



Synthesis and Characteristic of CMC/AM/PAC Polymer for Natural Organic Matter and Trihalomethanes Removal from Water



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A COMPOSITE Hydrogel of carboxymethyl cellulose/acrylamide/powdered activated carbon (CMC/AM/PAC) were prepared by γ -irradiation and characterized by spectroscopic and electron microscopic techniques. The effect of monomer concentration on the percentage of composite hydrogel formation was studied. The composite hydrogel content reached the maximum gel percentage at radiation dose of 25 kGy, the formed composite was used for removal of natural organic matter (NOM) from raw water. The (NOM) uptake increased by increasing the pH of the medium until reached a maximum value at (pH5). The increase in contact time led to increase of the amount of (NOM) adsorbed until the equilibrium was reached within for (CMC/AM/PAC) composite Hydrogel. The optimum adsorbent dose of 0.4 g/L for (CMC/AM/PAC) composite Hydrogel. The potential applications of the newly sorbents is extraction (NOM) from real samples from raw water from Nile Rosetta branch. Also, Trihalomethanes (THM's) produced as disinfection by-products (DBPs) formed from the reaction between chlorine and (NOM) were removed using the composite Hydrogel by a 1 minute rapid mix stage at 150 rpm followed by a 20 min flocculation stage at 40 rpm and a 30 min settlement period. Also, it is noticed that the prepared composite Hydrogel has the ability to remove NOM up to 66.8%.

Keywords: Composite Hydrogel, Removal of natural organic matter (NOM); Trihalomethanes; Water treatment

Introduction

Delivering safe drinking water to consumers is the main target of water treatment plants, and is achieved by passing water through the treatment train suitable for its quality. Disinfection of biological contaminants is a vital process in the water treatment train as it is the primary method to prevent or inactivate microbial infections leading to common waterborne diseases such as typhoid, cholera, dysentery and diarrhea in consumers [1]. Compared to conventional filtration units, disinfection processes such as chlorination units are considered more feasible and efficient

especially for large municipal water suppliers [2]. The first disinfection attempt in modern municipal water supply was in 1908 in New Jersey City, U.S.A, in which chlorine was introduced to public waters to mitigate sewage discharge from river communities' up-stream of the city's reservoir. As a result, causative agents of cholera and typhoid fever were efficiently removed, and the overall bacterial count was noticeably reduced. Since that time, chlorination has become widely accepted as a water disinfection technique [2]. However, increasing pollution rates of rivers from agricultural drainage, industrial discharge, and domestic sewage has often prompted the need to

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increase chlorine doses. The attempt to alleviate the contamination danger has unfortunately produced another problem, namely, the formation of potentially harmful disinfection by-products (DBPs) at increasingly higher concentration [1]. Accordingly, water utilities must strike a risk-based balance between vital protection against pathogen contamination and DBP production in treated Water. In this context, using alternatives to chlorine is a viable idea in developed countries, but in populous developing countries like Egypt, chlorine disinfection is the most popular, economical, and efficient method for drinking water [3]. Moreover, chlorine can help to stop the algal growth in coagulation tanks and filters; i.e. pre-chlorination. This is due to the ability of chlorine to disrupt essential enzymatic processes, which sterilize living organisms and prevent them from growth. One of which is the enzymatic action by triose phosphoric acid dehydrogenase, which make aquatic biota lose their ability of oxidizing glucose, which in turn deactivate their growth [4]. Pre-chlorination is also used to lower the pH of the raw water. Such lowering can help to improve the efficiency of the alum coagulant to form floc using weaker disinfectants like chloramine can decrease DBP levels, but often will not provide the finished water with the necessary level of residual protection. In the same context, water treatment facilities usually use post chlorination injection point after sand filtration. This could ensure the deactivation of all pathogens and water borne diseases escaping the filters and provide the sufficient residual protection from further contamination through distribution networks. However, chlorination should be added with caution, due to the health risks of its excess doses [5]. In modern water treatment practices the presence of NOM can negatively affect treated water quality and if incompletely removed, through the water distribution system. The presence of NOM, aside from the obvious taste and aesthetic issues, can impact water treatment. Removal of NOM in the coagulation stage can cause increased membrane fouling and increased filter backwashing and block activated carbon pores hindering the removal of taste and odor forming compounds [6].

Chlorination by-products are the chemicals formed when the chlorine used to kill disease-causing microorganisms reacts with naturally occurring organic matter (e.g. decay products of vegetation) in the water [7]. The most common chlorination byproducts found in

drinking water supplies are trihalomethanes (THMs). The principal (THMs) are chloroform, chlorodibromoethane bromodichloromethane, and bromoform. Other less common chlorination by-products include the haloacetonitriles and haloacetic acid (HAA).

Disinfectant by-products (DBPs) are probable carcinogens and short-term exposure can lead to headaches, dizziness as well as problems associated with the central nervous system. Recent studies have also linked (DBPs) to increased incidence of, neural tube birth defects, rectal and bladder cancer and miscarriage [8].

In the final disinfection stage, NOM not removed by previous treatment processes reacts with chlorine and produce (THMs) and (HAA). A continued reaction between free residual chlorine and NOM through the distribution system and a routine dosing of chlorine and strategic points within the distribution system can lead to higher DBP concentrations at consumer tap; NOM also supports microbial growth in the distribution system by acting as a food source. Humic acid (HA) is the major fraction of natural organic matter in water, which poses significant concerns to water utility and can interfere with several water treatment processes [9]. The proportion of humic substances in the total organic carbon content of ground and surface water may reach even 71.4 to 82.5%. Humic substances constitute a potential source of energy and carbon for microbes dwelling in domestic and municipal water as well as in water pipes. They may also be a source of water disinfection by-products, including chlorinated organic compounds like trichloromethane, chloroacetic acids and aldehydes posing a direct health threat to people drinking contaminated water. NOM, resulting from terrestrial and microbial sources in the environment, can cause biological instability of drinking water in distribution systems (re-growth). By-products formation after chemical disinfection, membrane fouling [10] and NOM often contributes to offensive taste and odors in potential drinking water sources and acts as a carrier for metals and various harmful organic chemicals.

