Immobilization of Alchidine on the Physical Polymer-clay Composite Gels

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Summary: The regularity immobilization of medical mixture of compounds –alchidine over the composite carrier on the basis of bentonite clay and physical polymer gels have been studied by the methods of sorption and desorption. It has been established that components of alchidine interacts with composite due to hydrogen bonds. The availability of composite as a support of alchidine has been shown.

Introduction

Current interests in polymer-clay compositions are based on the fact that highly dispersed powders, such as inorganic polymers with defined layer structures, can be used as fillers in a large range of polymeric compositions.

The use and characteristics of polymeric composites depend on the properties of their individual components [1]. Among possible fillers, the layered silicates have attracted a major attention. Introduction of clay into gels renders them several new properties. For example, it improves their mechanical characteristics and prevents the collapse of composite gel structures. The clay particles present in gel also lead to other properties such as they can with stand the significant chemical modifications without coagulation [2-4]. Among other clay minerals, bentonites, with the high content montmorilonite is extremely important. Montmorilonite possesses excellent ability to adsorb various organic molecules and also to catalyze the organic reactions [5].

The aim of the work is an establishment of an opportunity of creation of polymeric composite medicinal forms on the basis of polymer - clay carriers.

Results and Discussion

In the current study, we investigated the structures of composite gels of gelatin and polyvinyl alcohol (PVA) mixed with bentonite clay (Manrak deposit, East Kazakhstan). We also studied the immobilization of a medicinal substance - alchidine on them.

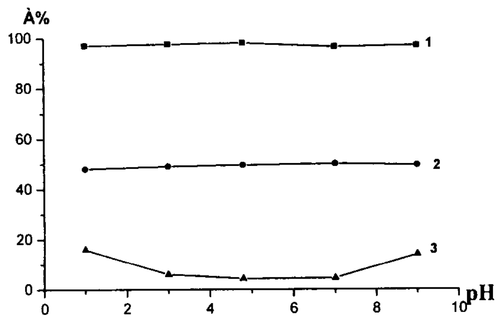
The following factors are considered when choosing a clay mineral and polymers. Firstly, the selected components must meet all the requirements of a medicinal preparation. Secondly, bentonite clay and organic polymers should be non-toxic and capable of forming a self-structured gel. On these basis, it is possible to design thermally stable complexes with the improved structural and mechanical properties, and also capable of forming quantitative and qualitative linkages with the medicinal substances [6].

For the preparation of appropriate compositions, a fundamental knowledge of the pattern of interlinkages of components is essential. For this purpose, properties of bentonite suspensions in solutions of gelatin and PVA were investigated. This includes the study of equilibrium swelling, sedimentation analysis and electrophoreses [7, 8]. It was established that bentonite clay and polymers form inter-compatible compositions. They are formed as a result of hydrogen bonding and are stabilized through the flocculation forces. This provides stability, compatibility and durability to the composition.

During preparation of medicinal gel and composites, it is important to have knowledge of the rate and sequence of sorption and desorption of various components. It is also essential to regulate the quantity of the pro-anthocyanidins in the drug system, in order to ensure the prolonged effect of the drug system. At the same time, knowledge of sorption-desorption rates enables to asses the nature of interaction of the pro-anthocyanidins with the carrier.

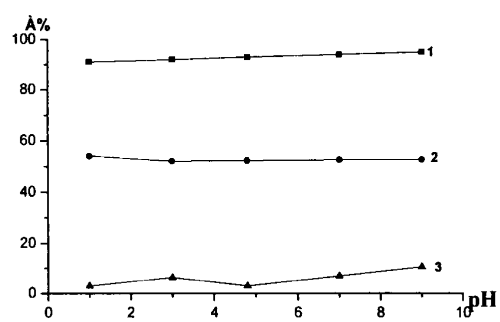
The study of kinetic curve of the sorption components of alchidine polysaccharides, proanthocyanidins, and amino acids on composite gels have shown that equilibrium is achieved within 2-3 h. In further study, sorption data was recorded within 2 h.

As shown in Figs. 1 and 2, the pH does not influence the sorption of polysaccharides and pro-anthocyanidins. The data indicates that sorption is independent of pH and hydrogen bonding. However, in case of amino acids, minimum sorption was observed at pH = 4.8 and maximum pH = 9.0. The reason apparently is that mobility of amino acids (as well as proteins) is dependent on isoelectric point.



[gelatin]:[clay] = 75:25; 1- pro-anthocyanidins; 2-polysaccharides; 3-amino acids, [alchidine] = 0.1 %.

