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Removal of Pb(II), Ni(II) and Cu(II) metal ions from industrial wastewater by nanocomposite hydrogel base starch

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Abstract

In this paper, nanocomposite hydrogel was synthesized by copolymerization of acrylamide with starch by using potassium persulfate (KPS) as free radical initiator, methylenbisacrylamid (MBA) as cross linker and nano hematite(nano Fe_2O_3). The nanocomposite hydrogel structure was confirmed by fourier transform infrared spectroscopy (FTIR) and scanning electron microscopy (SEM). Then nanocomposite hydrogel synthesized was used to remove of Pb(II) and Ni(II) metal ions from industrial wastewater and effect pH was investigated on absorbtion metals.

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Introduction

Lead can enter (drinking) water through corrosion of pipes. This is more likely to happen when the water is slightly acidic. That is why public water treatment systems are now required to carry out pH-adjustments in water that will serve drinking purposes.

For as far as we know, lead fulfils no essential function in the human body, it can merely do harm after uptake from food, air or water(Schwarzenbach *et al., 2010*). Lead can cause several unwanted effects, such as: disruption of the biosynthesis of haemoglobin and anaemia, a rise in blood pressure, kidney damage, miscarriages and subtle abortions, disruption of nervous systems, brain damage, declined fertility of men through sperm damage, diminished learning abilities of children, behavioural disruptions of children, such as aggression, impulsive behavior and hyperactivity (Fujita *et al., 2014*). Lead is a particularly dangerous chemical, as it can accumulate in individual organisms, but also in entire food chains. For more effects on freshwater ecosystem take a look at lead in freshwater(Al-Musharsfi *et al., 2013*). Humans may be exposed to nickel by breathing air, drinking water, eating food or smoking cigarettes. Skin contact with nickel-contaminated soil or water may also result in nickel exposure. In small quantities nickel is essential, but when the uptake is too high it can be a danger to human health. An uptake of too large quantities of nickel has the following consequences: Higher chances of development of lung cancer, nose cancer, larynx cancer and prostate cancer, sickness and dizziness after exposure to nickel gas, lung embolism, respiratory failure, birth defects, asthma and chronic bronchitis, allergic reactions such as skin rashes, mainly from jewelry, heart disorders (Naser, 2013). Copper is a very common substance that occurs naturally in the environment and spreads through the environment through natural phenomena. Humans widely use copper. For instance it is applied in the industries and in agriculture. The production of copper has lifted over the last decades. Due to this, copper quantities in the environment have increased. Various methods for removing heavy metals and compounds out of the environment, including industrial effluents are the major chemical methods; ion exchange and reverse osmosis are methods. Hydrogels are hydrophobic polymer networks that influence and ability to hold large amounts of water and aqueous solutions even under stress. The compounds are sensitive of environmental conditions such as pH, temperature and ionic strength solutions. Some limitations are due; in order to enhance the thermal and mechanical properties of hydrogels can be made of nanocomposite materials. Nanometer-scale particles such as clay soil as fillers and reinforcing materials added to the hydrogel and were prepared nanocomposite hydrogels. Nanocomposites are achieved interaction with the active site of mineral powders and nano particles, natural polymers and monomers, hydrogel. Due to the presence of clay and nano particles in the nanocomposite structure, thermal stability of these materials is better than the pure polymer. Refers to clay particles exiting gaseous material resulting from polymer degradation are prevented, resulting is observed in less weight loss than the pure polymer(Kasgoz *et al., 2008*). In this research, nanocomposite hydrogel was synthesized via grafting of acrylamide on starch and used nano hematite, methylenebisacrylamide (MBA) as acrosslinking agent and potassiom persulfate (KPS) as initiator. Then, nanocomposite hydrogel synthesis has been holes for trap metal ions and was used to remove heavy metal from industrial wastewater.

Experimental

Material and methods

Starch (Merck) was used as received. Acrylamide (AAm, Merck), Potassiom persulfate (KPS, Merck) was used without purification. Methylene bisacrylamide (MBA, Fluka), and nano hematite from company nano pasargad novin was used. FTIR model Bommem MB, SEM model M-XL 30 Philips instrument and absorption model SHIMATZO AA-680.

