

Preparation and Application of Nanocellulose in Removing Lead from Aqueous Solutions

Hassan Tawfeeq Hassan Yassir, Ali Hussein Fadhil Sdawi, Fatima Rashid Khader Rashid, Zaid Jawad Kazem Mohammed

University of Al Qasim Green College of Environmental Science Environment Department

Fatima Basim Mahdi Mutlak

University of Al Qasim Green College of Environmental Science / Environmental Health Department

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Annotation: The organic nanocellulose was prepared from starch by following the green chemistry methodology, adopting biomass as a natural source of organic nanomaterials. The prepared nanocellulose with its three different sources (laboratory starch, commercial starch, starch extracted from biomass (potato)) showed a high ability to remove exceeding (70%) with a short treatment time (only one hour), which indicates the high ability of nanocellulose to disperse and highly adsorb lead ions and include them between its folds or its long continuous chains composed of glucose units linked by 1-4 glycosidic bonds. It is worth noting that there is a high density of protons (H⁺) on the chemical structure of the nanocellulose chains carried on oxygen atoms in the form of hydroxyl groups (H-O-) which have a high ability to exchange and replace lead ions instead of them to form (Pb-O-) bonds, and this replacement and chemical adsorption of lead ions continues until saturation with it. The difference in the highest ability to remove lead followed the following

sequence: Nanocellulose from the laboratory starch source < nanocellulose from the biomass source < nanocellulose from the commercial starch source This is simply due to the high purity of the nanocellulose from the laboratory starch source, while the purity of the nanocellulose from the biomass source was slightly less than it, but the difference was clear with the nanocellulose from the commercial starch source and what it contains of materials, the most important of which is lignin or pectin that has the ability to gelatinize when mixed with water, thus reducing the amount of free protons on the surface of the prepared nanocellulose.

Keywords: Nanocellulose, Lead Adsorption, Green Chemistry, Water Purification, Biomass, Sustainable Materials.

Introduction

Water pollution is considered one of the most important and dangerous environmental pollutants due to the urgent need of humans for water, and its survival is linked to the survival and purity of water. However, despite this, it has not been dealt with well due to the increase in population, agricultural and industrial activities, especially in areas close to the sources of these waters, which has reduced their natural and chemical properties as a result of the increase in the concentration of many pollutants in these waters. In recent decades, the increasing local, agricultural and industrial activities around the world have led to the release of various pollutants, such as toxic heavy metals and organic materials into the aquatic environment, as the occurrence of heavy metal pollution in the environment is one of the biggest problems facing humans due to their toxicity and disease-causing effects on living organisms. At present, water pollution due to the presence of lead is one of the main problems at present, adsorption has become a focus of interest to remove heavy metal ions from water and wastewater. This interest is due to the possibility of renewing the adsorbent, its high efficiency, low cost, the possibility of metal recovery, and its simplicity in operation. Many adsorbents have been used to purify water, such as activated carbon, composite materials, and carbon nanotubes, such as graphene, zeolite, alumina, animal coal, and silica gel. Although conventional adsorbents are effective adsorbents due to their porosity and high surface area, their high cost and difficulty of renewal limit their wide applications. Therefore, waste generated from biomass has been found to be an alternative source of adsorbents, due to its easy availability from forests and agricultural wastes. Agricultural wastes can be. Cellulose has been used in many adsorption processes, where three types of nanocellulose were used, where nanocellulose extracted from biomass starch (potato), cellulose extracted from commercial starch (corn starch), and cellulose extracted from laboratory starch were used.

Definition of cellulose. :

It is a complex sugar, and is considered the main compound in plant cells, especially in the plant cell wall, and it is also found in all plant tissues, as it is considered a carbohydrate substance consisting of units to form long chains. Where "beta 1_4glycosidic" glucose linked together lengthwise by a bond called

The number of glucose units in the chain as well as the partial weight varies according to the type of plant

Chemically, cellulose is very stable and a polymer that is insoluble in water, has no taste, is odorless, loves water, and in most organic solvents is spiral, and is biodegradable. A highly crystalline substance that is difficult to dissolve in common organic solvents. This property serves it as an engineering material. Cellulose is the most abundant natural polymer on Earth, as many studies have been interested in the possibility of using polymers such as cellulose and its derivatives to produce chemical materials with new properties that carry practical solutions to many scientific issues, as they can be used as absorbent materials and at the same time are environmentally friendly.

