Research topic

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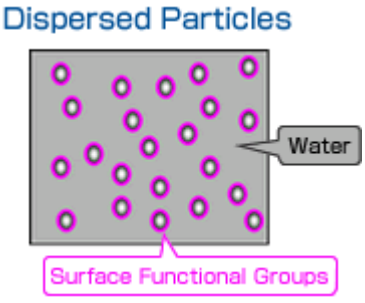
Research topic: Removal of Humic Substances by Adsorption-Ultrafiltration Process Using Self-Dispersible Carbon Black

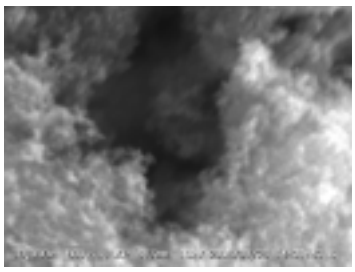
Resume:

The application of UF process in water purification of natural waters has suffered the decline of permeate flux caused by membrane fouling with humic substances (HS) and metal-HS complexity. Degree of fouling would depend upon membrane pore size, operating conditions, solute-membrane interaction, and solution physico-chemical parameters. Not only a major foulant, but also HS cause color, odor, taste problems, and generation of halogenated by-products which are suspected human carcinogens i.e. trihalomethanes (THMs) and haloacetic acids (HAAs) during disinfection processes. Adsorption-Membrane filtration is known to be effective in enhancement of the contaminant removal. However conventional adsorbents i.e. activated carbon (AC) are not very effective in removal of HS due to macromolecular character and limitations of adsorbent materials i.e. heterogeneity of surface, dispersion stability in an aqueous solution and slow adsorption kinetics. Carbon black (CB), a sub-micron particle, is pure elemental carbon in the form of colloidal particles produced from gaseous or liquid hydrocarbons under controlled conditions. Dispersion stability of CB in water can be enhanced by dispersing-aid surfactants or introducing surface functional groups at the edge of graphene layers. Grafting of surface groups can be achieved through a process of surface modification i.e. oxidation, streaming, ammoxidation, amination, thermal treatment and so on. Since CB contains a large accessible surface area for adsorption of macromolecules, CB coupled with UF would shorten the contact time required for the removal of HS and others emerging contaminants.

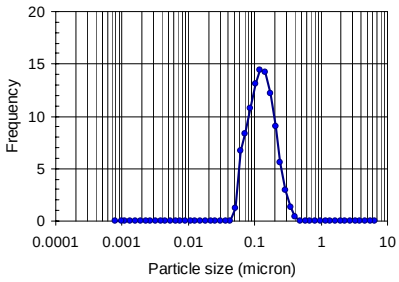
In this study, experiments on adsorption capacity and membrane filtration are performed with a lab-scale batch adsorption tests and dead-end ultrafiltration. Self-dispersible CB, commercial and natural humic acids are evaluated in this study. The as-received CB was chemically modified by the manufacturer to increase acidic surface groups so that it can be easily dispersed in water. With the aim to evaluate practicability of CB as an adsorbent for HA in hybrid CB-UF process, experimental design has been started from fundamental understanding of filtration with colloid-containing solutions and adsorption performance of commercial HA onto CB. Various parameters affecting dispersion stability of the CB and adsorption performances have been investigated with conventional and specific colloidal-science analysis.



Self-dispersible CB
(Tokai Carbon, Tokyo)



Micrograph of CB
aggregate by SEM



CB size distribution by Nanotrac
particle size analyzer

Published papers:

Research theme

A Hybrid Carbon Black-Ultrafiltration Process for removal of Humic substances

Background:

Carbon black (CB); Submicron pure elemental carbon in the colloidal form.

- ❑Widely used in industries as a pigment and coating materials
- ❑Presence of functional groups enhances dispersion stability
- ❑A large accessible area for adsorption of macromolecules

Adsorption of macromolecules; Physical & Chemisorption controlled by

- ❑Adsorbate-adsorbent-solvent interactions: Electrostatic interactions, van der Waals force, hydrophobic interaction, and selectively electrostatic chemisorption.
- ❑Adsorption kinetic was rate-limiting steps controlled by transports of molecules in solvent and through the adsorptive sites. Conventional adsorbate, i.e. activated carbon, has limited accessible adsorptive sites resulting in slow adsorption kinetic of macromolecules. Hence easily accessible site for adsorption is important.

A Hybrid Carbon Black-Ultrafiltration Process for removal of Humic substances

Problem:

- ❑Conventional adsorbents are not very effective in removal of macromolecules
- ❑Low dispersion stability in an aqueous solution thus high energy consumption for mixing
- ❑Cake formation causes significant flux decline reducing the economic viability of the water treatment process
- ❑ Ultrafiltration alone might not be very effective in removal of contaminants.

Advantages of the hybrid CB-UF system

- ❑Easily accessible surface area of CB might shorten contact time required for adsorption
- ❑Adsorption of humic substances occurs on the carbon surface and thus reduces membrane fouling potential due to the organic matters
- ❑Less energy consumption for dispersion due to the self-dispersion stability of the CB

A Hybrid Carbon Black-Ultrafiltration Process for removal of Humic substances

Research outline: