Struktūrinė acetilsalicilo rūgšties ir jos šiluminės disociacijos produktų analizė pasinaudojant žemos temperatūros virpesine spektroskopija

Structural analysis of acetylsalicylic acid and its thermal dissociation products by low-temperature vibrational spectroscopy

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Acetylsalicylic acid (ASA), more commonly known as aspirin, is a drug whose anti-inflammatory and pain-reducing properties have made it popular since its synthesis over a 100 years ago. ASA molecule is an aromatic compound with carboxy and ester groups at the ortho positions. It has several possible conformations, two of which could be observed in room temperature according to their energy (table 1).

Low temperature vibrational spectroscopy is a useful tool for structural analysis of a single molecule. Matrix isolation experiments have been previously performed for salicylic acid (SA) molecules[1]. As the vapor pressure of ASA is too low to make the mixture at room temperature, the sample has to be heated which means ASA molecules can easily thermally dissociate. During the course of this research, matrices such as nitrogen and argon were employed. Most recently, ASA was isolated in para-hydrogen matrix (figure 1). The para-hydrogen is obtained through a conversion process before each experiment and requires very low temperatures (in the range of 2 to 3 K). It forms a relatively "soft" matrix which allows large amplitude motions of the guest molecules.

Table 1. Calculated energies of three most stable acetylsalicylic acid conformers (B3LYP/6-311++G(3df,3pd))

Name	*E, H*	*ΔE, kJ/mol*	*% pop.*
1a	-648,936	0	82
2a	-648,935	3,9	16
2b	-648,928	22,8	0,008

ASA samples were heated to between 50 °C and 110 °C, searching for the optimal temperature to avoid thermal decomposition. The main thermal dissociation products of ASA are acetic acid (AA) and salicylic acid[2]. Acetylsalicylic acid also dissociates into salicylic acid in the presence of water.

In figure 1, infrared absorption spectra of ASA heated to different temperatures, and isolated in para-hydrogen matrix, are presented. When the sample is heated to the highest temperature (100 °C), the bands of AA can be clearly observed (the highest intensity band can be seen at 1780 cm^{-1}). As the sample heating temperature decreases, SA (1706 cm^{-1}) and ASA (1755 cm^{-1}) bands become more prevalent. If the concentration of thermal dissociation products is high, or after annealing, complex bands of ASA-decomposition products, as well as ASA-water, can dominate the spectra and complicate the analysis.

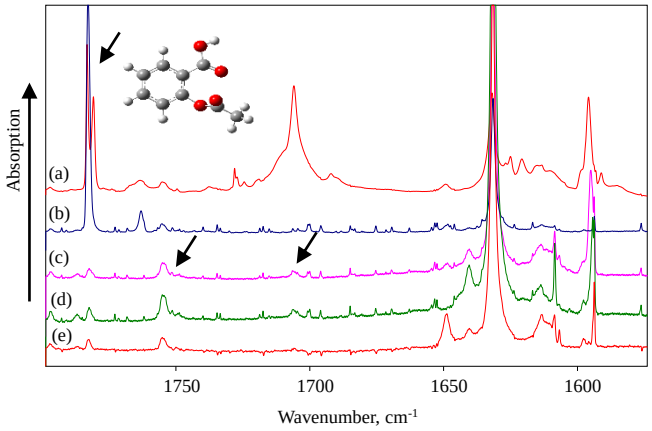

Fig. 1. Infrared absorption spectra of acetylsalicylic acid in para-hydrogen matrix. Sample heated to (a) 100 °C, (b) 70 °C, (c) 60 °C, (d) 55 °C and (e) 50 °C.

In order to better understand the structure of the molecule, irradiation and annealing experiments were also performed on the samples with best ASA to dissociation products ratio. The irradiation was performed with a tunable pulsed laser, at 300 nm, 290 nm and 270 nm. The biggest differences are observed after irradiation at 270 nm – the 1755 cm^{-1} band decreases in intensity, suggesting that ASA starts to disappear. However, there are several bands that grow in intensity, meaning it is possible that irradiation increases the concentration of higher energy conformer.

Keywords: vibrational spectroscopy, matrix isolation, conformers, NSAIDs.

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Literature

[1] M. Miyagawa, N. Akai, M. Nakata, *Chem. Phys. Letters*, **602** (2014).
[2] Y. Asakura Ribeiro, A.C.F. Caires, N. Boralle, M. Ionashiro, *Termochim. Acta*, **279** (1996).