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SYNTHESIS AND PROPERTIES OF DIFFICULT COMBUSTION MATERIAL BASED ON MODIFIED POLYACRYLONITRILE

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Abstract. Many ion exchange materials have been obtained on the basis of polyacrylonitrile (PAN) fibre. PAN is also used in the creation of hard-to-burn materials. This is achieved by introducing functional active groups into PAN. Therefore, polyacrylonitrile was modified with triethanolamine (TEA) to synthesize an ion exchange material in this work. The reaction mechanism of the synthesized ion exchange substances, their structure, physico-chemical properties, stability in different environments and sorption properties were studied. A flame retardant material containing nitrogen and phosphorus was obtained by attaching phosphoric acid to the resulting ion exchange material. The resulting ion exchange PAN fabric was treated with phosphoric acid to produce flame retardant PAN fabrics (FR-PAN). The incorporation of triethanolamine and phosphorus into PAN fabric was investigated using Fourier transform infrared spectroscopy (FTIR). To evaluate the thermal stability and fire resistance of the obtained FR-PAN, limiting oxygen index (LOI) and thermo gravimetric analyses (TGA) were performed.

Keywords: polyacrylonitrile, triethanolamine, phosphoric acid, chemical modification, ion exchange material, flame retardant material.

Modifikatsiyalangan poliakrilonitril asosida qiyin yonuvchan materialning sintezi va xossalari

Annotatsiya. Poliakrilonitril (PAN) tolasi asosida ko’plab ion almashinadigan materiallar olingan. Shuningdek adabiyotlardan ma’lumki PAN qiyin yonuvchi materiallarni yaratishda ham qo‘llaniladi. Buning uchun PAN tarkibiga funksional faol guruhlarni kiritish orqali erishiladi. Shuning uchun ushbu ishda ion almashinadigan material sintez qilish maqsadida poliakrilonitril trietanolamin (TEA) bilan modifikatsiyalandi. Sintez qilingan ion almashinuvchi moddalarning reaksiya mexanizmi, ularning tuzilishi, fizik-kimyoziy xossalari, turli muhitlarda barqarorligi hamda sorbsion xossalari o’rganildi. Olingan ion almashinuvchi materialga ortofosfat kislotani biriktirib azot va fosforni o'z ichiga olgan olovga chidamli material olindi. Qiyin yonuvchan PAN matolarini (QY-PAN) hosil qilish uchun olingan ion almashinuvchi PAN matoga ortofosfat kislotasi bilan ishlov berildi. Trietanolaminning va fosforning PAN matosiga birkritirilishi Fourier transform infraqizil spektroskopiyasi (FTIR) yordamida tekshirildi. Olingan QY-PAN ning termik barqarorligi va olovga chidamliligini baholash uchun cheklovchi kislorod indeksi (ChKI) va termogravimetrik (TG) analiz tahlillari o’tkazildi.

Kalit so‘zlar: Poliakrilonitril, trietanolamin, ortofosfat kislotasi, kimyoviy modifikatsiya, ion almashinadigan material, qiyin yonuvchan material.

Синтез и свойства трудно горючего материала на основе модифицированного полиакрилонитрила

Аннотация. Полиакрилонитрильное (ПАН) волокно часто используется в качестве исходного материала при производстве ионообменных смол. Также из литературы известно, что ПАН используется при создании трудно горючих материалов. Это достигается введением в ПАН функциональных активных групп. Поэтому в данной работе для синтеза ионообменного материала полиакрилонитрил был модифицирован триэтаноламином (ТЭА). Исследован механизм реакции синтезированных ионообменных веществ, их структура, физико-химические свойства, устойчивость в различных средах, сорбционные характер Для получения трудно горючих ПАН-тканей ионообменную ПАН-ткань обрабатывали ортофосфорной кислотой. Присоединение триэтаноламина и фосфора к ПАН-ткани исследовали с помощью инфракрасной спектроскопии с преобразованием Фурье.

Ключевые слова: полиакрилонитрил, триэтаноламин, ортофосфорная кислота, химическая модификация, ионообменный материал, трудно горючий материал.

