Water & wastewater

The purification of herbal medicines

Chinese herbal medicines have been gaining global recognition over the years. However, protein and other impurities must be removed from its water extract, to ensure safe treatment. This article looks at improvements to flocculation technology for purification.

The water extract of Chinese herbal medicines has complex components and often contains impurities, such as protein, pectin, tannin, starch, et al, which adversely affect the quality, treatment results, dosing, expiration period, and may even be harmful to human health if not removed[1].

The traditional Chinese herbal water extract purification methods, including alcohol precipitation, high speed centrifugation, etc., normally have many drawbacks. Due to the advantages of no solvent consumption, excellent clarity, high recovery rate, short and simple process, low cost and low energy consumption, the flocculation technology has been gaining more and more attention for Chinese medicine purification. This research focused on development of a flocculation technology to purify SBWE, in which the effective component is baicalin and the main impurity is protein. The optimal conditioned flocculation process was determined by using the baicalin retention rate (BRR), protein removal rate (PRR)and the supernatant turbidity (ST) as the evaluation indexes. The action mechanism between the flocculants and the effective component or impurity was analyzed as well.

Flocculant type selection

Figure 1 shows the influence on BRR and PRR by using different dosages of chitosan, HACC, and CHC. It can be seen that when the flocculants dosage increased from 0.75g/L to 1.0g/L, PRR obtained from HACC was the highest, while the PRR obtained by chitosan was the lowest. When the same dosages of chitosan, HACC, and CHC was added into the water extract, HACC ionized more positive charges than chitosan and CHC, leading to a better interface charge neutralization with the protein particles in SBWE which are negatively charged due to the existence of particles' surface free energy and the malconformation of the physical absorption. Therefore, better protein removal rate was achieved for HACC.

Besides, baicalin is small molecule substance, whereas the flocculants and protein particles in the soup are all

Table 1. Basic properties of SBWE

Density [kg/m3]	pH	ζ-potential [mV]	Baicalin content [mg/mL]	Protein content [mg/mL]	ST [NTU]
1007.0	5.15	-0.899	5.67	254	>200

Table 2. Factors and levels of orthogonal test

Factor / Level	Temperature [°C]	HACC dosage [g·L-1]	Fast-mixing speed [r·min-1]	Fast-mixing time[min]
1	30	1.0	350	1
2	40	1.25	450	2
3	50	1.5	550	3

macromolecule that far outweighs the baicalin molecule on the volume and molecular weight[2]. When the flocculant molecules were added into the soup, they touched and reacted with protein and colloid particles to form flocs that netted and swept some baicalin away during the sedimentation process. The flocs formed by HACC, protein, and colloid particles, were bigger and therefore settling faster than those formed from chitosan or CHC with proteinand colloid particles, leading to less chance to contact with baicalin and less baicalin to be netted and swept by settlements.

Therefore, the HACC was chosen as the best flocculant to carry out the subsequent experiments.

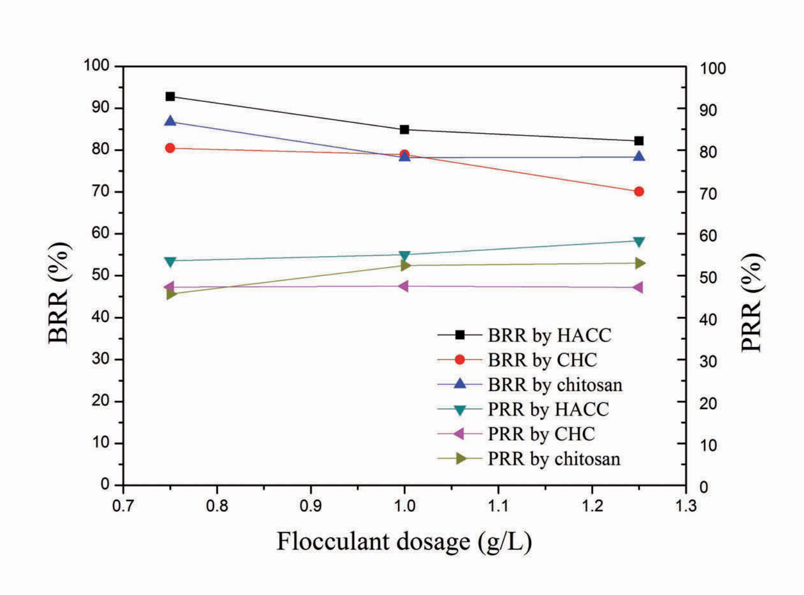

Figure 1. Comparison effect of three flocculants on SBWE.

