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OBTAINING AND STUDYING THE STRUCTURE OF COPPER NANOPARTICLES IN GUM ARABIC CONDITION

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Gum arabic is one of the most important representatives of the natural class of polysaccharides. Widely used in medicine, cosmetics, food and pharmaceutical industries. In this work, copper nanoparticles were immobilized on the surface of a natural polymer, gum arabic. The resulting compound was synthesized using the crosslinking agent glutaraldehyde. Gum arabic matrices were prepared using two types of cross-linking agents. The first option is the immobilization of copper nanoparticles on cross-linked gum arabic, the second is the immobilization of copper nanoparticles on gum arabic matrices. The composite material was studied by physical methods: IR-Fourier and X-ray diffraction analysis.

Keywords: polymer-gum arabic, immobilization, metal nanoparticles, physical methods.

INTRODUCTION

Gummiarabic is one of the most important members of the natural class of polysaccharides [1, 2].

It is widely used in medicine, cosmetics, food and pharmaceutical industries due to its properties such as biological activity, biological degradation, biocompatibility, complexing and sorption capacity. As a result, it is shown that on this basis it is possible to obtain highly mechanically resistant and elastic films [3, 4].

The chemical composition of gummirabic is heterogeneous. Its high functional properties are due to the complexity of its structure. In terms of chemical structure, it refers to biopolymers that contain both polysaccharides and protein fragments in the molecule. Due to the nature of the ion (hydrogen ion or cations of calcium, magnesium, sodium or potassium) against the carboxyl group, Gum Arabic (GA) creates a weakly acidic or neutral environment in the solution [4, 5].

Gummiarabic consists of elemental units of pentoses, methylpentoses, hexoses and polyuronic acids, which have a certain relationship with each other.The main skeleton of the gummiarabic macromolecule was formed from galactose and mannose, the side arms contain the units of pentose and xylose. Mannose residues are also part of the main chain or branching parts. Uronic acids include glucuronic acid units, mainly connected to galactose or mannose units [6].

Studies have shown that gum arabic consists of 45-46% galactose, 23-24% arabinose, 13-14% rhamnose and 14-16% glucuronic acid residues. Polysaccharide acids allow the replacement of calcium, magnesium and sodium salts (Fig.1).

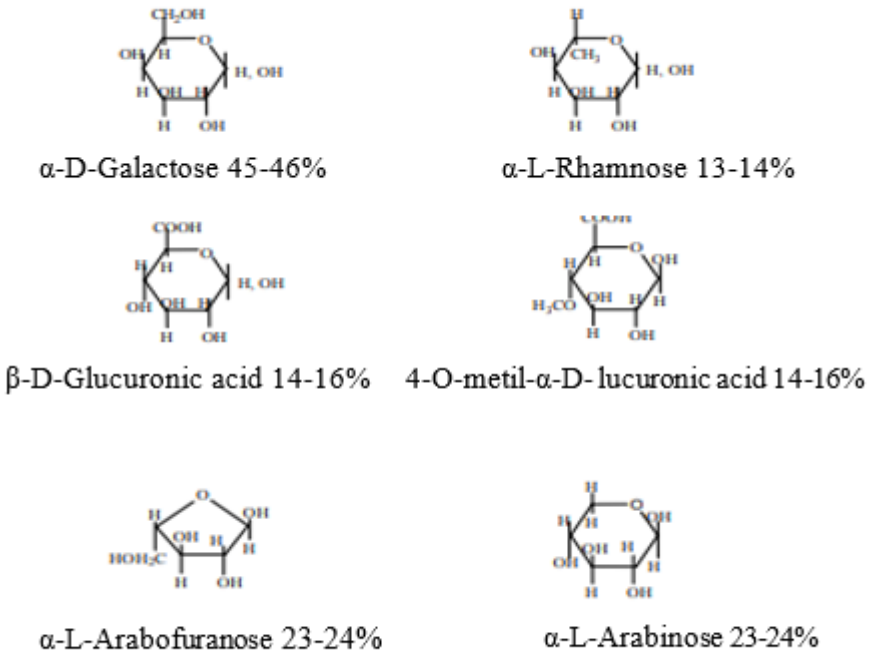

Fig. 1. Composition of gum arabic

Gum Arabic is a natural multifunctional hydrocolloid of arabino-galactan-protein of neutral or weak acid complex with a branched chain, containing calcium, magnesium and potassium. GA is a dried exudate obtained from the branches and core of an acacia tree [7].

