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USEBILITY OF HYDROGELS IN ADSORPTION TECHNOLOGHY FOR REMOVAL OF HEAVY METAL AND DYE

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Abstract: *Heavy metals and Dyes are very toxic and nonbiodegradable in waste waters to cause adverse health effects in human body and to induce irreversible pollution. Adsorption offers many potential advantages for removal of toxic heavy metals being flexibility in design and operation, high-quality treated effluent, reversible nature for multiple uses, and many commercially available adsorbent materials, such as activated carbon, zeolite, clay, sawdust, bark, biomass, lignin, chitosan and other polymer adsorbents. Compared to conventional adsorbent materials above, hydrogelbased adsorbents recently have attracted special attention to their highly potential for effective removal of heavy metals and dyes. Hydrogels are named "Hydrophilic Polymer" because of care for water. Hydrogels is not solved in water; however they have been swollen to their balance volume. Because of this swell behavior, they can adsorb big quantity of water in this structure. So they can term of "three sized polymers" due to protect their existing shape [9]. Hydrogels with porous structures and chemically-responsive functional groups, enable to readily capture metal ions and dyes from wastewater. Hydrogels with porous structures and chemically-responsive functional groups, enable to readily capture metal ions and dyes from wastewater. In adsorption applications, hydrogels are used in water purification, heavy metal/dying removing, controlled fertilizer released, ion exchange applications, chromatographic applications, dilute extractions, waste water treatments. This article general inform about usage of hydrogels in Dye and Heavy Metal adsorption.*

Key words: *Hydrogels, Adsorption, Waste Water, Dye, Heavy Metal*

1. INTRODUCTION

Hydrogels are named "Hydrophilic Polymer" because of care for water. Generally hydrogels is not solved in water; however they have been swollen to their balance volume. Because of this swell behavior, they can adsorb big quantity of water in this structure. So they can term of "three sized polymers" due to protect their existing shape [1]. Their cross linked bound structures are able to covalent or ionic and also one polymer which can for use of hydrogel polymer, must have hydrophilic groups such as carboxyl, carbonyl, amine and amide in main chains or side chains, and because of these groups water bound the polymer and polymer start to swell with rising volume and mass. Swell behavior of hydrogel is interested in quantity of hydrophilic groups [2] Polymer that has got the much more hydrophilic group has increased swell effect of polymer. Also hydrogel polymer has the soft and flexible properties because of having much more water. In figure 1 show that A is four function cross bounding, B is multi-function cross bounding, C and D are chain points, E is mixing chains, F is hooking of chain, G is cross bounding side chain, H is space of chain and Mc is molecule mass of two chain [3], [4].

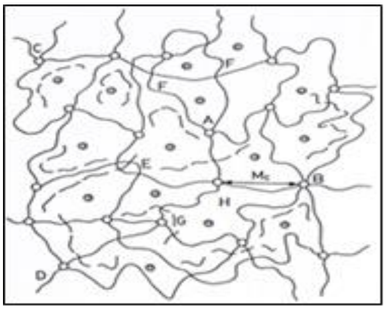

Fig.1: *Schematic View of Hydrogel [3].*

A polymer which has got the polar and hydrophilic function groups as –OH, -NH2,-COOH, -COOR, describe a hydrogel [5]. These groups are interacted with the water by the hydrogen bounding. Volume and mass of hydrogel polymer increase with this bounding water in hydrogel and gel start to swell. Also quantities of hydrophilic groups have raised the swell effect. Swell is characteristic feature of polymeric network structure and it is sudden change of volume in polymer. According to cross linked quantity, polymeric network can adsorb high quantity liquid without solved [6]. Swell feature of a polymeric gel is determined interaction of functional groups with each other and with diluent. Push and pull effect between chains, electrostatic interactions that are not covalent, Van der Waals; are not influenced from hydrogen bounding. Hydrophobic interactions are this type of physical cross linked interactions and this situation is affected of swell behavior [7].

2. ADSORPTION

Adsorption is the adhesion of atoms, ions, or molecules from a gas, liquid, or dissolved solid to a surface [8]. This process creates a film of the adsorbate on the surface of the adsorbent. This process differs from absorption, in which a fluid (the absorbate) is dissolved by or permeates a liquid or solid (the absorbent), respectively [9]. Adsorption is a surface-based process while absorption involves the whole volume of the material. The term sorption encompasses both processes, while desorption is the reverse of it. Adsorption process involves two components Adsorbent and Adsorbate. Adsorbent is the substance on the surface of which adsorption takes place.Adsorbate is the substance which is being adsorbed on the surface of adsorbent. Adsorbate gets adsorbed [10].

