



Chemical composition of Methylene Blue determined by IR spectroscopy

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Abstract

Methylene blue is a colored compound, which was introduced into medical practice due to its multiple benefits on the human body. In this article, we determined the chemical composition of methylene blue by IR spectroscopy using the Perkin-Elmer 1600 spectrometer. The wavelength range in which absorption bands appear is between 4000cm^{-1} and 500cm^{-1} . Methylene blue contains the following functional groups: C-H, C=N, C=S, N-S, C=C and O-H.

Keywords: Methylene Blue, composition, IR spectrum

Introduction

Methylene blue is a colored compound that was introduced into medical practice due to its multiple benefits on the human body.

Methylene blue is a colored substance that has multiple uses in medicine. It was first synthesized in 1876, and its first use was as a dye in the textile industry.

Later, the antiseptic properties of methylene blue were highlighted and it was introduced into medical practice. Due to its characteristics, in 1891 it was used in the treatment of malaria, a disease caused by the parasite *Plasmodium falciparum*.

The chemical structure of methylene blue is based on aniline, a cyclic compound. Chemical analysis of this compound revealed that it has a positive charge. This property causes methylene blue to interact with the cell membrane. Therefore, it is used for the processing of histological preparations as a dye. Its use allows the highlighting of cell membrane lesions. In the laboratory, methylene blue can also be used to highlight: erythropoiesis (red blood cell production); cellular aging.

Methylene blue is one of the active substances that is used in multiple conditions. Its effect in the body can be observed in a fairly short period of time^[1-5].

Methemoglobinemia is a pathology that manifests itself by modifying the structure of hemoglobin. The consequence of this condition is represented by the inability of hemoglobin to transport oxygen to the tissues. The iron in the structure of methemoglobin is in the form of ferric ion, which cannot bind oxygen. However, methylene blue transforms the ferric ion into ferrous ion, which can bind and transport oxygen.

Inflammation of the throat, also known as tonsillitis, causes the appearance of symptoms that cause significant discomfort. The cause can be viral or bacterial, but the manifestations are quite similar. Methylene blue can be used to reduce the symptoms of tonsillitis, as a result of its antiseptic properties. A rapid effect occurs if methylene blue is administered locally (spray, lozenges).

Urinary tract infections occur predominantly in women. They manifest as dysuria (discomfort when urinating), pollakiuria (frequent urination), pelvic pain. The antiseptic properties of methylene blue are extremely beneficial for cases of recurrent urinary tract infections.

Vasoplegia consists of the appearance of generalized vasodilation. This can cause hypotension (decreased blood

pressure), which has unpleasant effects on the body. In severe cases, even cardiac arrest can occur.

Methylene blue inhibits certain signaling pathways that lead to the dilation of blood vessels. Therefore, it is used in the therapeutic scheme: preoperatively (before surgery); intraoperatively (during surgery); postoperatively (after completion of surgery).

It is administered especially in cardiovascular surgeries. The recommended dose is established according to the patient's age, weight and clinical condition.

Hepatopulmonary syndrome occurs in the case of a liver disease, such as portal hypertension. It is manifested by the presence of vasodilation of intrapulmonary vessels, which can cause hypoxemia (decreased blood oxygen levels). The administration of methylene blue can increase the arterial pressure of oxygen and improve the patient's symptoms.

Ifosfamide is an anticancer, cytotoxic agent, which is recommended in the therapeutic regimen of patients diagnosed with various types of cancer, such as: lymphoma, lung cancer or sarcoma. The toxicity of this substance used in the treatment of cancer can manifest itself through the following symptoms: drowsiness; confusion; blurred vision; extrapyramidal symptoms (sweating, muscle spasms, muscle rigidity, confusion, palpitations); urinary incontinence; hallucinations; psychosis; seizures; coma^[6-12].

The toxicity of ifosfamide is due to the accumulation of NADH (nicotinamide adenine dinucleotide). Administration of methylene blue can inhibit the formation of NADH and help reduce its effects on the body.

Priapism is the maintenance of an erection for a long period of time (hours). Methylene blue is effective in reducing symptoms when administered for priapism caused by irregular flow of the arteries that supply the corpora cavernosa.

The effect on the brain occurs as a result of the fact that methylene blue can cross the blood-brain barrier. This fact allows the inhibition of the process by which serotonin and dopamine, two important neurotransmitters, are degraded. Thus, the concentration of these two substances increases, and cognitive functions improve: learning and memory capacity increases; attention and concentration are amplified; the general condition is better.

Some studies have shown that methylene blue can be used to reduce the risk of anxiety and depression. Not only can it maintain an increased level of serotonin, but it also prevents

cell membrane damage. Thus, it maintains the integrity of nervous tissue.

MRSA is methicillin-resistant *Staphylococcus aureus*. Methylene blue associated with photodynamic therapy can cause the destruction of this bacterium. Its properties have also been observed in the case of the following pathologies: hepatitis C; HIV infection (human immunodeficiency virus); treatment-resistant psoriasis.

Methylene blue may also be indicated in other situations than those presented. These include: neutralizing the effect of heparin - an anticoagulant (further studies are needed); inhibiting the formation of amyloid deposits in Alzheimer's disease; septic shock.

Administration of this substance in the form of lozenges or local spray to relieve the symptoms of tonsillitis is rarely associated with adverse reactions.

Most of the side effects of methylene blue are encountered when it is administered orally or intravenously. These include: abdominal pain; nausea; vomiting; intestinal transit disorders (diarrhea); headache (headache); pollakiuria (frequent urination); dizziness; chest pain; confusion.

