

Preparation and Influencing Factors of Sodium Lignosulfonate Nanoparticles

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Abstract: Lignin sulfonate, a by-product of pulp or fiber pulp production using the sulfite method, is directly extracted in its paper mill waste red liquor and is a non-toxic resource with a wide range of sources, low cost and renewable. In this paper, we combined nanotechnology with low-cost and abundant sodium lignosulfonate to prepare nano-sodium lignosulfonate preparation by nanotechnology, so as to improve its adsorption of zinc ions, and to study and investigate the effects of nano- and non-nano-sodium lignosulfonate treatment solution after adsorption of zinc ions on seedlings of wheat and mung beans by measuring the morphological and physiological and biochemical indexes of seedling growth and development. It will provide technical support for the treatment of heavy metal pollution in water environment and the agricultural application of treatment solution for zinc pollution, as well as the prevention of secondary pollution in water bodies after heavy metal treatment. The main research works are: (1) preparation of nano-sodium lignosulfonate formulations, focusing on the mass ratio of sodium lignosulfonate and sodium tripolyphosphate (STPP), magnetic stirring time, ultrasonic shaking time, pH value of the reaction system, and selection of suitable temperature; (2) characterization of the morphological structure of nano-sodium lignosulfonate formulations by laser pens, scanning electron microscopy, and optical microscopy; (3) The adsorption performance of nano-sodium lignosulfonate formulations on Zn²⁺ was studied, and the adsorption performance and effect of nano- and non-nano-sodium lignosulfonate formulations on Zn²⁺ were compared and observed.

1. Review of the literature

1.1 Nanotechnology

1.1.1 The rise and development of nanotechnology

Feynman gave a presentation at the annual meeting of the American Physical Society entitled "There's a lot of room at the bottom". A "bottom-up" approach was used to list the assembly of individual molecules or atoms to achieve the design requirements." Although the word "nano" was not used, it was the first time that the basic concept of nanotechnology was explained [1]. The concept of the word nano was first introduced by Norio Taniguchi in the 1970s. The first scanning tunneling microscope (STM) was developed at a laboratory in Zurich, Switzerland, in the 1980s [2].

Nanotechnology has provided mankind with precise and fine products and has also introduced a new way of thinking. By using nanotechnology in agriculture and medicine, it has transformed the face of agriculture and medicine and has had a significant impact on increasing the productivity of society and even fundamentally solving the huge environmental crisis facing humanity. Ultra-fine particles with nanoscale size have various characteristics such as small particle size, large relative surface area and macroscopic quantum tunneling, and thus can exhibit different qualities and functions. Nanotechnology itself has become highly important and valuable for research because of the practical applications and economic value of nanoparticles in many aspects of physical properties [3].

1.1.2 Preparation of nanoparticles

1) Vapor phase method

A method that transforms gaseous substances into solid particles under cooling conditions. The vapor phase method can be generally divided into four methods as follows:

- (1) Vapor-in-gas method
- (2) Chemical vapor phase reaction method
- (3) Chemical vapor phase condensation method
- (4) Sputtering method

2) Liquid-phase method

The liquid phase method is a homogeneous solution used as a raw material, and the solute and solvent are separated in different ways to prepare the pre-reactant of the particles, and then the reaction is heated to obtain the nanoparticles [4,5]. Mechanical stirring is not required in the preparation reaction, which makes the product less susceptible to impurities and enables to obtain a higher purity product. Therefore, it has a very promising application [6,7].

3) Solid-phase method

The common method used in the powder metallurgy, ceramic and mineral industries is the ball milling method. Because of the high production capacity and the simplicity of the production process, the ball milling method is commonly used in industrial production. Therefore, this method is commonly used in industrial production to prepare nanoproducts [8].

2. Solid-phase method

2.1 Main experimental apparatus and reagents

2.1.1 Main experimental apparatus

Electronic balance: FA2104B, measuring range 0~210g, d=0. 1mg, Shanghai Pingxuan Scientific Instruments Co.

Magnetic stirrer: 81-1, power 25W, 0~2000rpm, Jiangsu Jintan Huangyu Scientific Instruments Co.

Ultrasonic cleaning machine: FRQ-1030XH, Hangzhou Farrant Ultrasonic Technology Co.

Field emission scanning electron microscope: SU8010, Hitachi.

ICP Inductively Coupled Plasma Emission Spectrometer: SPECTRO BLUE, SPECTRO, Germany.

Scanning electron microscope: ZEISS EVO18, Carl Zeiss, Germany.

Transmission electron microscope: HT7700, Hitachi.

UV spectrophotometer: Changzhou Fipu Experimental Instrument Factory.

Centrifuge: Liaoning Fuyi Machinery Co.

2.1.2 Experimental materials and reagents

Sodium lignin sulfonate: Hubei Xing Yinhe Chemical Co.

Zinc oxide: Tianjin Bodi Chemical Co.

Propionamide: Zhengzhou Boxuan Chemical Products Co.

Sodium tripolyphosphate (STTP): Weifang Chenyang Chemical Co.

Sodium hydroxide: Guangzhou Dixindo Scientific Instruments Co.

Hydrochloric acid: Jinzhou Chemical Hydrochloric Acid Factory.

Wheat and mung beans: Purchased from Dalian Pulandian Seed Company.

