



REVIEW ARTICLE

The hydrophilic/hydrophobic ratio vs. dissolved organics removal by coagulation – A review



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Hydrophilic/hydrophobic ratio;
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Coagulation

Abstract This review discusses the hydrophilic/hydrophobic ratio as a function of the hydrophilic and hydrophobic contents removal by coagulation process. It is well established that coagulation process could bring a reduction in dissolved organic carbon of around 30–60% by increasing the coagulant dose and optimising reaction pH, in which large organic molecules with hydrophobic property was removed preferentially. Furthermore, the literature affirmed that the greater removal of UV-absorbing substances indicates that alum coagulation preferentially removed the hydrophobic fraction of the total organic carbon. For the hydrophobic fraction, it needs to be removed entirely without its transformation into hydrophilic fractions by coagulation process avoiding pre-chlorination/pre-oxidation due to the risk of organic molecules fragmentation. Determining the exact numerical values of the hydrophilic/hydrophobic ratio for raw water and treated water at different stages of the treatment processes in a water treatment plant, as for the DCO/DBO₅ ratio in the case of wastewater treatment, would help on more focusing on OM control and removal.

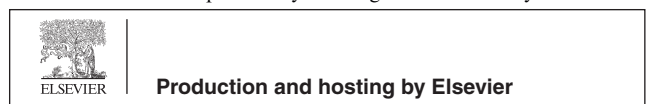
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Contents

1. Introduction	170
2. Coagulation for trace organic contaminant removal	170
3. Coagulation of organics in bio-treated textile wastewater	171
4. Cyanotoxins coagulation	171
5. Treatability of AOP-pretreated samples by coagulation.	172
6. Changes during coagulation in NOM reactivity towards DBPs formation	174

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7. Coagulation diagram	174
8. The hydrophilic/hydrophobic ratio	175
9. Conclusions	176
References	177

1. Introduction

It is well known now that natural organic matter (NOM) in the aquatic environment consists of a wide variety of organic compounds that are primarily derived from the decomposition of plant and animal residues (Chen et al., 2002; Joseph et al., 2012). Further, the presence of NOM in various water sources is a major concern for environmental scientists and engineers, specifically in water treatment (Ghernaout et al., 2011; Liu et al., 2012). There is no doubt here that NOM often contributes to offensive taste and odours in potential drinking water sources and acts as a carrier for metals and various harmful organic chemicals (Ghernaout et al., 2011). Moreover, NOM can disrupt various processes in a conventional water treatment facility (Baghoth et al., 2011). Indeed, NOM is considered to be a precursor for carcinogenic disinfection by-products (DBPs) such as trihalomethanes (THMs) and haloacetic acids (HAAs) that can form during chlorination (Chowdhury et al., 2009; Rook, 1974, 1977; Rice and Gomez-Taylor, 1986; Gang et al., 2005; Roccaro et al., 2008; Kristiana et al., 2013) and contribute to bacterial regrowth and biofilm formation in drinking water distribution systems (Ghernaout et al., 2011).

On the other hand, it is well established that coagulation/flocculation in water/wastewater treatment involves the addition of chemicals to alter the physical state of dissolved and suspended solids and facilitate their removal by sedimentation (Dentel, 1991; Cheng, 2002; Duan and Gregory, 2003; Matilainen et al., 2010; Sáez et al., 2010; Alexander et al., 2012; Kimura et al., 2013). As chemical products, coagulants react with the suspended and colloidal particles in the water, causing them to bind together and thus allowing for their removal in the subsequent treatment processes (Jiang, 2001; Li et al., 2006; Jiang and Wang, 2009). The aggregation mechanisms through which particles and colloids are removed include a combination of charge neutralisation, entrapment, adsorption and complexation with coagulant ions into insoluble masses (Duan and Gregory, 2003; Zhou et al., 2005; Zhang and Wang, 2009; Cheng et al., 2010;

Matilainen et al., 2010; Verma et al., 2012; Ghernaout and Ghernaout, 2012).

As an integral part of the conventional water treatment scheme, coagulation treatment has been employed to decrease turbidity and colour and to remove pathogens (Hai et al., 2007; Matilainen et al., 2010; Verma et al., 2012). Coagulation can remove efficiently the hydrophobic and high molar mass fractions of NOM (Matilainen et al., 2010; Mao et al., 2013). Moreover, coagulation/flocculation/precipitation processes have been intensively used for decolourising wastewater (Hai et al., 2007; Verma et al., 2012) and coagulation is often applied to augment biological phosphorous removal in activated sludge processes (Nguyen et al., 2010).

It is well established through the long and large literature that the coagulation process efficiency is highly dependent on hydrophilic and hydrophobic properties (Table 1) of NOM and dissolved organics (Edzwald, 1993; Jiang and Graham, 1996; Ghernaout et al., 2009; Weng et al., 2012; Zhao and Zhang, 2011; Wu et al., 2011). This review aims to discuss the influence of these fundamental characteristics on the coagulation performance. Several and different examples from the pertinent selected references treating coagulation of NOM and dissolved organics are given in the following sections. The main objective here is to find or establish a hydrophilic/hydrophobic ratio to well understand and optimise the coagulation process. In order to explain why the hydrophilic/hydrophobic ratio would be introduced, the following sections discuss coagulation of trace organic contaminants, organics in bio-treated textile wastewater, cyanotoxins, and AOP-pretreated samples. Coagulation diagram and changes during coagulation in NOM reactivity are also treated before discussing the hydrophilic/hydrophobic ratio.

2. Coagulation for trace organic contaminant removal

The term trace organic contaminants refer to contaminants present in water and wastewater at very low concentrations.

Table 1 NOM fractions and chemical groups (Edzwald, 1993).

Fraction	Chemical groups
<i>Hydrophobic</i>	
Acids	
Strong	Humic and fulvic acids, high MW alkyl monocarboxylic and dicarboxylic acids, aromatic acids
Weak	Phenols, tannins, intermediate MW alkyl monocarboxylic and dicarboxylic acids
Bases	Proteins, aromatic amines, high MW alkyl amines
Neutrals	Hydrocarbons, aldehydes, high MW methyl ketones and alkyl alcohols, ethers, furans, pyrrole
<i>Hydrophilic</i>	
Acids	
	Hydroxy acids, sugars, sulfonics, low MW alkyl monocarboxylic and dicarboxylic acids
Bases	Amino acids, purines, pyrimidine, low MW alkyl amines
Neutrals	Polysaccharides, low MW alky alcohols, aldehydes, and ketones

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