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NICOTINE AND TOBACCO ALKALOIDS: A GC-MS APPROACH

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Abstract

In this paper a way of identifying and determining the structure of tobacco alkaloids using GC-MS is presented. The main fragmentation reactions of the principal alkaloids from tobacco is also discussed.

Keywords*: nicotine; nornicotine; alkaloids; mass spectra; fragmentation.*

Introduction

Tobacco was probably first domesticated in South and Central America. After its initial domestication, the practice of cultivating tobacco spread throughout North America. By the contact of Native Americans with Europeans, tobacco cultivation was spread all around the world. The *Nicotinae* family plants (especially *Nicotiana tabacum* and *Nicotiana rustica*) and commercial tobacco contain a family of structurally related alkaloids with five and/or six member ring nitrogen heterocycles. Twelve alkaloids from tobacco are of core interest: *l*-nicotine, *l*-nornicotine, *d*-nornicotine, anatabine, anabasine, nicotyrine, *N*-methylanatabine, *N*-methylanabasine, 2,3'-bipyridyl, pyrrolidine, *N*-methylpyrrolidine, pyperidine, Figure 1.

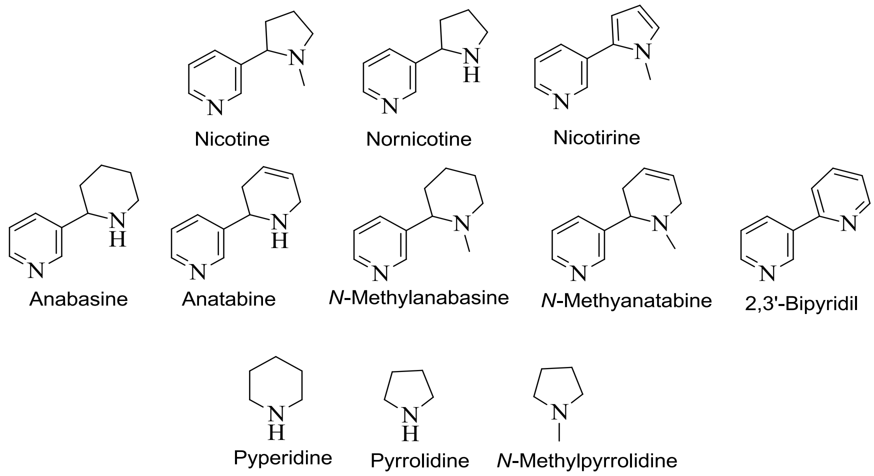

Fig. 1. Structure of the main alkaloids from tobacco

During the last decades, there has

of the toxic alkaloids from tobacco. GC-MS

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been an increasing focus on tobacco smoking and the adverse health consequences associated with it. Most people are aware of the dangers of smoking, and for the dependence properties of tobacco smoking. From the above twelve alkaloids, nicotine is the major one in tobaccos, accounting for about 95% of the total alkaloid content (anatabine and nornicotine are roughly in the equal amounts on about 2-3% each, anabasine on about 0.3% and, the remaining are in very small amounts). Having in view the health problems associaled with smoking, it appear as a necessity the corect identification (Gas Chromatography coupled with Mass Spectroscopy) is an important and powerfull tool in foresinc analysis, that allowed the scientists to perform the separation, identification, and structure determination of various classes of drugs/toxics.

Mass spectra of the tobacco alkaloids, are easily to be founded in the major databases from the internet and dedicated books. What does not exist usually, are fragmentation patterns and correlations between them, which we will present next.

Results and discussions

In Figures 2-7 are presented the mass spectra of the main alkaloids from tobacco.