Fig. 1: Sorption of alchidine on the gelatin-clay composition.

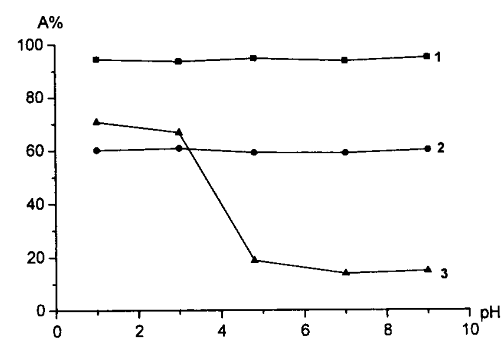


[gelatin]:[clay] = 50:50; 1- pro-anthocyanidins; 2-polysaccharides; 3-amino acids, [alchidine] = 0.1 %.

Fig. 2: Sorption of alchidine on the gelatin-clay composition.

During comparison of sorption of various components, following was noted: the largest amount of sorption is of pro-anthocyanidins - 95-98 %. The polysaccharides are next with ~50 %, and amino acids, depending on pH, were adsorbed at 5-15 % rate. For an explanation of such behavior of amino acids, we refered to previously reported data of the sorption components of alchidine on bentonite clay and gelatin [9-11], where equilibrium between sorption-desorption was studied and sorption of components of alchidine was found to be based on the sizes of molecules. In this case, because of formation of a complex between bentonite clay and gelatin, condensation of gel was observed, which apparently complicates the penetration of molecules of amino acids deep into the gel. For pro-anthocyanidins and polysaccharides, sorption is possible only on the surfaces of clay because of their larger sizes. Besides this, formation of complexes (gelatin-clay) strengthens the linkages of these macromolecules and thus increases the sorption of polysaccharides and pro-anthocyanidins.

For clay compositions of PVA, similar results (polysaccharides and pro-anthocyanidins) (Fig. 3) were obtained. In case of amino acids, present in alchidine, at the pH region of the isoelectric points of amino acids (pH = 4.8), a decrease in sorption was observed. In the region of above isoelectric points, the sorption values do not vary, and remain approximately at ~10 %. It is known that on conformational condition of PVA, the pH environment does not influence the sorption (if



[PVA]:[clay] = 75:25; 1- pro-anthocyanidins; 2-polysaccharides; 3-amino acids, [alchidine] = 0.1 %.

Fig. 3: Sorption of alchidine on the PVA-clay composition.

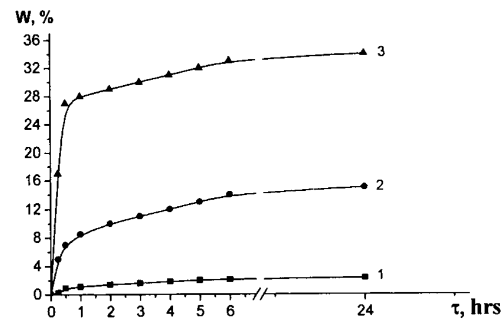
the ionic force is not considered). As reported earlier, the lateral sides of bentonite clay in the acid region are both positively and negatively charged [12].

With an increase in pH of particles, clay acquires identical negative charges. This can explain that in the region of pH < 4.8, positively charged amino acids molecules are attracted towards the negatively charged clay lateral side. In the region of pH > 4.8, amino acids are negatively charged. Particles of bentonite clay in this area are also charged negatively. Hence, interaction is only based on hydrogen bonding. This explains the observed decrease in the value of sorption with charges in pH [7].

The comparison of sorption values of components of alchidine, it was observed that the most sorbed are pro-anthocyanidins (95-97 %), followed by the polysaccharides (approximately 60 %), while sorption amino acids (10-75 %) depends on pH.

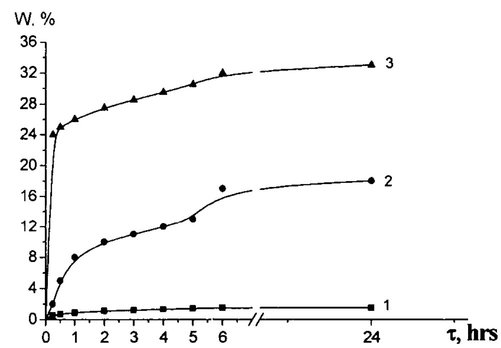
For understanding of prolongation effect of the received composite gels, qualitative and quantitative release of alchidine was studied. According to the desorption data of composite gels with the content of gelatin, 75 % of content was released within a day, which included 35 % polysaccharides, 15 % pro-anthocyanidins and 2.5 % amino acids. This pattern may be due to the relative sizes of molecules. Pro-anthocyanidins and polysaccharides interact with particles of clay superficially but the affinity of pro-anthocyanidins is higher because they have more hydroxyl groups and are capable of forming more hydrogen bonds. Amino acids are deeply inculcated into interpact spaces of gels, as a result only a slight release was observed. As shown in Figs. 4 and 5, the components of composite gels do not influence the release of components of alchidine.