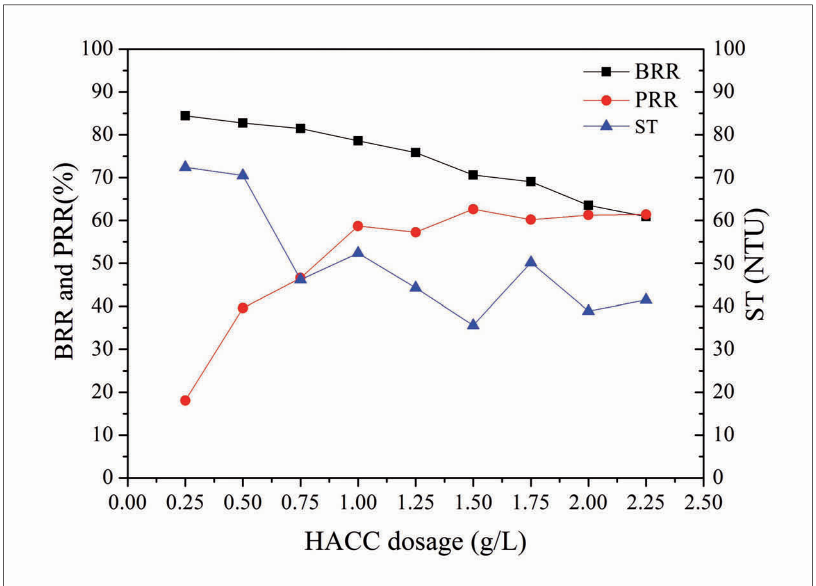

Figure 2. Effect of HACC dosage on the BRR, PRR and ST.

Single factor experiments

Effect of HACC dosage on flocculation performance. The flocculant dosage is a very important factor, which affects flocculation result directly. The insufficient flocculant dosage leads to a certain amount of impurities remaining in the soup and makes the soup unstable and turbid. While the excess flocculant dosage results in losing of effective constituents and restablizing of the colloidal system. So the flocculant dosage must be controlled approximately.

The effect of HACC dosage on the flocculation results was shown in Figure 2. The BRR decreased as the HACC dosage increased. When HACC dosage reached to 2.25g/L, the BRR reached to the minimum value 60.89%. The PRR first increased and then decreased with increase of the HACC dosage. When the HACC dosage reached to 1.5g/L, the PRR reached to the maximum value 62.62% and the ST declined to the minimum value 35.6NTU.

HACC molecule has mangy positive charges because it introduces the quaternary ammonium groups to the amidogen of chitosan and grafts a low-molecular quaternary ammonium salt on the amidogen to become a kind of chitosan quaternary ramification, the structure of which is shown in Figure 3. And HACC not only has the typical properties of quaternary ammonium salt such as antibacterial activity and hygroscopicity, but also keeps the intrinsically good properties of chitosan such as film-forming ability, flocculability, biocompatibility and biodegradability[3]. Further on, the nucleophilic center C_2 amino of chitosan molecule is gradually replaced by quaternary ammonium salt groups from Figure 3, which weakens the hydrogen bonding effect in chitosan molecule and destroys the crystal structure of chitosan, leading to loose state of HACC molecule and therefore easy to dissolve[4]. HACC also has strong electropositivity and cationic intensity because the cationic side chain of HACC has strong hydrophilia after quaternization.

Besides, it is shown from Table 1 that the Zeta electric potential of the SBWE system was -0.899mV,indicating that the net charge on the surface of the particles in SBWE was negative due to the ionization and dissociation of free electrons from protein, mineral substances and inorganic salt in SBWE. When HACC was added into the soup, the quaternized cationic groups of HACC touched and generated charge neutralization reaction with the negative charged suspended particle on their surface to form flocs. The flocs grew bigger with more particles being absorbed by HACC. When the flocs' size reached to a certain degree, they separated out from the soup to precipitate. In the sedimentation process, the flocs were crossly linked with each other to form a big net which netted and swept the small particles in the soup to make the soup clear. Some baicalin molecules were netted and swept leading to BRR decreasing. The more