2.2 Preparation and characterization of sodium lignosulfonate nanopreparations

2.2.1 Preparation of sodium lignosulfonate nanopreparations

The pH of sodium lignosulfonate solution was adjusted in 11 groups from 0 to 10, heated and stirred with a magnetic stirrer for 20 min, and then placed at a temperature of 25 °C, so that sodium lignosulfonate was precipitated from each group to obtain saturated solutions at each pH, and then filtered and prepared for use.

A certain volume of the saturated solution was adjusted to neutral pH with alkaline solution, and the absorbance of the solution at different pH values (wavelength=420nm) was measured after adding buffer solution to fix the volume. According to the experiment, the absorbance measured at room temperature was $A=0.302$, and the absorbance system was calculated to be 3.02L/g-cm.

To three flasks containing 4 g of sodium lignosulfonate each, deionized water was added to dissolve it fully. To the second group, add an appropriate amount of acrylamide (AM), stir to dissolve it fully, and then heat to 70 °C and continue stirring. The product was filtered and cleaned and dried in acetone, and then fixed in a volumetric flask with a volume of 500 ml, and stirred for a period of time at room temperature, and after adjusting the pH to 4.5, an appropriate amount of sodium tripolyphosphate (STPP) was added to the third group, stirred to dissolve it fully, and then adjusted the optimum acidity and alkalinity. Finally, the three groups of solutions were put into the ultrasonicator for a period of ultrasonic shaking to obtain the desired nanoformulations.

2.2.2 Characterization of nano-sodium lignosulfonate formulations

(1) Tindal phenomenon detection

The prepared nano-sodium lignosulfonate formulations were left to stand and observed by the naked eye for the appearance of emulsion color, and then the nano formulations were irradiated with a laser pointer to observe whether the Tindal phenomenon was produced.

(2) Scanning electron microscope (SEM) detection.

The prepared sodium lignosulfonate solution was added dropwise to the aluminum sheet, dried at room temperature, sprayed with gold and observed under SEM.

(3) Transmission electron microscope detection

The prepared sodium lignosulfonate nanopreparations were diluted to five times, carefully dipped in a small copper mesh, dried to a dry state at room temperature, and then placed under transmission electron microscopy for characterization.

2.3 Study on the adsorption of Zn^{2+} by sodium lignosulfonate nanopreparations

2.3.1 Formulation of sodium lignosulfonate nanopreparations

Exactly 50 ml of sodium lignosulfonate and its nano-reserve solution were transferred into

beakers, and then 350 ml of deionized water was added to each of the two groups and mixed well after thorough stirring to obtain sodium lignosulfonate solution and its nano-preparations with a concentration of 1 mg/ml.

2.3.2 Preparation of standard zinc solution

Firstly, zinc oxide was cauterized at 900°C until constant weight, then 1.2447g of zinc oxide was put into a beaker and sulfuric acid solution with a concentration of 0.05ml/L in a volume of 20ml was added and completely dissolved and set aside in a 1L volumetric flask.

2.3.3 Static adsorption experiment

In a conical flask with a volume of 100 ml, a certain amount of sodium lignosulfonate nanosolution was added, and then a certain volume of V and a standard solution of zinc sulfate with an initial solution concentration of C₀ were added. The capped conical flask was placed on a constant temperature shaker to make the adsorption proceed completely, and then the shaken supernatant was aspirated to determine the amount of Zn²⁺ participation C_e by ICP. The adsorption amount Q and the adsorption rate R% of sodium lignosulfonate and its nanopreparations on The adsorption amount Q of Zn²⁺ and the adsorption rate R% were calculated as follows:

$$Q=(C_0-C_e) \cdot V/M \quad (1)$$

$$R\%=(C_0-C_e) / C_0 \times 100\% \quad (2)$$

Where, C₀ is the initial concentration of the solution (mg/ml); C_e is the residual concentration (mg/ml); V is the volume of the solution; M is the volume of the added adsorbent (ml).

2.3.4 Selection of optimal conditions for the adsorption reaction

According to the operation method and steps of the static adsorption experiment, several repetitions were performed to determine the best conditions for the adsorption reaction by testing the initial concentration of sodium nano lignosulfonate adsorbent C₀, the adsorption reaction time, the amount of adsorbent used, the pH value of the solution, and the concentration of Zn²⁺, respectively.

2.3.5 Isothermal adsorption experiments

Five 100mL aqueous solutions of zinc ions at different concentrations were pipetted and 50ml of sodium lignosulfonate nano solution was added respectively. The concentration of residual zinc ions in the solution was measured after 2h adsorption at room temperature, and the adsorption equilibrium concentration and the adsorption capacity of the adsorbent were calculated. Then the isothermal adsorption experiments were performed for zinc sulfate at different temperatures according to the operation of the above steps, respectively.

The adsorption isotherm is a curve describing the adsorption capacity of a substance in relation to the concentration of the solution at a certain temperature. In this paper, the following two adsorption curves were mainly used:

(1) H.M.F. Freundlich's adsorption isotherm

The basic expression is

$$\ln Q_e = \ln K + (1/n) \ln C_e \quad (3)$$

Where: Q_e(mg/g) is the adsorption amount at adsorption equilibrium; C_e(mg/L) is the adsorption equilibrium concentration; K represents the adsorption capacity, and its value can be calculated

from the low rate of the linear equation; $1/n$ empirical constant, is the adsorption strength of the adsorbent, and its value can be found from the intercept of the linear equation.

