A RAMAN SPECTROSCOPY STUDY OF ALKALOIDS IN THE PLANT VINCA ERECTA

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https://doi.org/10.5281/zenodo.13828288

Abstract*. This article presents a method for the extraction of multiple alkaloids derived from Vinca erecta, a medicinal plant belonging to the Apocynaceae family. For the first time these alkaloids are analysed with the Raman spectroscopy method.*

Keywords*: fluorocurarine, fluorocurarine bromide, Vinca erecta Rgl et Schmalh, 12-methoxyfluorocurarine, combination scattering lines.*

It is established that the demand for herbal medicinal products is on the rise in the context of medical practice. Accordingly, they are primarily related to their low toxicity, wide range of effects, compatibility of medicinal plant sources with the endogenous environment of the human body, and their effective results even when used for an extended period without the occurrence of significant adverse effects [1-2].

The production of new drugs is an expensive and resource-intensive process, with significant costs associated with materials, equipment, and human resources. Given these financial and logistical constraints, the development of drugs derived from natural sources, rather than synthetic alternatives, represents a crucial and promising avenue of research. As reported by the World Health Organization, over 60% of the global population relies primarily on plant-based remedies for their healthcare needs.

Considering that there are approximately 25,000 species of high plants on Earth, it can be stated that the potential of this diverse group of organisms is currently being underused in scientific research.

In this regard, the urgent tasks are the extraction of biologically active compounds from natural resources and their analysis with modern, high-sensitivity methods.

From this perspective, the underground part of the plant Vinca erecta Rgl et Schmalh, which is rich in bioactive compounds, was selected as an object of scientific research. This plant is widely distributed throughout our region, occurring in both mountainous and sub-mountainous regions, including Kashkadarya, Surkhondarya, Fergana Valley, and Tashkent regions. This plant species is characterized by the presence of a complex mixture of alkaloids, including indole, indoline and oxindole derivatives. The alkaloids of the Vinca erecta have been identified as having medicinal properties and are recommended for use in a variety of medical applications. These include metvin, barvincan hydrochloride, ervinine and vincamine [3]. The plant's derived pharmaceuticals are utilized as hypotensive agents, sedatives and to enhance cerebral blood circulation [4].

It is established that fluorocurarine quaternary base can be derived from vincanine iodomethylate through alkaline processing. It is characterized by its yellow crystalline structure, with a melting point range between 248^{o} and 250^{o}C. Its empirical formula can be described as follows: $C_{20}H_{23}ON_2OH$.

Fluorocurarine. A solution of 3.15 g of vincanine iodomethylate in 60 ml of 1% potassium hydroxide was prepared. Following an interval of time, the precipitation of minute yellow needle-like crystals of fluorocurarine was observed. The yield of the reaction is 1.91 grams.

Fluorocurarine bromide was prepared by dissolving 1 g of fluorocurarine base in 30 ml of boiling water, followed by the addition of 1 ml of a 5% ammonium bromide solution. The resulting mixture was allowed to stand for 24 hours, after which the fluorocurarine bromide crystals were isolated. The melting temperature was found to be 277-278°C, and the reaction yield was calculated to be 0.355 grams.

12-methoxyfluorocurarine. The quaternary base of 12-methoxyfluorocurarine was isolated by dissolving 1.0 g of 12-methoxyfluorocurarine iodide in 10 mL of water and slowly adding an excess of a 20% sodium hydroxide solution. Following cooling, brown crystals precipitated, with a melting temperature range of 255-256°C and a reaction yield of 0.440 g. The specific wavelength of the UV spectrum (λ_{max}, nm) was as follows: 207 nm; 244 nm [5].

The objective of this research was to study the alkaloids extracted from the plant Vinca erecta using the high-resolution Raman spectroscopy method.

The research objects were selected to include fluorocurarine, fluorocurarine bromide, and 12-methoxyfluorocurarine alkaloids.

Materials and methods

The spectra were recorded utilising an R-532 Raman spectrometer, manufactured by the US company Enhanced Spectroscopy. Parameters of the device: the spectral range from 100 to 6000 cm^{-1}, spectral resolution of 5-8 cm^{-1}, the entrance slit – 20-30 microns, a holographic diffraction grating 1800 lines/mm, a set of highly selective and cut filters, as well as 50 mW single mode laser with a wavelength of 532 nm [6-8].

