

Chemical composition of Indigo dye

Ioana Stanciu*

Faculty of Chemistry, Department of Physical Chemistry, University of Bucharest, Elisabeta Blvd, Bucharest, Romania

Abstract

Indigo is a natural dye widely used in the textile industry and in various chemical applications, due to its stability and color intensity. In this study, the structural composition of indigo was investigated by FTIR spectroscopy, with the aim of identifying the functional groups and characteristic chemical bonds. The FTIR spectrum revealed specific bands corresponding to carbonyl (C=O), amine (N-H) and alkene (C=C) groups, confirming the molecular structure of the dye. The analysis demonstrated that FTIR is a rapid, non-destructive and efficient method for the qualitative characterization of indigo, being useful in quality control and research of natural dyes.

Keywords: Composition, ftir spectrum, indigotine

Introduction

Indigo pigment has been popular with artists since the beginning of history. First among the Romans and later, especially between the 14th and 19th centuries, among artists throughout Europe. The blue color was originally extracted from plants. This natural variant disappeared from the scene when the German chemist Adolf van Baeyer developed a synthetic alternative. Today, Indigo is made from pigments with excellent lightfastness.

The color Indigo has a long history that probably dates back to before the Christian era. The name comes from the Greek word Indikon, or "India dye." Indigo was originally extracted from plants that contained the dye Indigotine. In Europe, this was the Woad plant. Only the leaves were used, which were ground and then steeped in vats of hot water until they fermented. This process released a sweet-smelling dye that colored the water yellow. The plant remains were filtered and the water transferred to shallow basins. Then, by slapping the water with sticks, oxygen was added, which initiated a chemical process that produced a blue sediment on the sides and bottom of the basin. This sediment was scraped off, formed into cakes, and left to dry. To make paint, these "cakes" were ground and then mixed with a binder such as egg or wax^[1-5].

Dyeing textiles, on the other hand, was certainly a less fragrant process. The "cakes" had to be soaked in vats of water, bran, and urine, creating a yellow solution. The fabric was then added, usually on a Saturday, and hung out to dry on a Monday. The oxygen in the air gave the textiles a blue color. Hence the term "Blue Monday." This process of dyeing textiles gave rise to a huge, thriving trade, especially in England, the Netherlands, France, and Thuringia in Germany. However, the Portuguese explorer Vasco da Gama discovered in Asia at the end of the 15th century a plant that contained thirty times more blue than Woad. This plant was named *Indigofera Tinctoria* and the blue that was extracted from it was called Indigo. Despite fierce attempts to prevent imports and even ban them under penalty of death, Da Gama's discovery heralded the end of the lucrative Woad era.

During the Industrial Revolution, the German chemist Adolf von Baeyer was able to analyze and then synthesize Indigo. A production method was developed so that after 1915, the

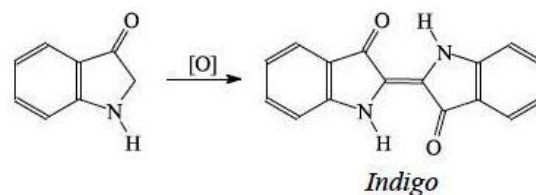
Indigo plant was almost never used again. But this pigment introduced by Von Baeyer has also been replaced since then. The main reason was that its lightfastness left much to be desired. The Indigo color in the Rembrandt watercolor range is made using a combination of two pigments that produce a lightfastness of at least a hundred years under museum conditions^[6-11].

Indigo blue cannot be truly defined, as it depended greatly on the type and quality of the plants from which it was extracted. In his book "Schilderkunst, materiaal en techniek" ("The Art of Painting, Material and Technique") Max Doerner writes that the hue is similar to Berlin blue. On the other hand, physicist Isaac Newton placed the tone in the spectrum between blue and violet. Rembrandt's watercolor opted for a darker Indigo, which tends towards green.

