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RESEARCH ARTICLE

Study on the Fragmentation Pathway of the Aconitine-Type Alkaloids under Electrospray Ionization Tandem Mass Spectrometry Utilizing Quantum Chemistry

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Abstract
Objective With the aim of developing a rapid and sensitive method for the relative molecular mass and the fragmentation pathway of target compounds without complicated experiments, we combined mass spectrometry (MS) with quantum chemistry to analyze protonated molecules and fragmentation pathway of target compounds.
Methods In this study, aconitine, mesaconitine, hypaconitine, benzoylaconine, benzoylmesaconine, and benzoylhypaconine were investigated by electrospray ionization multi-stage mass spectrometry, and the lost sequence of four CH_3OH molecules was studied using quantum chemistry.
Results The results showed that the typical neutral losses correspond to the molecules CO, CH_3OH, H_2O, $–C_6H_5CO$, and $–CH_3$, and so the lost sequence of four methoxyl groups and the structures of more fragmentation ions were identified for the first time.
Conclusions The study demonstrated that the method of MS coupled with quantum chemistry can be used to estimate the fragmentation pathway of compounds quickly and conveniently.

Keywords Aconitine-type alkaloids · ESI · Mass spectrometry · Quantum chemistry

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Introduction

Electrospray ionization mass spectrometry (ESI-MS) is a commercially available analytical tool, which has been widely used in trace analysis of organic compounds. For the identification of protonated molecules and fragmentation ions, this technique can enable fast sample analysis and identification in a complex system by providing relative molecular mass, with advantage of high sensitivity, high specificity, high efficiency, etc. [1–6]. However, it is difficult to explain the structure of fragmentation ions clearly, and therefore there is a particular need for additional approaches should be used to identify fragmentation ions, especially such as ChemSpider. ChemSpider is a very valuable internet database of known compounds useful in the identification of these types of compounds in commercial, environmental, forensic, and natural product samples [7].

Quantum chemistry is a qualitative theory of chemical bonding stressing the physical processes which occur during bond formation. Quantum chemistry can assist to identify fragmentation ions and clarify fragmentation pathway, especially the lost sequence of the same substituent by calculation bond length. Calculation based on quantum chemistry theory has been used to interpretation and analysis of data obtained from MS, especially results from tandem mass spectrometry [7–11].

Aconite plants are widely located in Europe, Northern Asia, and North America, and their active ingredients mainly include aconitum alkaloids (AAS) and some other minor components, such as chasmanine, kobusine, and higenamine [12–14]. AAS consist of aconitines, aconines, and benzoylaconitines, among which the most toxic components are aconitine, mesaconitine, and hypaconitine. Although the fragmentation pathways of aconitine-type alkaloids have been reported in the literature [1, 5, 10] previously, the fragmentation pathways in low-