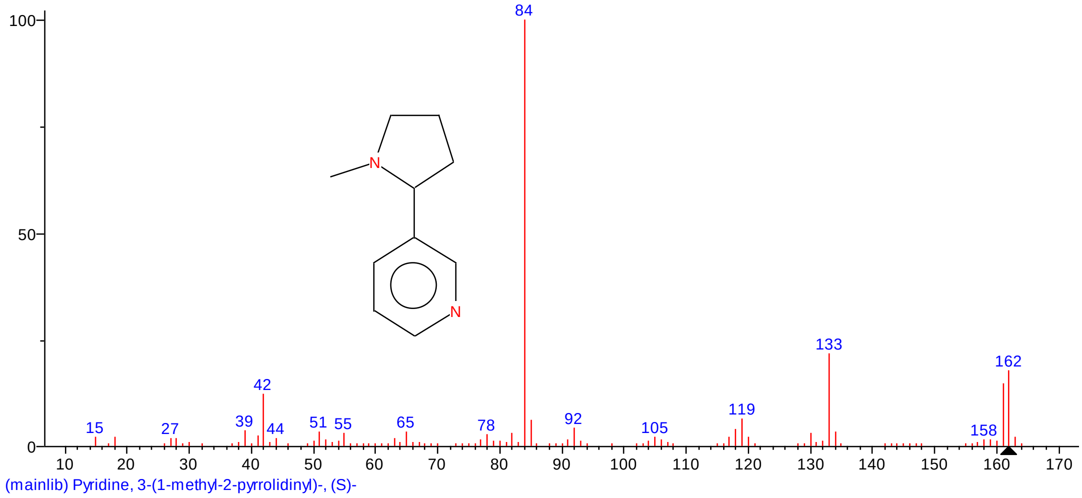
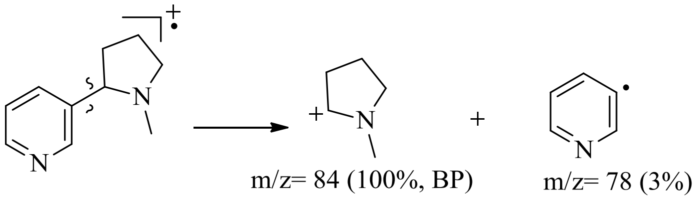


Fig. 2. Nicotine mass spectra

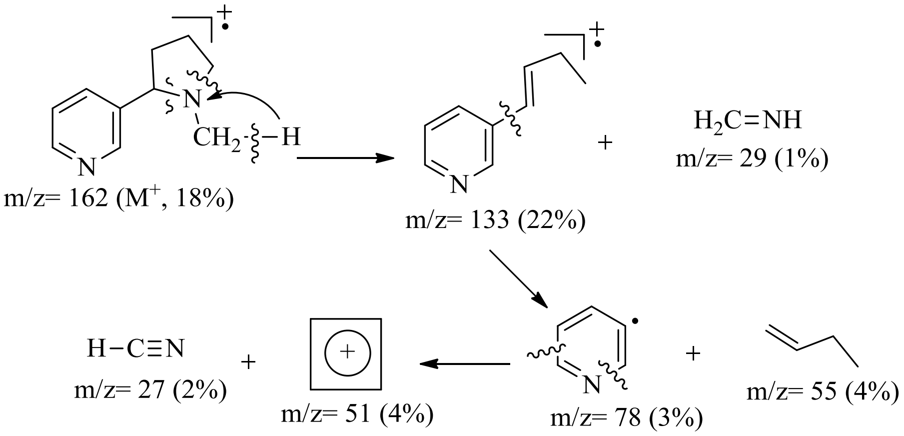
Analysing the data furnished by mass spectra of nicotine (Figure 2) reveals the following:

- the molecular ion, M^{+}, appears at m/z = 162 with an intensity of 18%, characteristic for cyclic amines; the M-1 peak (m/z = 161, 15%) is significant being characteristic for cyclic amines;
- the base peak (BP) appears at m/z = 84 (100%) and could be explained through a fragmentation on the bond level between the two nitrogen heterocycles; the same fragmentation explains the peak at m/z = 78 (3%);



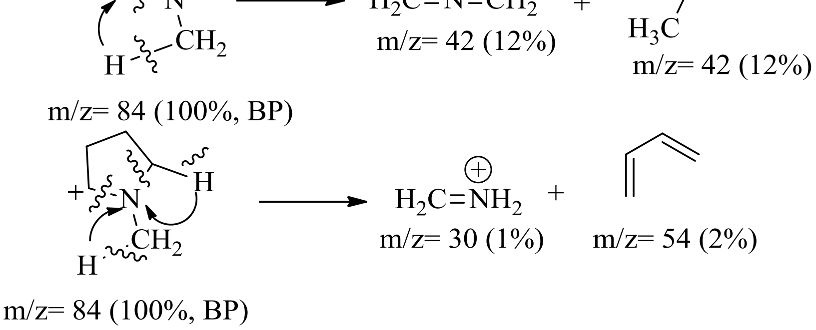
Scheme 1. The main fragmentation reaction of nicotine