Introduction. Today, polyacrylonitrile fibre is one of the most widely used synthetic fibresfibers, and it is widely used in the textile industry due to its good heat retention and resistance to physical and chemical effects [1]. However, since PAN fibre has an oxygen index of 17%, it burns quickly and emits harmful gases such as toxic hydrogen cyanide along with smoke. This severely limits its widespread use. Creating flame retardant PAN fibre helps overcome these challenges. One of these methods involves the synthesis of phosphorus-containing acrylonitrile polymers to improve the flame resistance of PAN fibre or fabric [2]. This is achieved by adding more than 3.5 wt.% phosphorus to PAN fibre and its fabrics [3]. Therefore, environmentally friendly and effective fire-resistant synthetic fibres containing phosphorus and nitrogen are widely used [4]. The addition of phosphorus has become one of the most reliable methods to ensure the fire resistance of PAN fibres [5]. However, in most cases, the incompatibility of additives added to acrylonitrile polymers increases fire resistance and the deterioration of the mechanical properties of PAN fibres. Materials based on synthetic and natural fibres containing phosphorus are of great interest due to their environmental friendliness, low smoke and gas emission, and high fire resistance. Complex combustible materials containing phosphorus contribute to forming a char layer in the condensed phase and are effective flame retardants for polymer fibres [6].

Two main methods are used to improve the flame resistance of PAN: surface modification by grafting different flame retardant groups and incorporation of flame retardant materials into the polymer composition, including mixing flame retardant materials with polymers and forming composites or nanocomposites, as well as synthesis of polymer chains containing fire-resistant groups [7].

In one work aimed at obtaining a fire-resistant material [8], polyacrylonitrile was first modified with hydroxyethyl methacrylate, and then phosphoric acid was attached using a urea catalyst to produce a fire-resistant polymer containing phosphorus. In this work, the limited oxygen index is 32%. In another work [9], to obtain FR-PAN, polyacrylonitrile was first modified with ethylenediamine, and then phosphoric acid was added under a urea catalyst. To create the corresponding FR-PAN fabric by researchers [10], phosphoric acid was bonded to the PAN fabric and aminated using triethanolamine. In this study, polyacrylonitrile was grafted onto the surface of polyacrylonitrile fabric in a novel way to create FR-PAN fabric containing nitrogen and phosphorus using triethanolamine and phosphoric acid. Based on PAN fabric and triethanolamine, an anion exchange material with basic properties was synthesized. The reaction mechanism of the obtained anion exchange substances, their structure, physicochemical properties, stability in different environments, sorption characteristics and fire resistance properties were studied. It shows that slightly better results were obtained than the obtained urea-based refractory material (PAN-KDM). The limited oxygen index did not exceed 30% in difficult combustible material obtained based on PAN-KDM.

Material and methods. Materials. Polyacrylonitrile fibre (Mw = 110000) is a product of Navoiazot OJSC and is a copolymer of acrylonitrile (92.5%), methyl acrylate (6.0%) and itaconic acid (1.3%). Before use, the fibre was cleaned of various industrial impurities and washed with water and inert solvents. Triethanolamine was obtained from Tianjin Fengchuan Chemical Reagent Technologies Co., Ltd., Tianjin, China.

Preparation of anion exchange fabric by grafting PAN and TEA. Temperature and time are the main factors affecting the course of chemical reactions. The influence of temperature and time on the reaction of nucleophilic addition of triethanolamine and modification of PAN fibres was studied. The modification process was initially carried out at different temperatures for a fixed period of 3 hours. The research results showed that the favourable temperature for modification of PAN with triethanolamine was 175-180°C. It was also observed that the process has a negative effect on the mechanical strength of the PAN fibre at temperatures higher than those selected at this fixed time for modification.

Changes in the physicochemical and sorption properties of anion exchange materials formed during the modification process were monitored by checking the value of the static exchange capacity

(SEC). SEC values ranging from 0.78 to 4.1 meq/g were obtained according to the temperatures mentioned (Table 1).

Table 1. The effect of temperature on the static exchange capacity during the modification process (time of reaction 3 hours).

