Preparation and Properties of Calcium Alginate Nano-Cu_2O Flame Retardant Antimicrobial Membrane Material

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Keywords: Calcium alginate; Nano-Cu_2O; Antibacterial; Flame retardant; In-situ method

Abstract. Nano-Cu_2O materials have many excellent properties, it is widely used, to overcome its sparingly solubility in water and poor stability among other defects, anhydrous cupric sulfate as raw materials, preparation of gel of nano-Cu_2O by in stiu reduction method in sodium alginate solution(SA). The structure and morphology of the Cu_2O in the gel was investigated by FT-IR and SEM were tested. On the basis of SA/nano-Cu_2O gel, Calcium Alginate nano-Cu_2O membrane were prepared by vacuum drying and crosslinking with Ca^{2+}. The material has flame retardant, antibacterial and other excellent performance. Has a wide range of applications.

Introduction

Antimicrobial material is a new type of functional material which has the function of killing or inhibiting microorganisms, and it has been widely used in various fields[1]. Copper as a relatively cheap material, not only a wide range of sources, low cost, and has the same excellent antibacterial properties as sliver, copper based antibacterial material will also become one of the important inorganic antibacterial materials[2].

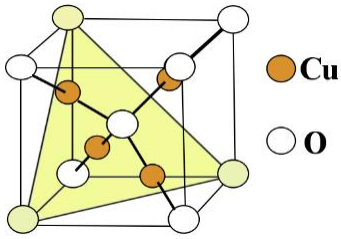

Fig. 1. Unit cell structure of Cu_2O

In recent years, the reproducibility and environmental friendliness of marine biomaterials have aroused great interest among scientists. Sodium alginate is a linear polysaccharide extracted from seaweed and consists of β-D-mannuronic acid (M unit) and α-L-guluronic acid (G unit). G unit and M Unit in the macromolecule content and arrangement of seaweed with the origin and type of difference will be different. Many of the O units present in the sodium alginate structure can chelate with Ca^{2+} to form a special "egg-box" structure[3,4].

Calcium alginate fiber has very good flame retardant properties. Its limiting oxygen index of 34.4%, in the air from the fire self-extinguishing; and in the combustion process of effective combustion heat, heat release rate and the total heat release is relatively low, but the carbon dioxide production rate is relatively high[5,6]. The thermogravimetric analyzer, pyrolysis gas chromatograph mass spectrometer and X-ray diffractometer were used to study the pyrolysis products and the pyrolytic products of pyrolysis products in the process of thermal decomposition of calcium alginate fibers. The results showed that calcium alginate fibers The flame retardancy is attributed to the special structure of the macromolecule of the calcium alginate constituting the fiber and the action of the calcium ion contained in the fiber [7,8].

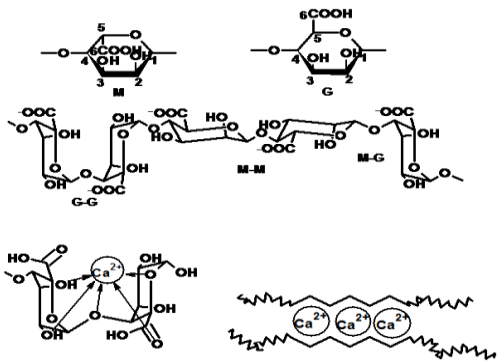

Fig. 2. The structure diagram of alginate and calcium alginate

Experimental

Materials. Sodium alginate (SA) was supplied by Jiejing Seaweed Co., Ltd. Shandong Province, P. R. China. Anhydrous cupric sulfate was purchased from Fukai chemical limited liability company. Ascorbic acid was supplied by Sinopharm Chemical Reagent Co., Ltd. All other reagents were of analytical grade.

Preparation of Calcium Alginate nano-Cu_2O membrane.

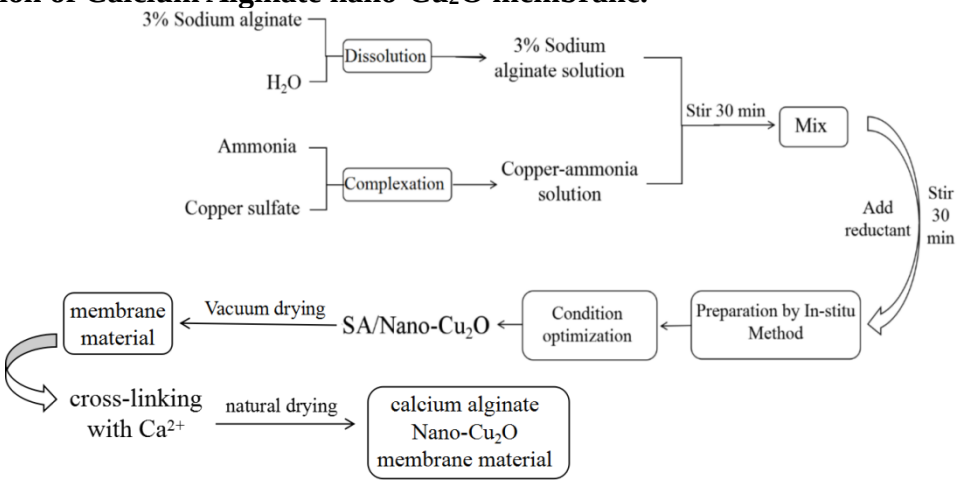

Fig. 3. Preparation flowchart

Display of the Prepared Samples. As shown in the Fig. 4, the sample of Cacium alginate nano-Cu_2O membrane material.