Modern water treatment processes are utilized in order to create an adequate and continuous supply of water that is chemically, bacteriologically and aesthetically pleasing. A major challenge in water treatment is the efficient removal of NOM with typical removal efficiencies

varying from 20-90%; [11]. Poor removal can lead to NOM reacting with disinfectants to form potential carcinogens DBP such as THM and HAA [6]. Additionally, the presence of NOM post treatment can aid biofilm re-growth in distribution networks, leading to further potential health risks.

Therefore, one of the principal aims of the present investigation is the usage of composite Hydrogel based on carboxymethyl cellulose/acrylamide/powdered activated carbon (CMC/AM/PAC) for the removal of natural organic matter (NOM) and trihalomethanes from raw and drinking waters. The effect of pH, contact time and the optimum adsorbent doses were studied.

Several treatment processes can be significantly removed DBPs precursors. There are two methods for controlling DBPs in water. The first and most common strategy for controlling DBPs is removal of its precursors and use of alternative disinfectants such as enhanced coagulation, activated carbon adsorption, biologic treatment and Nano filtration [12]. The second, compliance, strategy is removing DBPs after formation which can prevent of the formation of THMs by several methods such as: membrane technology, air stripping and granular activated carbon [13]. Which technologies can prevent the formation of THMs are combination methods such as; ozone, monochloramines, hydrogen peroxide-ozone, UV-ozone and UV-hydrogen peroxide.

Recently, numerous approaches have been studied for the development of cheaper and more effective adsorbents containing natural polymers. Among these, polysaccharides such as chitin, Starch, cellulose and their derivatives chitosan, cyclodextrin and methyl car boxy cellulose deserve particular attention. These biopolymers represent an interesting and attractive alternative as adsorbents 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. Moreover, it is well known that polysaccharides which are abundant, renewable and biodegradable resources, have a capacity to associate by physical and chemical interactions with a wide variety of molecules Hence adsorption on polysaccharide derivatives can be a low-cost procedure of choice in water decontamination for extraction and separation of compounds, and a useful tool for protecting the

environment . Besides, the increasing number of publications on adsorption of toxic compounds by these natural polymers shows that there is a recent interest in the synthesis of new adsorbent materials containing polysaccharides.

Experimental

Materials

Water supply:

Raw water used was collected from El- Sheikh Zayed water treatment plant (conventional water treatment plant with capacity 86.000 m³/day) which consist of (circular coagulation basin with mechanical stirrer , rectangular flocculation basin, 4 clarifiers, 12 rectangular rapid sand filters, 2 great tanks and gases chlorine system with evaporator) .[22]

Powdered activated carbon (PAC):

Rice husk obtained from local rice mills was washed several times with bi-distilled water followed by filtration. In the first step, (carbonization), a 25 g of rice husk was heated gradually at the temperature rate (50 °C/15 min), in a stainless steel pipe (furnace tube) up to 500 °C. In the second step (activation), the temperature of the furnace tube was raised suddenly to 900 °C for 1 h. At this temperature the carbon dioxide was supplied from a gas cylinder at a constant flow rate. The product was cooled giving the desired pure PAC adsorbent. [23]

Carboxymethyl cellulose (CMC) and acrylamide (AM):

CMC and AM were purchased from sigma Aldrich, and of highest purity available used without further purifications.

Preparation of (CMC/AM/PAC) composite Hydrogel

1 g of carboxymethyl cellulose (CMC) was dissolved in 100 ml of distilled water contained 15 g of acrylamide (AM) and 0.25 g of powder activated carbon (PAC) which placed on water bath at 60 °C for 3 hours to form homogeneous mixture. The viscous solution was put in test tube and series of test tube exposed to γ - radiation by cobalt isotope (⁶⁰Co) at different radiation doses (10, 15, 20, 25 and 30 kGy). The formed (CMC/AM/PAC) composite Hydrogel gels were washed by hot water in order to eliminate the unreacted component, and dried in air at room temperature.

The gel content was calculated gravimetrically using the following formula:

$$\text{Gel content (\%)} = W_d \times 100 / W_o$$

Where W_d and W_o are the dried sample weights after and before extraction, respectively.

Determination of natural organic matter (NOM):

100 ml of test water was collected in amber glass bottle, 5ml of hexane was introduced and the bottle was shaken vigorously for 10 min and stand until the phase separation (approximately 20 min). The organic layers containing NOM and THM's were collected. NOM was determined using total organic carbon analyzer (TOC) (VarioToc cube) by high-temperature combustion technique according to procedure in standard methods for the examination of water and wastewater (AWWA) 22th Ed., 5310 B.[24]

Gas-liquid chromatograph-mass spectroscopy (GC-MS)

The extracted residue containing NOM was analyzed on gas chromatography with mass spectroscopy (GC-MS) (Varian 320 MS) with DB5-MS (30 m × 0.25 mm × 0.25 μm) silica gel capillary column. The mobile phase was helium with injector temperature 280 °C and injection type split/split less, under programmed heating condition from 40 to 300 °C with heating rate of 4°/min, according to the method of EPA 625 for organic chemical analysis of municipal and industrial wastewater.

The extracted residue of THM's was analyzed on gas chromatography (GC) (Agilent 7890A) with capillary column. The mobile phase was helium with injector temperature 280 °C and injection type split/split less according to procedure in standard methods for the examination of water and wastewater (AWWA) 22th Ed., 6232 B. Liquid-Liquid Extraction Gas Chromatographic Method.[24].

