complex **2**, which showed remarkably high selectivity in the cyclization of various farnesol derivatives.1) Herein described is the application of this procedure to acyclic diterpene which provided one-step conversion of a geranylgeraniol derivative **1** to the tricyclic diterpenoid skeleton. Two kinds of bicyclic by-products in this reaction were also identified with the natural diterpenoids recently discovered from tabacco leaves.



Geranylgeranyl *p*-nitrobenzoate (**1**)4) was treated with mercury(II) triflate—*N*,*N*-dimethylaniline complex (**2**) (1.2 equiv.), prepared *in situ* from equimolar amounts of yellow mercuric oxide, trifluoromethanesulfonic anhydride, and *N*,*N*-dimethylaniline in nitromethane, at -20 °C for 4 h. The reaction mixture was directly treated with an excess of sodium chloride solution at the same temperature, and then stirred at room temperature for 10 h. Extractive work-up and silica gel column chromatography provided a mixture of mercury-containing carbocyclic compounds. This mixture was subjected to the reductive demercuration with sodium borohydride in aqueous sodium hydroxide.[5] Silica gel column chromatography of the crude product afforded a 1:2 mixture of two bicyclic alcohols 4 and 5 (28% yield) and a tricyclic alcohol 3 (22% yield). The latter was identified with the authentic sample derived from labda-8(17),13(E)-dien-15-oic acid (6).[6] The alcohol 3 has been employed as a key intermediate for the synthesis of a variety of spondian type diterpenoids such as isoagatholactone (7),[6,7] and 12α-hydroxyspondia-13(16),14-diene (8),[6] a growing class of marine origin diterpenoids.[8]

The mixture of bicyclic products was further purified by using HPLC[9] to give (±)-labda-7,13(E)-dien-15-ol (4) and (±)-labda-8,13(E)-dien-15-ol (5). These two diterpenes were recently isolated from leaves of *Nicotiana setchelli*.[10] Generation of tetra-substituted double bond as in 5 is very exceptional in this series of cyclizations.[1]



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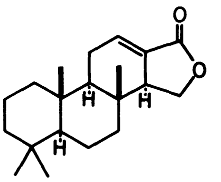

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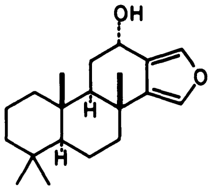

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The authors are indebted to Professor T.Nakano for generous gift of the authentic sample of 3, Dr. H. Suzuki for spectral charts of 4 and 5, and Dr. Y. Fujita of Kuraray Co. for the gift of pure E,E,E-geranylgeraniol. We also thank the financial aids from The Toyota Foundation (1981), and Grant-in-Aids for Special Project Research (1982, No.57218020) and for Scientific Research (1982, No.57470026) from The Ministry of Education, Science and Culture of Japan.

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(Received July 14, 1983)