- a complex fragmentation on the pyrrolidinyl ring (α-type fragmentation on the level of cyclic tertiary amino group followed by transfer of protons and electrons) explain the peaks at m/z =133 (22%) and m/z = 29 (1%); further fragmentation of the fragment from m/z =133 (α- fragmentation to the double bond and pyridinyl cycle) is generating the peaks at m/z 78 (3%), 55 (3%); subsequent fragmentation of the pyridinyl fragment from m/z = 78 (α– and β- fragmentation to the nitrogen atom, followed by transfer of protons and electrons) is generating the peaks at m/z 41 (4%) and 27 (2%);



Scheme 2. The fragmentations of the fragment with m/z= 162

- the peaks from m/z = 54 (2%), m/z = 44 (2%), m/z = 42 (12%) and m/z =30 (1%)], are characteristic peaks for the fragmentation of cyclic amines; the most likely fragmentation reactions which explain the above peaks are complex fragmentation of pyrrolidinyl ring (α and β-fragmentation to the nitrogen atom, followed by transfer of protons and electrons);



Scheme 3. The fragmentations of the fragment with m/z= 84

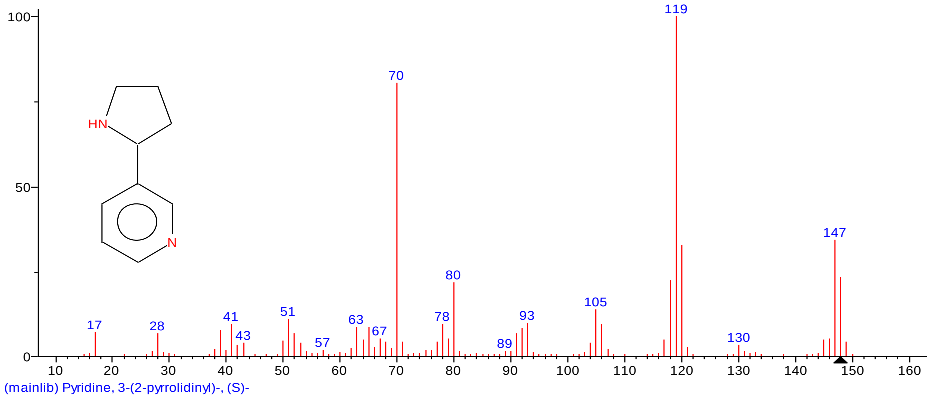
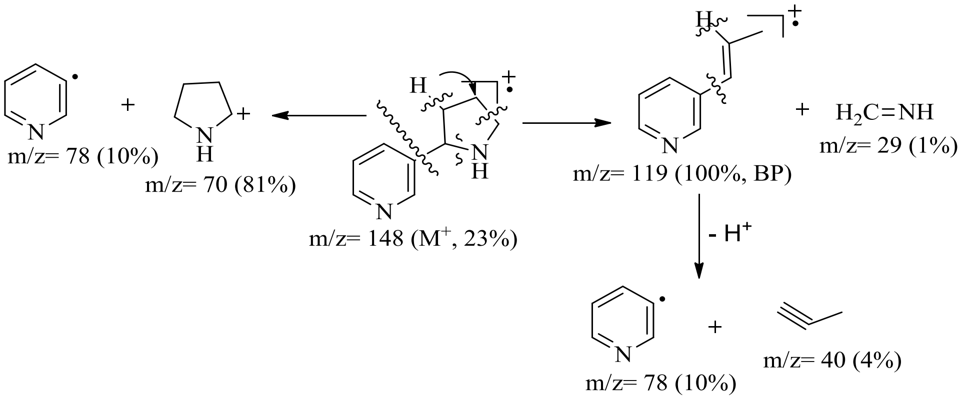