Adsorption Technic (Batch adsorption experiments)

The adsorption of organic matter by prepared composite hydrogel (CMC/AM/PAC) in batch mode sorption equilibrium experiments. All batch experiments were carried out in 250 mL glass-stoppered, Erlenmeyer flasks containing a fixed amount of adsorbent with 100 mL raw water at a known initial concentration. The flasks were agitated at a constant speed of 200 rpm for 2 h in an incubator shaker (Model Innova 42, New Brunswick Scientific, Canada) at 303 K. The influence of pH (2.0, 4.0, 5.0, 7.0, 9.0, 12.0), the optimum was 5 pH contact time (5, 10, 20, 30, 45,60,90 and 180 min the optimum was 45

min initial polymer concentration (0.2, 0.4, 0.6, 0.8,0.9,1.2,1.5,2.0 and 2.5) gm/l),the optimum was 0.4 g/l and temperature (298, 303, 303, 313 K) were evaluated during the present study. Samples were collected from the flasks at predetermined time intervals for analyzing and TOC, COD was measured and other parameters.[24]

Infrared Analysis Fourier Transfer Infrared Spectra (FTIR)

The functional groups of the synthesized copolymer were characterized by FTIR. FTIR spectra were recorded on Mattson 1000, Unicam infrared spectrophotometer, Cambridge, England in the range (400–4000cm⁻¹) using KBr pellets.

Scanning Electron Microscope (SEM)

In order to determine the morphological observation a cross section of samples put in liquid nitrogen and coated with gold before microscope testing (SME-5400 scanning electron microscope, JEOL, Tokyo, Japan

Results and Discussion

Effect of some parameters on synthesis of composite hydrogel

Gel content is defined as the amount of insoluble composite hydrogel in any solvent. Gel content measurement is an effective method for evaluating the degree of crosslinking of the composite hydrogel composite Hydrogel. The stability of the prepared composite against dissolution in hot water is simply known as gelation degree. The gel content is affected by several factors such as radiation dose and monomer concentration.

Radiation dose

Figure 1 represent the percentage of gel formed at different radiation doses. It was found that the gel percentage increased by increasing the radiation doses to maximum at 25 kGy and decreased. This means the optimum irradiation dose for the preparation of (CMC/AM/PAC) composite Hydrogel is 25 kGy. The γ-irradiation has two opposite effects the crosslinking effect and the degradation effect. The increase in the gel percent with the radiation dose due to the increase in the number of free radicals formed and thus an increase in the gel percent. At higher irradiation dose (> 25 kGy) the rate of radiation degradation may be higher than the rate of radiation crosslinking, as a result, the gel percent decreased at high irradiation dose.

Effect of (AM) monomer content on the gel percent

The initial monomer concentration used in the gel preparation highly impressed the network structure and the gel properties. The properties of composite Hydrogel are governed by the monomer content in the reaction mixtures. The effect of AM content on the gel percent of (CMC/PAC/AM) composite Hydrogel was studied and shown in Figure (2) which shows that as the (AM) content in the (CMC/ AM/ PAC) composite hydrogel was increased to 15%, the gel percent of the composite Hydrogel increased. When aqueous solution of (CMC/AM/PAC) was exposed to radiation with γ -rays, free radicals are generated which lead to formation of crosslinking composite hydrogel of the monomer-composite hydrogel mixture. As the monomer concentration is increased, effective density of crosslinks also increased resulting in a significant improvement in the degree of gelation. Meanwhile, the increase in the gelation degree as a result of the increase in the

reactants concentration could be referred to increase the viscosity of reaction medium as well as the increase in the number of the reactive vinyl groups [14]. This behavior was observed for (CMC/AM/PAC) composite Hydrogel as shown in Figure (2). The gelation percent of (CMC/AM/PAC) composite Hydrogel varies from (62.29, 78.5 to 81.95 %). For the increase in the concentration of (AM) in the feed solution from (5%, 10% to 20%) of the total monomer/composite hydrogel concentration at γ -irradiation dose (20 kGy). This may be explained on the formation of a complex by the temporary physical cross-linking hydrogen bonding between the (CMC), (PAC) and (AM) pendant groups. On the other hand, incorporation of AM in the composite hydrogel reduces the crosslink density as well as the gelation percent. During this process, presence of (AM) reduces crosslinking density by scavenging (OH/H) radicals and probably physically screening the approach of radical sites that form crosslinks. [15].

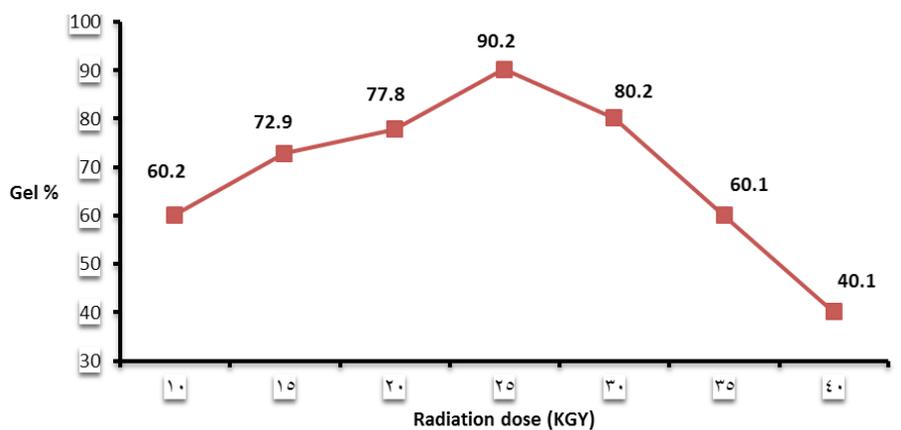


Fig. 1. Effect of γ - radiation dose on the gel percent of (CMC/AM/PAC) composite Hydrogel.

