

Smectite-Polymer Film Composites as a pH-Responsive System for Curcumin Release

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Layered silicates, particularly smectites, are highly attractive due to their high surface area, tunable interlayer spacing, and versatile surface reactivity. These materials allow intercalation of various species, including polycations, which leads to the development of composite materials. Incorporating a stimuli-responsive component, such as chitosan, can influence the function of these composites in response to stimuli like changes in pH, temperature, light, or magnetic fields. In particular, pH-responsive composites are promising materials for delivery systems. This study aimed to prepare composites using smectites and polymers to design a double-layer film that accounts for pH-dependent shape changes. Curcumin was also incorporated as a model drug to evaluate the system's effectiveness as a carrier.

The film composite was made of two smectite-polymer layers. Two types of smectites, trioctahedral synthetic hectorite (Sumecton SWN, Kunimine Industries, Japan) and dioctahedral montmorillonite (deposit Kopernica, Slovakia), were used to prepare composites with polyvinyl alcohol (PVA) and chitosan at varying smectite-polymer weight ratios. Five freeze-thaw cycles were performed to obtain a smectite-PVA layer, which served as the substrate. The SWN sample showed greater mechanical stability and a more uniform layer than the Kopernica samples. For the smectite-chitosan dispersions cast onto the substrate, the SWN-chitosan sample also formed a homogeneous layer, resulting in a double-layer film composite. Scanning electron microscopy (SEM) images of the SWN-PVA//SWN-chitosan film revealed two distinct layers in cross-section, forming a continuous stacked morphology with no significant interfacial defects. This indicated good adhesion between layers; the film resembled a unified, homogeneous material. The pH responsiveness of the film composite was assessed by immersing samples of defined dimensions in two different buffer solutions simulating gastrointestinal conditions (pH 4.5) and blood conditions (pH 7.4). This evaluation showed a pH-sensitive rolling behaviour due to protonation and deprotonation of the chitosan amine groups. Under acidic conditions, the SWN-chitosan layer exhibited an outward orientation. Besides the shape changes of the film, this responsiveness can be promising for the advancement of composite materials as pH-responsive delivery systems.

As an initial investigation of loading in both layers, curcumin was incorporated as a model drug into the SWN-chitosan layer only. The release profile was studied over 24 hours in the same simulated buffer solutions. At pH 7.4, the release reached the highest percentage of curcumin solubility. A reduced release rate was also observed under acidic conditions. These observations indicate that, through selection of components and their ratios, the preparation of smectite-based film composites yields a unified material that exhibits pH-dependent shape alteration and release profiles. Such layered composites can be potential candidates for stimuli-responsive delivery systems.

Acknowledgment: The project is funded by the Slovak Academy of Sciences program for PhD students, DoktoGrant No. APP0633, and the Slovak Research and Development Agency APVV-23-0635.