

# Characterization and Performance Analysis of an Adsorptive Polyacrylonitrile based Hydrogel for Heavy Metals Removal



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**Abstract:** Adsorption is a key technology for heavy metals removal from industrial effluents. The use of adsorbent polymers is considered to be an attractive solution for wastewater treatment due to their high selectivity for certain heavy metals.

Through the current study, an adsorptive polyacrylonitrile based hydrogel blend was used to examine heavy metals removal in simulated effluents incorporating chromium and nickel. Moreover, Fourier Transform Infrared Spectroscopy (FTIR), X-ray diffraction (XRD), Scanning Electron Microscopy (SEM) in conjunction to an Energy Dispersive X-Ray Spectroscopy (EDX) were used for characterization of the polymeric blend structure. Finally, for surface evaluation, the specific surface area and the pore size distribution Brunauer-Emmett-Teller (BET) analysis techniques were used together with electrical conductivity measurements. The obtained results from FTIR showed the appearance of the original bands of raw materials (polyacrylonitrile (PAN), polyvinyl alcohol and polyaniline (PAni) and the change of the peaks position confirmed the hydrolysis and combination of starting materials into the polymeric blend. Surface morphology studies showed that this gel has porous surface with an average pore size and surface area of 0.73 nm and 17.3 m<sup>2</sup>/g, respectively. Moreover, Electrical conductivity measurements indicated the presence of PAni in the polymeric blend assisted in the increase in conductivity of PAN. Finally, the different parameters of the polymeric hydrogel blend were investigated through swelling water ratio (SWR) and conventional adsorption processes at different operating conditions such as; initial salt concentration, pH and contact time.

The maximum chromium adsorption results were (12.44 mg/g for 10 mg/L initial salt concentration), (10.46 mg/g for 5.5 pH) and (4.91 mg/g for 1 hr. contact time).

Whereas, the maximum nickel adsorption was (7.67 mg/g for 20 mg/L initial salt concentration), (7.57 mg/g for 7 pH) and (6 mg/g for 2 hrs. contact time).

**Keywords:** Adsorptive polyacrylonitrile, Adsorption, blend, hydrogel, Chromium, nickel.

## I. INTRODUCTION

Hydrogels components, known for their high aqueous sorption capacity, high functionality property, hydrophilicity feature, regeneration ability and nontoxicity effect, are considered as good absorbers for the removal of various heavy metal ions especially those present as aquatic pollutants. Adsorption using different types of polymers is a cost efficient and popular method in the removal of wastewater pollutants besides their excellent mechanical strength properties.[1] Hydrogels with biomolecule-conjugation and stimuli-responsive character are representing the next generation of very promising materials due to their selective binding with different heavy metal ions enabling their detection and removal in a controlled systems. [2] Hydrogels can be synthesized using different techniques rendering either blend, copolymer, graft copolymer, composite or interpenetrating polymer networks (IPN) each having a different structural conformation. IPN is essentially a network of a component within the hydrogel network itself. It can be classified as a class of polymer blends in a network form, in which at least one component is polymerized in the presence of the other(s). [3], [4] Conducting polymer hydrogels can be synthesized through polymerizing a conductive polymer within a non-conducting hydrogel matrix. The electro-conductive hydrogels (ECHs), with their electrically tunable properties, primarily consist of an inherently conducting polymer within a three-dimensional crosslinked network of a polymer-based hydrogel. This provides a synergistic combination of the conductive properties of electro-active polymers (EAPs) and the swelling/de-swelling capabilities of the hydrogel.

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There are various types of EAPs that can be used as conducting polymers, such as polypyrrole, polythiophene, poly(3,4-ethylenedioxythiophene) (PEDOT) and polyaniline (PAni). Among these, the application of PAni as an EAP has attracted much attention in a wide variety. Synthesis of multifunctional polyaniline (PAni) hydrogel with excellent electronic conductivity, high surface area and three-dimensional porous nanostructures was reported. [5] The presence of PAni in the ECHs increased the conductivity. [3]

Polymer blending is one of the successful approaches used for modification and improvement of polymeric materials physical/chemical properties. Polymer blends are known for the miscibility of their ingredients resulting in superior mechanical properties, morphology, permeability, and degradation. The blending between the polyvinyl alcohol (PVA) and the polyacrylonitrile (PAN) represents an excellent example showing that PVA has good mechanical properties in its dry state nevertheless its high hydrophilicity limits its applications. However, PAN has both good mechanical property and hydrophobicity, and therefore has been widely used as a film forming material. The combination between PAN and PVA is expected to enhance the physicochemical properties for both through the formation of hydrogen bonds between PAN segments and PVA chains reinforcing their miscibility with each other and blend properties. [3], [4], [6]