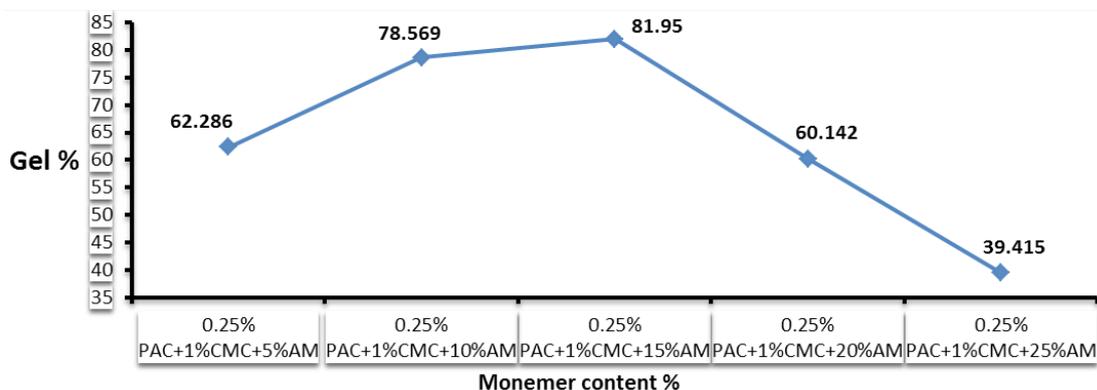


Fig. 2. Effect of (AM) content on the gel percent of (CMC/AM/PAC) composite Hydrogel at γ -irradiation dose (25 kGy) and (1% CMC) and 0.25% PAC concentration.

Effect of (CMC) concentration on the gel percent of (CMC/AM/PAC) composite Hydrogel

The effect of (CMC) content on the gel percent of (CMC/AM/PAC) composite Hydrogel at γ -irradiation dose (25 k Gy) and (15% AM) and 0.25% PAC Concentration was investigated and shown in Figure (3). It can be observed that as the radiation dose was increased the gel percent of the composite hydrogel decreased. Since (CMC) is a radiation degradable composite Hydrogel, (CMC) molecule degrades to low molecular weight that causes the reduction of the gel percent of (CMC / AM/PAC) composite hydrogel. It can be also observed that at the same irradiation dose as the (CMC) content is increased to 1% the gel percent of the composite hydrogel is decreased. This means that the gel percent is inversely proportional to the (CMC) content in the composite hydrogel. This observation may be based on the viscosity of composite hydrogel, as the (CMC) concentration increased the viscosity also increased as well as a small number of monomer

radicals can diffuse onto the (CMC) backbone and the crosslink intensity decreased resulted in a decrease in the gel percent.

Effect of (PAC) concentration on the gel percent of (PAC/CMC/AM) composite hydrogel

The effect of (PAC) content on the gel percent of (CMC/AM/PAC) composite hydrogel at γ -irradiation dose (25 kGy) and (15% AM) and 1.0% CMC concentration was investigated and shown in Figure (4). It can be also observed that at the same irradiation dose as the (PAC) content is increased the gel percent of the composite hydrogel is increased. This means that the gel percent is directly proportional to the (PAC) content in the composite hydrogel. This observation may be based on the viscosity of composite hydrogel, as the (PAC) concentration increased the viscosity also increased as well as a small number of monomer radicals can diffuse onto the (PAC) backbone and the crosslink intensity increased resulted in an increasing in the gel percent.

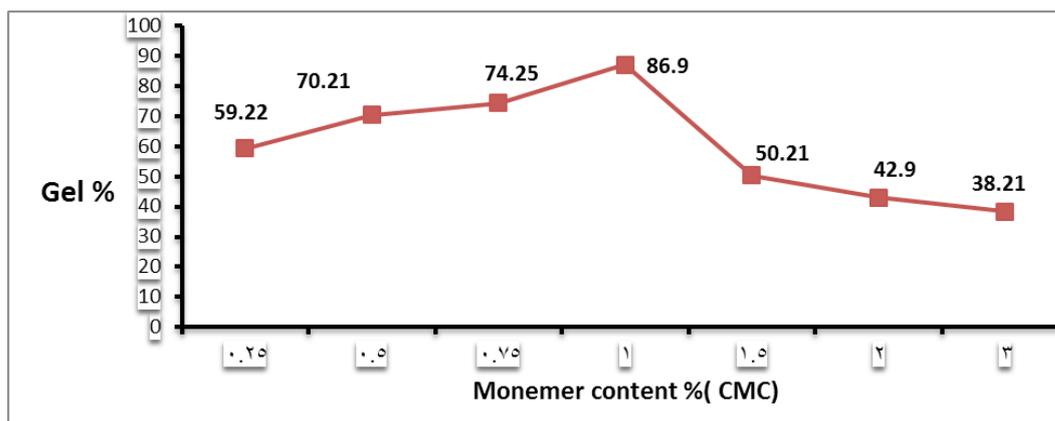


Fig. 3. Effect of (CMC) content on the gel percent of (CMC/AM/PAC) composite hydrogel at γ -irradiation dose (25 kGy) and (15% AM) and 0.25% PAC concentration).

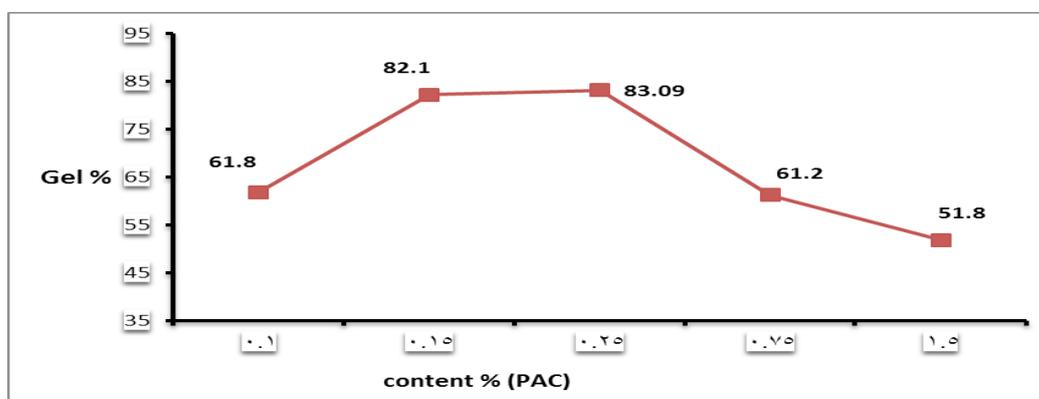


Fig. 4. Effect of (PAC) content on the gel percent of (CMC/AM/PAC) composite hydrogel at γ -irradiation dose (25 kGy) and (15% AM) and 1.0% CMC concentration).