A study of the Raman spectrum of fluorocurarine revealed the presence of combination scattering lines, which are characteristic of the functional groups present in its chemical structure. In the initial analysis of the lower spectral region, the formation of 319 cm^{-1} was observed for C-C deformation vibrations, while lines of average intensity were formed at 662 cm^{-1} and 739 cm^{-1} for C-C valence vibrations. The most intense lines in the spectrum are indicative of C-N and nitrogen in the aromatic ring, which are located at 1388 cm^{-1} and 1540 cm^{-1}, respectively. The formation of -C=O and -C=C- double bonds resulted in the appearance of lines with an average intensity of 1597 cm^{-1} and 1610 cm^{-1}, respectively (Fig. 1).

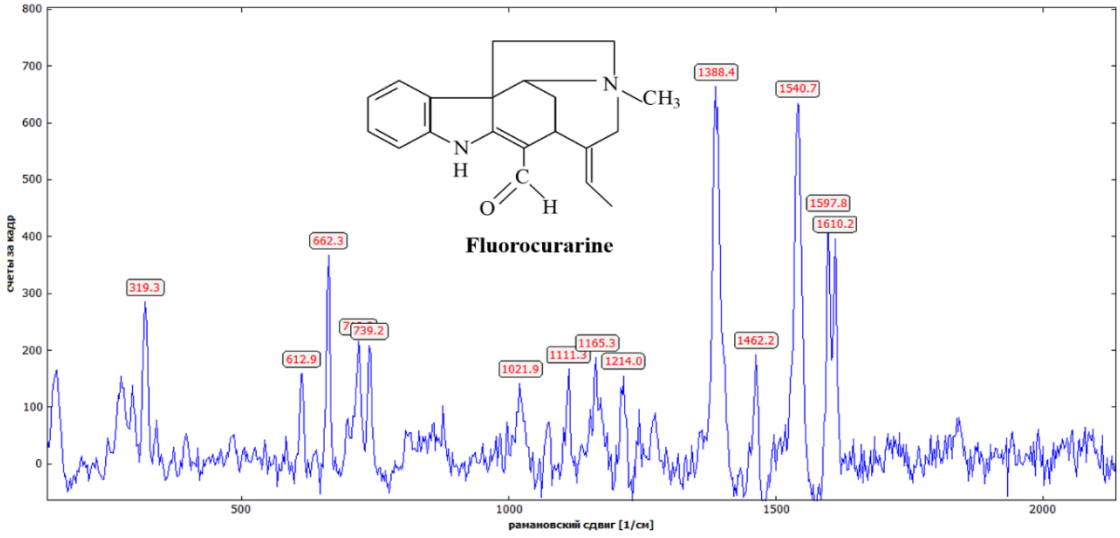

Figure 1. Raman spectrum of the fluorocurarine

The Raman spectrum of fluorocurarine bromide exhibits the characteristic scattering lines of fluorocurarine. In addition to the pure fluorocurarine, the bands corresponding to the bromide ion also display scattering bands at 808 and 840 cm^{-1} (Fig. 2).