Hydrogels have found excellent applicability for drug delivery and wastewater treatment, in the later, they can act as sorbents for (recalcitrant dyes, metal ions and polyaromatic hydrocarbons). [1] Heavy metals, known to be toxic for human beings and marine life, are discharged into water from several chemical industries. Their removal has proven to be crucial to minimize the risk of their uptake by plants, animal and humans. [7], [8] The commonly known removal/remediation process is considered to be expensive due to the use of high cost non-generable materials. [9] The most popular technology methods to remove heavy metal ions in industrial wastewater, especially electroplating wastewater, includes precipitation, adsorption, Ion-exchange, electrochemical, biological, water treatment technologies using membrane, Photocatalysis process and Nanotechnology [7], [8], [10]. In addition, adsorption membranes are offering a dual function of filtration and adsorption for the removal of trace amounts of pollutants. [11]

Adsorption process is an effective purification method due to its capability of removing heavy metals at a concentration range of (1–100 mg/L). [8] For that reason and according to literature, it has been widely favored over other conventional methods due to their high stability, availability, low cost, eco-friendly nature and their ease of operation and performance. [7]

Many adsorbents were reported recently, including: commercial adsorbents, bio adsorbents, clays, activated carbons, zeolites, metal oxides, coal fly ash, rice husk ash, nano material and conducting polymer to remove heavy metals from polluted water [9], [12], [13]. In addition, a review reported that heavy metal accumulation could happen with a numerous organic and inorganic matters, mostly organic compounds (as: biological and chemical). [14]

Adsorbents can be classified as: natural materials, industrial byproduct, agricultural, biological waste, biopolymers and hydrogels. [15]

Different hydrogel composites and blends have been studied in terms of mechanical and swelling properties for heavy metals removal such as conductive polymers as (PAni and Polypyrrole) with the PAN composites, PVA with PAN Blend and PVA with PAni as a conductive hydrogel [3], [16]–[18]

In the current work, the adsorptive properties of polyacrylonitrile based hydrogel will be characterized and tested towards removal of chromium and nickel from synthetic aqueous solutions as a wastewater treatment application.

## II. MATERIALS AND METHODS

### A. Materials

An adsorptive polyacrylonitrile based hydrogel have been provided by HF Pilot (National Research Center) group with starting materials polyacrylonitrile (PAN) (average MW 150,000 ALDRICH), polyvinyl alcohol (PVA) (Technical grad from local supplies, China) and PAni was prepared as previously reported.[19] Briefly, from aniline chemical polymerization with HCl at (0-2 °C) with Ammonium per sulfate (APS) as an oxidant forming a dark green precipitate after 24 h. This was followed by centrifuging separation then washing. The adsorbates such as Cr (III) and Ni (II) metal ions using Chromium nitrate (PANREAC QUIMICA, Barcelona, Spain) and nickel sulfate (ARABLAB, Dubai, UAE). The pH was adjusted using either hydrochloric acid or sodium carbonate (ADWIC, Egypt). Whatman filter paper no. 4 was used for filtration.

### B. Characterization And Instruments

Infrared spectrum (FTIR) was recorded using (FT/IR-6100typeA, Jasco, Japan) with measurement information as TGS detector and absorbance technique ranging from 399.193-4000.6 cm<sup>-1</sup>, 2 mm/sec scanning speed, 4 cm<sup>-1</sup> resolution and 10000 Hz filter. For the defining the nature of that blend using X-Ray Diffractometer (XRD) system (EMPYREAN, DY 1007, Netherlands) at 25 °C measurement temperature using Cu anode material with 30 mA, 45 kV generator settings and the position [<sup>o</sup>2Theta] ranging from 4.0150 to 79.9610. The morphology of the prepared hydrogel samples was studied using a Scanning Electron Microscope (SEM) and their Energy X-Ray Spectroscopy (EDX) data for the surface elemental analysis detection (QUANTA FEG 250, European union at 20 KV measurement. The specific surface area and the average pore size detection were found using Brunauer-Emmett-Teller (BET) analysis technique (PEL\_Sorb\_Max, Japan).

The electrical conductivity measurement for the polymeric hydrogel blend was tested via dielectric, conductivity and impedance spectrometers (NovoControl Co., Germany) based on the corresponding BDS systems in combination with the Quatro Cryosystem, with measurement data at Room temperature (the polymeric blend was measured at room temperature) and frequency range 3uHz to 20 MHz, and the conductivity was calculated by the following equation: [20]

The electrical conductivity ( $\sigma$ ) =  $(\ln 2(V/I)) / (\pi t)$  (1)  
Where: ( $\sigma$ ) is the sample static electrical conductivity (S/cm),

(V) is the applied voltage (v), (I) is the measured current (A) and (t) is the thickness of sample disk (1 mm approximately). The solution pH of the adsorption medium was adjusted using either hydrochloric acid or sodium carbonate via a pH meter (MARTINI, Mi 180 Bench Meter, Italy). A shaker (SCIOLOGEX SK-O330-Pro, USA) with a constant agitation rate (200 rpm) was used for shaking the samples during adsorption studies. Flame Atomic Absorption spectrometer (Agilent Technology 200 series AA, Australia). was used for detection of the tested metal ions.