Chemical study of GA has shown that it was determined as a result of its complete hydrolysis, aldobinic acid is formed, which consists of glucuronic acid and galactose residues.During gentle hydrolysis, arabinose, rhamnose and 3-galacto-1-arabinose disaccharide are removed from the GA. Partially depolymerized GA consists of elemental units of galactose and glucuronic acid [6, 8].

MATERIAL AND METHODS

Gum arabic is a branched-chain multifunctional hydrocolloid with a highly neutral or slightly acidic, arabino-galactan-protein complex containing calcium, magnesium, and potassium. Gum arabic is soluble in water (Fig.2).

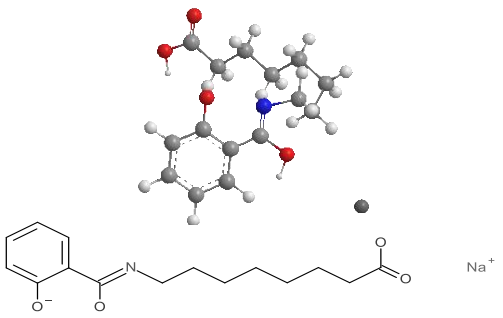

Fig. 2. 3D and 2D structure of gum arabic

Copper (II) sulfate, also known as copper sulphate, are the inorganic compounds with the chemical formula $\underline{CuSO_4}*5H_2O$. Copper sulphate is a bright blue salt, exothermically soluble in water. Anhydrous copper sulfate is a light gray powder (Fig.3).

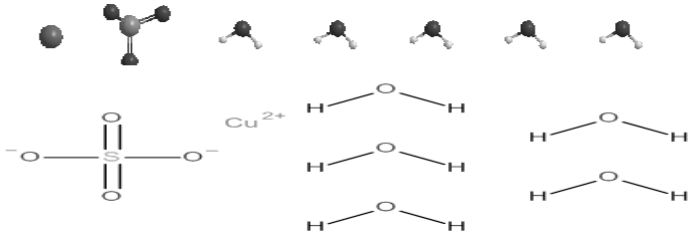

Fig. 3. 3D and 2D structure of copper(II) sulfate

Sodium borohydride (sodium tetrahydride borate) - colorless crystals, readily soluble in polar organic solvents and water.

***N,N′*-Methylenebisacrylamide (MBAm or MBAA)** is a cross-linking agent used during the formation of polymers such as polyacrylamide. Its molecular formula is $C_7H_{10}N_2O_2$. N, N'-methylenebisacrylamide is a white and crystalline solid that does not dissolve very much in cold water (Fig.4).

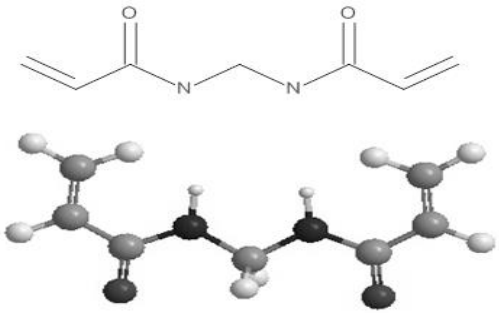

Fig. 4. 3D and 2D structure of MBAA

Obtaining matrices based on gum arabic

Gum arabic-based matrices were obtained using two types of cross-linking agents. 0.5 g of gum arabic dissolved in distilled water at a temperature of 20-30°C. In the first method, after mixing the solution at room temperature for two hours, 0.15 g (in 30% of the polymer) of the cross-linking agent N, N'-methylene bisacrylamide is added. Stir for 4-5 hours and keep at room temperature until the additives evaporate. After drying, the substance was cross-linked in the UV-lamp at a temperature of 40°C for 4 hours. In the second case, 0.03 ml (6% of the polymer) of the cross-linking -glutar aldehyde is added to the medium after mixing the solution with gum arabic. The process continues as in the first method.