From these results, it is clear that the higher gel percentage of (CMC/AM/PAC) at 1% CMC, 0.25% PAC, and 15% Am and 25 KGY. Therefore, this concentration was used for all the removal studies.

Characterization synthesized composite hydrogel:

Fourier transfer infrared spectra (FTIR)

The FTIR spectrum of (CMC/AM/PAC) composite hydrogel in Figure (5) show a wide transmittance band at 3437 cm^{-1} assigned to the O-H stretching mode of hydroxyl groups and absorbed water. Also, there are absorption bands at 2942 and 2853 cm^{-1} due to aliphatic C-H stretching vibration. The spectrum also shows a strong band at $1600\text{--}1580\text{ cm}^{-1}$ due to C-C vibrations in aromatic rings. The peak at 1185 cm^{-1} may also assigned to the stretching mode of hydrogen bond to O-C stretching vibrations in P-O-C (aromatic) linkage and to P,OOH, [16].

Scanning electron microscope (SEM)

SEM has been a primary tool for characterizing the surface morphology and fundamental physical properties of an adsorbent surface. It can be used to determine the particle shape, porosity, and appropriate size distribution of an adsorbent. Figure (6) shows the surface morphology of (AM), (CMC), (PAC) and (CMC/AM/PAC) as a blank demonstrates a coarse surface with spots and some porous structure. There are numerous carboxylate anions in the composite hydrogel surfaces and inner structures. The electrostatic repulsions among the carboxylate anions can result in the expansion of the composite hydrogel

s network and increasing the pores size. It can be noted that, the introduction of (AM), (CMC) and (PAC) monomer, in (CMC/AM/PAC) composite hydrogel leads to change in the hydrogel surface. The surface appears as a tough surface with continuous and uniform morphology [17].

There are three factors optimize the removal process of (NOM) from the water treatment plants pH, the contact time, and adsorbent dose.

Effect of pH

The pH plays an important role in the removal mechanism. The effect of pH on the removal of (NOM) was studied in the range from 2 to 12. Figure (7) shows the effect of pH on the adsorption of (NOM) by (CMC/AM/PAC). It can be observed that the (NOM) adsorption increased by increasing the pH of the medium until reached a maximum value at pH 5 and above this value a drop in the removal percent was observed. The results suggested that the change in the pH value of the medium resulted in a remarkable change in the amount of adsorption capacity of (NOM); this means the chelating properties of the functional groups of prepared composite hydrogel are affected by pH. At lower pH values the carboxylic groups are both easily protonated lead to the low removal percent. At higher pH conditions, the protonated functional groups would be deprotonated. The maximum removal of (NOM) was achieved at pH 5 although AM the amide group is nonionized group but the hydrolysis increase with increasing the pH value.

