



Advances in the quest for substitute for synthetic organic polyelectrolytes as coagulant aid in water and wastewater treatment operations



Nurudeen Abiola Oladoja

Department of Chemical Sciences, Adekunle Ajasin University, Akungba Akoko, Nigeria

ARTICLE INFO

Article history:

Received 16 December 2015

Received in revised form

20 March 2016

Accepted 9 April 2016

Available online 26 April 2016

Keywords:

Coagulation-flocculation

Polyelectrolytes

Coagulant aid

Water treatment

ABSTRACT

In order to optimize the performance efficiency and reduce the process economy of coagulation-flocculation (CF) based water treatment operations, coagulant aids (CA) are used as an auxiliary to the primary coagulant. Synthetic polyelectrolytes are widely used as CA but the use are synonymous with negative human and environmental challenges. As an antidote to the challenges associated with the use of synthetic polyelectrolytes, natural and eco-friendly materials have been studied as substitutes for the synthetic polyelectrolytes. At present, a comprehensive review on the efforts that have been made in the quest for substitutes for synthetic polyelectrolytes has been conducted. The justifications for the choice of the materials, the operational performance efficiency, the operational shortcomings and the underlying reaction mechanism of the process were expounded. The prospects and the limitations of the advances made in the quest for substitutes for the synthetic polyelectrolytes were also highlighted

© 2016 Elsevier B.V. All rights reserved.

Contents

1. Introduction	48
2. Polyelectrolytes	48
2.1. Cationic polyelectrolytes	48
2.2. Anionic polyelectrolytes	48
2.3. Nonionic polymers	49
2.4. Pectin	49
2.5. <i>Enteromorpha</i> polysaccharides	49
2.6. Tannin	50
2.7. Clay minerals	51
2.8. Gastropod shell	52
2.9. Starch	52
2.10. Psyllium husk	53
2.11. Plantain peelings ash extract	53
2.12. <i>Opuntia</i> species	54
2.13. <i>Ipomoea</i> seed gum	54
2.14. <i>Pistacia atlantica</i> (Baneh)	55
2.15. <i>Hibiscus rosa-sinensis</i> leaf extract	55
3. Sustainability, prospects and limitations of the quest	56
4. Conclusion	57
References	57

1. Introduction

In coagulation-flocculation (CF) based water treatment operations, coagulant aids (CA) are used, mainly to enhance the performance efficiency of the primary coagulant and to reduce the process economy. The use of CA helps to build stronger floc that settles faster, enhance floc formation in cold water system, reduce the dosage of the optimum primary coagulant and reduce the volume of sludge produced (Jessey and Sydney, 1971). Oladoja and Aliu (2008) posited that, the choice of materials to be used as CA depends solely on the physicochemical properties of the colloidal phase or the aqua matrix on which CF operation is to be performed. Premised on the operational requirements for CA in CF process, activated silica, weighting agents (e.g. bentonite clay, powdered limestone, and powdered silica) and polyelectrolytes or organic polymers (ionic and non-ionic polymers) are the commonly used CA. Amongst the aforementioned CA, the use of polyelectrolytes is usually preferred because of the dual role it serves; as primary coagulant and CA. It also possesses the features inherent in the other genre of CA.

In water treatment parlance, the term “polyelectrolytes” referred to a category of macromolecules that are classified, as cationic, anionic or nonionic. The classification is based on the electric charge that is present on the hydrolysis products of the macromolecule. Cationic polymers are frequently used as primary coagulants while anionic and nonionic polymers are used as CA (Bolto and Gregory, 2007). The fundamental operational mechanism of the polyelectrolytes, either as the primary coagulant or CA, occurs via destabilization of dissolved or particulate matters by bridging mechanism. Bridging mechanism occurs when segments of the polymer chain adsorb on more than one dissolved or particulate matters, thereby linking them together to form an easily settleable macro flocs (Fig. 1a) (Bolto and Gregory, 2007). Bolto (1995) and Yukselen and Gregory (2004) opined that the flocs produced from the bridging mechanism are stronger than those formed from particles destabilization by simple metal salt coagulants. Therefore, aggregates formed by polyelectrolytes are more resistant to breakage via hydrodynamic stress (Ray and Hogg, 1987). An overview of the role of polyelectrolytes in CF operation showed that they enhance floc settling rate, improve process economy, enhances the product water quality, and produced sludge with improved quality characteristics (Bolto, 1995; Yukselen and Gregory, 2004; Ray and Hogg, 1987).

