Dual functionality of a graft starch flocculant: flocculation and antibacterial performance in water treatment

Water treatment agents, including coagulants / flocculants, bacteriostatic / bactericidal agents, scale inhibitors, etc., play very important roles in the field of water treatment. However, traditional water treatment agents usually possess single functionality only, causing a wide variety of agents with high doses, complicated devices, and fussy operations in actual applications. Therefore, it is of great significance to develop multi-function water treatment agents containing coagulation/flocculation, bacteriostasis/sterilization, and scale inhibition in both scientific researches and practical applications. After combination of various functionalities into one agent, the multi-functional materials may have the potentials of more cost efficiency and wider application ranges.

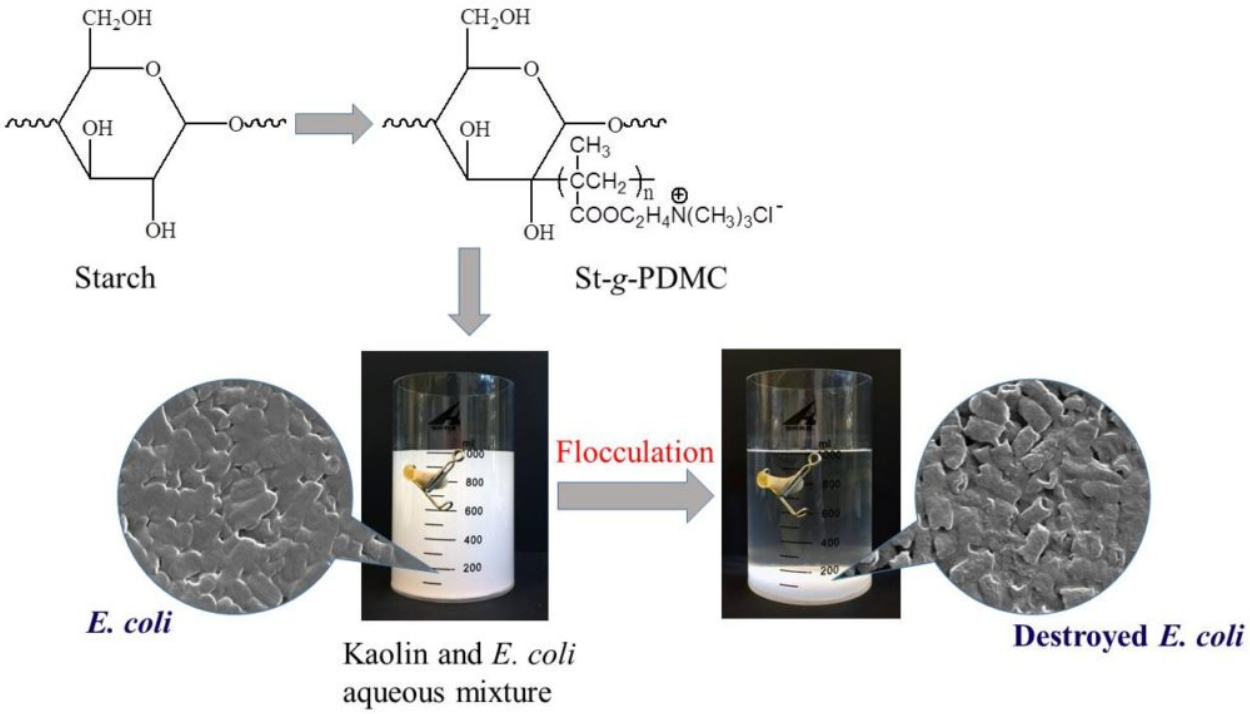

Fig. 1. Simultaneous removal of turbidity and inhibition of E. coli in water using a graft starch flocculant.

Flocculation and disinfection are two necessarily steps in drinking water treatment. However, rapid industrial development and population growth lead to continued contamination of surface water and groundwater, contributing to serious deterioration of water qualities. As a result, required doses of flocculants and disinfectants have increased to meet the national drinking water health standards.

Accordingly, the treatment costs have increased remarkably, as well as the secondary pollution risk of disinfection byproducts (DBPs) produced in disinfection processes using chlorine. Therefore, a dual-function agent for water treatment with high-efficiency flocculation and antibacterial properties is needed.

Recently, considerable attention has been given to natural polymers owing to their wide availability, environmental friendliness, and biodegradability. Among them, starch is considered one of the high-performance, low-cost natural polymeric materials. Many kinds of efficient starch-based flocculants have been developed for water treatment because they are inexpensive, biodegradable, and effective. However, little work has been reported regarding dual-function starch-based flocculants, and their widespread use need experimental validation in field operation. Grafted quaternary ammonium salt groups onto polymers are mostly beneficial to both flocculation and antimicrobial activity for the enhancement of positively charge characteristics, given that most inorganic suspended colloidal particles and microbes in water possess negative surface charges. Moreover, the dangling branches on the polymeric flocculants' backbone cause easier accessibility to and adsorption of contaminants in water.

In the present work, a series of Starch-*graft*-poly(2-methacryloyloxyethyl) trimethyl ammonium chloride (St-*g*-PDMC) with different grafting ratios was prepared by graft copolymerization. The flocculation and antibacterial properties of St-*g*-PDMC were investigated in detail. Kaolin and *Escherichia coli* suspensions, as well as their mixtures, were employed as synthetic wastewaters in laboratory experiments. Experimental results indicated that St-*g*-PDMC exhibited not only a highly flocculation effect on the three kinds of synthetic water samples via charge attraction but also an effective antibacterial property. The flocculation properties of St-*g*-PDMC were enhanced with the increase of grafting ratio, which supported the importance of charge attractions. Moreover, according to the results of the three-dimensional excitation-emission matrix spectra and direct cell morphological observation by scanning electron microscopy, it was qualitatively inferred that St-*g*-PDMC showed efficient inhibition of *E. coli* in water due to the grafted quaternary ammonium branches. St-*g*-PDMC may effectively destroy the cell wall of *E. coli* through strong electrostatic interactions. Thus, owing to the dual functionality of St-*g*-PDMCs with favorable both flocculation and antibacterial properties, it is expected that the required doses of coagulants/flocculants and disinfectants in water treatment plants may be both evidently reduced, resulting in considerable cost reduction and notable diminution in the secondary-pollution risk of disinfection byproducts. However, practical applications of this starch-based flocculant in treating various wastewaters, including different kinds of bacterial suspensions, domestic and industrial effluents, need further investigation. Highly efficient production techniques should be also developed and optimized to enable widespread use of the prepared dual-function starch-based flocculants in water treatment.

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