THE INFLUENCE OF INORGANIC HOST TYPE IN THE DRUG-LAYERED SILICATE BIOSYSTEMS

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Intercalarea tiaminei clorhidrat (vinamina B_1, VB_1) între straturile a două tipuri de montmorilonit (MMT) a fost caracterizată prin spectroscopie de infraroşu cu transformată Fourier (FT-IR), difracţie de raze X (XRD) şi analiză termogravimetrică (TGA). Eliberarea VB_1 intercalate a fost studiată în fluid gastric (pH 1.2) la 37 ^oC prin spectrometrie UV-VIS.

Intercalation of thiamine hydrochloride (vitamin B1, VB1) within the layeres of two types of montmorillonite (MMT) was characterized by Fourier transformed infrared spectroscopy (FT-IR), X-ray diffraction (XRD) and thermogravimetric analysis (TGA). Release of the intercalated VB_1 was studied in simulated gastric fluid (pH 1.2) at 37 ^oC by UV-VIS spectrometry.

Keywords: layered silicate, drug delivery, UV-VIS

1. Introduction

Clay minerals like kaolin, halloysite, talc, sepiolite, montmorillonite are used in pharmaceutical field due to their high specific area and absorbtion capacity. [1]. Montmorillonite is a smectite; it has two tetrahedral silicate layers sandwiching a central octahedral layer of aluminium atoms. Montmorillonite may exchange metal ions with organic cations which imply a larger basal spacing and thus a lower surface energy results in the compatibility with organic liquids or polymers [2]. Due this ability the use of montmorillonite in drug delivery system was investigated by several researchers [3- 5].

Vitamins play an enormous role in the functionality and development of human body. They are used as antioxidants or in enzymatic processes. Since they can not be synthesized by the human body, it is compulsory to be administrated [6].

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The aim of this article is to study the absorption of B_1 vitamin (VB_1) on montmorillonites with different cation exchange capacity (CEC) at distinct interaction times.

2. Experimental part

2.1 Materials

Thiamine hydrochloride (VB_1) and K10 montmorillonite (K10- MMT) with a CEC of 26 meq/100 g were purchased from Sigma-Aldrich. Sodium montmorillonite (Na-MMT) with a CEC of 92 meq/100 g was received from Southern Clay Products.

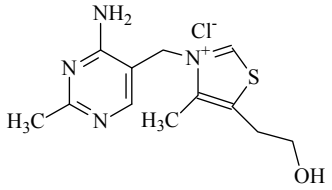

Fig. 1. Structural formula of thiamine hydrochloride

2.2 Intercalation of VB_1 in montmorillonites

The intercalation of VB_1 within the silicate layers at different reaction times (16 and 68 hours) was studied. Thus 1 g of montmorillonite was swelled in 200 mL distillated water for 24 h at 80 °C. Then 1.05 g of VB_1 was dissolved in 10 mL distillate water and poured over the swelling montmorillonite and mechanically mixed at 50 °C. The mixture was separated through centrifugation at 3000 rpm and washed with distilled water to eliminate the unreacted VB_1. The concentration of VB_1 in filtrate was determined by UV-VIS spectroscopy at λ_{max} = 242 nm.

2.3 Characterization

FTIR spectra were recorded on a Bruker VERTEX 70 spectrometer using 32 scans with a resolution of 4 cm^{-1} in 4000 - 400 cm^{-1} region. The samples were analyzed from KBr pellets.

X-Ray Diffraction (XRD) analysis was performed on a XRD 6000 SHIMADZU diffractometer.

Thermogravimetric analysis (TGA) was done on a Q 500 TA Instrument. The samples of 2 mg were heated from 20 to 800 ^oC at a scanning rate of 10 ^oC/min under a constant nitrogen flow rate (40 mL/min).

UV-Visible absorbance of VB_1 solutions was measured at λ_{max} = 242 nm (UV-3600 Shimadzu equipment) provided with a quartz cell having a light path of 10 mm.

2.4 *In vitro* drug release

The drug release was performed in the thermostatic shaking bath by suspending dialysis membrane bag containing 0.01 g MMT-VB_1 and 0.330 mL buffer solution of pH 1.2 (simulated gastric fluid) in 25 mL of the same buffer solution. Rotation speed was 50 rpm, and the medium temperature was kept constantly at 37 ^oC. At intervals of 20 min 3 mL of the dissolution medium was taken and the VB_1 concentration was determined by UV absorption at 242 nm. The dissolution medium was put back to maintain a constant volume and concentration.