(2) I. Langmuir (Langmuir) adsorption isotherm

The basic expression is:

$$C_e/Q_e = 1/(aQ_m) + C_e/Q_m \quad (4)$$

Where: Q_e (mg/g) is the adsorption amount adsorbed by the adsorbent at equilibrium; C_e (mg/L) is the adsorption equilibrium concentration; Q_m is the maximum adsorption amount of the adsorbent, representing the adsorption capacity under monolayer adsorption conditions. A is the Langmuir constant, and the Q_m and a values can be calculated from the slope and intercept of the linear equation.

2.3.6 Adsorption kinetics experiment

Add 100ml of sodium nano lignosulfonate solution to the conical flask, and then add 10mL of Zn^{2+} solution with different concentrations respectively, and shake at a constant temperature in a water bath at 30°C for 2h, wait for the adsorption reaction to reach equilibrium, measure the equilibrium concentration C_e of the solution, and calculate the equilibrium adsorption amount Q_e of the adsorbent.

3. Analysis of results and discussion

3.1 Factors affecting the preparation of sodium lignosulfonate nanopreparations

3.1.1 Influence of dispersant types on sodium lignosulfonate nanoformulations

For the preparation of sodium lignosulfonate nanopreparations, the dispersants propionamide (AM) and sodium tripolyphosphate (STPP) were added to the reaction solution at a concentration of 1 mg/ml, respectively. By stirring and sonication process, it was found that STPP could produce the Tyndall effect, while AM would produce foam and precipitation. The effect of STPP as a dispersant was found to be superior by electron scanning microscopy Figure 1 to Figure2.

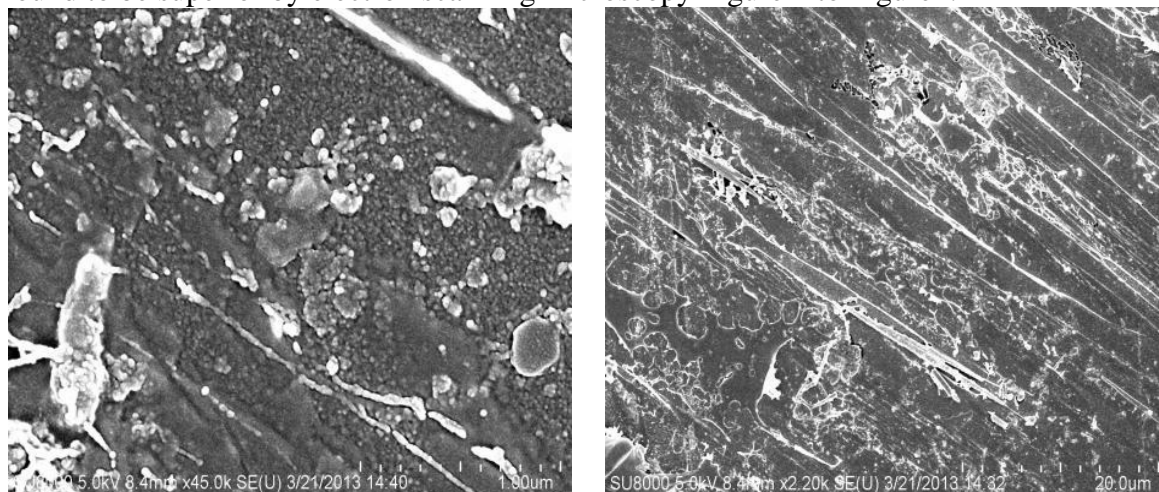


Figure 1: Join AM under SEM images as dispersant

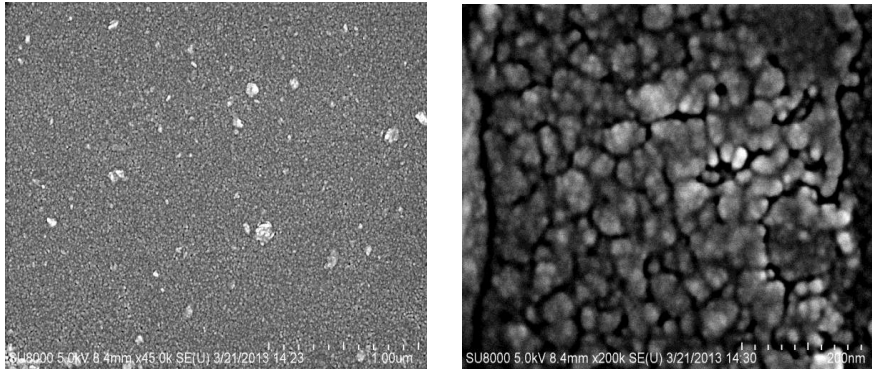


Figure 2: Join STPP under SEM images as dispersant

3.1.2 Effect of dispersant and adsorbent dosage on the particle size of nanoformulations

Five concentration gradients of sodium lignosulfonate solution were set up in five parallel groups of 50 ml each, and 20 ml of five concentration gradients of sodium tripolyphosphate solution were added to the five parallel groups of sodium lignosulfonate solution slowly while stirring to observe their effects on the particle size formation of the nanoformulations, as shown in Table 1.

