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Studies on The Adsorption Capacity for Bilirubin of The Adsorbent Chitosan-β-Cyclodextrin

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Abstract: The adsorbent crosslinked chitosan-β-cyclodextrin (β-CD) was prepared by the reaction of glutaraldehyde with chitosan and β-cyclodextrin. This type of adsorbent has high adsorption capacity for unconjugated bilirubin. The adsorption capacity was related to the β-CD content of the adsorbent; phosphate buffer concentration; temperature; pH value; ionic strength and the adsorbent beads. The results indicated that the chitosan-β-CD was a good adsorbent for unconjugated bilirubin with high capacity.

Keywords: Chitosan-β-CD, adsorption, bilirubin.

Bilirubin is a metabolite of heme from hemoglobin in the blood. Disorders in its successive metabolism or excretion may cause the accumulation of the unconjugated bilirubin in blood of the patients who suffer from hyperbilirubinemia. The accumulation of bilirubin can cause serious tissue damage[1,2]. Hyperbilirubinemia may be treated by the removal of bilirubin from body. The ways for its removal include phototherapy, orally administered sorbents[3] and adsorbents for hemoperfusion. Successful hemoperfusion requires the adsorbents to be specific; high adsorption capacity; blood compatible; and no poisonous.

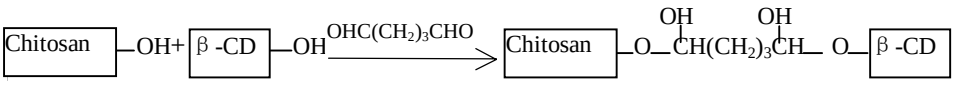
The common adsorbents such as activated charcoal, polar or nonpolarpolymers have some shortcomings, such as low adsorption capacity, lack of specificity, and poor blood compatibility, and consequently are not satisfactory for use in hemoperfusion[4].

Chitosan, 2-amino-2-deoxy-β(1,4)-glucan and its chemical modified derivatives can adsorb organic compounds. The crosslinked chitosan and their derivatives have high mechanical intensity, chemical stability, good blood compatibility and can adsorb bilirubin in hemoperfusion. However, they have lack of specificity[5,6].

β-Cyclodextrin (β-CD) has been subjected to numerous studies, particularly in terms of its complexing ability with a variety of components[7]. The use of β-CD as an adsorbent for the selective removal of components from aqueous fluids is, however, limited due to its inherent water solubility.

We presume that the product formed by crosslinking β-CD onto chitosan would have improved its complexing ability and specificity (see **Scheme 1**), additionally, the reaction converted β-CD into an insoluble matrix. This study reports the factors which affect the adsorption for bilirubin in the use of chitosan-β-cyclodextrin.

Scheme 1



Materials and Methods

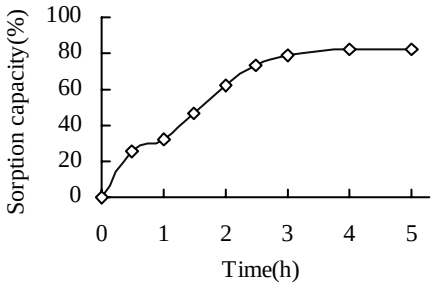
Chitosan samples (the degree of deacetylation: 94.3%) were supplied by Zhejiang Yuhuan Aoxing Chitin Company. β -CD was recrystallized and dried under vacuum at 100^0C for 24 hrs. The Chitosan- β -CD resin was prepared in hydrochloric acid solution[8]. The Chitosan- β -CD resin were tested for the adsorption of bilirubin in a phosphate butter solution (0.05-0.20 mol/L , pH 7.4). The solution of the adsorbate was freshly prepared with concentration ranging from 10 to 100 g/L. The whole process was carried out in a dark room[9]. General conditions of adsorption experiments were sorbent 100 mg, bilirubin solution 200 mg/L, buffer solution pH 6.1, temperature 25°C. The solution of the adsorbate was analyzed by measuring the absorbency at a wavelength of 438 nm using an UV-1201 spectrophotometer.

Results and Discussions

Relation of the adsorption time with adsorption capacity for bilirubin

Figure 1 shows the effects of the adsorption time on the adsorption capacity for unconjugated bilirubin. Chitosan- β -CD resin can adsorb 75 percent of all the bilirubin in the solution in 3 h. This shows the Chitosan- β -CD resin not only has high adsorption capacity for bilirubin, but also can reach sorption balance in a short time, so the resin can be used in practice.