Fig. 4. The sample of Calcium alginate Nano-Cu_2O membrane material

Results and Discussion

The Antibacterial Properties Valuation of Calcium Alginate Nano-Cu_2O Membrane Material. As shown in the Fig. 5, the calcium alginate nano-Cu_2O membrane material had excellent bacteriostatic activity towards escherichia coli and staphylococcus aureus. Konishi[9] and others to Staphylococcus aureus as a model, the cuprous oxide and Staphylococcus aureus antibacterial

mechanism of the study, ruled out the mechanism of copper ions dissolution mechanism and reactive oxygen species, from the experimental results obtained antibacterial mechanism May be adsorbed on the cell surface of the cuprous oxide nanoparticles, by destroying the cell wall of bacteria in order to increase the permeability of its cell membrane, so that the integrity of the destruction of bacteria, reduced viability.

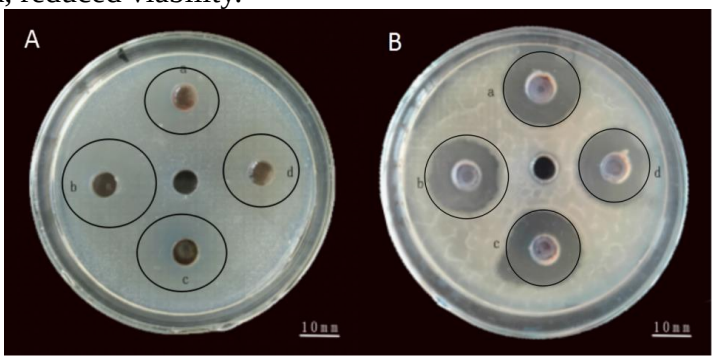

Fig. 5. The antibacterial property contrast of different dosage of reductant: A escherichia coli B staphylococcus aureus

IR Analysis. IR spectra is made for synthesized Cu_2O and purchased Cu_2O. It is quite matched. The results are as in Fig. 6. Characteristic vibration absorption of Cu(I)-O is at 628cm^{-1}. Synthesis Cu_2O for their synthesis of Cu_2O, buy Cu_2O for the market to buy the Cu_2O. It can be seen from the infrared image that the peaks of the two are basically the same, except for the special vibration absorption of Cu_2O, and the two curves are absorption peaks of water at approximately 1630 cm^{-1} and 3440 cm^{-1}.

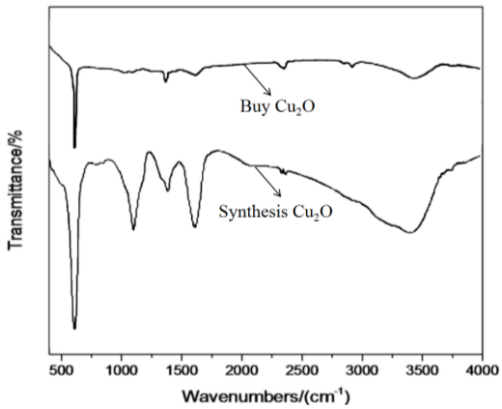

Fig. 6. IR spectra of the synthesis Cu_2O and the buy Cu_2O

The Limited Oxygen Index Test. Under specified conditions, the minimum oxygen required to maintain a steady combustion in a mixed gas stream of oxygen and nitrogen is called the limiting oxygen index (LOI) [10]. The higher the limit oxygen index indicates, the more difficult to burn the material. The lower the limiting oxygen index is, the more likely the material will burn. Generally speaking, when the limiting oxygen index is less than or equal to 22, the oxygen index of the material is less than or equal to 22, The substance can be burned in air. Oxygen index is generally considered to be less than 22 flammable materials, oxygen index between 22-27 is a combustible material, oxygen index greater than 27 is a flame retardant material [11]. The limiting oxygen index of the calcium alginate Nano-Cu_2O membrane material was 35.2%, smoldering in the flame, white smoke, self extinguishing in the air, which belongs to the low smoke and flame retardant materials.

SEM Morphological Analysis. As shown in the Fig. 7., the SEM of Cu_2O was prepared under the optimal conditions, view from the figure, the prepared sample Cu_2O is in ball shape with quite plump particles and even distribution. The particle diameter is about 500nm, and it had been up to nano material. It indicates that the preparation process still has improvement space.

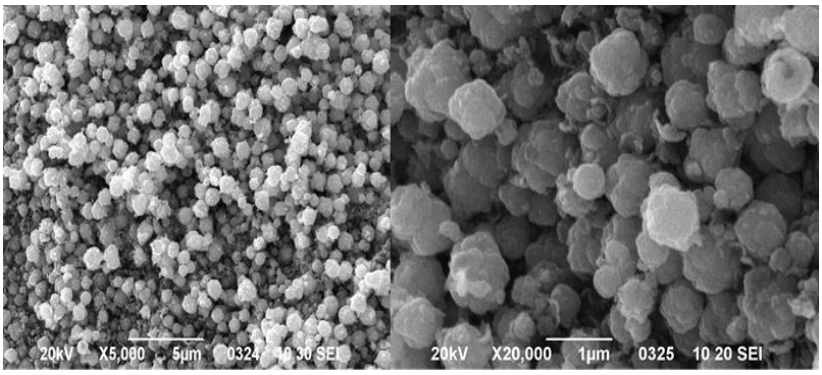

Fig. 7. SEM images of the Cu_2O

Conclusions

This experiment by in situ reduction method introduced nano-Cu_2O particles in the SA gel, calcium alginate Nano-Cu_2O membrane material was prepared and It was characterized by IR and SEM, the antibacterial properties of Escherichia coli and Staphylococcus aureus and the flame retardant properties were also investigated. The results showed that the membrane materials prepared by this method had excellent inhibitory effect on the growth of some common strains. And its limiting oxygen index can reach 35.2%, can be self extinguishing in the air, has a good flame retardant properties.

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