### C. Process Specification

#### ▪ Swelling water ratio (SWR)

0.5 g of the dry polymeric hydrogel blend was soaked in 0.5 L distilled water (Dose 1g/L) for 24 h and filtered using Whatman filter paper to remove the excess surface water. The swollen hydrogel was weighed before and after swelling. SWR has been calculated by the following equation: [21]

Swelling water ratio (SWR) =  $(W_s - W_d) / W_d$  (2)

Where: (SWR) is the amount of absorbed water per the amount of dry hydrogel sample (g/g), ( $W_s$ ) is the weight of the swollen sample (g) and ( $W_d$ ) is the weight of the dry sample (g).

#### ▪ Adsorption Procedure

The improved adsorptive properties of polyacrylonitrile blend hydrogel will be examined onto the adsorption tests to study its ability of removing the heavy metals from the synthetic wastewater to be applied later on for wastewater treatment applications. In this study, chromium nitrate and nickel sulfate were tested.

The ions adsorption capacities were evaluated using batch to equilibrium technique. 1g of pre-swollen hydrogel was added to 1L of a specific concentration of the salt solution in a suitable flask. The flask was closed and shaken with constant rate (200 rpm) for 3 hrs. at room temperature. Solid liquid separation was conducted by filtration after a specific time using a Whatman filter paper no. 4. The concentration of Cr (III) and Ni (II) in solution determined through analyzing the liquid after filtration using the Flame Atomic Absorption spectrometry.

The performance of the adsorptive polyacrylonitrile based hydrogel towards the tested heavy metals (Cr (III) and Ni (II)), was optimized in terms of adsorption conditions such as

pH, time, metal concentration. The heavy metal removal efficiency (%) and the adsorption capacity (q) were calculated by mass balance using the following equations (3) and (4):

Removal efficiency =  $((C_0 - C_e) / C_0) \times 100$  (3)

Adsorption capacity (q) =  $((C_0 - C_e) \times V) / m$  (4)

Where: (q) is the equilibrium adsorption capacity (mg/g), ( $C_0$ ) is the initial salt concentration (mg/L), ( $C_e$ ) is the salt concentration in the solution after the adsorption (mg/L), (V) is the solution volume (L) and (m) is the amount of hydrogel used (g).

## III. RESULTS AND DISCUSSION

### A. Polymeric Hydrogel Blend Characterization

#### ▪ Fourier Transform Infrared Spectroscopy (FTIR)

Infrared spectroscopy of the adsorptive polyacrylonitrile based hydrogel blend and their starting polymers PAN, PVA, PANi are illustrated in "Fig. 1" By appearance of mean peaks (as: 3394-3416 , 2974-2975, 2926-2895, 1640-1639.2, 1450-1410 and 1086-1049  $\text{cm}^{-1}$ ) nearly at the same position from the pure PAN including PVA till the final product PAN based hydrogel blend which seems the same as that of PVA and near to the pure PAN but for the PANi its mean peaks appear at the same positions but with high intensity values not in the others intensity values.

PAN shows its main peaks according to the literature at (2924, 2242 and 1731  $\text{cm}^{-1}$ ) which are assigned to ( $\text{CH}_2$ ) the methylene stretching vibration group, (CN) the cyanide group (which is the main functional group of its structure) and (CO) the carbonyl group. [22] Through the hydrolysis there are appearance of two new peaks than its mean peak of the ( $\text{C}\equiv\text{N}$ ) at 2242  $\text{cm}^{-1}$  triple bond becomes a double bond ( $\text{C}=\text{N}$ ) at 1697  $\text{cm}^{-1}$  before the formation of the amide group ( $\text{CONH}_2$ ) at 1575  $\text{cm}^{-1}$ . [23]

For PVA, its main characteristic peaks were observed at (3280, 2917, 1690, 1425, 1324, 1081 and 839  $\text{cm}^{-1}$ ). These peaks are assigned to (O-H) hydroxyl group stretching vibration group, ( $\text{CH}_2$ ) asymmetric stretching vibration, (C=O) carbonyl stretch, (C-H)  $\text{CH}_2$  bending vibration, (C-H) deformation vibration, (C-O) acetyl group stretching and (C-C) stretching vibration, respectively. [24] The (C=O) stretching peak intensity decreases by the increase of hydrolysis degree. [25]

For PANi, its main characteristic peaks at (1455, 1293, 1114, 954, 799, 693  $\text{cm}^{-1}$ ) is assigned to the benzenoid ring of polyaniline, (C-N) secondary aromatic amine stretching and p-di-substituted benzene ring. [19] Other sources from literature show at (3450, 3055, 1585, 1490, 1380, 1305, 1215, 1160 and 820  $\text{cm}^{-1}$ ) are its major characteristic peaks. [26]

For the polymeric blend, most of the bands for the starting materials (as: PAN, PVA and PANi) has appeared while, the absence of some peaks of polyaniline in the polymeric blend confirms the formation of hydrogen bonding between the hydrolyzed PAN and solubilized PVA hydrogel with the PANi. This result supports the successful blending between the PANi network that of PAN/PVA hydrogel.