Reaction temperature, °C	Weight of PAN, g	Weight of modified PAN, g	Weight gain, %	Exchange capacity: meq/g
150	5.02	5.77	14.94	0.78
160	5.07	5.91	16.57	1.62
170	5.11	6.23	21.92	3.4
180	5.05	6.16	21.9	3.31

The effect of time on the modification process of PAN with triethanolamine was also investigated. Additionally, experimentally, a reaction time of 4 hours at 175°C was found to be sufficient and optimal (Table 2). Apparently, after a certain immobilization of triethanolamine molecules in the polymer matrix, the further possibility of the reaction is hindered by the large conformation of the modifying reagent.

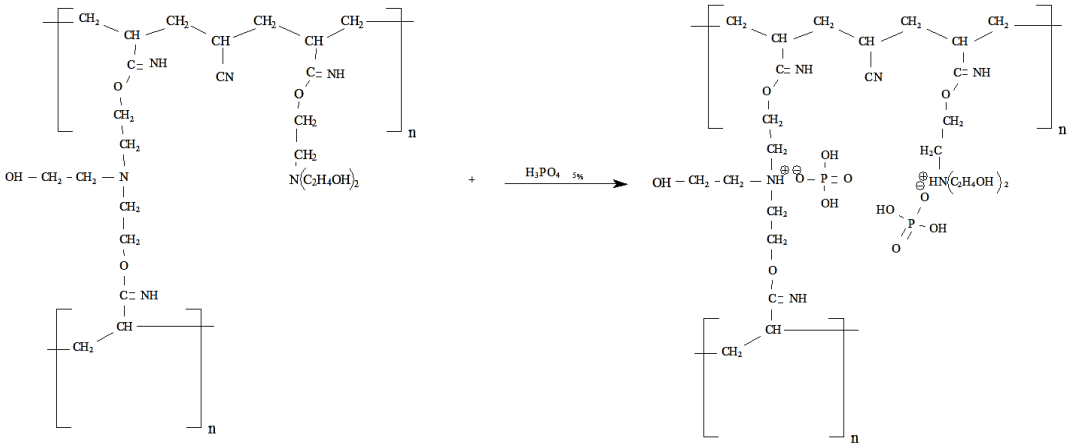
Table 2. The effect of time on the static exchange capacity of the modification process (temperature of reaction 170°C).

Reaction time, h	Weight of PAN, g	Weight of modified PAN, g	Weight gain, %	Exchange capacity: meq/g
1	5.12	6.07	18.55	2.54
2	5.11	6.23	21.8	3.4
3	5.19	6.86	32.17	3.74
4	5.06	6.71	32.61	4.01
5	5.14	6.73	30.93	3.6

To determine the grafting percentage of TEA, the modified fibre (PAN-TEA) was dried in an oven at 50°C, and the grafting percentage was determined using the following equation: $GP = \frac{W_2 - W_1}{W_1} \times 100\%$, where W_1 is the mass of the original PAN and W_2 is the mass of the modified PAN.

1.1. Preparation of FR-PAN from anion exchange fabric

The phosphorylation of anion-exchange materials and changes in their combustion properties were studied at this stage of the research. The modified PAN fabric was properly washed with deionized water before being dried in a 60°C oven. The dried fabric was placed in a 500 ml conical flask and immersed in a 5 wt.% phosphoric acid solution at room temperature for 24 hours. A schematic view of the reactions is shown in Scheme 1.



Scheme 1. FR-PAN fabric formation scheme.

Results and discussion. ***TG analysis.*** Figure 1 shows the TGA curves of the original PAN fabric and the Fr-PAN fabric. In this figure, when pure PAN fabric is heated, it in turn begins to decompose, and the mass loss increases dramatically as heating continues.

