Development of Advanced Membrane Filtration of Particulate Suspension Containing Macromolecule Using Sodium Chloride

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Summary

In recent years, membrane filtration of particulate suspensions containing macromolecule is being applied with increasing frequency to such widely diversified fields as wastewater treatment, biotechnology and food industry. It is well understood that the filtration behaviors of the colloids are affected significantly by the solution properties, including pH and electrolyte concentration. In this study, a method has been developed for improving the filtrate flux in ultrafiltration of particle/macromolecule mixtures by means of the control of pH and electrolyte concentration.

Dead-end ultrafiltration of titanium dioxide (TiO_2) suspensions containing bovine serum albumin (BSA) molecules was conducted using both-impermeable membranes for various pH and sodium chloride (NaCl) concentrations, keeping the total mass fraction of colloids constant. The average specific filtration resistance α_{av} of the filter cake in the absence of NaCl at pH 4.2 where both colloids are electropositive increased gradually with an increase of the mass fraction of BSA. This means the resistance α_{av} of BSA is significantly larger than that of TiO_2. At pH 6.0 where TiO_2 and BSA have opposite electric charges, however, α_{av} in the range of quite small BSA fraction tended to become smaller than α_{av} of the cake composed of TiO_2 alone. The result is perhaps surprising when one considers the high resistance of BSA. Under this pH the positive charge of TiO_2 particle is canceled by the adsorption of negatively charged BSA molecules, and then the flocculation of TiO_2 occurs due to a marked decrease of the zeta potential. This brought about the marvelous behavior of α_{av} at pH 6.0. Moreover, the same phenomena were observed in the presence of NaCl at pH 4.2. The addition of NaCl leads to a less extensive electrical double layer, which promotes the flocculation of TiO_2 due to charge-shielding between the colloids. In addition, the combined effects of NaCl and BSA coexisting in liquid much more greatly encourage the flocculation in the range of quite small BSA fraction. This caused an effective decrease of α_{av} at pH 4.2.

It is thus concluded that the ultrafiltration rate of a particulate suspension containing macromolecule can be enhanced by the appropriate control of pH and/or electrolyte content.