Simple, efficient and eco-friendly solutions for water and wastewater treatment

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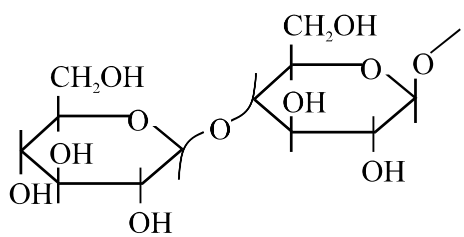
Water is our most exploited natural resource. Almost all sources around the world are polluted to some degree due to heavy influx of industrial effluents, domestic and agricultural wastes. These discharges vary from simple nutrients to highly toxic hazardous chemicals. Therefore removal of toxic substances from wastewater before they get into water sources is necessary to control and manage water sources. This imposes a lot of challenge to the research scientists.

Organic and inorganic adsorbents are used in treatment of water and industrial effluents. Polymeric flocculants, natural as well as synthetic, because of their natural inertness to pH changes, low dosage requirements, and ease of handling, have become popular in water and wastewater treatment. Organic polymeric flocculants have been used in water purification for several decades for their significant inherent advantages. The main advantages are; faster processing, lower content of insoluble solids, and a much smaller sludge volume.

Biodegradable polymers are naturally produced by all living organisms. They represent truly renewable resources. In the continuing search for suitable polymers as flocculants to supplement environmentally recalcitrant synthetic polymers, biodegradable polymers are a useful option since they have no adverse impact on human or environmental health.

Definitions:

Polysaccharides are naturally occurring carbohydrate polymers in which monosaccharride residues are linked directly through glycosidic linkage [1]. They are found in the plant, animal and microbial kingdoms.



Structure Indicating Glycosidic Linkage

Gums and mucilages are plant polysaccharides referred to as plant exudates. A gum is any material that swells or dissolves in water and exhibits gelling or adhesive characteristics. This wide-ranging term covers not only plant gums but also materials such as alginates, cellulose derivatives and modified starches. Historically the term mucilage was associated with seeds and gums. Mucilages were considered chemically different from gums containing D-glucoronic acid and mucilages, D-galacturonic acid. Now that some gums and mucilages have been found to contain both acids, this distinction is chemically untenable, but the custom of referring to seed mucilages rather than seed gums continues.

Flocculation is a simple and efficient treatment from an economical and technical point of view. Flocculation can be described as an agent-induced aggregation of particles suspended in liquid media into larger particles called ‘flocs’. This destabilizing of a stable colloidal dispersion is induced by addition of a chemical known as flocculant. It is capable of removing substantial portion of organic content, and colloidal and dissolved substances from effluents by sedimentation, filtration, flotation, or biological conversion.

Graft copolymers are branched molecules where the main chain is entirely made of one repeat unit and branch chains are made of yet another repeat unit.

Improvement in flocculating properties of the polymer

Natural polymers, mainly polysaccharides, act as good flocculating agents. They are cheap, fairly shear stable and easily produced from sustainable agricultural resources. The biodegradability of natural polymers reduces their self-life and needs to be suitably controlled. Thus many attempts have been made to combine the desirable properties of natural and synthetic polymers by grafting synthetic polymers onto the backbone of natural polymers. When synthetic polymers branches are grafted on to the rigid backbone of natural polysaccharides, the dangling grafted chains have easy access to contaminants in water and wastewater. Grafted polysaccharides provide efficient, shear stable and biodegradable flocculants.

Grafting techniques have received considerable attention from scientists all over the world, especially systems in which the monomer involved is a polysaccharide. This is probably due to their availability and low cost. Graft polymerization results in the formation of active sites at a point on the substrate polymer molecule. Most graft copolymers are formed by radical polymerization, ultraviolet or ionising radiation or redox initiation. Other methods can also be used to produce the polymer radicals that lead to graft copolymers.