Figure 1 The effect of the sorption time (crosslinking agent: Gly) on the sorption

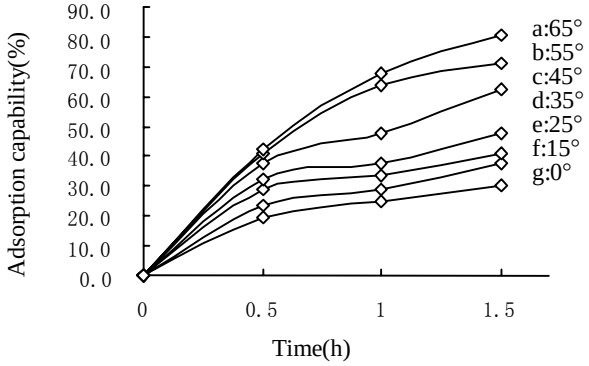


Effect of temperature on adsorption capacity for bilirubin

From **Figure 2**, we can see that the higher the temperature is, the greater adsorption capacity and the faster the adsorption rate are. The reason is that increase of temperature affects the swelling of the resin and accelerate the movement of bilirubin, the swelling capacity became larger the bilirubin molecules can enter the inner of the

resin easily[10].

Figure 2 Influence of temperature on sorption capacity for bilirubin



The effect of ionic strength in solution on adsorption capacity

The result of the relation between adsorption capacity and the concentration of the buffer solution is studied. When the ionic strength increase, the adsorption capacity of the resin for bilirubin decrease (**Table 1)**. There is competitive adsorption between ion and the resin for bilirubin, that may be relate to the charge on the resin.

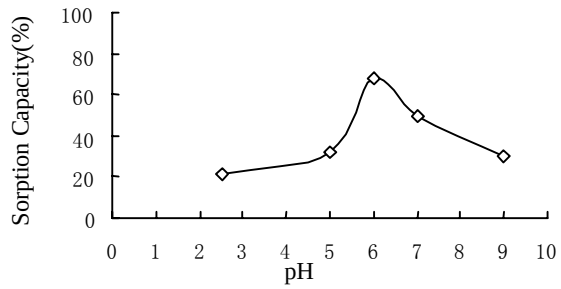
Table 1 The relation between bilirubin sorption capacity and concentration of buffer solution

concentration of buffer solution (mol/L)	0.05	0.1	0.2
sorption capacity (%)	67.42	58.69	49.91

The effect of pH value on adsorption capacity

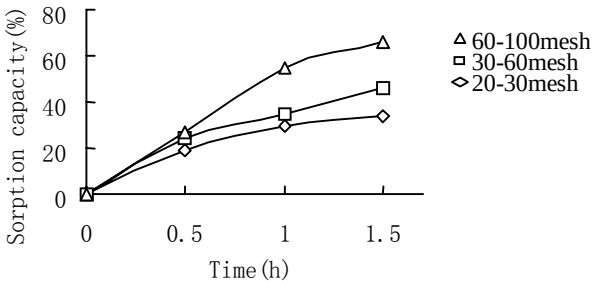
Figure 3 shown that pH value obviously affect the adsorption capacity of the resin for bilirubin.

Figure 3 The effect of pH value on the sorption capacity for bilirubin



The best value of pH is 6.1 for the resin. The more acidic or more basic solution would result in decrease of adsorption capacity for bilirubin. Because in acidic or basic solution, there are static repulsive force and molecular repulsive force between bilirubin molecules and the resin. This result fits well with literatures[11,12].

Figure 4 Absorption capacity of bilirubin on different size of Chitosan--β-CD



Effect of particle size on adsorption capacity

In **Figure 4**, as the diameter of the resin beads increases, the adsorption capacity decreases. This is due to the fact that the larger the diameters of the beads, the slower the diffusion rate of the bilirubin molecules through the adsorbent. Besides, the beads of smaller size possess higher specific surface area[4].

Conclusion

β-CD is immobilized onto chitosan by crosslinking agent glutaraldehyde and a new resin chitosan-β-CD is synthesized. The adsorbent has high adsorption capacity for bilirubin, and the adsorption capacity is related to the β-CD content of the adsorbent, pH value, temperature, phosphate buffer concentration and the size of the adsorbent.

Acknowledgments

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