Smectite-based nanocomposites as a pH-responsive material for biomedical applications

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The development of advanced hybrid materials based on layered silicates has garnered attention due to their unique properties and potential in various industrial, environmental, and biomedical applications. Incorporating stimuli-responsive components into the hybrid materials is frequently studied in pH-responsive nanocomposites designed as controlled delivery systems. Layered silicates are attractive for such systems due to their functional surfaces that enable encapsulation and controlled release of active molecules [1]. This work investigates the potential of smectites, in creating nanocomposite with biopolymers for pH-responsive drug delivery systems preparation. Four smectites: trioctahedral synthetic and natural hectorites and dioctahedral montmorillonite were used to prepare nanocomposites with polyvinyl alcohol (PVA) and chitosan (in an acidic environment consisting two organic acids). Smectite-PVA film was formed during a freeze-thaw process to serve as a substrate. Subsequently, the smectite-chitosan suspension was cast onto the film through solution casting to produce the layered nanocomposite. Considering the pH-responsiveness of the nanocomposites, samples of defined sizes were exposed to different biological buffers simulating gastrointestinal media (pH 4.5), and blood media (pH 7.4). The observed transformation of the layered films into a rolled shape upon exposure to buffers can be considered as a promising step toward the further development of dual-delivery systems.
Preparation procedure subject smectites to a highly acidic environment, making it important to evaluate impact of this environment to their structure. This influence was assessed using FTIR spectroscopy for the measurement of smectite samples treated with organic acids. No significant changes were observed in the main absorption bands associated with stretching (ν) and/or bending (δ) vibrations of structural O-H or Si-O groups in dioctahedral smectite, while all trioctahedral smectites showed slight shifts in bands positions and intensities, along with appearance of new bands attributed to amorphous silica formation (near 1070 and 800 cm^{-1}). The presence of these bands in hectorites highlights the higher susceptibility of trioctahedral smectites to acidic environments. The intensity of the band near 1070 cm^{-1} increased relative to the νSi-O in order SHCa ≈ SWN < Lap. A similar trend was detected also from spectra measured in near infrared region where of trioctahedral samples showed new bands assigned to 2ν and ν+δ of SiOH groups (4429 and 7314 cm^{-1}), indicating presence of a partially protonated silica phase. The spectra of the nanocomposites exhibited strong absorption bands corresponding to all components involved in preparation with some differences compared to the spectra of individual components. Reaction of chitosan with organic acids did not completely prevented structural changes in hectorites and presence of amorphous silica band near 800 cm^{-1} was detected. Although using acidic environment in preparation of the pH responsive composites may evoke decomposition of layered structure of smectites, formation of amorphous phase may also positively contribute to the enhancing of interaction between components in the composite.

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References:

[1] Wang, X., et al. (2021) *Chemical Society Reviews*, 50(15), 8669-8742.