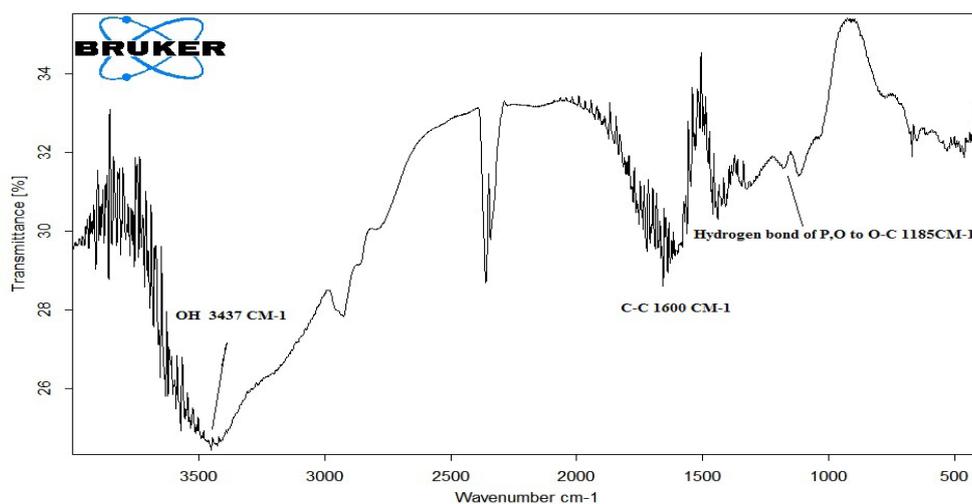


Fig.5. FT-IR spectra of (CMC/AM/PAC) composite hydrogel

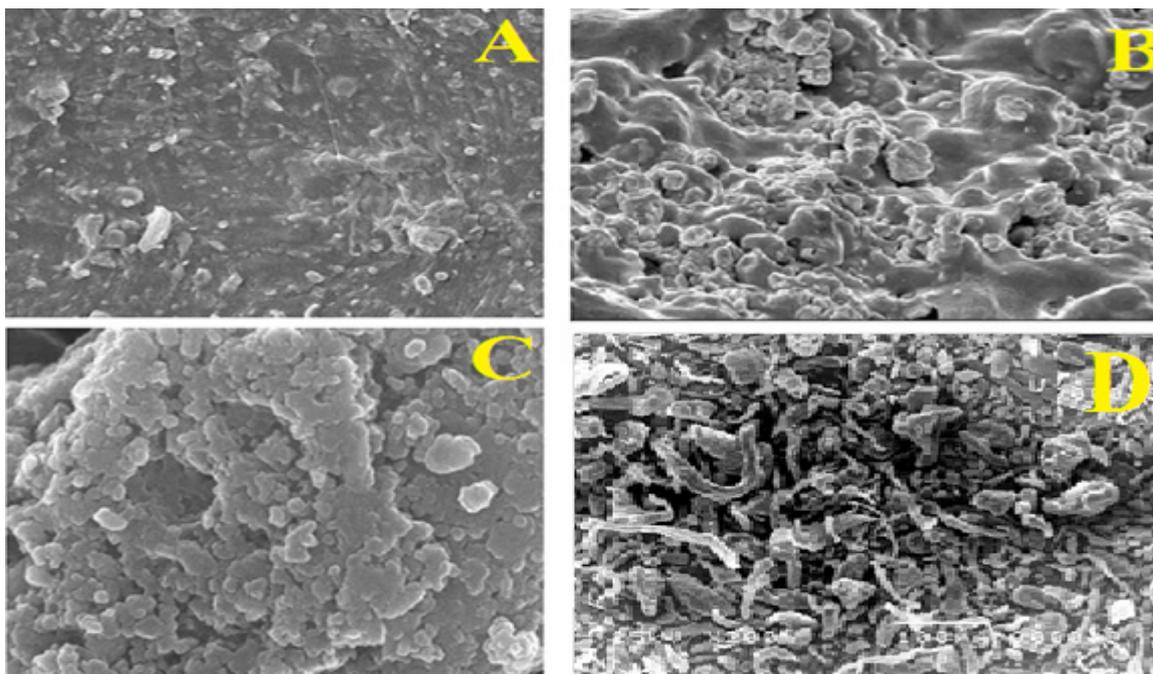


Fig.6. SEM images of: (PAC)(A), (AM)(B) of, (CMC) (C) and (CMC/AM/PAC)(D).

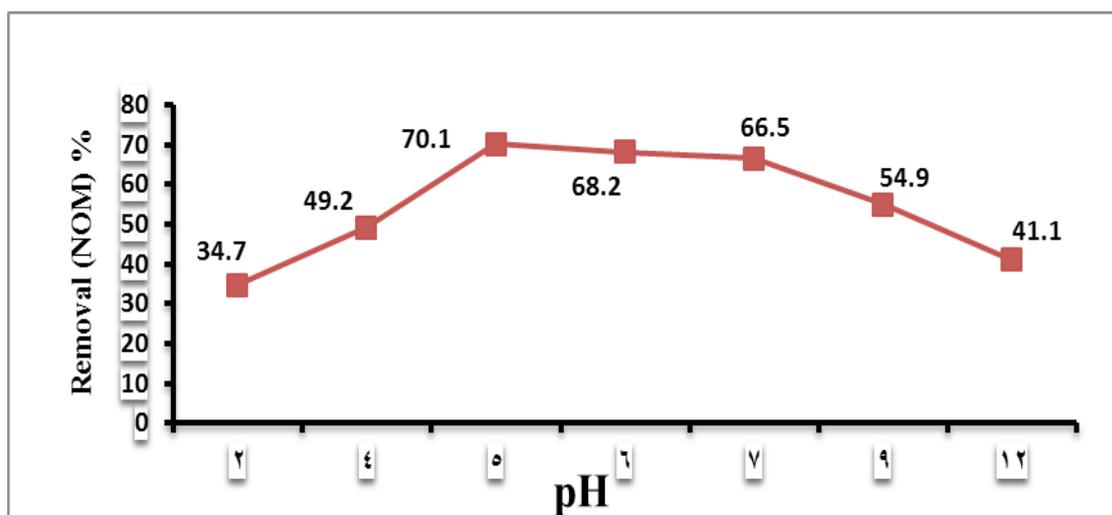


Fig. 7. Effect of pH on the removal percent of NOM by (CMC/AM/PAC) at contact time 45 min composite dose 0.4 g/l

Effect of contact time

Contact time is an important parameter because this factor can reflect the adsorption kinetics of an adsorbent for a given initial adsorbent concentration. The adsorption process consists of several steps: initially the (NOM) ions molecules migrate from the bulk solution to the composite hydrogel surface (bulk diffusion); the molecules diffuse through the boundary layer to the surface

of the material (film diffusion); then, the (NOM) ions diffuses from the surface to the interior of the particle (pore diffusion); and finally the molecule reacts with an active site on the material surface (chemical reaction). Figure (8) shows the effect of contact time on the adsorption of (NOM) ions by (PAC/CMC/AM), the equilibrium is reached within 45 min [17].

Effect of adsorbent dosage

Study the influence of adsorbent dosage gives an idea of the effectiveness of an adsorbent and the ability of ions to be adsorbed with a minimum dosage that is an economical point of view [18]. The effect of adsorbent dose on the removal of (NOM) ions were studied by varying the dosage of different composite hydrogel s from (0.1 g/L to 2 g/L) and the corresponding results are shown in Figure (9) a drop in removal percent was observed above these values. With increasing the adsorbent dosage, more surface area are available for adsorption owing to the increase in active sites on the surface of composite hydrogel s and

thus giving easier penetration of adsorb ate to adsorption sites but further increase in the amount of the adsorbent does not cause any considerable change in the adsorption yield. This is due to the establishment of the equilibrium between the (NOM) molecules on the adsorbent and in the solution was occurred [19]. Besides, higher adsorbent amount enhances the probability of collision between solid particles and therefore creates particle aggregation, causing a decrease in the total surface area and an increase in diffusion path length, both of which contribute to a decrease in the adsorption capacity of (NOM) [20].