2. Polyelectrolytes

In water industries, organic polymers have been utilized for at least four decades (Kawamura, 1991). They are mostly water-soluble linear polymers of very high molecular weights (MW) (Bolto, 1995). The group of these organic polymers that are charged, when hydrolyzed, are referred to as “polyelectrolytes” and they possess many

characteristic features of their own. Relative to the metal based coagulants, the use of organic polymers, as the primary coagulant or CA in water treatment procedures, is preferred because it requires lower optimum primary coagulant dose, smaller volume of sludge generation, minimal increase in the ionic load of the treated water, reduced level of residual aluminum in treated water, overall cost savings of up to 25–30% (Rout et al., 1999; Nozaic et al., 2001).

An overview of the genus of polyelectrolytes, as enunciated by Tripathy and Ranjan De (2006) and Bolto and Gregory (2007), is presented below:

2.1. Cationic polyelectrolytes

Tripathy and Ranjan De (2006) posited that cationic polyelectrolytes derived their properties from the density and distribution of positive charges along the skeletal framework and the chain conformation and solubility depend on the degree of hydrolysis in aqua medium. Oftentimes, these macromolecules possess quaternary ammonium groups, with formal positive charge, irrespective of the pH value of the aqueous phase. They are usually referred to as strong electrolyte polymers and examples include polydiallyldimethyl ammonium chloride, epichlorohydrin/dimethylamine polymers, cationic polyacrylamides etc. (Bolto and Gregory, 2007). Aside the strong electrolyte polymers, weak electrolyte polymers that acquire cationic properties in acidic pH range have also been listed by Bolto and Gregory (2007). Tripathy and Ranjan De (2006) have also delineated water-soluble polymers, containing cationic charge, into three categories thus: ammonium (including amines), sulfonium and phosphonium quaternaries.

Several biobased polymers, that characteristically contains cationic functional groups or whose skeletal framework are amenable to modifications, to produce cationic polymers, have also been highlighted by Bolto and Gregory (2007). The most prominent biobased polymer in this category is chitosan, a partially deacetylated chitin (Fig. 1b). Chitosan is a weak base polymer of medium molecular weight; whose charge density is pH dependent. Starch, a natural polysaccharide that consists of large number of glucose units, joined by glycosidic bonds, has been modified to produce an array of cationic spinoffs. Grafting synthetic polymers onto natural polymers (e.g. amylopectin, guar gum and glycogen) has produced retinue of cationic polymers, that have been reported to exhibit improved performance efficiency in water and wastewater treatment operations. Kraft lignin has also been modified, appropriately to produce lignin based cationic polymers (McKague, 1974).

2.2. Anionic polyelectrolytes

An overview of the chemistry of polyelectrolytes that are anionic in nature showed that the values of the monomer units that contribute to the charge and molecular weights are in the range of 1–100%. Several

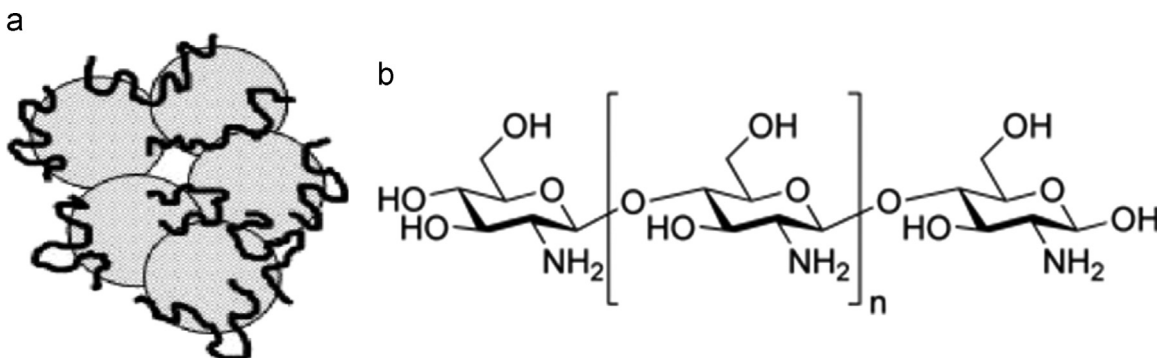


Fig. 1. (a) Schematic representation of coagulation through the bridging mechanism (Bolto and Gregory, 2007). (b) Chemical structure of Chitosan (i.e. D-glucosamine).

Download English Version:

<https://daneshyari.com/en/article/4434503>

Download Persian Version:

<https://daneshyari.com/article/4434503>

[Daneshyari.com](https://daneshyari.com)