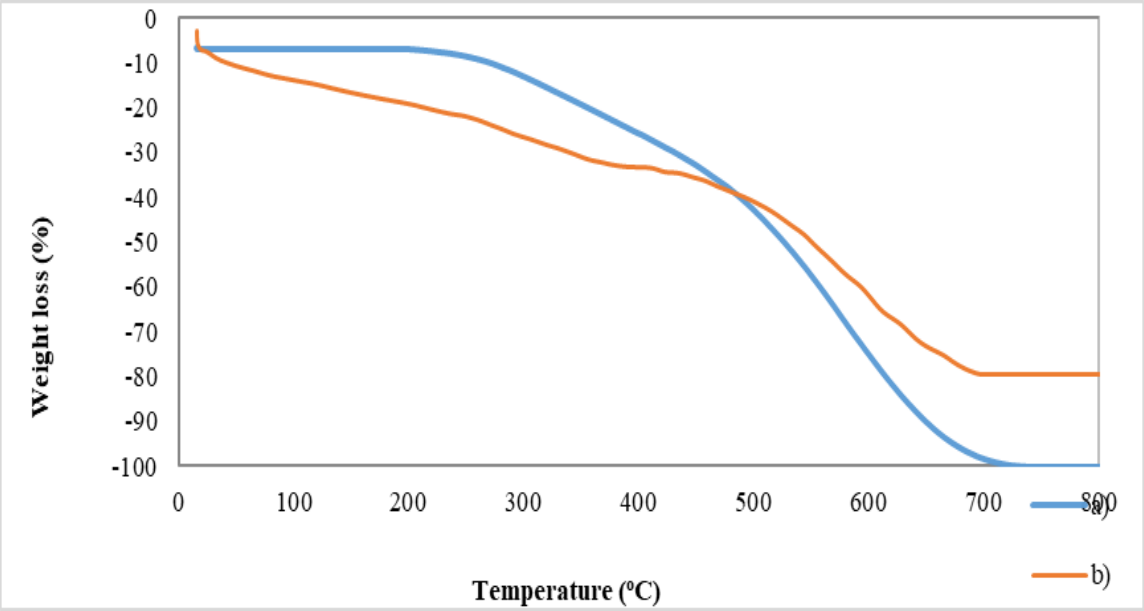


Figure 1. TG curves of PAN (a) and FR-PAN (b) fabrics.

If the decomposition of initial PAN is divided into phases, a small mass loss was detected in the first stage of the decomposition curve in the temperature range up to 258°C. This phase has been reduced slightly due to the cyclization process. The cyclization process occurs mostly for neighbouring cyano groups [10], and the mass falls as a result of gas release from subsequent decomposition. There is a loss of mass and a minor drop in the curve as a result of gas separation. The rate of weight loss increases between 260°C and 482°C. The carbon–carbon structure degrades in this zone. As a result, various gases, including light gases such as hydrogen, hydrogen cyanide, and ammonia, are emitted during this step [11]. Thermal decomposition occurs during the following weight loss, resulting in a higher weight loss than the prior ones. As a result, hydrogen gas is one of the primary emitted gases during this stage of decomposition. When the thermal analysis of the original PAN is compared to the thermal analysis of the FR-PAN, it can be shown (Fig. 1, b) that the weight loss curve is slightly higher at the beginning temperatures. If the weight loss process for FR-PAN is broken down, the first stage occurred at temperatures ranging from 44.9°C to 395.4°C, with a mass loss of approximately 24.38 wt.%. This loss is caused by the changed bound water and partially bound amino acids in the fabric. Furthermore, this stage is one of the primary stages of mass loss. The second stage occurred between 395.4°C and 513.8°C, resulting in a 5.29 wt.% mass loss. This could be due to the mass loss caused by the breakdown of the ammonium and phosphate groups of the flame retardant PAN [12]. Phosphoric acid, ammonia, polyphosphoric acid, and other chemicals may increase at this stage [13]. The second step of fabric weight loss began at 513.8°C and proceeded to 692.4°C, the main degradation stage of FR-PAN, resulting in a weight loss of approximately 35.9 wt.%. The carbonized layer transmits heat very poorly in this process, which serves to slow down the combustion process, lower the flame temperature, and prevent burning [14]. The final stage started at 692.4°C and ended in the temperature range of 785.4°C, with a mass loss of approximately 0.5 wt.%.

1.1.1. FTIR Analysis

The analysis of the IR spectrum of polyacrylonitrile fabric revealed (Fig. 2, a) that in the IR spectrum of unmodified polyacrylonitrile (a), there are peaks corresponding to -CN groups in the 2241 cm^{-1} area, corresponding peaks for CH_2 groups in the 2920 cm^{-1} area, and deformation vibrations of

CH_2 groups in the 1450 cm^{-1} regions. It was also discovered that C=O groups in methyl acrylate and itaconic acid have deformation vibrations in the 1729 cm^{-1} range.