Table 1: Sodium lignosulphonate and STPP concentration on its particle size

Concentration of sodium lignosulfonate mg/ml	Concentration of sodium tripolyphosphate (mg/ml)					
	0.4	0.6	0.8	1.0	1.2	1.4
0.4	×	√	√	√	↓	↓
0.8	×	×	√	√	↓	↓
1.6	×	×	×	√	√	↓
2.4	×	×	√	√	√	√
3.2	×	×	√	√	√	↓

Note 1: “×”For clarification of status, “√”For the suspended state, “↓”For precipitation state

3.1.3 Effect of pH on the solubility of sodium lignosulfonate

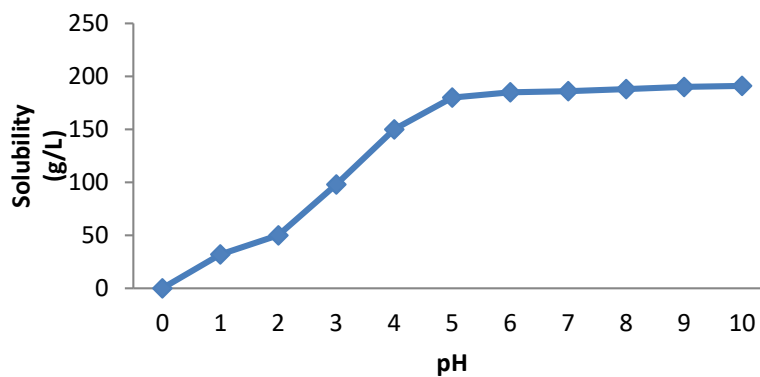


Figure 3: The pH of their influence on the solubility of sodium lignosulphonate

Figure 3 shows that the solubility of sodium lignosulfonate increases with increasing pH, and the

increase starts to stabilize at pH=5. Its solubility was best under alkaline conditions at about 200 mg/ml, while it was less soluble under acidic conditions.

3.1.4 Effect of pH on the particle size of sodium lignosulfonate nanopreparations

50 ml of sodium lignosulfonate solution with a concentration of 1.6 mg/ml was measured in turn, and then the pH was adjusted with HCl to make the pH of each group from 3 to 9, and then 20 ml of sodium tripolyphosphate was added slowly to observe the particle size of the sodium lignosulfonate nanopreparations at different pH values. The experimental results are shown in Table 2.

Table 2: Different pH on the influence of nanometer particle size of the sodium lignosulphonate

pH	3.0	4.0	5.0	6.0	7.0	8.0	9.0
Ball formation	No ball	No ball	No ball	No ball	Ball formation	Ball formation	No ball

3.1.5 Optimal stirring and sonication time

The stirring time is 20 min when the obvious Tyndall phenomenon starts to appear, and the sonication time is too long which will exotherm and produce flocculation, so 30 min of sonication is most suitable.

3.2 Morphological characterization of sodium lignosulfonate nanopreparations

3.2.1 Direct observation

It can be used as a direct judgment of the success of the nanoformulation by direct observation of the presence of milky white light. Further by irradiation of the laser pointer, the observation of whether it can produce Tyndall phenomenon was used as the initial detection criteria, and the results are shown in Figure 4.

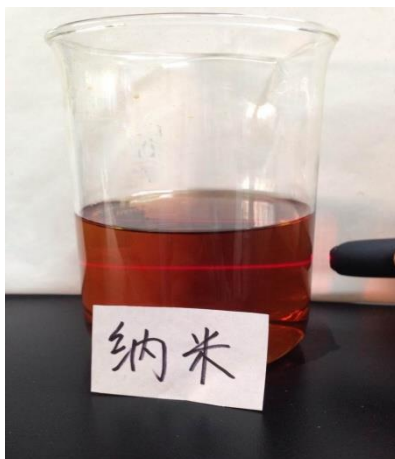


Figure 4: Sodium lignosulphonate nano preparation of butyl phenomenon

3.2.2 Scanning electron microscope characterization

The photos of sodium lignosulfonate under 400x optical microscope in Figure 5, and the photos under field emission electron scanning microscope in Figure 6 show that the original agent of sodium lignosulfonate itself has uneven particle distribution and large particle size.



Figure 5: The images of sodium lignosulphonate under optical microscope (400 times)

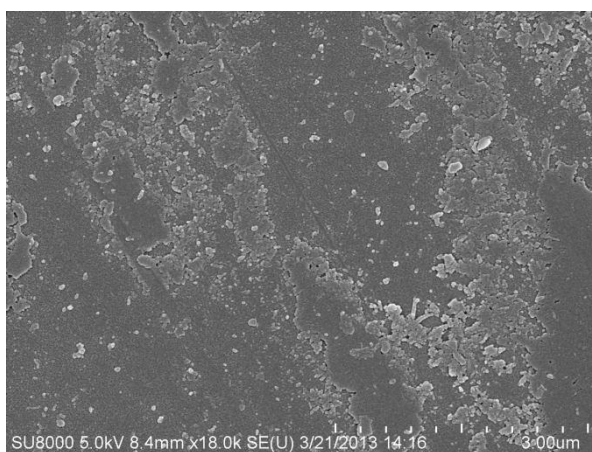


Figure 6: The picture of Sodium lignosulphonate under scanning electron microscope

Figure 7 and Figure 8 show the images of the nano-sodium lignosulfonate preparation under field emission electron scanning microscopy at 45k and 200k magnification, respectively. The photographs show that the prepared sodium lignosulfonate reagents are regularly and uniformly distributed, with particle sizes in the range of 20 nm to 60 nm, and exhibit a distinct spherical shape.