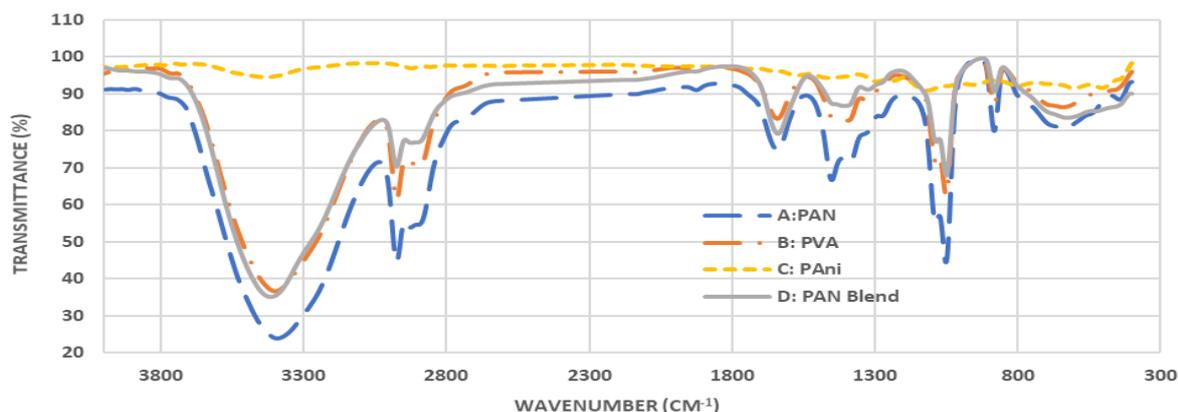


Fig. 1. Infrared Spectrum (FTIR) for the blend by comparison with its starting materials.

▪ **X-ray diffraction (XRD)**

X-Ray Diffractometer patterns corresponding to the polyacrylonitrile based hydrogel blend in comparison with its starting polymers (PAN, PVA and PANi) are shown in Fig. 2. For each polymer separately, the XRD pattern show the characteristic PAN maximum peak at (16.683°) 2θ value with (5.3 Å) d-spacing value, for PVA its maximum peak at (19.302°) 2θ value with (4.59 Å) d-spacing and while for PANi, its pattern shows several specific peaks with a maximum one at (44.6°) 2θ value with (2.02 Å) d-spacing value.

Finally, to recognize the final polymeric blend, the XRD pattern show its maximum peak at three different values at (25.35°, 6.4° and 44.6°) 2θ values with d-spacing values at (3.51, 13.8 and 2.02 Å), respectively with choosing two expected resulted compounds of them by two cards one of them is (3,5-Dimethylpyrazole) with its empirical formula (C<sub>5</sub>H<sub>8</sub>N=) by its reference code (00-042-1822) and the other one is (1,4-Diphenylhexahydro -1,2,4,5-tetrazine) with its empirical formula (C<sub>14</sub>H<sub>16</sub>N<sub>4</sub>) by its reference code (00-031-1678).

By comparison with the literature, the XRD patterns of PAN and its conductive polymers composites reported at (16.788° and 29.18°) 2θ values indicates the strongest PAN fiber peak

and a weak hill indication for an amorphous structure, in the case of PANi/PAN fiber, the intensity of the peak at (16.788°) decreases, which can be attributed to the hydrogen-bonding with the PAN chains.[18]

For PVA, the reviewed XRD pattern corresponding to its pure and hydrolysis forms have peaks at (19.8° and 40.58°) 2θ values indicating its semi-crystalline structure, where by reaching to the complete hydrolysis its crystallinity degree reach to its maximum value due to the difference between the (CH<sub>3</sub>COO) acetate group and the (O-H) hydroxyl group. [25] For the PANi,[26] major characteristic peaks are shown at (29.7°, 27.2°, 25.4°, 20.2°, 14.7°, and 8.8°) 2θ values with corresponding d- spacing at (3.0, 3.3, 3.5, 4.3, 6.0, and 10.0 Å), respectively which are very similar to the standard PANi-HCl salt (semi crystalline nature). Also, at (6.0° to 9.0°) 2θ values broad peak together with small intense peak at (6.5°) 2θ were observed that can be due to long chains of PANi structure.