Examples

Recently, numerous approaches have been studied for the development of cheaper and more effective flocculants containing natural polymers. Among these natural flocculants, polysaccharides deserve particular attention. These materials offer a better flocculant alternative because of their particular structure, physico-chemical characteristics, chemical stability, high reactivity and excellent selectivity towards aromatic compounds and metals, resulting from the presence of chemical reactive groups (hydroxyl, acetamido or amino functions) in polymer chains. [2]

Natural polysaccharides such as such as starches [3-5] and amylopectin, guargum, xanthangum sodium alginates [5, 6], kendu mucilage [7] find extensive application as flocculants. [2]. Food grade polysaccharides Okra, fenugreek, tamarind, psyllium and their grafted forms have been used for treatment of wastewater with very good pollutant removal capacity. [8-11] . Table below illustrates the efficiencies of some of the natural and modified polymers in water treatment.

Name of the polymer	Effluent used	Polymer dose (mg/L)	% removal of Suspended Solids (SS)	% removal of Total Dissolved Solids (TDS)
Psyllium	Textile	1.6	90	68
	Tannery	1.2	95	NA
	Sewage	1.2	87	NA
Psyllium grafted polyacrylamide	Textile	1.6	93	72
	Tannery	60	95	NA
	Sewage	60	89	NA
Psyllium grafted polyacrylonitrile	Textile	1.6	94	80
	Tannery	1.2	89	27
	Sewage	1.2	90.12	29.02
okra	Textile	0.8	98	37.5
	Tannery	0.04	95	69
	Sewage	1.2	86	NA
Fenugreek	Textile	0.04	94	44
Sodium Alginate	Textile	0.08	82	42
Sodium alginate grafted polyacrylamide	Textile	0.04	91	49
Tamarindus	Textile	10	60% of golden yellow dye	25% of scarlet Red dye

Table: Summary results application of the natural polymers and their grafted forms in water treatment

References:

1. Pigman, W. and Horton, D. eds. The Carbohydrates, 2nd ed., Academic press, Inc., New York, 1970.
2. Gregorio C. Recent Developments in polysaccharide based materials used as adsorbents in wastewater treatment. Progress Polym. 2005, Sci. 30(1), 38-70.
3. Chan, W.C; Chiang, C.Y. Flocculation of clay suspensions with water insoluble starch grafted acrylamide/sodium allylsuphonated copolymer powder. J. Appl. Polym. Sci. 1995, 58, 1721- 1726.
4. Khalil, M.I; Farag, S. Utilisation of some starch derivative in heavy metal ion removal. J. Appl. Polym. Sci. 1998, 69, 45-52.
5. Singh, R. P; Karmakar, G. P; Rath, S. K; Pandey, S. R; Tripathy, T; Panda J; Kanan, K; Jain, S. K; Lan N.T. Biodegradable drag reducing agents and flocculants based on polysaccharides, Polymer Eng. and Sci. 2000, 40(1), 46- 60

6. Samantaroy, S; Mohanty, A.K; Misra, M. Removal of hexavalent chromium using kendu mucilage. J. Appl. Polym. Sci. 1997, 66(8), 1485-1494.
7. Rajani, S; Agarwal, M; Vankar, P.S; Mishra, A. Synthesis, characterization and flocculation efficiency of sodium alginate –g - Polyacrylamide in textile waste water. Asian Textile Journal. 2002, 11(2-3), 48-52
8. Agarwal, M; Rajani, S; Mishra, A. Study on flocculation efficiency of okra mucilage in sewage wastewater. Macromol. Mat. Eng. 2001, 286(9), 560-563.
9. Rajani, S; Agarwal, M; Mishra, A. Plantago psyllium grafted polyacrylonitrile-synthesis, characterization and its use in suspended and dissolved solid removal from textile effluent. Water Qual. Res. J. Canada. 2002, 37(2), 371-378.
10. Rajani, S., Mishra, A., Okra (Hibiscus esculentus) and Fenugreek (Trigonella foenum graceum) mucilage: Characterisation and application as flocculants for textile effluent treatment, Chinese Journal of Polymer Science, 2008, 26 (6) 679-687.
11. Mishra, A; Bajpai, M. Flocculation behaviour of model textile wastewater treated with food grade polysaccharide. J. Hazard. Mat. 2005, B118, 213-217.