Studies on Plant Terpene “Borneol”

Borneol is one of the components used in “Jinchuang Ointment”. It is a plant terpene commonly used in traditional Chinese medicine (TCM) for restoring consciousness, treating coma due to heat-blockage, or reducing skin irritation and itching. (+)-Borneol used in TCM can be isolated from the resin and essential oil of woody plants of the Dipterocarpaceae family or certain camphor tree. Its optical isomer counterpart, (-)-borneol, can be obtained from the herbaceous plant *Blumea balsamifera*.

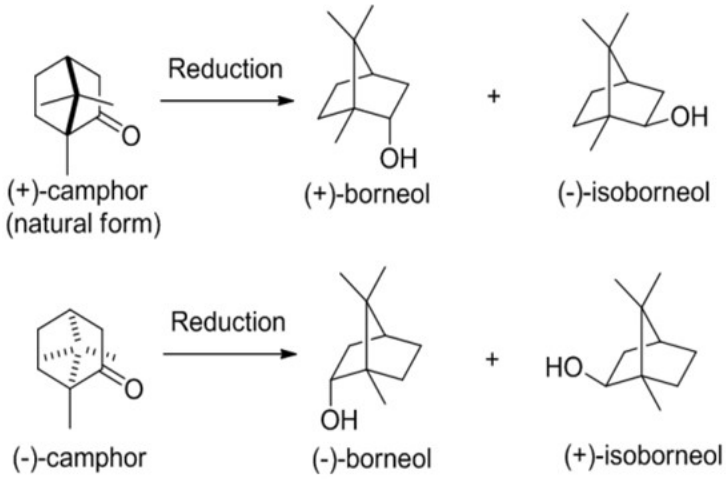


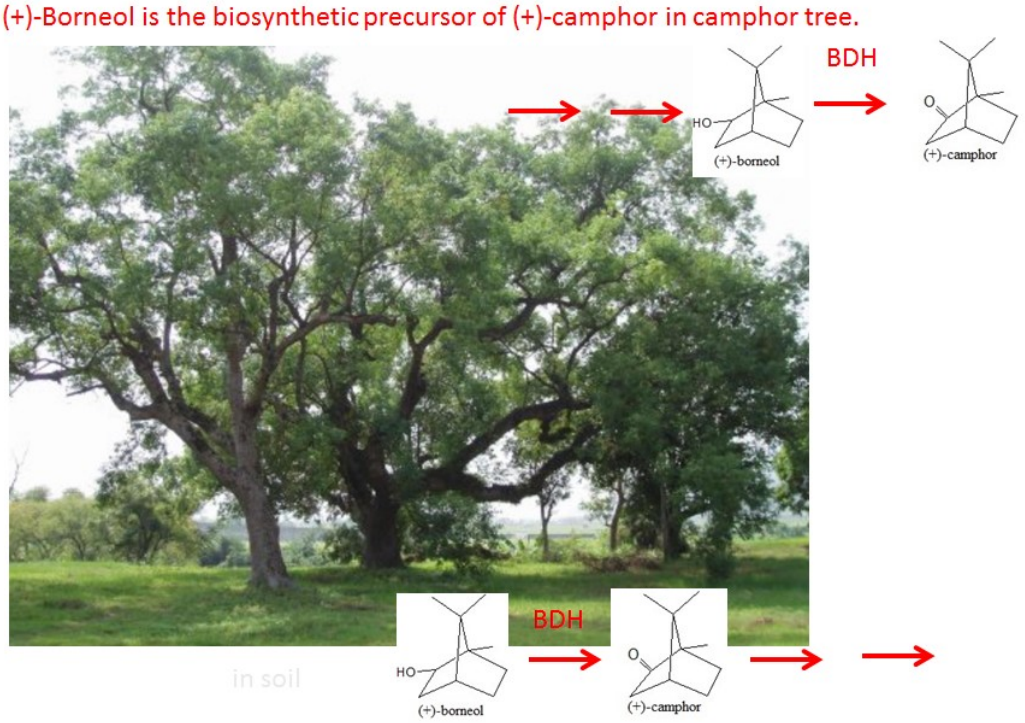
Figure 1. Structures of (+)-borneol, (+)-isoborneol, (-)-borneol and (-)-isoborneol. The “semi-synthetic borneol“ is synthesized from natural (+)-camphor to afford two isomers, (+)-borneol and (-)-isoborneol. The “synthetic borneol“ is a mixture of four stereoisomers, (+)-borneol, (+)-isoborneol, (-)-borneol and (-)-isoborneol which are obtained from reduction of (±)-camphor. [1]

Analysis of Borenol Stereoisomers by Gas Chromatography

Chemically-synthesized borneol contains four stereoisomers, (+)-isoborneol, (−)-isoborneol, (−)-borneol, and (+)-borneol. (Fig. 1) The ratio of these four isomers in chemically-synthesized and natural borneol products was determined by GC mass spectrometry with the use of chiral Cydex-B column. Five different “natural" borneol commercial products sold in Taipei's traditional Chinese medicine stores were examined. In all five samples of “natural” borneol, the content of (±)-isoborneol was greater than 20%. In other words, none of them are authentic “natural" borneol. [1] Because Cydex-B chiral column is costly, the ratio of above four borneol isomer derivatives was examined by using general HP-5MS gas chromatography column. [2]

Interactions Between Borneol and Soil Bacteria

One hundred years ago Taiwan was the major producer of natural camphor accounting for more than 70% of the world-wide natural camphor production. In addition to the major terpene, camphor, there are still many other terpenes, including borneol, present in the essential oil of the camphor tree. This is probably one of the reasons why there have been so many camphor or borneol-degrading strains of microorganisms isolated by our group on this camphor tree-covered green island. (Fig. 2)



One borenol-degrading strain, *Pseudomonas sp.* TCU-HL1, was isolated in Hualien by our group. The k_{cat} and k_{cat}/K_m values of lavender's borneol dehydrogenase (BDH) are about 1800-fold and 500-fold lower than those of TCU-HL1! The kinetic properties of plant and microbial BDH might reflect their different physiological roles. For soil microbial BDH, its physiological role is to degrade borneol in order to provide an energy supply to keep cells alive. Microbial BDH with weak activity means that microbial cells cannot obtain energy very efficiently from borneol. However, plant BDH is responsible for the biosynthesis of the secondary metabolite, camphor. Generally speaking, secondary metabolites are not vitally essential for plant survival. [3]

Our Publication

1. Ho TJ, Hung CC, Shih TL, Yiin LM, Chen HP. "Investigation of borneols sold in Taiwan by chiral gas chromatography." (2018) *Journal of Food and Drug Analysis* **26,** 348-352.
2. Yang MY, Khine AA, Liu JW, Cheng HC, Hu A, Chen HP, Shih TL. "Resolution of Isoborneol and its Isomers by GC/MS to Identify “Synthetic” and “Semi-synthetic” Borneol Products." (2018) *Chirality* **30**, 1233-1239.
3. Tsang HL, Huang JL, Lin YH, Huang KF, Lu PL, Lin GH, Khine AA, Hu A, Chen HP. "Borneol dehydrogenase from *Pseudomonas* sp. TCU-HL1 catalyzes the oxidation of (+)-borneol and its isomers to camphor." (2016) *Applied and Environmental Microbiology* **82**, 6378-6385.