1-Main sources of cellulose:

Cellulose can be obtained from a wide range of plants, animals and bacteria. The source of cellulose is very important because it affects the dimensions and properties of the extracted cellulose. In this section we will mention the most important different sources of cellulose fibers.

A- Plant fibers:

A variety of plant fibers were studied with the aim of extracting cellulose from them, including: wood, husk, (coconut husk), (flax) flax seeds, (hemp) hemp, (rice husk) rice. Cotton fibers were used as a high-quality source due to the low non-cellulose components in it. Extracting cellulose requires several chemical and physical stages that work to remove all other materials accompanying it in the fibers.

B- Algae:

After several studies, algae of various types were considered as a source of cellulose. For example, Valonia

Micrasterias

Coldophora

Boerogesenia

were extracted. A difference appeared in the properties and dimensions of the isolated cellulose fibers according to the type of algae. The extracted fibers, either extracted from and the type of their crystallization, are in the form of square parts (Valonia) from Valonia and the type of their crystallization x 50nm) are in the form of rectangular cross-sections)

C- Bacteria:

(Primary Metabolism) Through primary metabolism (BC) the biosynthesis of bacterial cellulose is carried out by Gluconacetobacter for certain types of bacteria under studied conditions. The most commonly used types of bacteria are the resulting cellulose, which has a thick gelatinous nature and has a granular layer on the surface in contact with air.

Previous studies on cellulose:

It is prepared by reacting cellulose with a mixture of anhydrous acetic acid, acetic acid and sulfuric acid. When the resulting solution is treated with water, cellulose acetate is obtained. It is a white woolly mass. The physical properties of cellulose acetate are:

1- Appearance under the microscope: irregular circular cross-section, and flat cylindrical and curved longitudinal section.

2- Tensile strength (dry and wet): Tensile strength of dry fibers is 1.4 grams, and tensile strength of wet fibers is 0.9 grams. For triacetate, tensile strength ranges from 1.2 grams to 1.8 grams.

3- Regular moisture of cotton: Regular moisture of diacetate is 6.5% and 4.2%.

4- Elongation: Average dry and wet elongation of diacetate and triacetate ranges from 20-40%

Melting point: 270-300 °C.

5- Electrical insulation: Good electrical insulator but includes static electricity.

6- Affected by heat and its smell during burning is the smell of acetone.

Nanocellulose Characteristics

The term nanocellulose describes cellulose fiber or crystalline cellulose that has at least one dimension in the range of the nanoscale, and can be obtained by chemical or mechanical processing of wood pulp or plant cellulose, etc.

The use of nanocellulose depends on the structural-property relationship, and is broadly classified into different types (microfibrinous cellulose, NFC) nanofibrinous cellulose, MCC (including microcrystalline cellulose

CNC and nanocrystalline cellulose, MFC

Areas of use of cellulose:

Bio-based cellulose has many applications in various industries. The potential application of nanocellulose and its biocomposites is widely adopted in the paper and packaging industry. However, the application of cellulose-based nanocomposites has gained much attention due to its nano-dimensionality, high strength and stiffness for use in many industries such as construction for manufacturing structural vehicles, automobiles for manufacturing microtube-based parts, and electronics as a membrane for the device Photovoltaic (and pharmaceutical) for biomedical applications (and cosmetics) Moreover, nanocellulose composites can be used as membranes for ultrafiltration, ion exchange, fuel cells, etc. to name a few. A wide range of nanocellulose applications have been extensively reviewed in the past decade. 1-3

Research objective:

1- Preparation of nanocellulose as a sustainable green organic material friendly to humans and the environment according to the concepts of green chemistry and sustainable development.

2- Adoption of the source of organic nano (cellulose) biomass (potato starch) and comparing it with other sources of nanocellulose such as commercial starch and laboratory starch.

3- Application of the three prepared nanomaterials in chemical pollution removal in order to know which one has the best ability to remove chemical pollution with toxic heavy elements such as lead in its aqueous solutions.