3. Results and discussion

3.1 FTIR Analysis

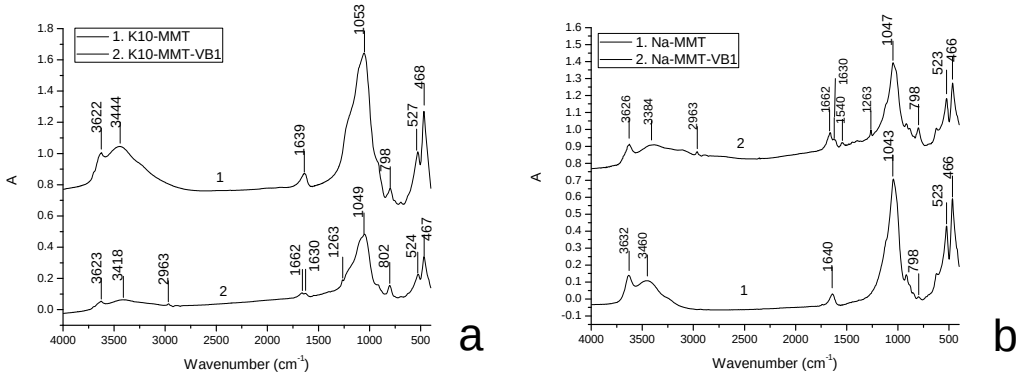

Fig. 2. FT-IR spectra of a) unmodified K10-MMT and modified K10-MMT with VB_1, b) unmodified Na-MMT and modified Na-MMT with VB_1

In the montmorillonite spectrum the absorption at 3626 cm^{-1} corresponds to the –OH stretching vibration from Al-OH bond. The band at 3460 cm^{-1} is assigned to the –OH stretching vibration from water and the band at 1640 cm^{-1} is attributed to HOH deformation vibration. The Si-O-Al and Si-O-Si bending vibrations corresponds to 523 cm^{-1} and 466 cm^{-1} respectively. In the spectrum of the modified montmorillonite the appearance of a new peak at 2963 cm^{-1} can be

observed, assigned to the stretching vibration of CH and the peak at 1263 cm^{-1} atributed to aromatic ring of the thyamine hydrochloride. The bands at 1540 cm^{-1} and 1630 cm^{-1} are attributed to the stretching vibrations of the pyrimidine ring. The band at 1662 cm^{-1} is assigned to N-H bending of NH_2 which proves the incorporation of VB_1 within the silicate layers.

3.2 TGA Tests

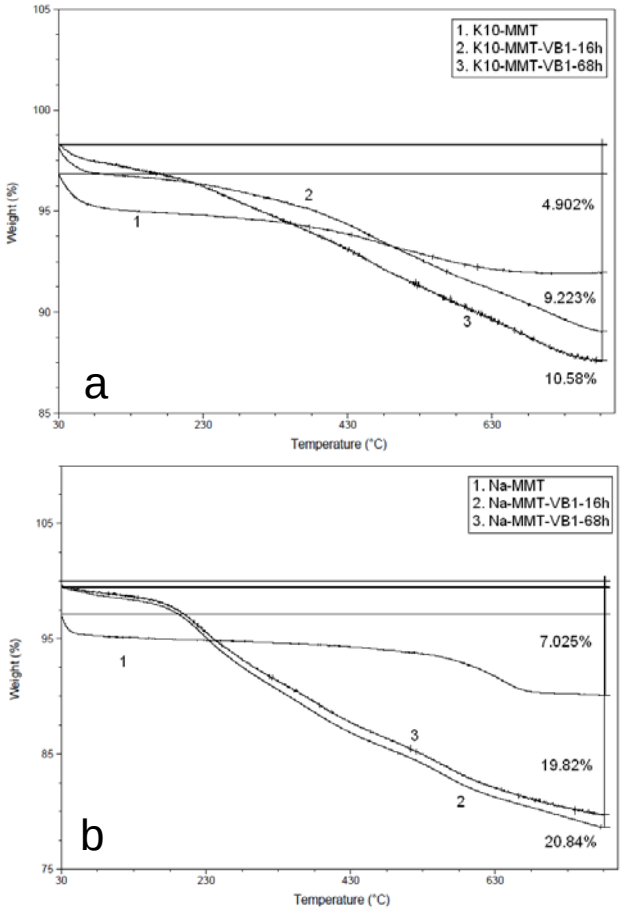

Fig. 3. TGA curves of a) unmodified K10 montmorillonite and modified K10 montmorillonite at different interaction time; b) unmodified sodium montmorillonite and modified sodium montmorillonite at different interaction time

The TGA curves in both cases of unmodified montmorillonites show a first weight loss in the range of temperature 70-100 °C due to the water evaporation. The second weight loss at 700 °C is due to the loss of structural

hydroxyl groups. In the case of modified montmorillonites three steps of weight loss may be observed. The loss at 200-300 °C corresponds to thiamine hydrochloride decomposition which is another proof that VB_1 was incorporated into the silicate structure.