It is important that immediately after observing these side effects, presentation to the doctor is carried out in the shortest possible time. It is also essential to respect the doses indicated by the doctor.

Increasing the amount of methylene blue ingested can become toxic to the kidneys.

Interaction of methylene blue with other drugs Methylene blue is a substance that has many benefits, but it is not indicated to be administered to all people. Thus, it is preferable not to prescribe it to people diagnosed with: severe kidney disease; renal failure; glucose-6-phosphate dehydrogenase deficiency; hemolytic anemia [13-17].

Also, the administration of this substance is contraindicated in people who have previously experienced severe reactions after ingesting methylene blue preparations.

Methylene blue is not indicated for babies under 1 month of age. In these babies, there is a risk of accumulation of this substance in the body, as a result of incomplete maturation of the renal system.

Studies conducted so far on the administration of methylene blue during pregnancy are inconclusive. Some of them have shown that it does not pose any risk to fetal development.

Pregnancy is a beautiful period in the life of any woman, but it is quite demanding. Find out what is the most appropriate diet for a healthy pregnancy in the article.

In other research, an association was observed between the administration of methylene blue in the second trimester of pregnancy and intestinal atresia (lack of formation of the intestinal lumen). Therefore, the prescription of methylene blue during pregnancy is avoided by most doctors. It can be replaced with other drugs that do not pose a risk of side effects on pregnancy.

During breastfeeding, the administration of methylene blue is not indicated. If, however, its prescription is necessary, breastfeeding is interrupted. It can be resumed approximately 8 days after the end of methylene blue treatment.

Although studies on the adverse effects of this substance administered during breastfeeding are not conclusive, some of them have shown: hemolysis; genotoxicity (alteration of the structure of genetic material).

Proper storage of methylene blue pharmaceutical forms is essential for maintaining their optimal properties.

It is desirable that the administration of any pharmaceutical product be carried out only within its validity period, which can be consulted on the packaging.

Correct storage of medicines involves the following: keeping them in their original packaging; avoiding humid places, with an increased temperature and with direct exposure to light; storing in a space intended for medicines; choosing a place that is difficult for children to access.

Methylene blue is a remarkable substance, with multiple uses and health benefits. Its extensive use in laboratory sample processing, treating various conditions (tonsillitis, urinary tract infections, methemoglobinemia), makes methylene blue considered an extremely valuable compound. However, it is recommended to approach its administration with caution, especially in people diagnosed with renal failure, pregnant or breastfeeding women.

Materials and Methods

Functional bonds present in methylene blue were studied using an FTIR spectrophotometer (Perkin-Elmer1600). The absorbance of the dry sample was measured in the spectral range of 4000–500 cm^{-1} for 128 scans at a speed of 16 cm^{-1} .



Fig 1: FTIR spectrophotometer Perkin-Elmer1600

Result and discussion

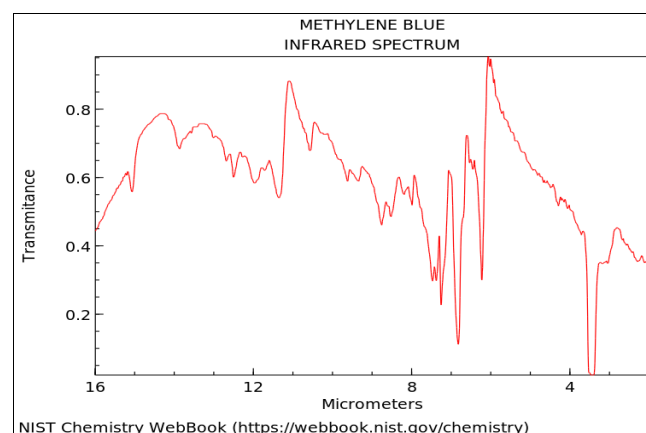


Fig 2: Spectral IR al albastrului de metilen

The methylene blue molecular structure transformation was further evaluated by the FTIR analysis of the treated and untreated samples. UV-Vis spectra illustrated the presence of aromatics along with conjugates of N-S heterocycle

group and phenothiazine structure [29]. The results in Figure 2 showed that the broad peak at 3451 cm^{-1} was determined as the O-H stretching vibration of water molecules. It could be seen that the peak corresponding to C-H absorption of benzene ring occurred at 2975 cm^{-1} . The peak at 2105 cm^{-1} denoted the stretching vibration peak of the methyl group. The C=C framework corresponding to benzene ring vibration and the C=N stretching vibration was found at 1646 cm^{-1} . The absorption peak at 1420 cm^{-1} was related to another typical vibration in methyl bending. Other prominent peaks were in the vibration of C=O and -C-C at 1206 cm^{-1} and 991 cm^{-1} . It was noticed that the intensity of absorption peaks for C=N and O-H had significant decrease in C=C aromatic stretch in the treated sample, indicating a change in chemical composition. This could be possibly attributed to the breakdown of the N-S heterocyclic compound during the degradation process [18-20]. The characteristic peak of benzene and C-H bending vibration of aromatic C-H declined substantially, indicating the variation in chemical compositions of phenyl groups.

Conclusion

Methylene blue has numerous applications in medicine and has health benefits and uses. The chemical structure of methylene blue is based on aniline, a cyclic compound. Chemical analysis of this compound has revealed that it has a positive charge. This property causes methylene blue to interact with the cell membrane. Methylene blue contains the following functional groups: C-H, C=N, C=S, N-S, C=C and O-H determined by IR spectroscopy.

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