Fig. 3. Nornicotine mass spectrum

The mass spectrum of nornicotine is presented in Figure 3. In the nornicotine case the main fragmentation reactions are the following:

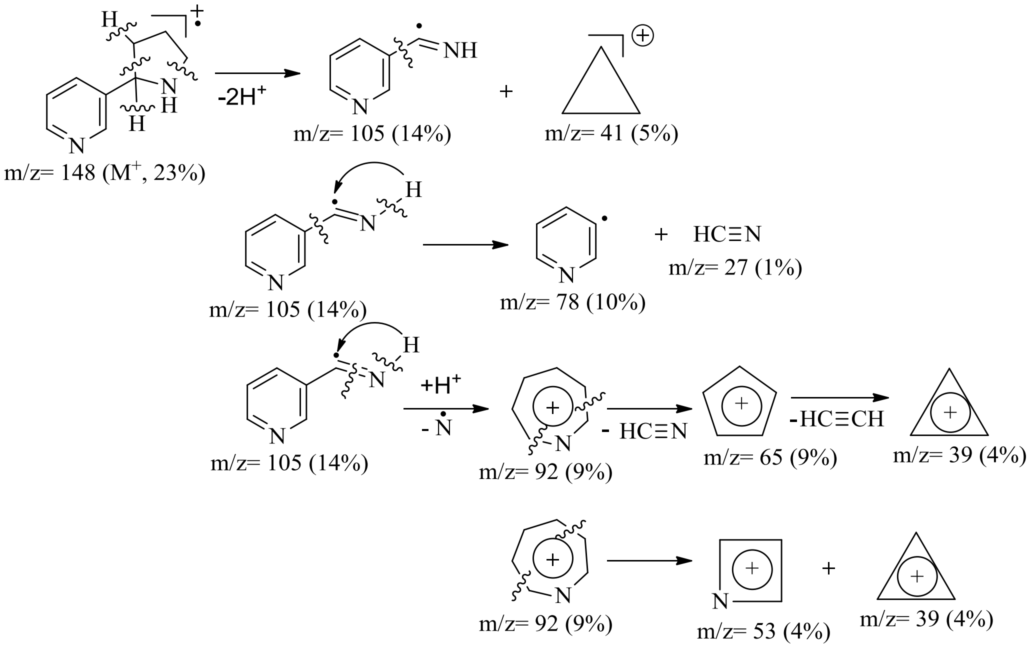
- the molecular ion, M+, appears at m/z = 148 with an intensity of 23%, characteristic for cyclic amines; ; the M-1 (m/z = 147, 34%) and M+1 (m/z = 161, 2%) peaks, are also present, being characteristic for cyclic amines;
- the base peak appears at m/z = 119 (100%) and could be explained through a complex fragmentation on the pyrrolidinyl ring (α- and *ipso-* type fragmentation on the level of cyclic secondary amino group followed by transfer of protons and electrons); the main peak at m/z = 70 (81%) and those one at m/z = 78 (10%), could be explained through a fragmentation on the bond level between the two nitrogen heterocycles;



Scheme 4. The main fragmentations reactions of nornicotine

- the peak from m/z = 105 (14%) and from m/z = 41 (5%), could be explained through a complex fragmentation on the pyrrolidinyl ring (α- and β- type fragmentation on the level of cyclic secondary amino group followed by transfer of protons and electrons; the fragment from m/z = fragmentation patterns generating the fragments from m/z = 78 (10%), m/z =27 (1%)], and m/z = 92 (9%); the last fragment is an azatropiliu cation and, will suffer analogous fragmentation with tropiliu cation, is generating the peaks from 65 (9%), 53 (4%), 39 (4%);

105 may undergo multiple complex



Scheme 5. The fragmentations of the fragment with m/z= 148

- the peaks from m/z = 42 (4%) and m/z =30 (1%)], are characteristic peaks for the fragmentation of cyclic amines.

The mass spectrum of anabasine is presented in Figure 4.