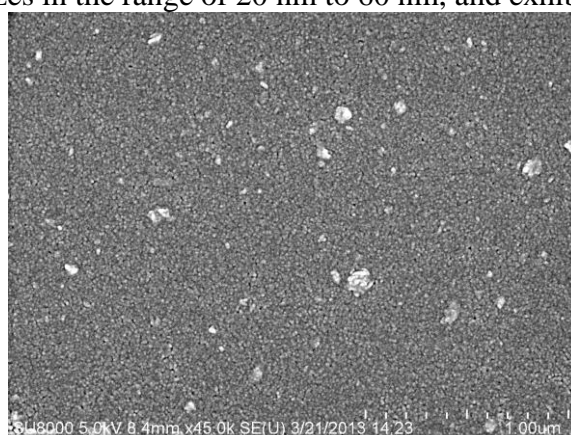


Figure 7: The image of nano sodium lignosulphonate under electron scanning microscope (45k times)

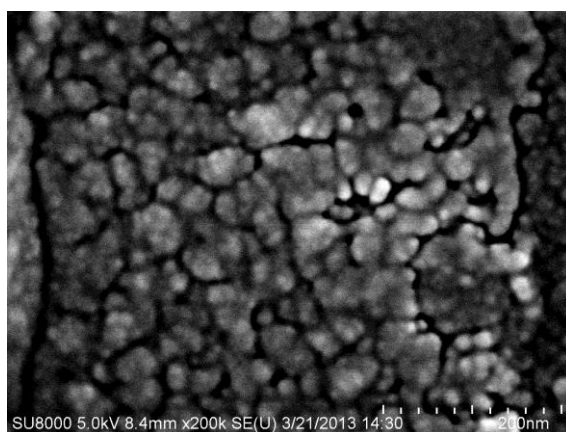


Figure 8: The image of nano sodium lignosulphonate under electron scanning microscope (200k times)

3.3 Adsorption of Zn²⁺ by nano-sodium lignosulfonate

3.3.1 Comparison of the adsorption of sodium lignosulfonate and its nanoformulations

Under the condition of room temperature at pH=7.0, 40 ml of solutions containing heavy metal Zn²⁺ at a concentration of 1 mg/ml were added to 100 ml of the same concentration of 4 mg/ml of sodium lignosulfonate, the original agent, respectively, and adsorbed for 2 h. The adsorption amounts of sodium lignosulfonate, the original agent and nano on heavy metal ions were obtained by ICP, as shown in Table 3.

Table 3: Adsorption quantity of the original and Nano Sodium Ligninsulfonate on Zn²⁺

	Sodium lignosulfonate original agent	Sodium nano lignosulfonate
Before adsorption mg	40	40
After adsorption mg	9.46	6.78
Adsorption amount mg/g	76.35	83.05
Adsorption rate (%)	76.35	83.05

According to Table 3, the adsorption of nano sodium lignosulfonate was higher than that of the original agent under the same conditions. The adsorption of Zn²⁺ by the nano preparation was 83.05 mg/g and 83.05%, respectively; the adsorption of Zn²⁺ by the original agent was 76.35 mg/g and 76.35%, respectively. This is because the nano-sized sodium lignosulfonate has more active groups released, so it has better adsorption capacity for Zn²⁺.

3.3.2 Effect of sodium lignosulfonate nanopreparation dosage on the adsorption reaction

Table 4: Different dosage of nanometer sodium lignosulphonate and adsorption effects of Zn²⁺

Nano sodium lignosulfonate dosage (ml)	10	20	30	50	80	100
Adsorption amount (mg/g)	160.28	138.24	116.32	90.7	63.79	43.25
Adsorption rate %	43.3	86.6	97.2	97.4	97.5	97.5

Under the conditions of pH=7.0 and temperature of 20 °C, different volumes of sodium lignosulfonate nanopreparations were added to the Zn²⁺ solution with a volume of 20 ml and both concentrations of 50 mg/ml, and after 2 h of adsorption, the content of Zn²⁺ in the solution was

measured by ICP as shown in Table 4.

The effects of different additions of sodium nanolignosulfonate formulations on the adsorption amount and adsorption rate of Zn^{2+} are shown in Figure 9 to Figure 10.

