Diels-Alder Reactions
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Classic reaction of phellandrene with maleic anhydride is a lab unit in Chem 346:

There are four possible resulting structures (excluding enantiomers).

Conversion to the lactone proves the Diels-Alder reaction formed the ENDO adduct.

But the orientation of the isopropyl group is unresolved:

Published assignments are incorrect [B. Singaram and J. Verghese, J. Indian Chem. Soc. LIV, 630-633 (1977)].
Stereochemistry of Me-Lactone

\[\text{ENDO}\]

\[\text{methanol} + \text{HCl}\]

\[\text{rotate}\]
COSY 2D spectrum - U500;
assists with assignments
Normal $^1$H Spectrum of Methyl-Lactone
NOESY-1D Spectra of Methyl-Lactone
NOESY-1D Spectra of Methyl-Lactone
NOESY-1D Spectra of Methyl-Lactone
NOESY-1D Spectra of Methyl-Lactone

Unity-500, ambient temp
nt=64