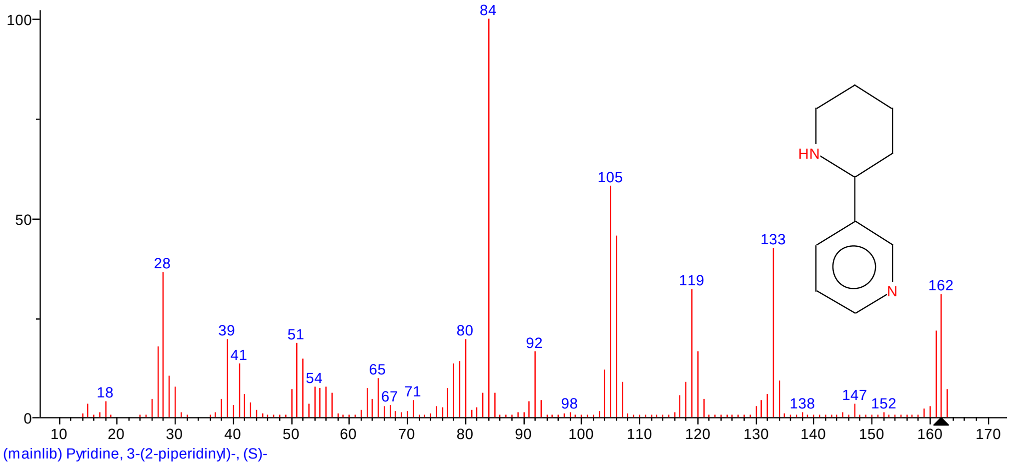


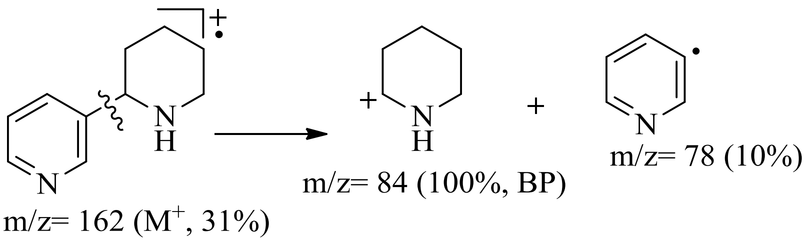
Fig. 4. Anabasine mass spectrum

The main fragmentation reactions in the anabasine case are the following:

- the molecular ion, M+, appears at m/z = 162 with an intensity of 31%, characteristic for cyclic amines; ; the M-1 (m/z = 161, 22%) and M+1 (m/z

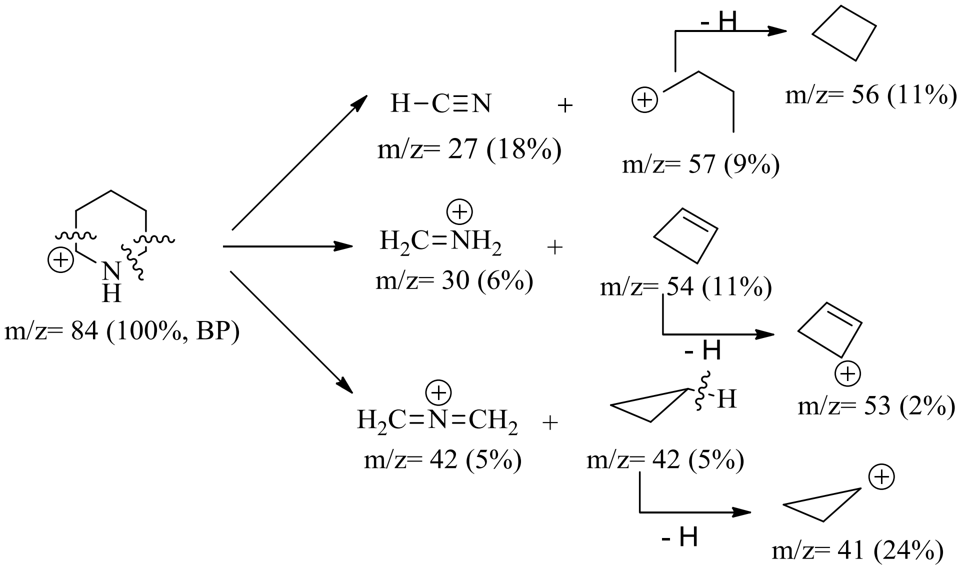
- the base peak appears at m/z = 84 (100%) and could be explained through a fragmentation on the bond level between the two nitrogen heterocycles; the same fragmentation explains the peak at m/z = 78 (14%);