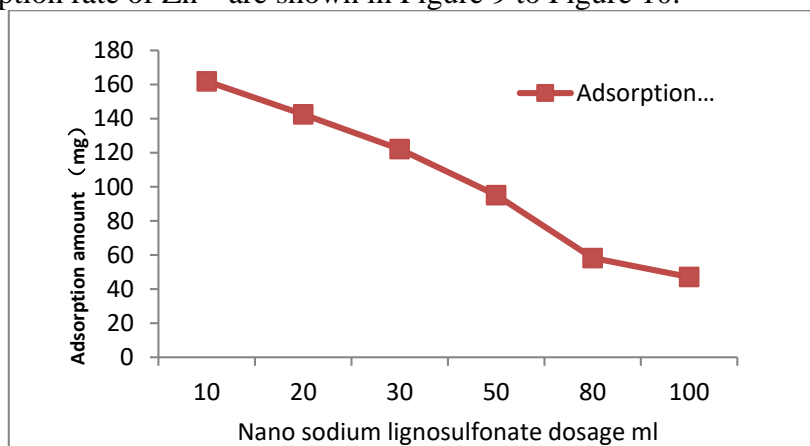


Figure 9: Nano lignin sulfonate on the adsorption quantity of Zn^{2+}

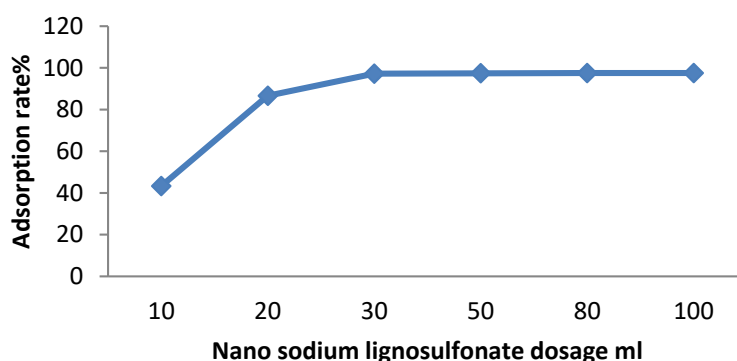


Figure 10: Nano lignin sulfonate on the adsorption rate of Zn^{2+}

As shown in Figures 9 and 10, the adsorbent dosage was inversely proportional to the unit adsorption amount under the same reaction conditions, but the adsorption capacity was gradually increased with the increase of adsorbent. The optimal input amount and concentration are 30ml and 4mg/ml respectively, at this time, the unit adsorption amount of Zn^{2+} is 116.32mg/g, and the removal rate is 97.2%. Reason analysis: The content of Zn^{2+} in the solution is certain, and increasing the adsorbent does not increase the unit adsorption amount, but as the adsorbent increases, the adsorption of Zn^{2+} is more complete and the adsorption rate is higher.

3.3.3 Effect of different pH values on the adsorption of sodium lignosulfonate nanopreparations

The adsorption temperature was set to the most common room temperature of 20 °C, and since most of the wastewater was acidic, only the adsorption under acidic conditions was measured, and other conditions were kept consistent, and the results are shown in Table 5.

Table 5: Different pH on the influence of sodium lignosulphonate adsorption capacity

pH	2.0	3.0	4.0	5.0	6.0	7.0
Nano sodium lignosulfonate dosage	20.32	40.36	73.94	102.83	120.34	93.28

Figure 11 and Figure 12 show the adsorption amount and adsorption rate of Zn^{2+} by sodium

lignosulfonate nanoparticles under different pH conditions.

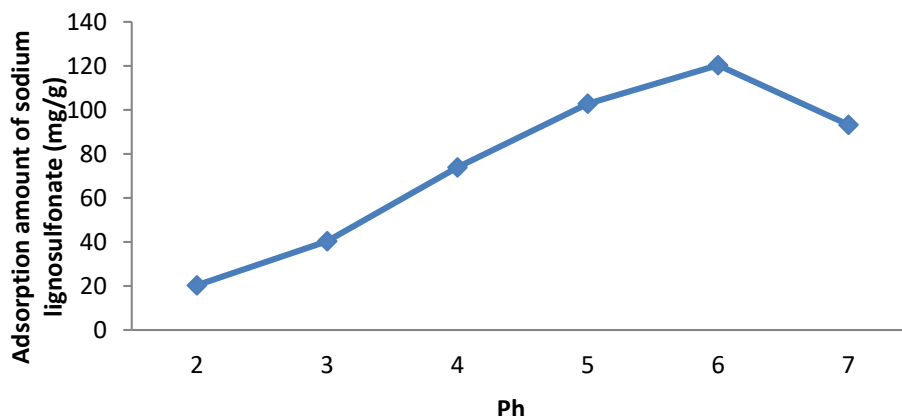


Figure 11: The influence of different pH of Zn^{2+} adsorption quantity

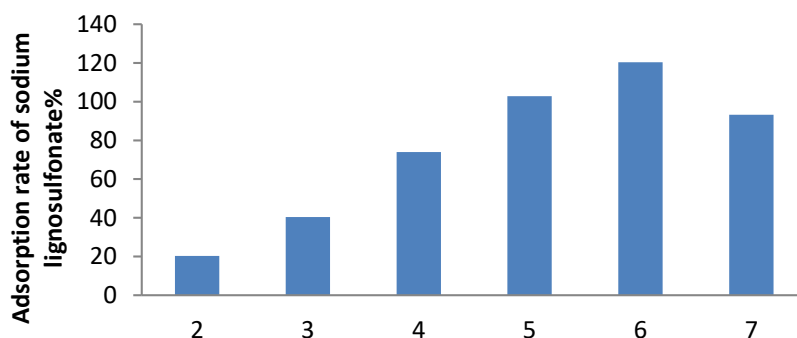


Figure 12: The influence of different pH for Zn^{2+} adsorption rate

As seen from according to Table 5 and Figures 11 to 12, the adsorption rate and amount of adsorption increased gradually with increasing pH and reached a maximum at pH=6. At a small pH there is more H^+ and mainly charge repulsion occurs, thus inhibiting the adsorption of Zn^{2+} . With the increase of pH H^+ decreases, at this time it is mainly ion exchange reaction, and Zn^{2+} reacts with the adsorption group on the adsorbent to produce more stable complexes. So the adsorption conditions are optimal at pH=6.

