Problem N-302 (C_{17}H_{19}NO_{4}): 250 MHz $^1$H NMR spectra of the four isomers of cocaine are shown below. Which proton appears at $\delta$ 5.3-5.6? Assign relative stereochemistry to the four isomers. Assign the protons at $\delta$ 1.8 and 2.5 for 1 and 2.1 for 2 (JOC 1982, 47, 13).
Problem N-302 (C₁₇H₁₉NO₄): 250 MHz ¹H NMR spectra of the four isomers of cocaine are shown below. Which proton appears at δ 5.3-5.6? Assign relative stereochemistry to the four isomers. Assign the protons at δ 1.8 and 2.5 for 1 and 2.1 for 2 (JOC 1982, 47, 13).

**Answer**

**Allopseudococaine**

No Jₘₙ - so H³ must be equatorial. The Jₑₑ is too small to detect - see only the the two Jₑₑₙₑ (flattening of the cyclohexane ring)

**Allococaine**

No Jₘₙ - so H³ must be equatorial. The Jₑₑₑₑ are too small to detect - see only the Jₑₑₑₑ

**Pseudococaine**

2x Jₘₙₘₙ - so both H³ and H⁵ must be ax. The small coupling is Jₑₑₑₑ

1x Jₘₙₘₙ - so H³ is axial, but H² is eq, so see two Jₑₑₑₑ

**Cocaine**

Calc:
- H¹: 3.1
- H²: 2.5
- H³: 5.0
- H⁴: 1.8
- H⁵: 2.9
In Bicyclo[3.3.1]nonanes and bicyclo[3.2.1]octanes (as in these examples) the cyclohexane ring is flattened due to repulsion between the two larger bridges, so the eq-eq dihedral angle approaches 90 degrees, and the $J_{\text{eq-eq}}$ coupling can be too small to resolve. The ring flattening has the effect of making $^3J_{\text{ax-eq}}$ unusually large, 5.4 Hz for Allopseudococaine, 6.2 Hz for Allococaine.

![Chemical structure of Allopseudococaine](image)

Steric interaction causes ring flattening.

![Idealized cyclohexane](image)

Flattened cyclohexane $60^\circ \rightarrow 90^\circ$ ($J$ smaller).

![Flattened cyclohexane](image)

Flattened cyclohexane $60^\circ \rightarrow 30^\circ$ ($J$ larger).