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Study of Physical and Chemical Properties of Polyaniline Polymer

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ABSTRACT: The article presents the results of a study of the physicochemical properties of the polyaniline polymer (PANI). The polyaniline base and salts are very unstable and quickly decompose to form products with a smaller number of quinone structures.

From the given structures, as well as from the electronic spectra of solutions of the corresponding oxidation state of the PANI base, it is evident that with an increase in the oxidation state of the PANI base, the number of amine fragments decreases and the content of imine fragments of PANI increases.

The fully reduced form of PANI - leucoemeraldine - contains only amine fragments, while the fully oxidized form - pernigraniline - contains the maximum number of imine fragments.

KEYWORDS: Polyaniline, aniline, polymer, spectrum, molecular weight.

I.INTRODUCTION

Today, the demand for polymeric materials is growing in the chemical and metallurgical industries, as well as in all regions of the world. It is especially important that these polymeric materials are multifunctional. In this regard, many studies are being conducted on the synthesis of multifunctional polymeric materials and their intended use in industrial enterprises.

Currently, research is being conducted in countries around the world to create polymeric materials that are relatively cheap, multifunctional, have physical and mechanical properties and, accordingly, durability, which is an important task. Similar studies are being conducted in the Republic of Uzbekistan, especially relevant is the production of polymeric materials based on polyaniline and the synthesis of various raw materials based on them.

This study is also based on the production of polyaniline containing an amine group and the study of its properties.

II. SIGNIFICANCE OF THE SYSTEM

The article presents the results of a study of the physicochemical properties of the polyaniline polymer. The study of methodology is explained in section III, section IV covers the experimental results of the study, and section V discusses the future study and conclusion.

III. METHODOLOGY

Aniline – C6H5NH2, molecular weight 93.2, boiling point 184.4 ºC, has a characteristic odor. At room temperature it is a colorless liquid. Under the influence of light it can acquire a slightly yellow color. Under vacuum it is distilled at 91 ºC. IR spectra of valence vibrations of N-H bond of aniline are in the region of 1180-1360 cm-1, and at 3200-3500 cm-1 valence vibrations are amplified, resonate δ=1-5 nm. Aniline is a very toxic compound.

Polyaniline is a polymer with electron conductivity, unlike most known polymers, which are insulators under normal conditions.

Polyaniline consists of repeating N-phenyl-p-phenylenediamine and quinonediimine blocks. Depending on their ratio, there are leucoemeraldine (n = 1, m = 0), pernigraniline

(n = 0, m = 1) and emeraldine (n = 0.5, m = 0.5). The last two exist in the form of a salt and a base.

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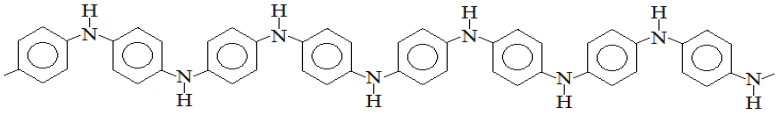
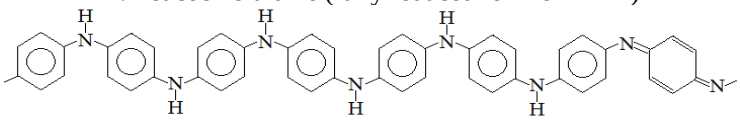
The structures presented below belong to the main (non-salt) forms and represent the basic oxidation states of PANI molecules. The base and salts of PANI are very unstable, they quickly decompose to form products containing a smaller number of quinoid structures.

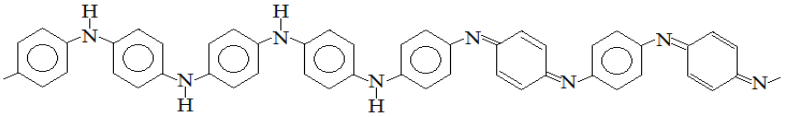
It should be taken into account that the presented structures of PANI in intermediate oxidation states are idealized and generally correspond to real ones only with respect to their quantitative composition. From the given structures, as well as from the electronic spectra of PANI base solutions in the corresponding oxidation states, it is evident that with an increase in the oxidation state of PANI, the content of amine fragments decreases and the content of imine fragments increases. The fully reduced form of PANI, leucoemeraldine, consists of only amine fragments, while the fully oxidized form, pernigraniline, contains the maximum number of imine fragments. The intermediate structures consist of both fragments in various proportions. PANI in a semi-oxidized state is the most stable with respect to various types of influences. The transition to this salt-like semi-oxidized state can occur in two ways. Forms of polyaniline are shown in Scheme 1.