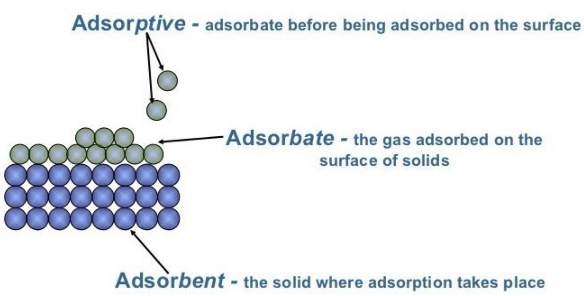

Fig.2: *Schematic View of Adsorption [11]*

The most common industrial adsorbents are activated carbon, silica gel, and alumina, because they present enormous surface areas per unit weight. Activated carbon is produced by roasting organic material to decompose it to granules of carbon - coconut shell, wood, and bone are common sources. Silica gel is a matrix of hydrated silicon dioxide. Alumina is mined or precipitated aluminum oxide and hydroxide. Although activated carbon is a magnificent material for adsorption, its black color persists and adds a grey tinge if even trace amounts are left after treatment; however filter materials with fine pores remove carbon quite well [12].

3. ADSORPTION APPLICATIONS WITH HYDROGELS

Adsorption, the binding of molecules or particles to a surface, must be distinguished from absorption, the filling of pores in a solid. In adsorption applications, hydrogels are used in water purification, heavy metal/dying removing, controlled fertilizer released, ion exchange applications, chromatographic applications, dilute extractions, waste water treatments.

3.1 Heavy metal adsorption by hydrogels

Xu, et al., made a research about a poly(sodium acrylate)–graphene oxide (PSA–GO) double network hydrogel adsorbent in order to remove Cd+2 and Mn+2 heavy metal ions from water solutions. The results of this research show that PSA-GO hydrogel polymer adsorbs 2383 mg/g Cr+2 and 165.5 mg/g Mn+2 heavy metal ions in pH6 and in 303 oK temperature. Also they found that this adsorbent kept high removal efficiencies of Cd+2 and Mn+2, indicating a good reusability after experiencing four cycles [13].

Bajpai and Johnson investigate poly (acrylamide-co-maleic acid) hydrogels for removing Cr+6 heavy metal ion and end of the research, was found that poly (acrylamide-co-maleic acid) hydrogels provide %72 Cr+6 removal (Fig. 3) [14].

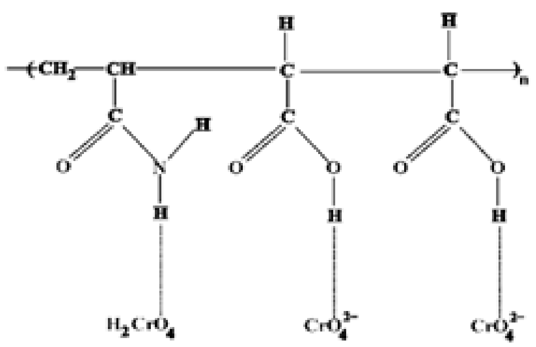

Fig. 3: *Interactions between chromium (VI) and hydrogel [14].*

In a research, the magnetic hydrogel sorbent was prepared with radiation-induced crosslinking polymerization of chitosan (CS), 2-acrylamido-glycolic acid (AMGA), and acrylic acid (AAc), which stabilized by magnetite (Fe3O4) as nanoparticles and this sorbet was used to isolate toxic heavy metal ions from the aqueous solution by the magnetic nanopolymers. The adsorption activity for heavy metals such as Cu+2 and Co+2 by nonmagnetic and magnetic hydrogels, Fe3O4/CS/ (AMGA-co-AAc), in terms of adsorption amount was studied. As a result of hydrogel networks with magnetic can effectively be used in the removal of heavy metal ions pollutants and provide advantageous over conventional ones [15].

Antic, et al., research in order to remove Cd+2 heavy metal ions from aqueous solution by novel hydrogels based on 2-hydroxyethyl acrylate (HEA) and itaconic acid (IA), P(HEA/IA) copolymers, were prepared by free radical cross-linking copolymerization. Desorption studies showed that hydrogel can be reused three times with only 15% loss of adsorption capacity. All results indicate that the sample with the highest IA content is the most promising adsorbent for Cd2+ removal [16].

Roy, et al., investigates the removal of Cr6+, Ni2+, Cu2+ , and Pb2+ by acrylic acid hydrogels. In this way the hydrogels prepared by redox polymerization of acrylic acid in the presence of polyethylene glycol diacrylate as the cross linker. The results show that this chelating hydrogel-bearing O, O donor groups exhibited high-metal sorption capacity of 41.1, 58.2, 43.1, and 81.2 mg/g for Cr6+, Ni2+, Cu2+, and Pb2+, respectively, under optimum conditions and also in desorption conditions sorbent could be used repeatedly for at least 10 cycles without any loss in chelating efficiency [17].