Materiale and methods

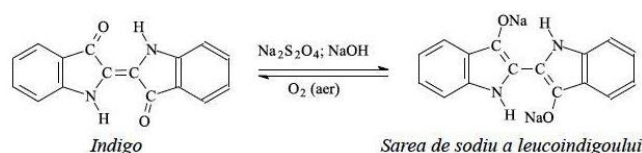
Obtaining indigo

Indoxyl is important because it is easily oxidizable with oxygen in the air in an alkaline environment, it turns into a dark blue dye, known as indigo, used for dyeing textiles and in printing



For textile dyeing, indigo is first reduced with sodium dithionite in the presence of a base. A soluble, colorless salt of leucoindigo is formed.

The fabric is impregnated with the aqueous solution of this salt, then exposed to air to reoxidize the leucoindigo to indigo



The use of indigo as a dye has been mentioned since antiquity. In the modern era, indigo is the dye for blue jeans.

Materials

FT-IR spectra of these samples were obtained on a Varian 620-IR spectrometer equipped with a diamond ATR using 16 scans/sample.



Fig 1: Varian 620-IR spectrometer

Results and discussions

The bands attributed to C=O vibrations are detected near 1623 cm^{-1} (stretching), 1065 cm^{-1} (rocking) and 697 cm^{-1} (wagging). The rocking vibration of N-H together with stretching vibration of C-N contributes to bands near 1389 cm^{-1} and 1123 cm^{-1} . The signal at about 1170 cm^{-1} can be assigned to stretching vibration of C-N group composed with rocking of the C-H and N-H groups. The most intense band at 1065 cm^{-1} is attributed to the vibration of a five-membered ring, which gives rise also to the signals at 1297, 1196, 1065, 878, 712 and 697 cm^{-1} . The stretching and bending vibrations of six-membered rings occur at 1609, 1584, 1481, 1459, 1315, 1196, 1009, 878, 751, 712, 697 cm^{-1} whereas bands attributed to vibrations of C-H arise at 1481, 1459, 1297, 1196, 1170 cm^{-1} (rocking) and 751 cm^{-1} (wagging). It should be mentioned that some assignments are in discrepancy to previous papers, especially when calculations were performed at the HF level (fig. 2) [11-17].

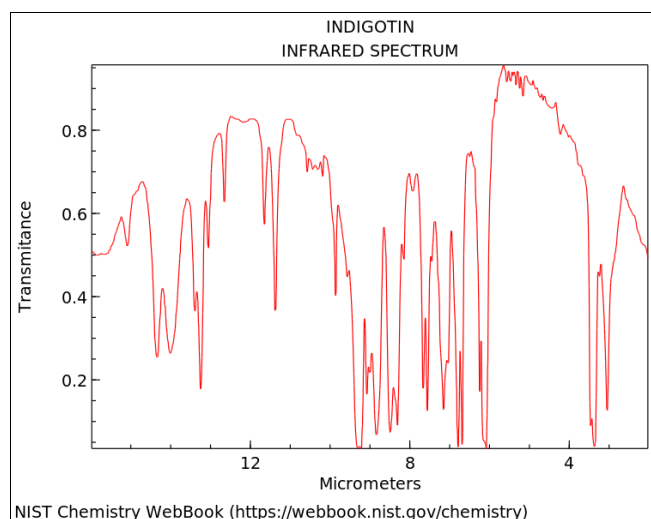


Fig 2: Spectrul FTIR al colorantului Indigotin

Conclusions

FTIR spectroscopy allowed the identification of functional groups characteristic of indigo, including carbonyl (C=O), amine (N-H) and alkene (C=C). The bands observed in the spectrum confirm the chemical structure of indigo and the integrity of the sample. FTIR analysis has been shown to be rapid, non-destructive and efficient for the qualitative characterization of the dye. The method can be used for indigo quality control in the textile industry and for research on natural dyes. The results obtained provide a useful reference for further studies on the purity and stability of indigo in various applications. From the FTIR (Fourier transform infrared spectroscopy) testing of indigo dyes there are C=C, -CH, and CN groups where the absorption peaks occur in $3200\text{--}3600\text{ cm}^{-1}$, $1500\text{--}1600\text{ cm}^{-1}$, $1340\text{--}1470\text{ cm}^{-1}$, and $1180\text{--}1360\text{ cm}^{-1}$.

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