3.3.4 Effect of reaction temperature on the adsorption of sodium lignosulfonate nanopreparations

The adsorption reactions were carried out at different temperatures at pH=6. Finally, the adsorption of Zn^{2+} in the solution containing 30 ml of sodium lignosulfonate nanopreparations with a concentration of 4 mg/ml was determined and the results are shown in Figure 13:

According to Figure 13, the adsorption amount rises and then falls with the increase of the adsorption reaction temperature. The maximum value of 132.5 mg/g is reached at 50 °C, and it decreases instead after exceeding this temperature, mainly because the temperature increases, the intermolecular reaction is intense and the adsorption performance is good, but too high temperature will produce the phenomenon of side reaction.

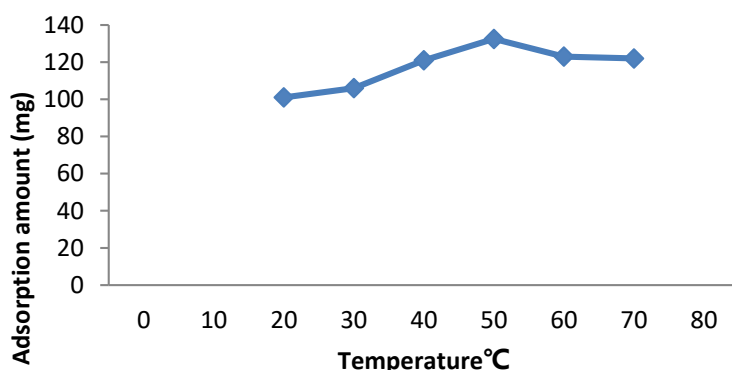


Figure 13: The influence of different temperature on the Zn²⁺ adsorption

3.3.5 Effect of reaction time on the adsorption of sodium lignosulfonate nanopreparations

The concentration of Zn²⁺ in a solution containing 30 ml of sodium lignosulfonate nanopreparations at a concentration of 4 mg/ml was measured hourly using ICP at pH = 6 and a temperature of 50 °C. The results are shown in Figure 14:

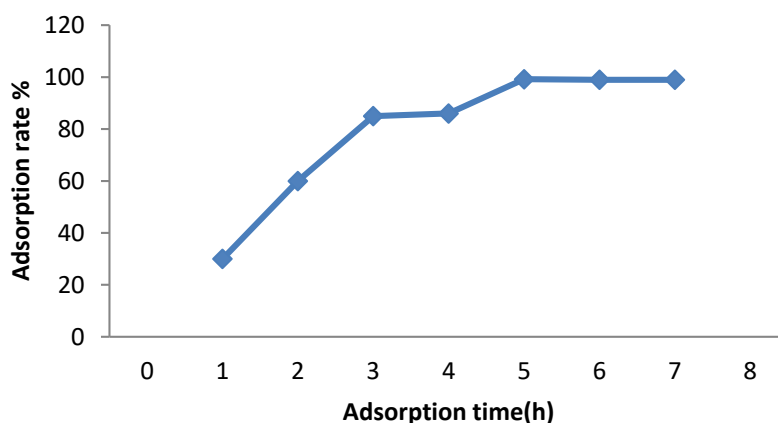


Figure 14: Effect of reaction time on the adsorption of Zn²⁺ by sodium lignosulfonate nanopreparations

According to Figure 14, the adsorption became more and more complete with the increase of adsorption time. The adsorption rate shows a fast and then slow increase rate: the rate increases faster before 3h, and then the increase rate starts to slow down gradually, and finally reaches the maximum value of 99.2% at 5h, so the best time for Zn²⁺ adsorption is 5h.

3.3.6 Two adsorption isotherms of nano sodium lignosulfonate

The adsorption equilibrium concentrations and the adsorption capacities of the adsorbents obtained after adsorption for 2 h at room temperature by adding 50 ml of the nanopreparations to five solutions of Zn²⁺ with different concentrations, all in a volume of 100 ml, are shown in Fig. 15 to Figure 17.