3.2 Dyestuff adsorption by hydrogels

Torun and Solpan studied about dye capacity of poly(N-vinylpyrrolidone-co-methacrylic acid) (P(VP/MAA)) hydrogels for cationic dye removal. In this way they prepared poly(N-vinylpyrrolidone-co-methacrylic acid) (P(VP/MAA)) hydrogel by gamma radiation and they prefer Janus Green B (JGB) and Magenta (M) cationic dyes. End of the research they found that P(VP/MAA) hydrogels may be successfully used in the purification of waste water containing certain textile dyes [18].

Bahram, et al., worked about removal of two azo dyes, methylene blue and methyl orange, from water using a synthesized hydrogel entitled poly (styrene-alt-maleic acid). For this purpose superabsorbent hydrogel poly (styrene-alt-maleic anhydride) was prepared through a thermally initiated free-radical polymerization of styrene and maleic anhydride. End of the research, they found that at the optimum conditions, 80-95 % of the mentioned dyes could be removed in less than 10 min and the synthesized hydrogel can use for the application in azo dyes removal from water [19].

Gupta, et al., was used 2-Hydroxyethylmethacrylate (HEMA), 2-Hydroxyethyl methacrylate–ethoxy ethyl methacrylate–methacrylic acid (HEMA–EEMA–MA), and Polyvinyl alcohol (PVA) as an adsorbent for the removal of two hazardous toxic azo dyes, being Malachite green (MG) and Congo red (CR). The adsorption affinity of MG onto HEMA–EEMA–MA is increased from 245 to 330 mg/g CR onto PVA 169-236 mg/g MG onto HEMA 130-205 mg/g CR onto HEMA–EEMA–MA 90-155 mg/g MG onto PVA 35-140 mg/g CR onto HEMA 17-57 mg/g, respectively [20].

Dhanapal and Subramanian used modified chitosan hydrogel as adsorbents for uptaking reactive blue 4 (RB4), arsenic (AsO_2^-) and mercury (Hg^{+2}) uptake and they found that the adsorption of hydrogel showed RB4 (701 mg/g), and the uptake of $AsO2^-$ (551 mg/g) and Hg^{+2} (455 mg/g) [21].

In another work, sulfonated graphene (SG) were incorporated into the poly (vinyl alcohol) (PVA) networks to fabricate the SG/PVA (SP) composite hydrogel. It was found that the SP hydrogel could be used as intelligent absorbent in selective adsorption and separation of the Methylene Blue (MB) and Malachite Green (MG) dye mixtures [22].

Lucic, M., used TiO2/hydrogel nanocomposite for investigation of photocatalytic degradation of three different groups of anionic azo dyes in aqueous solutions under solar light simulating source in order to evaluate its potential application for treatment of textile wastewaters. This TiO2/hydrogel based on chitosan, itaconic and methacrylic acid (monomers ratio Ch/IA/MAA = 1:1.56:10) was modified with synthetized 0.2 M colloidal TiO2 nanoparticles and

0.2 M commercial Degussa P-25. End of the research they found that TiO2 nanoparticles completely removed C.I. Acid Red 18, C.I. Acid Blue 113, C.I. Reactive Black 5 and C.I. Direct Blue 78, while removal degree of C.I. Reactive Yellow 17 was 55%. (Fig. 4) Also after four cycles TiO2/hydrogel nanocomposites could be reused without significant loses [23].

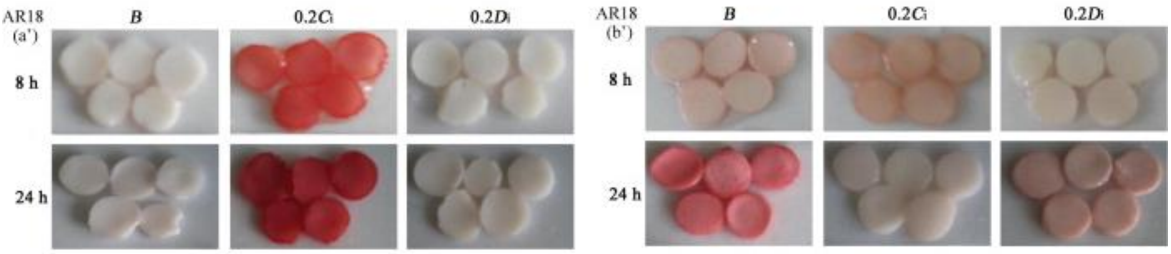

Fig. 4: After 8 h and 24 h; sample photographs of removal of dye by hydrogel [23].

5. CONCLUSIONS

Recently, many hydrogel based networks have been designed for different applications such as industry, environmental, medicine, healthy, etc.The favorable property of these hydrogels is either ability to swell when put in contact with an aqueous solution. The presented review demonstrates can be chosen in order to remove dye or heavy metal adsorption from waste waters. In this purpose loss of polymers and their combinations are utilised, and adsorption labours have made real according to target material which is wanted to adsorb.

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