Chapter 18
Coagulation–Flocculation Technology in Water and Wastewater Treatment

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ABSTRACT

Coagulation and flocculation processes are widely used in potable water treatment due to its high efficiency in turbidity removal. Egyptians discovered this method in 1500 BC by using alum to settle the suspended solids in the water. Today, the coagulation and flocculation processes are implemented with the purpose of agglomerate colloids and fine particles in water into larger particles, which is also known as floc. Therefore, reduction of turbidity and pollutants e.g. organic matter, inorganic matter, suspended solid, etc. can be achieved. This chapter covers the principle of coagulation and flocculation process which includes the charge neutralization and various binding mechanisms e.g. interparticle bridging, sweeping coagulation, and absorption. Besides, various types of coagulants and flocculants that have been discovered and their respective effectiveness in potable water treatment are discussed as well in this chapter. Polymer modifications to synthesize new coagulant/flocculant i.e. grafting and crosslinking are also included.

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INTRODUCTION

The demand for fresh water has exponentially increased due to the increase of human population and the rapid industrialization and domestic activities, which generated a large amount of polluted wastewater. Fine suspended solids, metals, organic and inorganic particles and other impurities are generally found in industries and domestic wastewater. These pollutants are hard to be removed due to their surface charge and small size properties. Various methods, e.g. coagulation-flocculation, ion exchange, precipitation, adsorption, biological and advanced oxidation process have been used to remove the colloidal particles in the wastewater. Among all the treatment method, the coagulation-flocculation process is one of the oldest treatment methods and essential for most of the water and wastewater treatment. Apart from water and wastewater treatment, the coagulation-flocculation process is used in diverse disciplines e.g. rubber manufacturing, cheese manufacturing, biochemistry etc. (Bratby, 2016).

Coagulation-flocculation involved two-phase process to remove the stable colloids in water by forming larger aggregates that can be separated by the sedimentation process. The coagulation process is the first phase, which involved the addition of coagulant into the water to destabilize the particles by reducing the repulsive forces between the colloids. The second phase involved the flocculation process where the destabilized particles are bonded together to form flocs through the attraction of van der Waals force. The coagulation-flocculation process has been primarily used in drinking water treatment since 1500 BC to remove the turbidity of the water. Recently, coagulation-flocculation processes have received greater attention as they have been proven to be an effective process for various contaminants removal, which includes toxic organic matter, heavy metals, viruses etc. Due to its high-efficiency properties in removing contaminates, this process has been extensively applied in the treatment of palm oil mill effluent (Chung et al., 2018), food and beverage wastewater (Jusof Khadidi & Hamid, 2013; Muryanto et al., 2018), textile wastewater (Meriç et al., 2005), yeast wastewater(Zhou et al., 2008) and others.

The efficiency of the coagulation-flocculation process in the treatment process are mainly depend on few factors such as the type and dosage of coagulant, the temperature and pH of the wastewater, the concentration of the pollutant in wastewater, mixing speed and settling time of the floc formed. Therefore, the choice of coagulant and optimization of all operating parameters are essential for cost optimization in industrial application. Traditionally, inorganic metal salts, i.e. ferric chloride and aluminium sulphate are widely used in industrial wastewater treatment. However, the usage of inorganic coagulants has been reduced nowadays due to its narrow application and less inefficiency in small dosage (Lee et al., 2014). Instead, natural or synthetic polymeric flocculants are preferable for the treatment process.

PRINCIPLE OF COAGULANT AND FLOCCULATION PROCESS

Particle Collision Theory

Colloids are the particles with the size smaller than 10^{-5} mm and they are strongly influenced by the electrokinetic charge (Bratby, 2016). In water, there are two types of colloids, hydrophobic and hydrophilic colloids which divided based on their surface properties (Suopajärvi, 2015). For hydrophilic colloids in the water, the primary charges are caused by their polar groups, e.g. amine and carboxylic group. Hydrophilic colloids are more likely to aggregate as compared to hydrophobic colloids as they interact with water. However, most of the colloids remain discrete in the water and hardly agglomerate attribute