

VIBRATIONAL SPECTROSCOPY INVESTIGATION OF MONTMORILLONITE - CHITOSANE NANOCOMPOSITE MATERIALS

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Abstract

Biomaterials basing on natural polysaccharides, i.e. hiauronic acid, alginate, chitosane are an alternative for already applied bioresorbable synthetic materials basing on synthetic polyhydroxyacids. Their main advantages are good accessibility, low cost, easy forming and high biocompatibility. Additionally, they are a perfect matrix for bioactive nanoparticles i.e. hydroxyapatite (HAp), tricalcium phosphate (TCP) and silica (SiO₂).

The work presents results of research on nanocomposite consisting of chitosane matrix (CS) modified with a nanofiller, which was natural montmorillonite (MMT). Nanocomposite foils were produced by the casting method. In order to induce better biocompatibility, the surface of the CS/MMT composite was neutralized (bath in NaOH solution). The nanocomposite foils were subjected to a bioactivity test by incubation in SBF at 37°C for 7 days. It was observed that the CS/MMT material surface showed a local supersaturation, which was a result of apatite nucleation. The CS/MMT nanocomposites were investigated using FT-IR (Fourier Transform Infrared Spectroscopy) and Fourier Raman Spectroscopy.

FTIR measurements of the samples were carried out on the transmission and reflection modes. The FTIR microscopy spectra were collected using Bio-Rad Excalibur with ATR attachment as well as microscope UMA500 equipped with MCT detector. Spectra were measured at 4 cm⁻¹ resolution in the region from 4000 cm⁻¹ to 600 cm⁻¹. FT-Raman spectra were obtained using a FTS6000 Bio-Rad spectrometer with Ge detector. The samples were excited with a Nd-YAG laser (1064nm). Additional all materials in all steps experiments were observed under Scanning Electron Microscopy (Nova NanoSEM).

Vibrational spectroscopy methods (FT Raman and FTIR) can be used for investigation of nanocomposite foils basing on biopolymers. High sensitivity the applied spectroscopy techniques show that in the result of the neutralization of CS/MMT foil (via incubation in NaOH solution) the biopolymer chain breaks. This phenomena is visible by intensity ratio between COC/COH bands. Increase of reactivity of chitosane chain lead to entrapment of PO₄³⁻, which is the origin of the apatite forms nucleation process.

Chemical treatment of the nanocomposite foils, i.e. NaOH washes influences their chemical structure and microstructure. Neutralisation of the foils is the first processing stage which precedes the potential use of CS/MMT foils in biomedical applications. The materials show a tendency to apatite crystallisation which may support regeneration of damaged bone tissue.

The applied spectroscopic methods allowed to observe changes in the whole volume of the sample.

Individual ATR measurements taken at various spectral ranges and penetration depths allow to observe subtle changes in the polymer matrix caused by chemical treatment (NaOH and SBF incubation). Results of the investigations indicate that in the CS/MMT systems new chemical bonds and related to them vibrations appear. Quantity and quality of the interactions is related to characteristics of the nanoparticle and the presence of forming apatite structures.

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