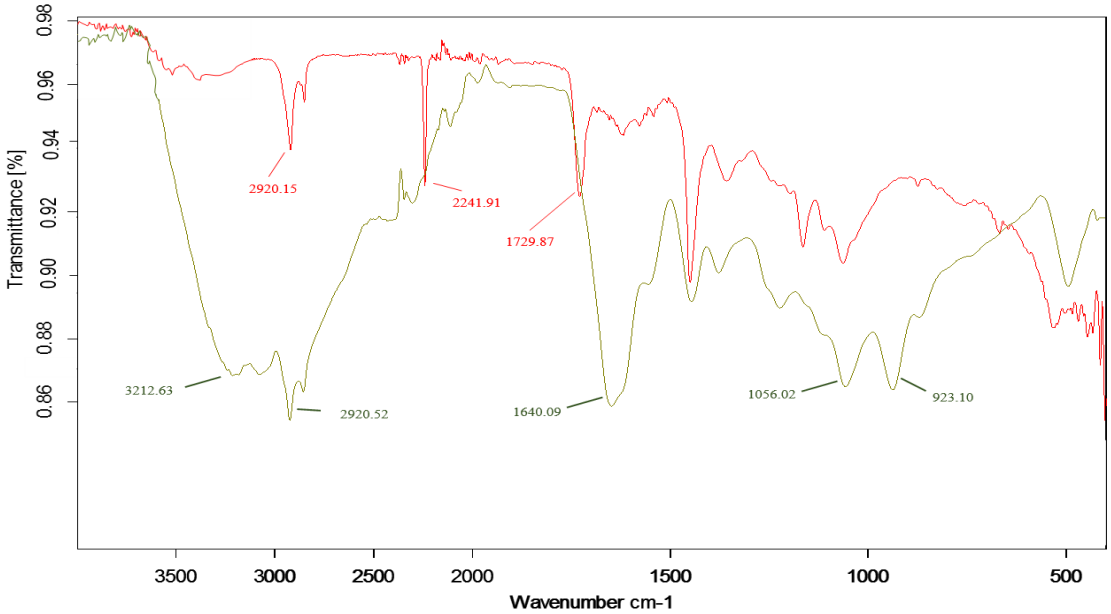


Figure 2. FTIRspectra of PAN (a) and FR-PAN (b) fabrics.

As seen from the IR spectrum of modified PAN (Fig. 2, b), a decrease in the intensity of the absorption line was observed in the region of 2241 cm^{-1} belonging to the -CN group. This indicates a decrease in the amount of –C≡N groups in the sample. Additionally, in the IR spectrum of FR-PAN, new extended absorption lines corresponding to -OH and -NH_2 groups appeared in the regions of 3303 cm^{-1} and 3214 cm^{-1}, and vibrations corresponding to the -C=NH groups appeared in the region of 1246 cm^{-1}. The wavelength of 923 cm^{-1} in the modified sample was found to belong to the O-P-O groups in phosphoric acid.

The limiting oxygen index values of the original PAN and FR-PAN are presented in Table 3. The limited oxygen index value of FR-PAN (31.5%) was shown to be significantly higher than that of the original PAN fabric (18%), even after 20 washing cycles.

Table 3. The limiting oxygen index values of different fabrics before and after washing.

Samples	LOI **(%)**					
	Cycles	**0**	**5**	**10**	**15**	**20**
PAN		18	18	18	18	18
FR-PAN		31,5	30,2	29,8	29,2	29.0

The main disadvantage of modified PAN cloth is that its dyeing qualities deteriorate after alteration. Furthermore, modified PAN loses transparency [15] and turns yellowish-brown in color.

Conclusion. A new ion exchange material was created by chemically modifying PAN with triethanolamine. From the acquired ion exchange material, a method for creating difficult flammable compounds comprising phosphorus and nitrogen was created. The composition and qualities of the resulting non-flammable polyacrylonitrile fabric were studied using TGA, FTIR analysis, and limited oxygen index testing. According to the TG study, the thermal stability of FR-PAN is higher than that of the original PAN fibre, and the char residue is 21 wt.% higher than that of the original PAN. The limited oxygen index value of FR-PAN grew to 31.5% after 20 washing cycles, indicating that hard-to-burn materials based on PAN were created.