***1.* Immobilization of copper nanoparticles in the cross-linked Gum Arabic matrices.**

Immobilization of copper nanoparticles in the cross-linking GA matrices is carried out as follows: first, the GA is dissolved in water at room temperature. Cross-linking agent of N, N'-methylene bisacrylamide add to the solution and mix for 3 hours at a temperature of 20-30 degrees. The resulting product was cross-linked in the UV-lamp at a temperature of 40°C for 4 hours. Then

the degree of swelling is determined. The amount of swelling polymer should be at least 1.5-2 times more than the amount taken. 0.58 g of $CuSO_4 \cdot 5H_2O$ (in 30% of the polymer) solution is added to the obtained product. In this case, the color of the solution turns blue. We add 0.62 g of reducing agent $NaBH_4$ in 30% of the metal to the obtained blue solution and bring Cu^{2+} ions to Cu^0. The color changes from blue to dark brown. At the end of the reduction process, the solution is washed several times with distilled water and dried after removal of additives. The obtained product was studied by physical research methods.

2. **Immobilization of copper nanoparticles on gum arabic matrices**

Immobilization of copper nanoparticles on gum arabic matrices is carried out as follows. Thus, the gum arabic is first dissolved in water and stored overnight. We add $CuSO_4 \cdot 5H_2O$ -30% of the polymer to the solution and keep it overnight after mixing. We add 30% reduction metal $NaBH_4$ to the obtained blue solution and bring Cu^{2+} ions to Cu^0. In this case, the color changes from blue to black. At the end of the reduction process, cross-linking agent N, N'-methylene bisacrylamide is added to the solution. The resulting product is dried, washed several times with distilled water, cleaned of additives and it was cross-linked in the UV-lamp at a temperature of 40°C for 4 hours (Fig. 5) [9].

RESULTS AND DISCUSSION

The results obtained were studied by IR spectroscopy method and determined that the instead of the 968 cm^{-1} absorption band in the original gum arabic (Fig. 4), a 996 cm^{-1} absorption band is formed in the spectrum of the gum arabic-based composite containing Cu nanoparticles gum arabic (Fig. 6).

At the same time, the study of the immobilization of Cu nanoparticles in the crosslinked gum arabic was carried out by X-ray analysis. In this case, copper ions were observed both in the form of free and compound (Fig. 7).

The substance obtained as a result of the cross-link process after immobilization of copper ions in a natural polymer - gum arabic was also studied by FTIR and X-ray methods. At the same time, the 968 cm^{-1} absorption band observed in pure gum arabic shifted to the 985.2 cm^{-1} absorption band. (Fig. 8) Cu ions in the form of free and compounds were also observed during X-ray analysis. (Fig. 9) In this case, immobilization of copper ions gave better results.