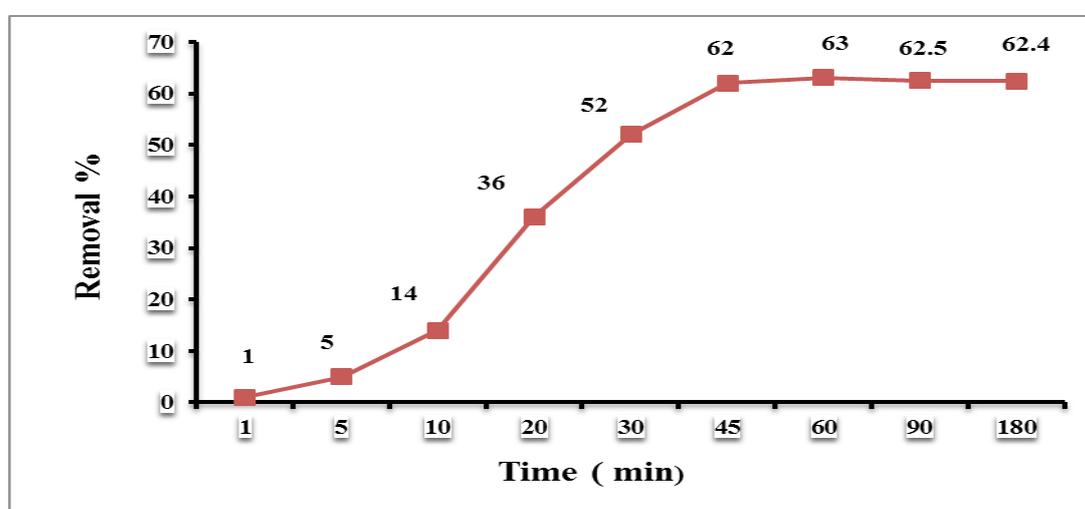


Fig. 8. Effect of time on the removal percent of NOM by (CMC/AM/PAC) composite hydrogel at pH 5

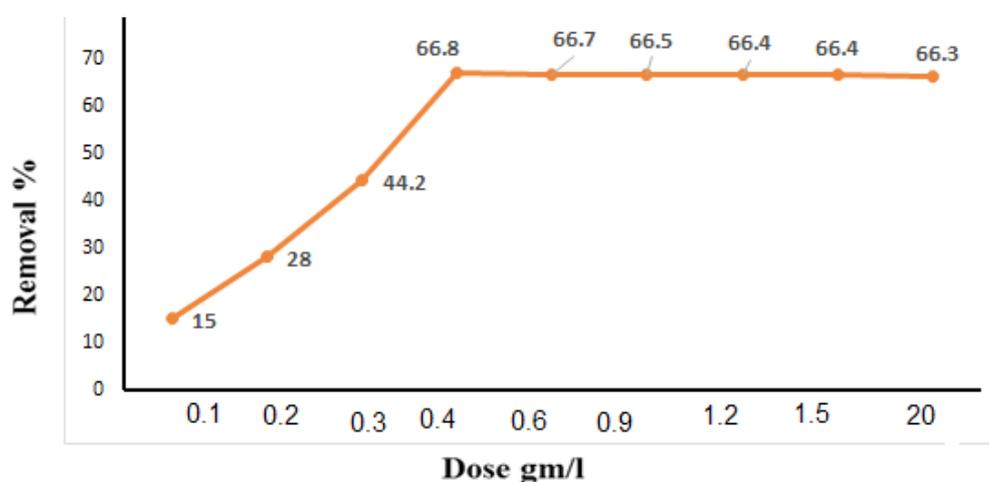


Fig. 9. Effect of (CMC/AM/PAC) composite hydrogel dose on the removal percent of (NOM) at pH5 and contact time 45 min.

Efficiency of composite hydrogel in (NOM) and (THM'S) removal from water

Removal of (NOM) of treated water from EL-Mahmoudia plant using (CMC/AM/PAC) composite hydrogel

Every day there are 8 million m³ of waste and industrial water are discharge in the Nile Branch Rashid which is mixed with 20 million m³ of raw water but in the winter closure period about 8 million m³ of waste and industrial water are discharge in the Nile Rosetta branch which is mixed with 5 million m³ of raw water [21].

El-Mahmoudia water treatment plant is a traditional treatment plant located in Behera, Egypt and produces 86.000 m³/day of treated

water. Fig. 10 represents comparison studies between different adsorbent materials for the removal of NOM in raw water. It was found that (CMC/AM/PAC) composite hydrogel process high efficiency than the other materials.

Table (1) summarizes the compounds obtained after each process of treatment. There are approximately ten compounds of NOM before treatment with chlorine. These compounds were reduced to two after the treatment with combined chlorine 3.2mg/l without Alum and also two after the treatment with Alum dose 60 mg/l without chlorine and to six compounds after treatment with CMC/AM/PAC composite hydrogel.

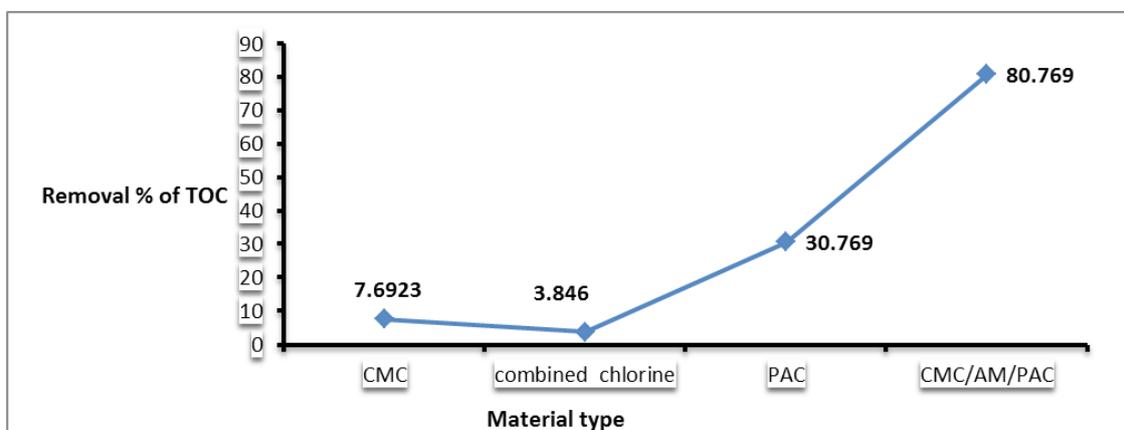


Fig. 10. Comparison between different adsorbent materials for the removal of NOM at pH5 and contact time 45 mint and the same doses 0.4 g/l.