The polymeric blend pattern match with the idea of changing of the peaks position due to the hydrolysis and confirming the combination of the starting materials into the produced polymeric blend.

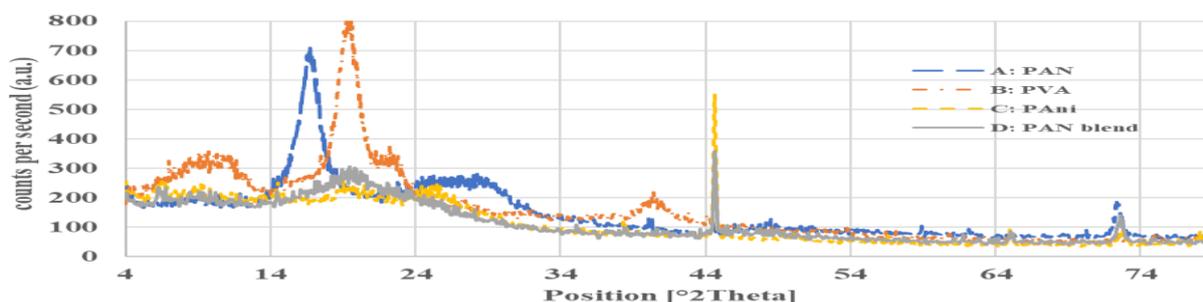


Fig. 2. X-Ray Diffraction for the polymeric blend in comparison with its starting materials.

▪ **Scanning Electron Microscopy (SEM)**

The SEM micrographs for the pure PAN and its blending form are given in “Fig. 3” indicating the difference of their porous surface morphology. The pure PAN has a uniform particles[27] of size between (180-300 nm). The PAN based hydrogel surface morphology indicating disappearing of the pure PAN uniform particles and combination with others polymers in blending form.

EDX data illustrated the change in percentage of the presence of some metals from pure to blended form in a randomly chosen area onto the surface within the scanning. The results indicated an increase in both % carbon and oxygen from 71.68 to 75.17 % and 5.75 to 16.3 %, respectively and a decrease in nitrogen from 22.57 to 7.47 % which matched with literature for PANi/PAN composite (as 70.80 % C, 25.20 % N and 4.00 O for PAN fiber) also (71.30 % C, 24.47 % N and 3.73 O for)[18]

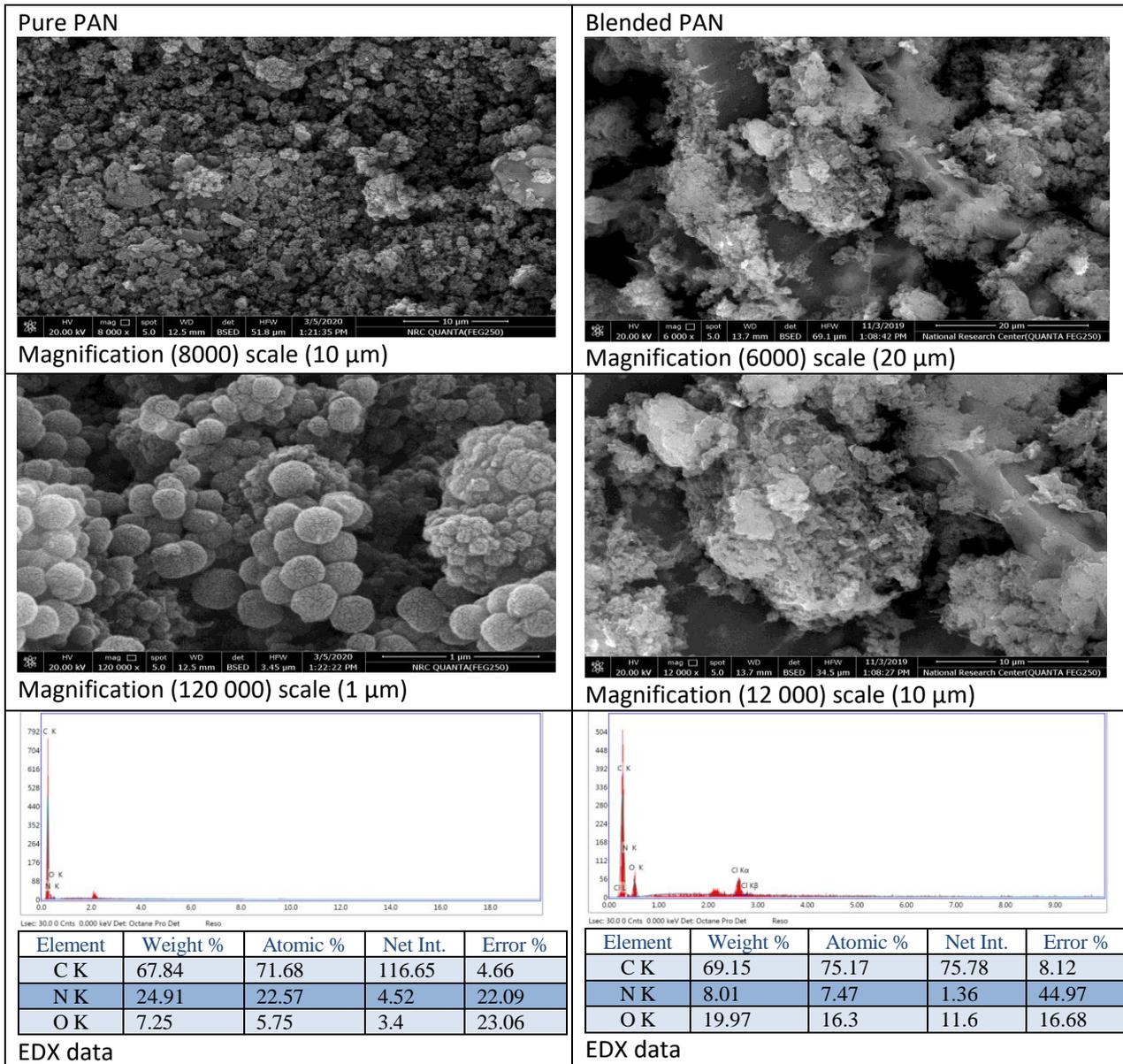
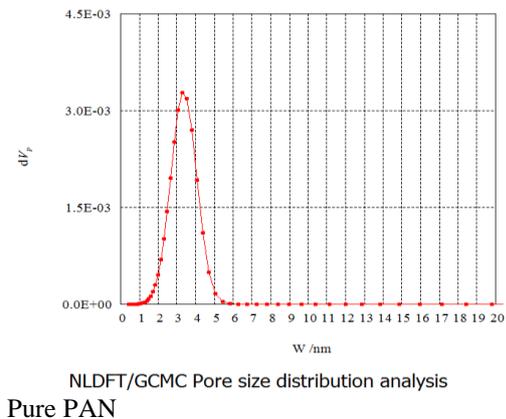