Nanocomposite hydrogel Synthesis

Amounts of starch (0.35 g) were added to reactor equipped with a mechanical stirrer (600 rpm), including 30 mL doubly distilled water. The reactor was placed in a thermo stated water bath to control the reaction temperature at 70ºC. After complete dissolution of pectin, amounts of nano hematite (0.08 g) were added to the solution and allowed to stir for 10 min. Then, KPS initiator (0.02 g, dissolved in 5mL water) was added to the reaction mixture and the mixture was stirred for 10 min. MBA (0.04 g, dissolved in 5mL water) and AAm (2.5 g) were poured into the reactor. All of the reactions were carried out at 70ºC under an argon gas atmosphere and the reaction mixture was continuously stirred (300 rpm) for 1 h. At the end of the reaction, were poured into the reactor and the gel product was poured in ethanol (200 mL) and allowed to dewater for 24 h. Then, the product was filtered and washed with 200 mL ethanol. The filtered product was dried in an oven at 40ºC for 2 day. After grinding, the powdered nanocomposite hydrogel was stored away from moisture, heat, and light(Weian *et al., 2005*).

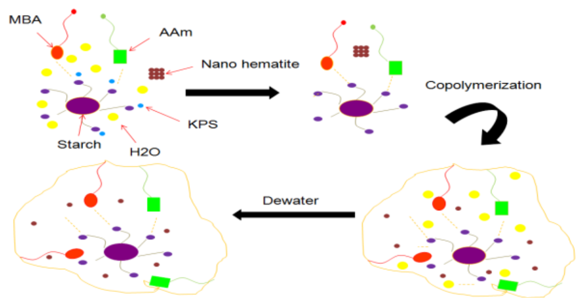


Fig.1. Pereperation of nanocomposite hydrogel.

Measurement of absorption and desorption of metals in use the nanocomposite hydrogel

To absorb Pb(II), Ni(II) and Cu(II)metal ions by nanocomposite hydrogel after clearing of the wastewater effluent reviewed 50 cc and added to 1.0 g of nanocomposite hydrogel. After 48 hours away from light and stored in a closed bottle then filtered and the filter absorption solution investigated and then with 20 ml of nitric acid wash 25% until desorption take place. Then filter solution absorption by atomic absorption(Ozay *et al., 2009*; Wang *et al,. 2013*).

Result and discussion

Spectral properties

In spectrum of the starch; –OH groups show absorption bands at 3406 cm^{-1}. The spectrum of the nanocomposite hydrogel peak 1650 cm^{-1} corresponding to the stretching vibration peak of C=O group of the amide bond, spectrum infrared wavelengths below (≤800cm^{-1}) bonds Fe-O show.

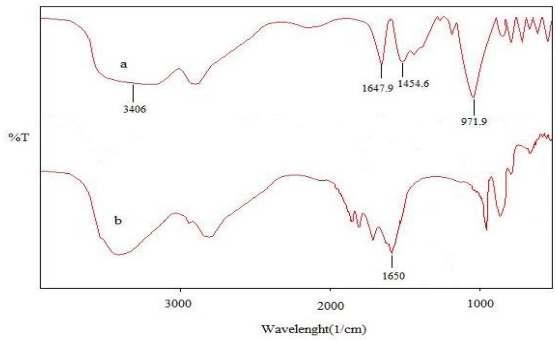
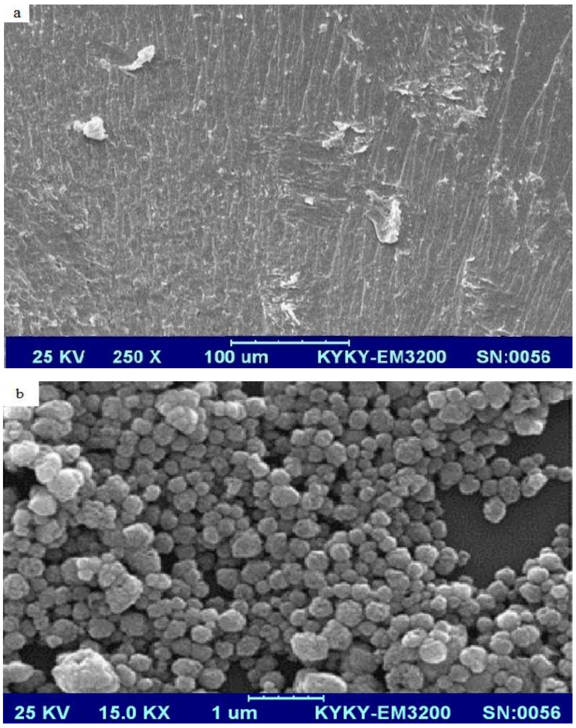


Fig. 2. FT-IR spectra of a) starch, b) nanocomposite hydrogel.