References

1. Bajaj, P., Agrawal, A. K., Dhand, A., Kasturia, N., & Hansraj. Flame retardation of acrylic fibres: an overview//Journal of Macromolecular Science, Part C: Polymer Reviews. – 2000. – T. 40. – №. 4. – C. 309-337.
2. Akovali G., Gundogan G. Studies on flame retardancy of polyacrylonitrile fibre treated by flame-retardant monomers in cold plasma//Journal of applied polymer science. – 1990. – T. 41. – №. 9-10. – C. 2011-2019.
3. Tsafack M. J., Levalois-Grützmacher J. Flame retardancy of cotton textiles by plasma-induced graft-polymerization (PIGP)//Surface and coatings technology. – 2006. – T. 201. – №. 6. – C. 2599-2610.
4. Li, Y. M., Deng, C., Shi, X. H., Xu, B. R., Chen, H., & Wang, Y. Z. Simultaneously, improved flame retardance and ceramifiable properties of polymer-based composites via the formed crystalline phase at high temperature//ACS applied materials & interfaces. – 2019. – T. 11. – №. 7. – C. 7459-7471.
5. Wyman, P., Crook, V., Ebdon, J., Hunt, B., & Joseph, P. Flame-retarding effects of dialkyl-p-vinylbenzyl phosphonates in copolymers with acrylonitrile//Polymer international. – 2006. – T. 55. – №. 7. – C. 764-771.
6. Norouzi M., Zare Y., Kiany P. Nanoparticles as effective flame-retardants for natural and synthetic textile polymers: application, mechanism, and optimization/ //Polymer Reviews. – 2015. – T. 55. – №. 3. – C. 531-560.
7. Ma, C., Yu, B., Hong, N., Pan, Y., Hu, W., & Hu, Y. Facile synthesis of a highly efficient, halogen-free, and intumescent flame retardant for epoxy resins: thermal properties, combustion behaviors, and flame-retardant mechanisms//Industrial & Engineering Chemistry Research. – 2016. – T. 55. – №. 41. – C. 10868-10879.
8. Ren, Y., Huo, T., Qin, Y., & Liu, X. Preparation of flame retardant polyacrylonitrile fabric based on sol-gel and layer-by-layer assembly//Materials. – 2018. – T. 11. – №. 4. – C. 483.
9. Yu, L., Zhang, S., Liu, W., Zhu, X., Chen, X., & Chen, X. Improving the flame retardancy of PET fabric by photo induced grafting//Polymer Degradation and Stability. – 2010. – T. 95. – №. 9. – C. 1934-1942.
10. Рустамов М.К. Химическая модификация полиакрилонитрильных волокон и материалов на его основе карбамидом.//Вестник НУУз. 2012. №3/1. -С.56-60. (02.00.00, №12).
11. Joseph P., Tretsiakova-McNally S. Combustion behaviours of chemically modified polyacrylonitrile polymers containing phosphorylamino groups//Polymer degradation and stability. – 2012. – T. 97. – №. 12. – C. 2531-2535.
12. Ren Y., Huo T., Qin Y. Preparation of phosphorus-containing and nitrogen-containing durable flame retardant polyacrylonitrile fabric via surface chemical modification//Fire and Materials. – 2018. – T. 42. – №. 8. – C. 925-932.
13. Yan, X., Zhou, W., Zhao, X., Xu, J., & Liu, P. Preparation, flame retardancy and thermal degradation behaviors of polyacrylonitrile fibres modified with diethylenetriamine and zinc ions//Journal of Thermal Analysis and Calorimetry. – 2016. – T. 124. – C.719-728.
14. Ren, Y., Huo, T., & Qin, Y.. Preparation of phosphorus-containing and nitrogen-containing durable flame retardant polyacrylonitrile fabric via surface chemical modification. *Fire and Materials*, *42*(8), 2018, p.925-932.
15. Yan, X., Zhou, W., Zhao, X., Xu, J., & Liu, P. Preparation, flame retardancy and thermal degradation behaviors of polyacrylonitrile fibresfibers modified with diethylenetriamine and zinc ions. Journal of Thermal Analysis and Calorimetry, - 2016, 124, p. 719-728.

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