Methodology

Organic material was used to prepare nanocellulose

1- Use commercial starch (corn starch)

2- Use laboratory starch

3- Use starch from biomass (potatoes)

➤ Method of extracting potato starch

Use 3 kg of potatoes

➤ Washing

First, the potatoes are washed well with distilled water to remove dirt and soluble materials. After washing, the potatoes are peeled well

➤ Cutting

The potatoes are cut into very small pieces to facilitate the extraction of starch from them

➤ Washing process

After the first washing process, the potatoes are washed after cutting several times and the water and extract from washing the potatoes are left for one hour to precipitate the extracted starch

➤ Drying

The extracted starch is dried at room temperature

➤ Grinding

It is done by a grinding machine to obtain a fine and homogeneous material

➤ Screening

The material resulting from the grinding process and intended to be used in the removal process is screened by passing it through a (sieve) Removal method

Steps of work:

1- Take 5 grams of each type of starch (laboratory starch, commercial starch, starch extracted from biomass (potatoes), then dissolve in (50) milliliters of distilled water.

2- Heat for one hour at a temperature of (50) degrees Celsius.

3- Add ten drops of citric acid (natural lemon) to it.

4- Centrifuge it for a time of (15) minutes and at a speed of (3000) revolutions per minute.

5- Filter the solution and separate the resulting precipitate.

6- Dry the white precipitate.

7- Take 0.1 of each type of prepared nanocellulose, regardless of its source.

8- Prepare water contaminated with lead at a concentration of (10) parts per million of lead nitrate salt $Pb(NO_3)_2$ by dissolving (10) mg of it in one liter of distilled water.

9- Each type of nanocellulose was dissolved in (50 ml) of water contaminated with lead at a concentration of (10 ppm).

10- The mixture solution was stirred for an hour and then the solutions were prepared for measurement by flame atomic absorption spectrophotometer to measure lead after treatment with nanocellulose.

Materials and devices used in the experiment

The calibration curve showed the accuracy of the results and the sensitivity of the device to the lead solutions prepared according to the following readings ($R=0.9988$), and the lead concentrations after treatment with nanocellulose prepared from different sources:

Discussion

: We note from the results of the success of the technological approach of the organic nano prepared from cellulose by following the green chemistry and sustainable development methodology in removing chemical pollution with toxic heavy elements such as lead ions Pb^{+2} .

The nanocellulose prepared from its three different sources showed a high ability to remove exceeding 70% with a short treatment time (only one hour), which indicates the high ability of nanocellulose to disperse and highly adsorb lead ions and include them between its folds or its long continuous chains composed of glucose units linked by 1-4 glycosidic bonds.

It is worth noting the presence of a high density of protons (H^+) on the chemical structure of

nanocellulose carried on oxygen atoms in the form of hydroxyl groups (H-O-) which have a high ability to exchange and replace lead ions instead of them to form (Pb-O-) bonds, and this replacement and chemical adsorption of lead ions continues until saturation with it.

The difference in the highest ability to remove lead followed the following sequence:

Nanocellulose from laboratory starch source < nanocellulose from biomass source < nanocellulose from commercial starch source

This is simply due to the high purity of nanocellulose from laboratory starch source while the purity of nanocellulose from biomass source was slightly lower, but the difference was clear with nanocellulose from commercial starch source and what it contains of materials, the most important of which is pectin that has the ability to gelatinize when mixed with water, thus reducing the amount of free protons on the surface of the prepared nanocellulose.

Conclusions:

1. Successful preparation of nanocellulose from its available sources and replacement of natural citric acid with acetic acid.
2. It gave a high ability to adsorption and removal of chemical pollution with heavy chemical elements, specifically lead in its aqueous solutions.
3. Successful application of the philosophy and concept of applying the principles of green chemistry, including the use of biomass to manufacture sustainable green organic nanomaterials for the purpose of removing chemical pollution

Recommendations and future prospects

- Valuing the use of cellulose extracted from biomass in many fields.
- Cellulose extracted from biomass is a promising material in the adsorption process
- Working on searching for other adsorbent materials extracted from biomass and from renewable sources.
- Research on the efficiency of lignin and hemicellulose in the adsorption process.
- Working on modeling adsorption experiments in many programs in order to save time and effort and to obtain the optimal conditions for adsorption processes in the shortest possible time.

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