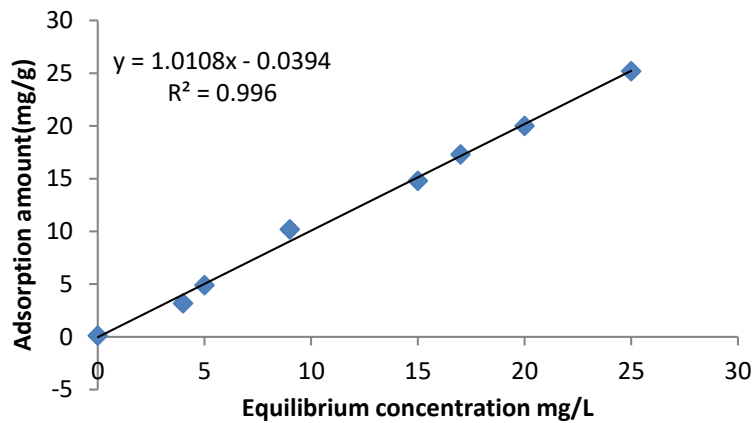


Figure 15: Adsorption isotherm of Zn^{2+}

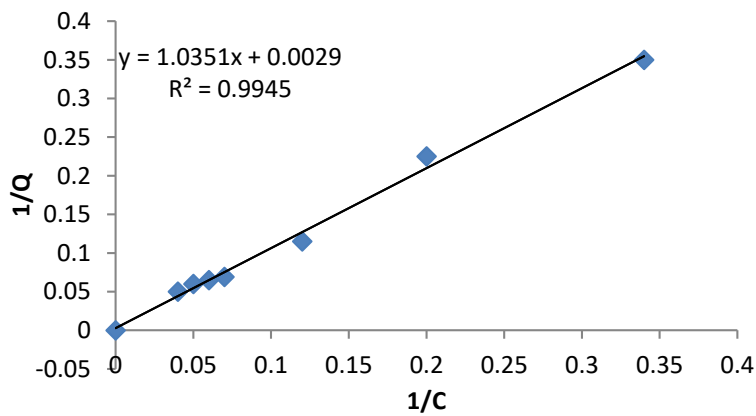


Figure 16: Langmuir isotherm of Zn^{2+}

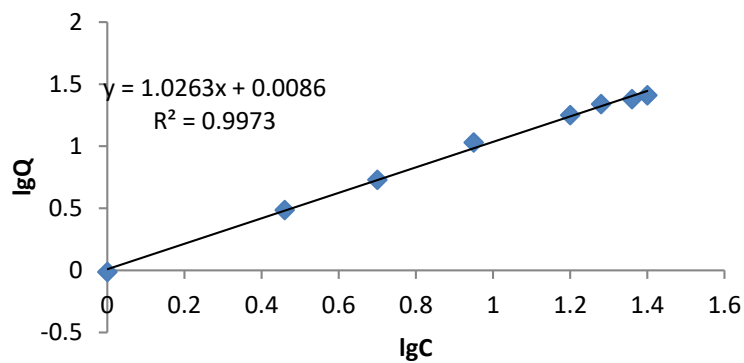


Figure 17: Freundlich isotherm of Zn^{2+}

From Figure 15 to Figure 17 and the fitted correlation coefficients, it can be seen that the Langmuir isotherm adsorption line and Freundlich isotherm adsorption line of sodium nanolignosulfonate for Zn^{2+} are well fitted under this experimental condition. The maximum adsorption amount of sodium nanolignosulfonate on Zn^{2+} was calculated as 129.5 mg/g according to the equations, respectively, and the theoretical value was close to the real value of 132.5 mg/g measured experimentally.

4. Conclusion

Sodium lignosulfonate was used as the object of study to prepare sodium lignosulfonate nanoformulations, and the experiments compared the effects of different dispersants and dosages on the nanoformulations. And the optimal preparation scheme of sodium lignosulfonate nanoformulations was determined based on the addition amount of sodium lignosulfonate, pH value of the solution, reaction time and reaction process. The prepared sodium lignosulfonate nanopreparations were characterized, and the size of the prepared nanopreparations in terms of granularity was determined by optical microscopy and electron scanning microscopy. Then the nanopreparations were used as adsorbent materials for heavy metal wastewater containing Zn^{2+} , and the adsorption of sodium lignosulfonate nanopreparations on Zn^{2+} was investigated in terms of the dosage of nanopreparations, pH of the solution, reaction temperature, reaction time, and adsorption isotherms, and the original agents were compared with the nanopreparations.

(1) The optimal preparation conditions for the sodium lignosulfonate nanoformulations were: pH neutral (7 to 8); room temperature (20 to 25 °C); sodium lignosulfonate concentration: 2.4 mg/ml, dispersant (STPP) concentration: 0.8 mg/ml, and the mass ratio of the two was 1:3; the optimal magnetic reaction stirring and ultrasonic shaking times were derived from the experiments: 20 min, 30 min, respectively. By SEM characterization, the prepared nanoparticles showed a uniform distribution of regular spherical shape with particle size ranging from 20 nm to 60 nm.

(2) Under the same conditions, the adsorption of nanoparticles was higher than that of the original agent. The adsorption amounts of Zn^{2+} by nanoparticles and the original agent were 89.45 mg/g and 79.35 mg/g; the adsorption rates of Zn^{2+} by nanoparticles and the original agent were 89.45% and 79.35%.

(3) Using the same concentration of Zn^{2+} solution as the reaction condition, the amount of sodium lignosulfonate nanopreparation used was inversely proportional to the unit adsorption amount, but positively proportional to the adsorption rate. The adsorption capacity and adsorption rate of Zn^{2+} were both significantly affected by the pH value under the same reaction conditions, and the optimal adsorption pH value for Zn^{2+} by sodium lignosulfonate nanopreparation was 6.0 mg/g. The best adsorption pH=6. The best adsorption performance of sodium lignosulfonate nanopreparations on Zn^{2+} was achieved when the adsorption reaction temperature was 50 °C and the adsorption time was 5h.

(4) Both the Langmuir isotherm adsorption line and Freundlich isotherm adsorption line of sodium lignosulfonate nanopreparation for Zn^{2+} were well fitted, and relatively, the Freundlich isotherm adsorption line of sodium lignosulfonate nanopreparation for Zn^{2+} was better fitted and better correlated, indicating that the sodium lignosulfonate adsorption reaction was more likely to be multilayer adsorption.

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