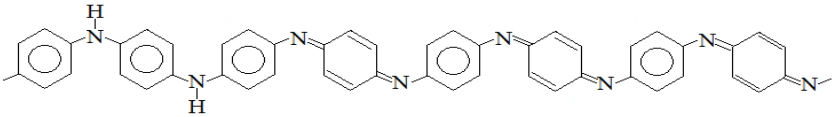
1. Leucoemeraldine (fully reduced form of PANI)



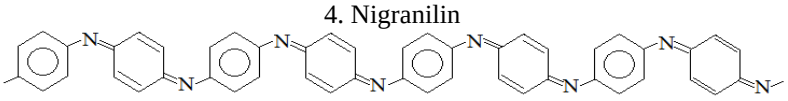
2. Protoemeraldine



3. Emeraldine



4. Nigranilin



5. Pernigranilin (fully oxidized form of PANI)

Scheme 1. Various forms of PANI

Unlike most other conducting polymers, the transition to intermediate oxidation states of the protonated form of emeraldine can occur both through protonation of the main form with the corresponding oxidation state and through oxidation of the corresponding protonated form (Scheme 1). This circumstance is not characteristic of most other conducting polymers.

Polyaniline was obtained electrochemically: for this purpose, aniline was added to 0.2 N hydrochloric acid. The synthesis was carried out in a U-shaped electrochemical cell with a porous glass partition located between the electrodes. The setup used in our work is an anode made of a platinum plate and a cathode consisting of a platinum mesh. In our experiments, a calomel electrode was used for comparison. A 0.2 N solution of aniline in hydrochloric acid was added to the electrochemical cell with the working electrode.

The process was carried out at room temperature in a potentiostatic mode at E = 0.8 V for 8 hours. The PANI obtained on the anode plate was purified by washing with 1 N aqueous solution of hydrochloric acid, and then with distilled water. To convert the hydrochloric PANI into a base, it was repeatedly washed with 8% ammonia solution, dried in a vacuum for 48 hours, the yield was 80% of the theoretical calculation. The PANI obtained in this way was dried in a vacuum for 48 hours.

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IV. EXPERIMENTAL RESULTS

Infrared spectra of PANI samples were recorded on a SHIMADZU spectrophotometer in the range of 4000-400cm^{-1}. PANI samples were prepared in the form of tablets with potassium bromide in the ratio of 97,5:2,5%. A press mold with vacuuming was used to remove moisture.

PANI in which macromolecules are linked by strong salt bonds, depending on the strength of the initial polyelectrolytes, can be obtained both by chemical and electrochemical methods. The most important factor in such reactions is cooperativity. It is due to the cooperativity of the intermolecular interaction of polyelectrolytes that they turn out to be very stable compounds. We studied the kinetics of PANI formation, as well as their physicochemical properties using IR spectroscopy.

A SHIMADZU spectrophotometer (Japan) in the range of 4000-400 cm^{-1} was used to study the IR spectra of PANI.

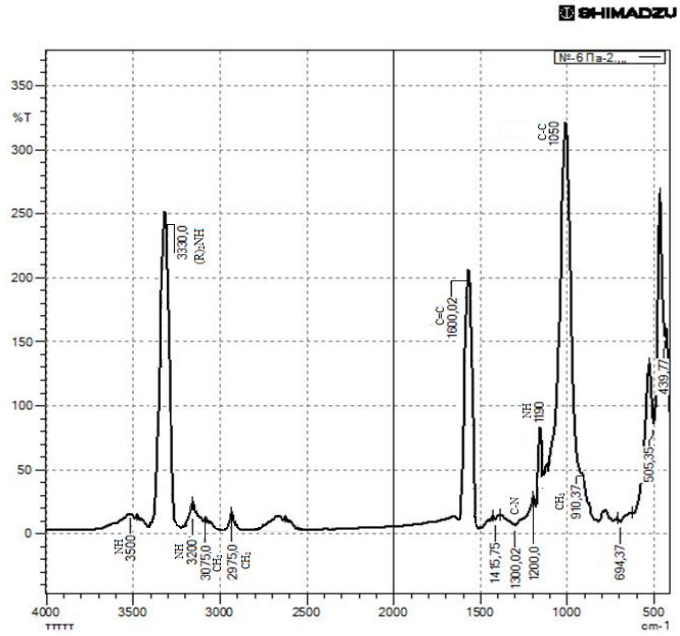
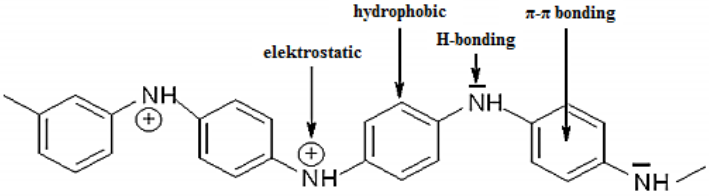