= 163, 9%) peaks, are also present, being characteristic for cyclic amines;



Scheme 6. The main fragmentation reaction of anabasine

- the complex fragmentation on the piperidinyl ring (α-, β- and *ipso*- type fragmentation on the level of cyclic secondary amino group followed by protons and electrons transfer) explains the fragments from 57 (9%), 56 (11%), 53 (2%), 42 (5%), 41 (24%), 39 (29%), 30 (6%), 27 (18%).

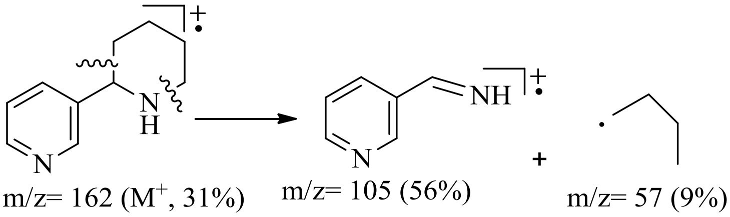


Scheme 7. The fragmentations of the fragment with m/z= 84

- the other type of complex fragmentation on the piperidinyl ring (α- and *ipso*- type fragmentation on the level of cyclic secondary amino group followed by transfer of protons and electrons) could explain the resulted fragments from 105 (56%) and 57 (9%).
- Subsequent fragmentation of the fragment from m/z = 105 will generate the peaks from 92 (19%), 78 (14%), 65 (14%), 53 (2%), 41 (24%), 39 (29%), 30 (6%), 27 (18%) (as in the nornicotine above case).

The mass spectra of pyrrolidine, N-methylpyrrolidine and piperidine are presented in Figure 5-7.

The fragmentation reactions could be easily deducted from the above fragmentation reactions.



