Flocculation using starch-based flocculants: An efficient pretreatment for purification of the textile dyeing secondary wastewater

China is a major textile manufacturer in the world; as a result, large quantities of dyeing effluents are generated every year in the country. Textile dyeing effluents are distinguished by high levels of chrominance, chemical oxygen demand, and salinity. Thus, the textile dyeing industry has faced the formidable challenges of wastewater treatment and water reuse in view of the current water resource shortage as well as stricter regulation. Biological treatment such as anaerobic anoxic–oxic (A^2O) process is essential to the purification of dyeing wastewater. However, the residual contaminants after biological treatment are still difficult to handle. Among the various types of contaminants in secondary treated wastewater, dissolved organic matter is one of the most disconcerting threats to human health and environmental safety.

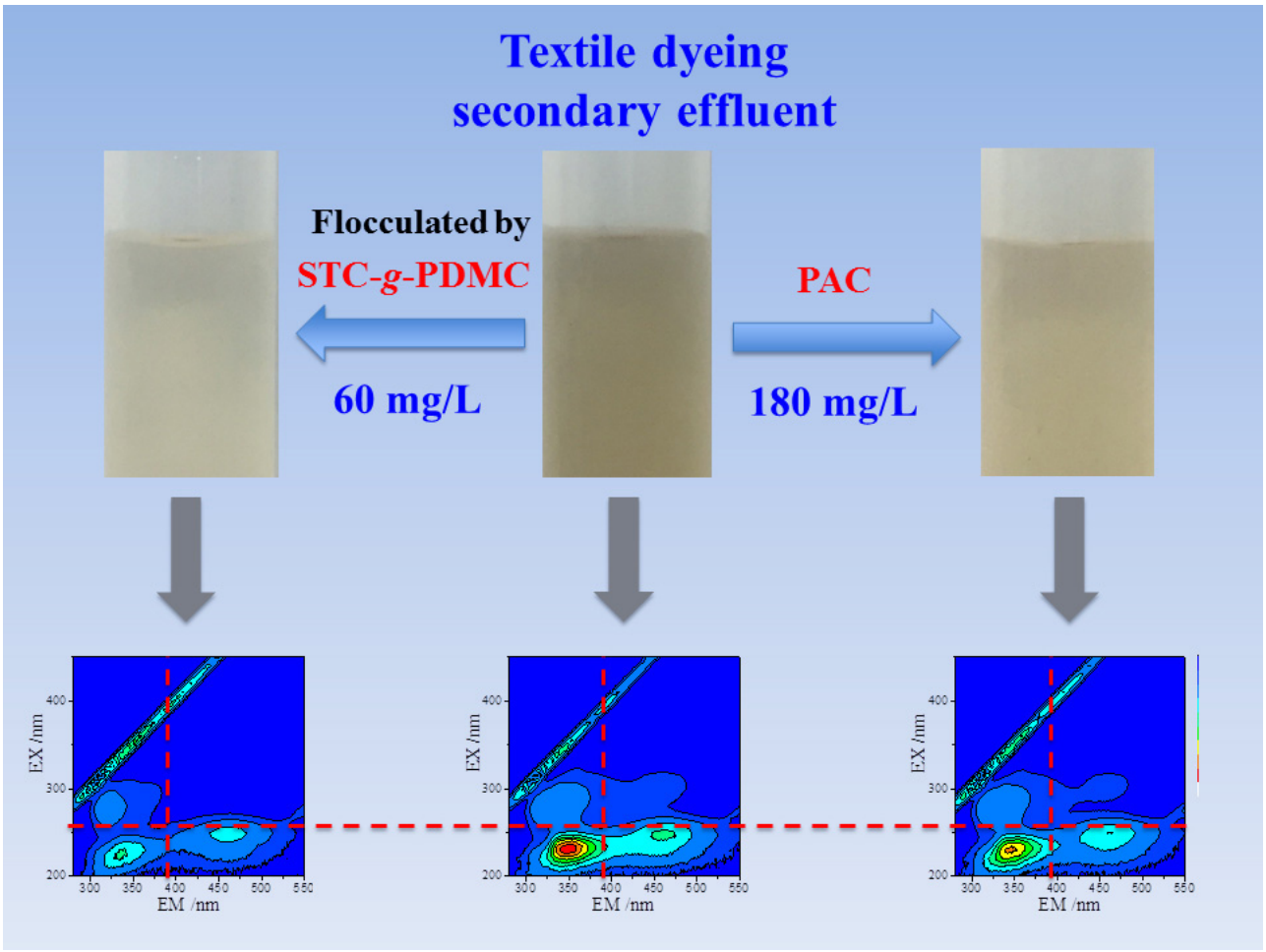

Fig. 1. Comparison of the flocculation performance of a starch-based flocculant (STC-g-PDMC) and an inorganic coagulant (PAC) for purification of the textile dyeing secondary wastewater.

A variety of methods have been employed to treat dyeing secondary effluents, including activated carbon adsorption, advanced oxidation, ultrafiltration/microfiltration, reverse osmosis, and magnetic ion-exchange resin treatment. In fact, a single method can never achieve complete treatment of the diverse objects from wastewater, and the extensive application of these methods is hindered by their respective limitations. Therefore, flocculation is generally applied as a pretreatment technology for tertiary treatment. The integration of flocculation allows for a comprehensive treatment, which can evidently alleviate the load of contaminant removal on the subsequent processes and reduce the operation cost.

In the flocculation process, the flocculant always plays a key role. Natural polymer-based flocculants, a sort of organic polymers, are distinct from traditionally commercial coagulants, such as polyaluminum chloride (PAC), in many aspects because of their several significant advantages, such as biodegradability and high efficiency. Among these natural polymer-based flocculants, starch-based flocculants have received a considerable attention owing to their abundant supply and low cost; many kinds of starch-based flocculants have been designed and reported. However, the precise control of the materials' molecular structure on the basis of the structure–activity relationship is highly important to improve their final application performance.