Fig. 1. IR spectrum of PANI

The results of IR spectroscopy studies showed (Fig. 1) that the IR spectra of the initial components and the obtained PANI coincide with the absorption bands of the corresponding functional groups, that the stretching vibrations of PANI in the region of 3330 cm^{-1}; 1305 cm^{-1} belong to the CN group, the stretching vibrations of 3085; 2750; 910 cm^{-1} belong to the CH_2 group, the stretching vibrations of 1600; 1580 cm^{-1} belong to the benzene ring, the stretching vibrations of 3500; 3200; 1360; 1180; 960; 690 cm^{-1} belong to the -NH group, and the stretching vibrations in the regions of 3500; 960; 690 cm^{-1} belong to the NH group. Studies show that polyaniline has aromatic rings linked to nitrogen atoms. This chemical structure allows for different interactions between the PANI layer and different analytes. The nitrogen atoms can form hydrogen bonds, and hydrophobic p-p interactions can occur due to the presence of aromatic rings. In addition, in Scheme 2, we see that PANI has charged ionic groups that can electrostatically bind to the anionic form.



Scheme 2. Types of interactions in polyaniline

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V. CONCLUSION AND FUTURE WORK

According to the results of experimental studies of the physicochemical properties of the polyaniline polymer (PANI), it was found that polyaniline has excellent properties. From the given schemes it is evident that with an increase in the oxidation state of the PANI base, the number of amine fragments decreases, and the number of imine fragments in the PANI composition increases. The fully reduced form of PANI - leucoemeraldine - contains only amine fragments, while the fully oxidized form of pernigraniline contains the maximum number of imine fragments.

REFERENCES

1. Ireneusz Sowa, Magdalena Wójciak, Katarzyna Tyszczuk-Rotko, Tomasz Klepka, Sławomir Dresler. Polyaniline and Polyaniline-Based Materials as Sorbents in Solid-Phase Extraction Techniques//Materials 15, 8881. Switzerland. 2022, pp. 1-23. https://doi.org/10.3390/ma15248881.
2. Jin-Chih Chiang and Alan G. Mag`diarmid. Polyaniline: Protonic acid doping of the emeraldine form to the metallic regime. Synthetic Metals. V.13. 2003. –pp.193.
3. Nabiev A., Avlyanov Zh.K., Yuldasheva M.A. Molecular mass characteristics of polyaniline and poly-ortho-toluidine // Uzbek Chemical Journal. No. 4. Tashkent. 1991. – P. 45-47
4. Genies E.M. and Tsintavis O. Redox mechanism and electrochemical benaviour of polyaniline geposits //Journal electroanal. Chem. V.195. 1998. – P.128
5. M.Bartonek and H.Kuzmany. Resonance Raman Scattering of spincarrying states in polyaniline //Synthetic Metals. V.37. 1997. –P.57-62
6. Kogan Y.A., Shunina I.G. and Savchenko V.I. Electrochemical properties of polyaniline in highly concentrated acids. Synthetic Metals. V.37. 1990. –P.63.
7. Djalilova I.S.Shonazarova N.U., Tukhtaev F.S., Negmatov S.S. Determining the swelling properties of sorbents. International conference on “Science, technology and educational practices”. Indonesia. February 20-21, 2021. pp. 205-206.
8. Tukhtaev F.S., Djalilova I.S., Shonazarova N., Sadinova O.O. Strength characteristics of bentonite filler sorbents (PANI-PAC). “International journal for innovative engineering and management research”. Volume 10. Issue 3. pp. 114-115.