Fig. 3. Scanning Electron Microscope (SEM) and Their EDX data for pure PAN and blended PAN with low and high magnification.

▪ **The porosity measurements**

The DFT mathematical modeling for the Pure PAN and the Blended PAN respectively resulted in average pore size (3.295, 0.7305 nm) which illustrated in “Fig. 4” The surface area calculated is (17.3 m<sup>2</sup>/g) and the total pore volume is (0.02467 cm<sup>3</sup>/g). According to literature, the surface area of PAN was reported to be (26.223, 17.318 m<sup>2</sup>/g) and the total pore volume (0.0308, 0.02467 cm<sup>3</sup>/g) using Brunauer-Emmett-Teller (BET) analysis.[28]The measurements illustrated decreasing in the average pore size, the surface area and the total pore volume by blending than for pure PAN form.



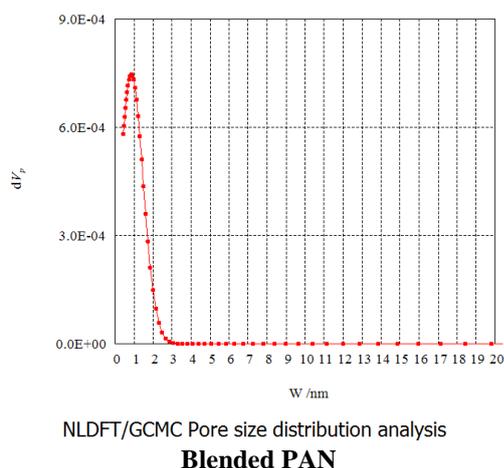


Fig. 4. The pore size distribution analysis for the Pure PAN and its blended form.

▪ **The electrical conductivity measurements**

The electrical conductivity measurements were applied to study the change in current at 1volt fixed value for the polymeric blend in comparison with its starting materials (PAN, PVA and PANi). The results show that the difference in the conductivity values for each participating material is in the following sequence PANi > PVA > PAN. Accordingly, the combination between them in a polymeric blend enhances the conductivity of the PAN as given in “Fig. 5”

According to literature, polyacrylonitrile powder is an insulator (its conductivity < 10-10 S/cm).[16] For PVA, chain mobility can enhance and improve electric conductivity as a result of increasing the hydrolysis degree.[25] Others studies,[18]indicated that pure PAN fiber is nonconductive, while it has a conductivity in the range from 3.3 to 5.5 × 10<sup>-2</sup> S/cm in a composite form with the PANi.