In our study, the performances of two cationic starch-based flocculants containing the similar functional groups but with different chain architectures, i.e., starch-*graft*-poly[(2-methacryloyloxyethyl) trimethyl ammonium chloride] (STC-*g*-PDMC) and starch-3-chloro-2-hydroxypropyl trimethyl ammonium chloride (STC-CTA), in flocculation of dyeing secondary wastewaters, obtained from a textile dyeing plant at Yixing of China, were investigated and compared with that of PAC. Based on experimental results, STC-*g*-PDMC presents low optimal doses and corresponding high removal percentages, showing significant advantages over STC-CTA and PAC in treating this wastewater. The superiority of STC-*g*-PDMC is due to its enhanced positive charge and branched chain architecture, which contribute to more efficient charge neutralization and bridging flocculation effects (Fig. 1). The benefits of this chain architecture are of significance in guiding the design and selection of a suitable polymeric flocculant in treating target wastewater.

Besides, starch-based flocculants, as natural polymers, still possess other advantages, such as widespread availability, environmental friendliness, and biodegradability. However, the cost of these flocculants may restrict their practical applications in water treatment. However, in this study, the optimal dose of STC-*g*-PDMC for flocculating real textile dyeing secondary effluent is only one-third of the optimal dose of the conventional coagulant PAC. Furthermore, the volume of the sludge produced from wastewater treatment by STC-*g*-PDMC is significantly reduced, allowing for the considerable reduction in the cost of sludge disposal. Although the performance of this starch-based flocculant in treating various domestic and industrial effluents in real application should be further tested, we firmly believe that well-prepared natural polymer-based flocculants, owing to their

superior performance and environmental friendliness, have wide-ranging uses in wastewater treatment, especially when more effective production techniques are developed and optimized in the near future.

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