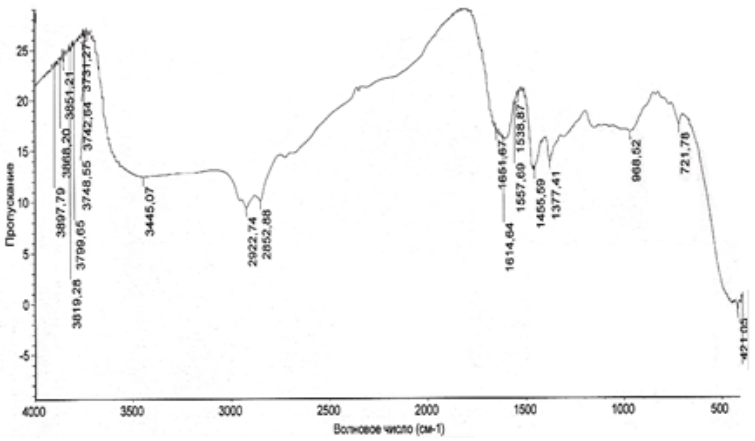

Fig. 5. FTIR spectra of the gum arabic

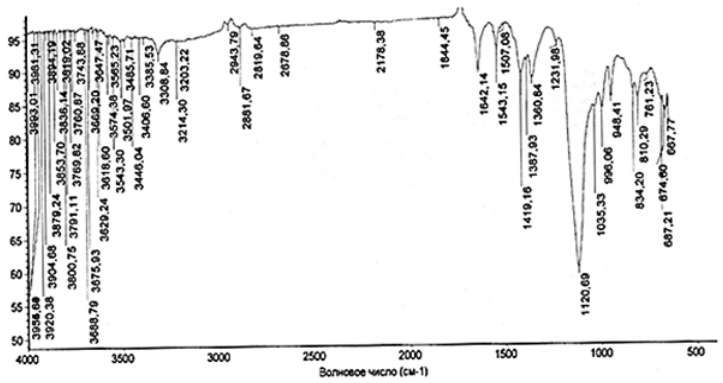

Fig. 6. FTIR spectrum of the cross-linked gum arabic - Cu complex

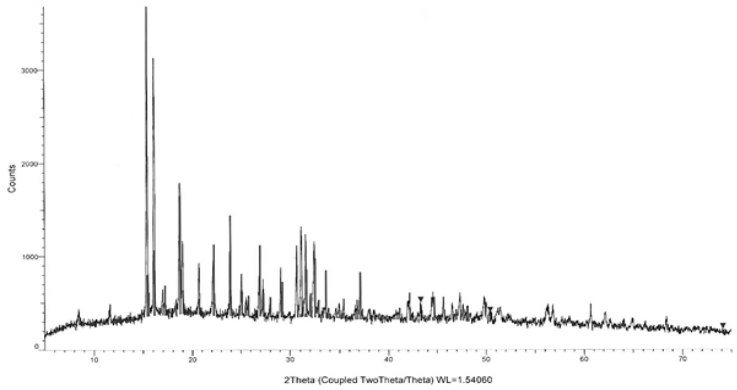

Fig. 7. Difractogramm of the cross-linked gum complex

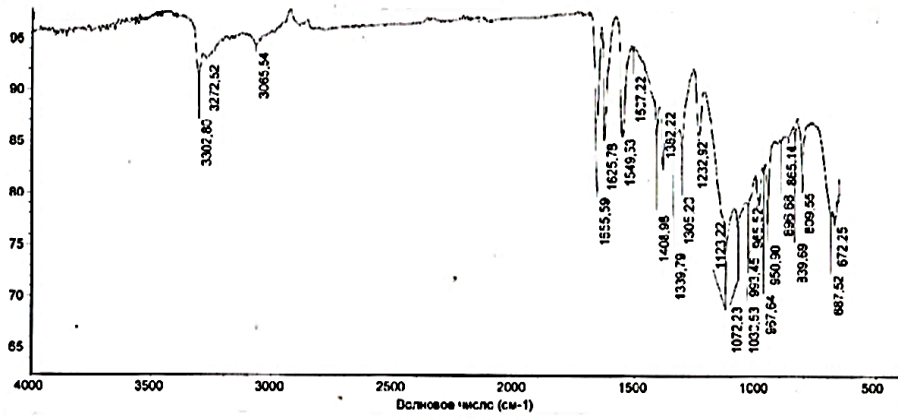

Fig. 8. FTIR spectrum of gum arabic-based composite containing Cu nanoparticles

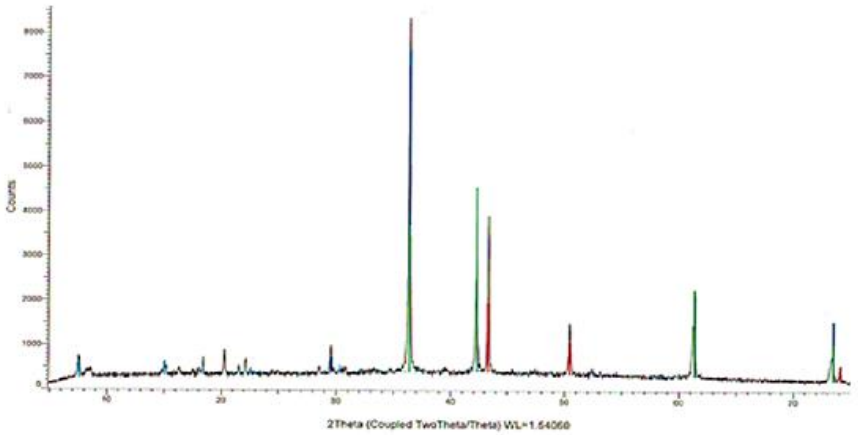

Fig. 9. Difractogramm of gum arabic-based composite containing

CONCLUSION

Copper nanoparticles were synthesized in gum arabic medium and their structures were studied by IR spectroscopy and RF analysis methods. In the second case, immobilization of copper ions was more successful. Because initially, when the cross-linking is carried out, most of the functional groups of the polymer are combined with the cross-linking agent groups. In this case, when immobilization of copper ions is carried out, the process proceeds poorly, since many of the groups are combined with the cross-linking agent. This reaction is mainly carried out in order to obtain smart polymers.The analysis of the compounds obtained in the presented work, conducted studies and literature materials makes it possible to use these substances as catalysts and adsorbents in various fields in the future.

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QUMMİARABİK MÜHİTİNDƏ MİS NANOHİSSƏCİKLƏRİNİN ALINMASI VƏ QURULUŞUNUN TƏDQİQİ

H.F. Aslanova, N.T. Rəhimli, A.R. Cavadzadə, Ü.Ə. Məmmədova, N.A. Zeynalov