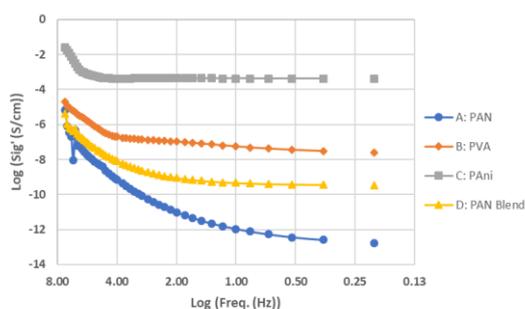


Fig. 5. The conductivity for the blend in comparison with its starting materials.

**B. Process Swelling And Adsorption**

▪ **Swelling water ratio (SWR) measurements**

The swelling of the polymeric blend was tested through calculation of the swelling water ratio (SWR). SWR was found to be 180 % which is considered much lower than the reported value for pure PVA hydrogel of 416%.[29] The decrease in the SWR for hydrogels at the adsorption application is very important because the high SWR values retards the adsorption process.

▪ **Conventional adsorption processes**

Batch to equilibrium technique experiments were used to study each metal separately at different operating conditions as mentioned before in the methodology.

**Chromium removal**

**1. The initial salt Concentration**

The effect of initial Cr (III) concentration were conducted at (10, 20, 40, 60 and 80 mg/L) with fixed other adsorption parameters as dose (1g/L) polymeric hydrogel blend to Cr (III) solution volume with pH (5.5) and 24 h as contact time. The results of the removal efficiency R (%) and the adsorption capacity q (mg/g) illustrated in “Fig. 6” indicate that the maximum concentration is 20 ppm and decreased afterwards till reaching 60 ppm returned to increase again up to 80 ppm.

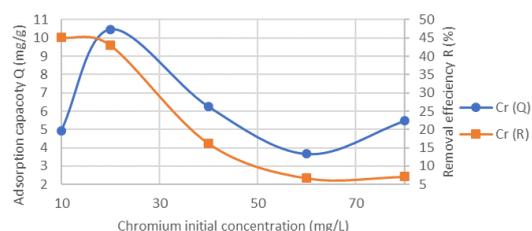


Fig. 6. The removal efficiency R (%) and the adsorption capacity q (mg/g) for chromium initial concentration effect.

**2. Medium pH**

The effect of medium pH was conducted at pH values 4, 4.5, 5 and 5.5 with fixed other adsorption parameters as dose 1g/L polymeric blend to Cr (III) solution volume with initial Cr (III) concentration (20 mg/L) and 24 hr. as contact time. The removal efficiency R (%) and the adsorption capacity q (mg/g) results illustrated in Fig. 7 indicate that the adsorption capacity increases gradually from pH 4.5 reaching a maximum value at pH 5.5.

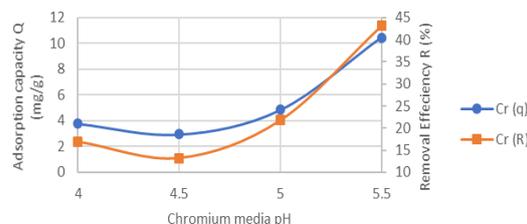
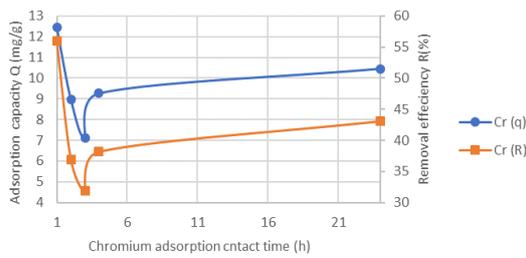


Fig. 7. The removal efficiency R (%) and the adsorption capacity q (mg/g) for chromium media pH effect.

**3. The contact time**

The effect of contact time was tested at 1, 2, 3, 4 and 24 hrs., while other adsorption parameters were fixed at: dose 1g/L polymeric blend to Cr (III) solution volume, initial Cr (III) concentration (20 mg/L) and pH 5.5. The removal efficiency R (%) and the adsorption capacity q (mg/g) results illustrated in Fig. 8 indicate that the maximum contact time is 1 h afterwards a decrease was noticed till 3 hrs followed by a slight increase up to 24 hrs.