Morphology of the synthesized nanocomposite hydrogel

As we can see, nanocomposite hydrogel structure has many pores can be connected to each other.



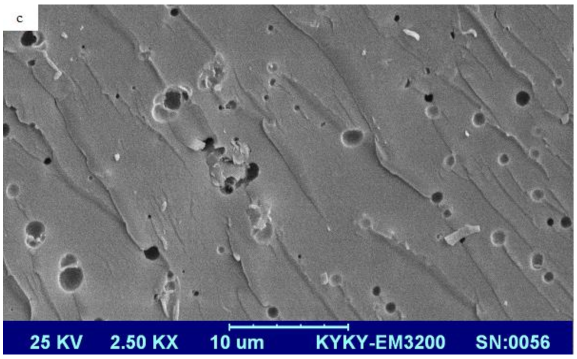


Fig.3. Morphology of a) starch, b) nano hematite, and c) nanocompositehydrogel.

Effect pH

The results of the effect of pH on the absorption of metal ions is shown in Fig. 4. Minimal absorption efficiency happened in pH=3 . Ion adsorption efficiency increased with increasing pH at pH=7 to maximum so that the reaches. The absorption efficiency decreases at pH 8 and 9. Therefore, pH=7 was selected as the optimum pH.

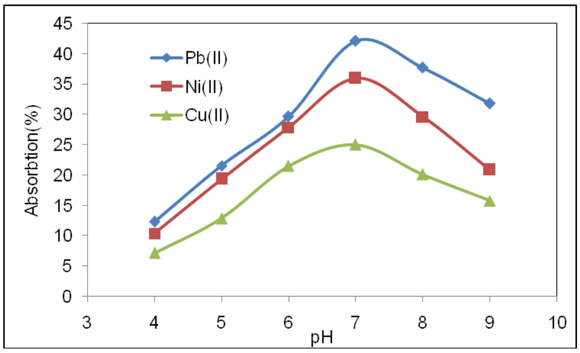


Fig.4. The effect of solution pH on the absorption efficiency.

Absorption Metals from industrial wastewater

To calculate the percent efficiency of metal ion uptake by the nanocomposite hydrogel using the following equation:

$$R = \frac{(C_i - C_{eq})}{C_i} \times 100 \quad (1)$$

The C_i and C_{eq} in order are initial concentration and final concentration of metal ion in wastewater. To calculate the percentage of metal ion desorption efficiency of nanocomposite hydrogel comes from the following equation:

$$R = \frac{C_m}{C_i} \times 100 \quad (2)$$

The C_i and C_m in order are initial concentration and final concentration of metal ion in solution after desorption.

Table 1. Different concentrations of metals in industrial wastewater.

Metal ion	C_o (ppm)	C_{ab} (ppm)	C_{Des} (ppm)	Absorption (%)	Desorption (%)
Pb(II)	0.19	0.11	0.01	42.10%	5.26%
Ni(II)	0.64	0.41	0.04	35.93%	6.25%
Cu(II)	0.12	0.09	0.01	25.00%	8.33%

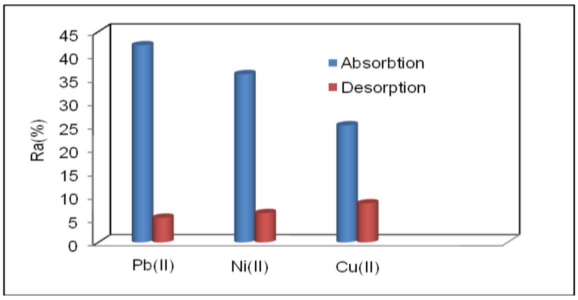


Fig. 5. Absorb and desorption metal ion curve measurable concentrations in industrial wastewater.

Conclusions

Grafting acrylamide on starch by using nano hematite synthesized nanocomposite hydrogel. Nanocomposite hydrogel synthesis can be used to remove metal ions in different wastewater and the results showed that the concentrations of these metal ions nanocomposite hydrogel absorption top 42.10 percent and the rate of return of 8.33 percent is the desorption of metals. The maximum absorbtion capacity in optimum pH for the different metal ions was in the order Pb(II) > Ni(II) > Cu(II).

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