Scheme 8. The fragmentation of the fragment with m/z= 162

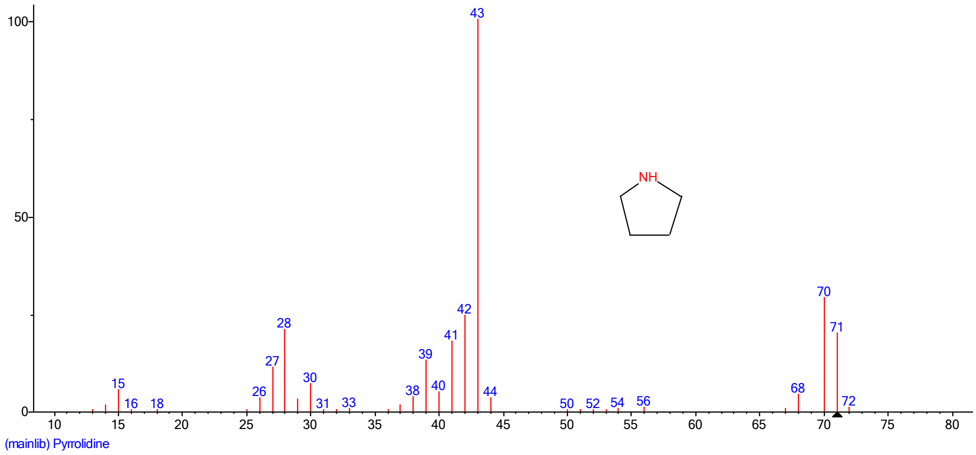


Fig. 5. Pyrrolidine mass spectra

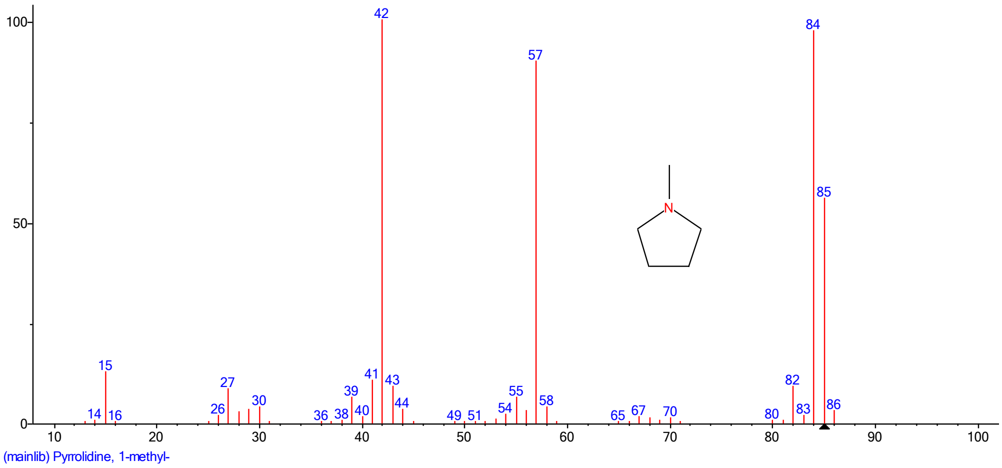


Fig. 6. N-Methylpirrolidine mass spectra

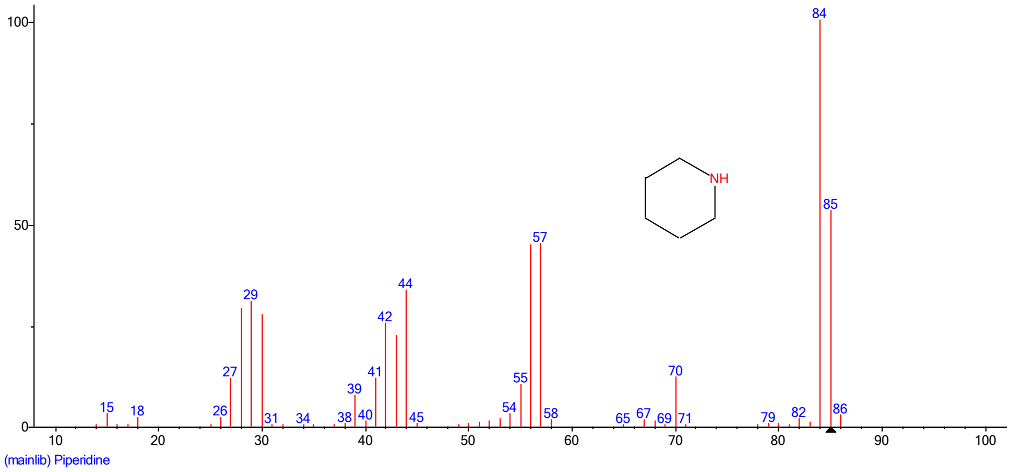


Fig. 7. Piperidine mass spectra

Conclusions

In our study some tobacco alkaloids were studied by GC-MS technique. The main fragmentation reactions of three different alkaloids from tobacco were presented. The peaks relative abundance and m/z values can be further used for their identification in different sources.

Acknowledgments

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References

Jacob P., Yu L., Liang G., Shulgin A.T., Benowitz N.L., *Gas chromatographic-mass spectrometric method for determination of anabasine, anatabine and other tobacco alkaloids in urine of smokers and smokeless tobacco users*, **J. Chromatogr. Biomed. Applic.**, 619, 49-61, *1993*.

McLafferty F.W., Turecek F., **Interpretation of Mass Spectra** (4-thy Ed.), University Science Books, Sausalito, California, 1993.

Parviainen M.T., Puhakainen E.V.J., Laatikainen R., Savolainen K., Herranen J., Barlow R., *Nicotine metabolites in the urine of smokers*, **J. Chromatogr. Biomed. Applic.**, 525, 193-202, *1990*.

Toumi T, Johnsson T, Reijula K., *Analysis of nicotine, 3-hydroxycotinine, cotinine, and caffeine in urine of passive smokers by HPLC-tandem mass spectrometry*, **Clin. Chem.**, 45, 2164-2172, *1999*.

Zbancioc G., Moldoveanu C., Gradinaru R., Drochioiu G., Olteanu G., Mangalagiu I.I., *The metabolism of drugs/ toxics in the body. Case study: BZP*, **International Journal of Criminal Investigation**, 1, 17-24, *2011*.