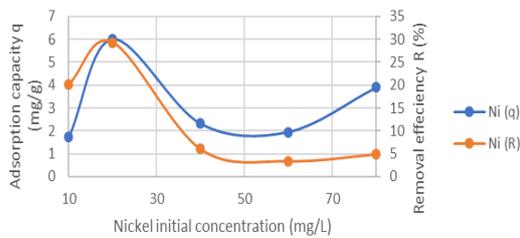


**Fig. 8. The removal efficiency R (%) and the adsorption capacity q (mg/g) for chromium adsorption contact time.**

**Nickel removal**

**1. The initial salt concentration**

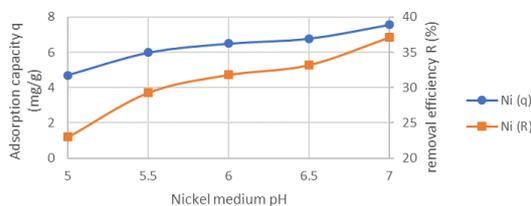
The effect of initial Ni (II) concentration was conducted at different concentrations: 10, 20, 40, 60 and 80 mg/L, at fixed other adsorption parameters including dose (1g/L) polymeric hydrogel blend to Ni (II) solution volume with pH (5.5) and (24 h.) contact time. The removal efficiency R (%) and the adsorption capacity q (mg/g) results illustrated in Fig. 9 showed that the maximum concentration is 20 ppm afterwards a decrease is gradually noticed till 60 ppm followed by a slight increase till 80 ppm.



**Fig. 9. The removal efficiency R (%) and the adsorption capacity q (mg/g) for Nickel initial concentration effect.**

**2. Medium pH**

The effect of medium pH was conducted at variable pH in the range of (5, 5.5, 6, 6.5 to 7) at fixed other adsorption parameters such as dose 1g/L polymeric blend to Ni (II) solution volume with initial Ni (II) concentration (20 mg/L) and (24 hr.) contact time. The removal efficiency R (%) and the adsorption capacity q (mg/g) results illustrated in Fig. 10 indicate that the maximum pH is 7 before that decrease slightly till 5.

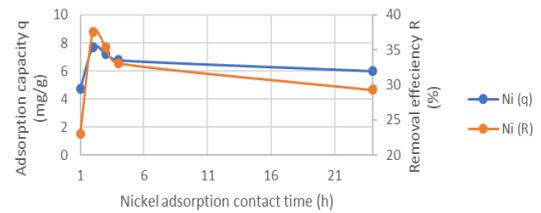


**Fig. 10. The removal efficiency R (%) and the adsorption capacity q (mg/g) and for nickel medium pH effect.**

**3. The contact time**

The effect of contact time was tested at different time intervals that are: 1, 2, 3, 4 and 24 h at fixed adsorption parameters at: dose 1g/L polymeric blend to Ni (II) solution volume, initial Ni (II) concentration (20 mg/L) and pH 5.5. The adsorption capacity q (mg/g) and the removal efficiency (%) results

illustrated in Fig. 11 show that the maximum contact time is 2 h then a decrease was noticed on reaching 24 h.



**Fig. 11. The removal efficiency (%) and the adsorption capacity q (mg/g) for nickel adsorption contact time effect.**

Through the adsorption variables experiments the ability of the polymeric blend towards the adsorption of chromium and nickel each one at its optimum conditions.

For Cr (III) to reach to its maximum removal efficiency's (%) (40.5, 43.12 and 56 %) at adsorption capacity's q (12.44, 10.46 and 4.91 mg/g) respectively, at initial salt concentration of 10 mg/L, pH (5.5) and contact time (1 h).

While for Ni (II), the maximum removal efficiency's (%) (29.34, 37.08 and 37.5 %) at adsorption capacity's Q (7.67, 7.57 and 6 mg/g) respectively, can be attained at initial salt concentration of 20 mg/L, pH (7) and 2 h contact time.

**IV. CONCLUSION**

The polymeric blend structure illustrated by FTIR showed bands peaks of the starting materials Polyacrylonitrile, polyvinyl alcohol and polyaniline. XRD showed that the polymeric blend pattern matched the change of peaks position due to the hydrolysis, confirming the combination of starting materials into the produced polymeric blend. Its surface morphology has porous nature. Its average pore size and surface area has been determined by SEM (0.7305 nm and 17.3 m<sup>2</sup>/g) respectively. The electrical conductivity measurements indicated that the presence of PANi in the polymeric blend assisted the increase of PAN conductivity. Different parameters of the polymeric hydrogel blend were investigated through the swelling water ratio (SWR) and the conventional adsorption processes at different operating conditions: the initial salt concentration, pH of the medium and the contact time to detect its adsorption ability toward the heavy metals which are under investigation. The results of the uptake of chromium by the polymeric blend showed maximum adsorption capacities (12.44 mg/g for 10 mg/L initial salt concentration), (10.46 mg/g for 5.5 pH) and (4.91 mg/g by 1 h. contact time). Also, the uptake of nickel revealed by the polymeric blend maximum adsorption capacities (7.67 mg/g for 20 mg/L initial salt concentration), (7.57 mg/g for 7 pH) and (6 mg/g by 2 h. contact time).

These previous adsorption results shed light on further for future studies on the chemical and electrochemical desorption properties as reported in literature[8].

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