A High Resolution Analysis of "Forbidden" Vibrational Bands of C_2H_4: The $\nu_8 + \nu_{10}$ Band

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The C_2H_4 is an asymmetric top molecule with twelve different vibrational modes. Because of its symmetry (D_{2h}), all the vibrational states of the C_2H_4 molecule are divided into 8 groups of the states of different symmetry. However, only bands of three types of symmetry are allowed in absorption from the ground vibrational state. At the same time, information about rotational structure of as many as possible upper vibrational states of the C_2H_4 molecule is necessary for analysis of its fundamental properties.

In the present study we consider the $\nu_8+\nu_{10}$ (A_u) band of C_2H_4 which is forbidden in absorption by symmetry. The FTIR spectrum of that band was recorded for the first time in University of Oulu (Finland) with a pressure of 0.78 Torr, absorption path length 3.2 m, and room temperature.

Because ro-vibrational transitions in the $\nu_8+\nu_{10}$ band can be appeared only as a result of borrowing intensity from the bands $\nu_4 + \nu_8$ and $\nu_7 + \nu_8$, line strengths of the studied band are very weak. In spite of that, we were able to undoubtedly assign 1814 transitions (641 upper energy levels) to the $\nu_8+\nu_{10}$ band with $J^{max.} = 38$ and $K_a^{max.} = 19$. To correctly fit the assigned transitions (energy levels), three additional vibrational states most strongly interacting with the studied ($\nu_8=\nu_{10}=1$) state, were taken into account. As the results, a set of 41 fitted parameters reproduce the initial 641 energy levels (1814 transitions) with the $d_{rms}=0.0003$ cm^{-1}.