In the case of alchidine-clay-PVA, a similar pattern of release of components of alchidine was observed (Figs. 6 and 7). The release of pro-anthocyanidins and polysaccharides components of compositions is shown in Figs. 6 and 7. With increase in the contents of clay, release of these components also increases, therefore the linkages between the polysaccharides and pro-anthocyanidins PVA seems to play a greater role.



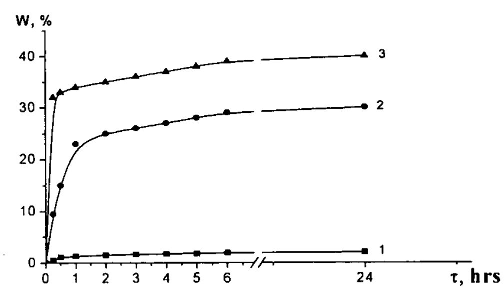
[gelatin]:[clay] = 75:25; 1- amino acids; 2-proanthocyanidins; 3- polysaccharides, [alchidine] = 3 %.

Fig. 4: Kinetics of the desorption of alchidine from the gelatin-clay composition.



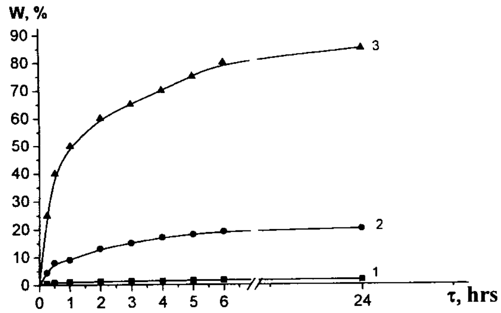
[gelatin]:[clay] = 50:50; 1- amino acids; 2-proanthocyanidins; 3- polysaccharides, [alchidine] = 3 %.

Fig. 5: Kinetics of the desorption of alchidine from the gelatin-clay composition.



[PVA]:[clay] = 75:25; 1- amino acids; 2 – proanthocyanidins; 3- polysaccharides [alchidine] = 3 %.

Fig. 6: Kinetics of the desorption of alchidine from the PVA-clay composition.



[PVA]:[clay] = 50:50; 1- amino acids; 2 – proanthocyanidins; 3- polysaccharides [alchidine] = 3 %.

Fig. 7: Kinetics of the desorption of alchidine from the PVA-clay composition.

Experimental

For production of polymer composites on a base of bentonite clay, the natural self-structured polymer – polyvinyl alcohol (PVA) was used.

PVA ($[-CH_2-CHOH-]_n$, M = 80000, type 16/1) was used without additional purification.

Gelatine (GOST: 11 293-89, type П-11) has been used without additional purification.

In these studies, alchidine – local medical extract was used. Alchidine is a bioactive mixture obtained from the camel prickle (*Alhagi kirgisorum* Shrenk.). It is known to contain polymeric pro-anthocyanidins, polysaccharides, flavonoids, amino acids, and microelements and have exhibited a wide spectrum of bioactivities, like anti-inflammatory, inhibition of bleeding, wound healing, and knitting properties. Pharmacological actions of alchidine are largely due to the presence of polymeric pro-anthocyanidins [13].

Texture Determination

Chemical and phase components of natural and cleaned [14] bentonite clay were studied by the diffraction (DFS-13) and the X-ray-phase analysis (DRON-4-07) methods. Investigation of bentonite clay revealed the presence of three phases: α-quartz SiO_2, montmorilonite $Al_2 [OH]_2 \{Si_4O_{10}\} \cdot mH_2O$, and an amorphous phase [15].

The amount of pro-anthocyanidins and amino acids released from a gel were determined by UV-spectrophotometry ('SF-26' spectrophotometer, Russia).

FTIR spectra were recorded by using the KBr pellets at the "Satellite" FTIR "Mattson" - unit (USA). Amount of polysaccharides was determined by the Hagedorn-Jensen micro-method, based on iodometric titration. Degree of swelling was determined by gravimetery.

Conclusion

These results indicated the importance of composites as carriers of medicinal substances with prolonged effects.

Acknowledgments

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