3.3 XRD Analysis

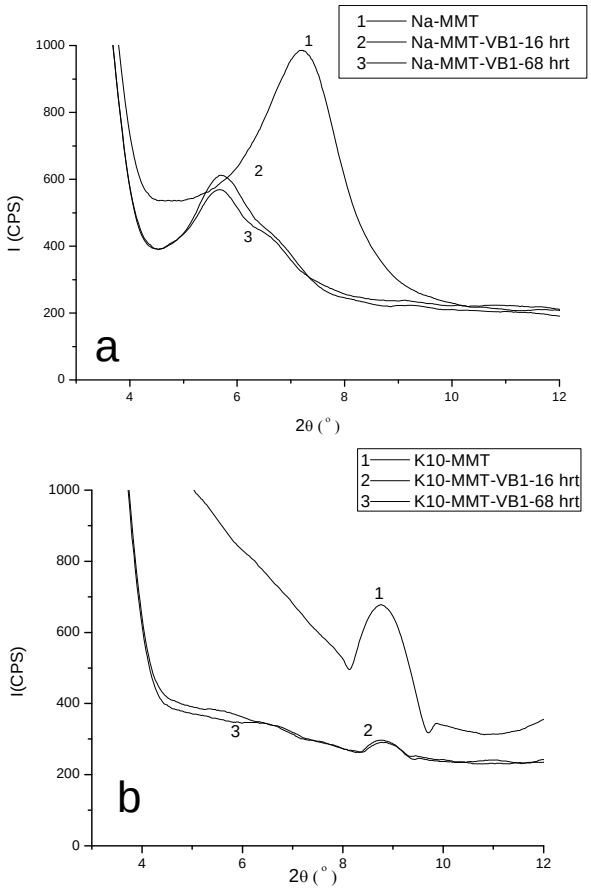

Fig. 4. XRD paterns of Na-MMT and Na-MMT-VB_1 (a), K10-MMT and K10-MMT-VB_1 (b) at different times

Table 1

Montmorillonite interbasal distance

System	d001 (Å)	2θ (°)
K10-MMT	9.8	8.9
K10-MMT-VB1-16hrt	9.8	8.9
K10-MMT-VB1-68hrt	9.8	8.9
Na-MMT	12.1	7.2
Na-MMT-VB1-16hrt	14.5	6.0
Na-MMT-VB1-68hrt	14.5	6.0

From figure 4 one may notice that for Na-MMT a significant shift of the peak assigned to basal distance occured when the silicate was modified with VB_1, from angle 2θ of 7.2 ° to 6.0 °. Thus the interbasal distance, d_{001} increased from 12.1 Å to 14.5 Å which proves the intercalation of VB_1 within the silicate layers. For K10-MMT this change of the XRD peak is not significant.

3.4. UV-VIS Analysis

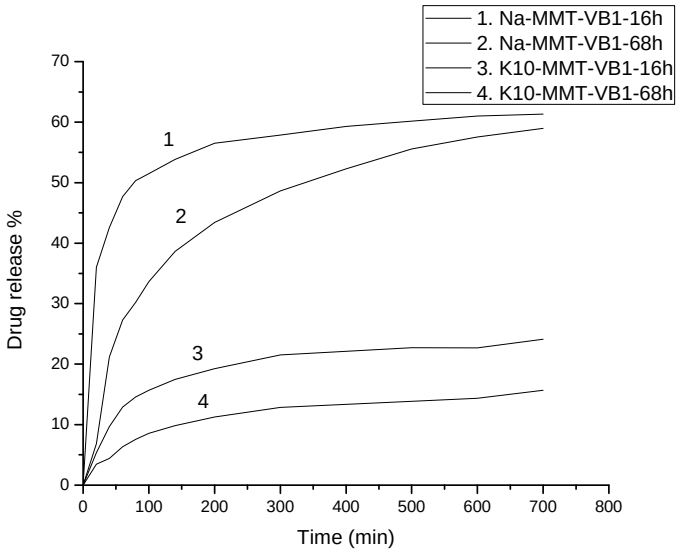

Fig. 5. Drug release from MMT-VB_1 at different reaction times

From figure 5 it can be observed that for Na-MMT-VB_1 the equilibrium was reached within 10 hours, 57% for Na-MMT-VB_1 – 16h respectively 61 % Na-MMT-VB_1 – 68h and as the reaction time is longer, a bigger amount of VB_1 is

intercalated. In K10-MMT-VB_1 case the equilibrium is reached within 4 hour 19 % for K10-MMT-VB_1 – 16h respectively 11% for K10-MMT-VB_1 – 68h but the amount of VB_1 intercalated was lower than those for Na-MMT-VB_1 due to the lower cation exchange capacity. The release process can be explained by the ion exchange process between the intercalated cations of VB_1 and the cations presented in the buffer solution.

4. Conclusions

Due to the high cationic exchange capacity of montmorillonites, thiamine hydrochloride (VB_1) was intercalated within the silicate layers. Two types of montmorillonites, Na-MMT and K10-MMT incorporated various amounts of VB_1.

The incorporation process of VB_1 was proved by FTIR spectra which show distinctive bands assigned to VB_1 for modified MMT with VB_1. An extra proof was obtained from the XRD tests which showed a significant increase of the basal distance for modified MMT with VB_1 especially in the case of Na-MMT.

The TGA tests also proved the incorporation of VB_1 within the silicate layers of MMT by a new step of weight loss between 200 and 300 °C assigned to the VB_1 decomposition.

The drug release process from the inorganic montmorillonite matrix was monitored by UV-VIS analysis showing that the VB_1 quantity released is lower in the case of K10-MMT-VB_1 due to the lower incorporation of VB_1 within the K10-montmorillonite.

5. Acknowledgement

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R E F E R E N C E S

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