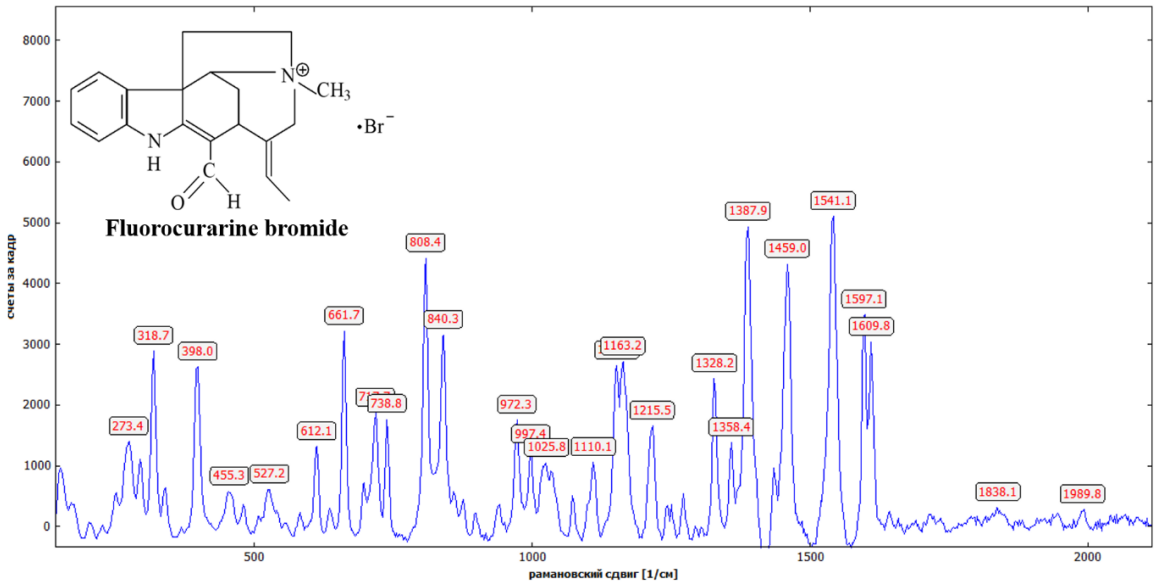

Figure 2. Raman spectrum of the fluorocurarine bromide

Another alkaloid belonging to this group, 12-methoxyfluorocurarine, displays a distinct Raman spectrum. In contrast to fluorocurarine and its bromide salt, the scattering lines belonging to the methoxy group are located at 1493 cm^{-1}, while the C-O bond is located at 1287 cm^{-1}. Furthermore, a shift was observed in the lines related to the -C=O and aromatic nitrogen functional groups, which increased by 20 and 44 cm^{-1}, respectively (Fig. 3).

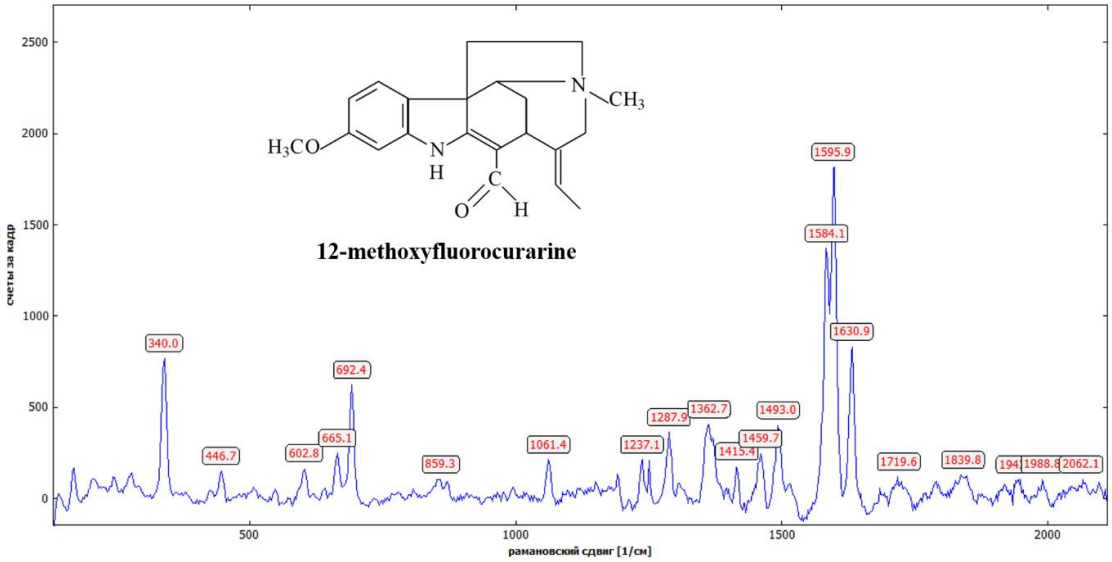

Figure 3. Raman spectrum of the 12-methoxyfluorocurarin

Conclusion

A methodology for the extraction of a number of alkaloids derived from the medicinal plant Vinca erecta was presented. The bioactive substances fluorocurarine, fluorocurarine bromide, and 12-methoxyfluorocurarine were analyzed for the first time using Raman spectroscopy, following their isolation from the alkaloids. Accordingly, the combination scattering lines specific to their functional groups were determined in the Raman spectra of these substances. Moreover, the

potential for distinguishing these substances from one another was validated through the application of this methodology.

Table 1

The functional group-specific combination scattering lines of alkaloids isolated from the plant Vinca erecta

Functional groups	Fluorocurarine, cm^{-1}	Fluorocurarine bromide, cm^{-1}	12-methoxyfluorocurarin, cm^{-1}
ν-C=O	1610	1609	1630
-C=C-	1597	1597	1595
Aromatic nitrogen	1540	1541	1584
$\delta_{asym}O\text{-}CH_3$	-	-	1493
$\delta_{asym}N\text{-}CH_3$	1462	1459	1459
ν C-N	1388	1387 1358	1362
C-O	1214	1215	1237 1287
δ C-H	1165 1111	1163 1110	
ν C-C $_{arom}$	1021	972 1025	1061
ν Br	-	808 840	-
ν C-C	739 662 612	738 662 612	692 665 602
δ C-C	319	398 319	340

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