TABLE 1. NOM compounds of raw and treated raw waters

NOM compounds in raw water	NOM compounds in raw removed by combined chlorine 3.2 mg/l	NOM compounds in sample removed by Alum dose 60 mg/l without chlorine	NOM compounds in raw water removed by (CMC/AM/PAC) composite hydrogel
1. Phenol			1. Phenol
2. Bis (2-chloroisopropyl) ethane			2. Bis (2-chloroisopropyl) ethane
3. Phenol , 2 ,4 – dimethyle-			3. Phenol , 2 ,4 – dimethyle
4. Methane , bis (2 – chloroethane)			4. Methane , bis (2 – chloroethane)
5. Naphthalene	1. Phenanthrene	1. Phenanthrene	5. Phenanthrene
6. Diethyl phthalate	2. Anthracene	2. Anthracene	6. Anthracene
7. Phenanthrene			
8. Anthracene			
9. Dibutyl phthalate			
10. Bis (2 – ethylhexyl) phthalate			

Removal of Trihalomethanes (THM's) from treated water from EL-Mahmoudia plant using (CMC/AM/PAC) composite hydrogel

Concern with chlorinated water is the tendency to form disinfection by-products, particularly trihalomethanes (THM's). Chlorination by-products (THM) are the chemicals formed when the chlorine used to kill disease-causing microorganisms reacts with naturally occurring organic matter (e.g. decay products of vegetation) in the water [7]. The most common chlorination byproducts found in drinking water supplies are the trihalomethanes (THM's). The principal (THM's) are chloroform, bromodichloromethane, and chlorodibromoethane. Other less common chlorination byproducts include the haloacetic acids and haloacetonitriles. Generally, this is a concern with surface water supplies, since ground water tends to be free of the chemical that react with chlorine to produce (THM's) [21]. (THM's) by reacting with organic matter that may cause cancer (chlorine itself does not appear to be a carcinogen).

The (THM's) compounds have been found in most chlorinated water supplies in the world; typically they are produced in the treatment process as a result of chlorination. The formation of these compounds is a function of precursor concentration, contact time, chlorine dose, and pH. Toxicological studies suggest that chloroform is a potential human carcinogen. Consequently, total trihalomethanes are being regulated in potable waters. Chlorinated organic solvents are found in many raw waters because of industrial contamination. In Table (2) there is no any concentration of (THM'S) was detected in the solvent which used in the extraction of samples which was measured on the gas chromatography. As shown in table (2) there is no any concentration of (THM'S)

was detected in the raw water which inters EL-Mahmoudia water plant to be treated. It is observed that the sample which treated by high combined chlorine the concentration of is **170.64** $\mu\text{ml/L}$ (THM'S) which is upper the limits of world health organization (WHO), while the treated water sample by the (CMC/AM/PAC) composite hydrogel as in In table (2) before addition of chlorine there is no (THM's) found. It can be concluded that the prepared hydrogels can be added as a primary step in the treatment whatever a decrease in the chlorine amount used in the treatment. This means a reducing in the probability of (THM's) formation as in the Table (2).

Conclusion

(CMC/AM/PAC) composite hydrogel prepared by γ -irradiation and used for the removal of (NOM) from raw water. The most important conclusions of this investigation are the following:

- 1- The composite hydrogel content increased with increasing the monomer (AM) content in the hydrogel and the maximum gel percent was obtained at radiation dose of 25 kGy.
- 2- The (NOM) uptake increased by increasing the pH of the medium until reached a maximum value at (pH 5)
- 3- The increase in contact time led to increase the amount of (NOM) adsorbed until the equilibrium was reached within for (CMC/AM/PAC) composite hydrogel.
- 4- The optimum adsorbent dose of 0.4 g/L for (CMC/AM/PAC) composite hydrogel.
- 5- Addition of composite for a 1 minute at 150 rpm followed by a 20 min flocculation stage at 40 rpm and a 45 min settlement period has the ability to remove NOM up to 66.8%.

TABLE 2. THM's compounds of raw and treated raw waters

Parameter	Raw water	Solvent N. Hexane	Treated water with CMC/AM/PAC composite hydrogel	Treated water with chlorine
Trihalomethanes(THM'S) $\mu\text{ml/L}$	ND	ND	ND	170,64

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ازالة المواد العضوية الطبيعية والترابي هالوميثان من محطات مياه الشرب بواسطة بوليمر معدل

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تم تحضير الهيدروجل المكون من كاربوكسي ميثيل سيليلوز و اكريلاميد و كربون نشط بواسطة اشعة جاما وتم توصيفة بواسطة الميكروسكوب الالكتروني الماسح ومطياف الاشعة تحت الحمراء وتم دراسة تأثير تركيزات مختلفة من المونيمرات علي الهيدروجل المحضر. وجد ان الجرعة الاشعاعية ٢٥ ك/جراي هي الجرعة المثلي وتم دراسة قدرة الهيدروجل المحضر علي ازالة المواد العضوية الطبيعية من المياه الخام (ماخذ محطة مياه المحمودية الجديدة الواقعة علي فرع النيل رشيد بمحافظة البحيرة) ووجدت ان الجرعة المثلي من الهيدروجل المحضر هي ٠,٤ جم/لتر كما تم دراسة تأثير الهيدروجل المحضر علي تقليل تركيز الهالوميثان الناتج من عملية التطهير بالكور كاحد نواتج التفاعل بين الكلور الحر والمواد العضوية الطبيعية. اثبت الهيدروجل المحضر نجاحه في ازالة الواد العضوية الطبيعية بنسبة ٦٦,٨٪.