Qummiarabik təbii polisaxaridlər sinfinin ən vacib nümayəndələrindən biridir. Tibb, kosmetika, qida və əczaçılıq sənayesində geniş istifadə olunur. Bu işdə mis nanohissəcikləri təbii polimer olan qummiarabik səthinə immobilizə olunmuşdur. Alınan birləşmə tikici agent olan qlutaraldehidindən istifadə edilərək sintez edilmişdir. Qummiarabik əsaslı matrislər iki metodla tikilmişdir. Birinci variant mis nanohissəciklərin tikilmiş qummiarabik üzərində immobilizasiyası, ikincisi isə mis nanohissəciklərin qummiarabik matrisləri üzərində immobilizasiyasıdır. Kompozit material İQ və RFA fiziki üsullarla tədqiq edilmişdir.

Açar sözlər: *qummiarabik polimeri, immobilizasiya, metal nanohissəciklər, fiziki üsullar.*

ПОЛУЧЕНИЕ И ИЗУЧЕНИЕ СТРУКТУРЫ НАНОЧАСТИЦ МЕДИ В ГУММИАРАБИЙСКОЙ СРЕДЕ

Х.Ф. Асланова, Н.Т. Рагимли, А.Р. Джавадзаде, У.А. Мамедова, Н.А. Зейналов

Гуммиарабик является одним из наиболее важных представителей природного класса полисахаридов. Широко используется в медицине, косметической, пищевой и фармацевтической промышленности. В настоящей работе наночастицы меди были иммобилизованы на поверхность природного полимера гуммиарабика. Полученное соединение было синтезировано с использованием сшивающего агента глутарового альдегида. Матрицы на основе гуммиарабика были получены с использованием двух типов сшивающих агентов. Первый вариант – иммобилизация наночастиц меди на сшитом гуммиарабике, второй – иммобилизация наночастиц меди на матрицах гуммиарабика. Композитный материал исследовали физическими методами: ИК-Фурье и рентгеноструктурным анализом.

Ключевые слова: *полимер-гуммиарабик, иммобилизация, наночастицы металлов, физические методы.*