

UDC541.64:546.22

**POLYVINYLCHLORIDE COMPOSITIONS OF FINISHING
APPOINTMEN WITH IMPROVED THERMAL AND COLOUR
STABILITY**

**ПОЛИВИНИЛХЛОРИДНЫЕ КОМПОЗИЦИИ ОТДЕЛОЧНОГО
НАЗНАЧЕНИЯ С УЛУЧШЕННЫМИ ПОКАЗАТЕЛЯМИ
ТЕРМОСТАБИЛЬНОСТИ И ЦВЕТОСТАБИЛЬНОСТИ**

A.K. Mazitova, L.B. Stepanova, G.F. Aminova, A.I. Gabitov, A.R. Maskova,
FSBEI NPE “Ufa State Petroleum Technological University”,
Ufa, the Russian Federation,
FSBEI NPE “Ufa State Petroleum Technological University”, Branch of
Sterlitamak, the Russian Federation

Мазитова А.К., Степанова Л.Б., Аминова Г.Ф., Габитов А.И., Маскова А.Р.,
ФГБОУ ВПО «Уфимский государственный нефтяной технический
университет», г. Уфа, Российская Федерация
ФГБОУ ВПО «Уфимский государственный нефтяной технический
университет», филиал, г. Стерлитамак, Российская Федерация

e-mail: asunasf@mail.ru

Abstract. Polyvinyl chloride (PVC) takes a special place in a class of the large-capacity organochlorine compounds obtained on the basis of products of petrochemistry. It has good physic-mechanical properties and relatively low cost in comparison with the hydrocarbon polymers. Obtained on its base materials differ with a wide range of properties and are used in a wide variety of purposes in all industries, as well as agriculture and households. With development of the production of PVC the role of plasticizers used in its processing has increased significantly. In application the ester plasticizers, capable to plasticize almost all polymers, especially polyvinylchloride are considered as the most practical.

Currently, the industry has mastered production of more than three hundred brands of plasticizers, most of which are esters of phthalic acid: phthalates occupy more than 80% of the market, thus over 90% of phthalates used to plasticize PVC. However, despite the rather large range of plasticizers, their number is insufficient to meet the needs of modern industry. In this regard, development of new plasticizers for compositions of PVC materials of finishing appointment is relevant and practically significant problem. On the other hand due to the extremely low stability of PVC during the storage, processing and operation continuous growth rates of production of this polymer extremely sharply put a stabilization problem. In order to improve the thermal stability of the polymer composition based on plasticized polyvinyl chloride in the present work we investigated the possibility of selecting effective chemical additives required for processing and exploitation of polymer products. Formulation of PVC films of upper and intermediate layers of linoleum with the use of new compounds – butoxyalkylphenoxyalkylphthalates, proposed as PVC plasticizers, are developed. The possibility of increasing of thermal-oxidative stability of the new plasticizers with a phenolic antioxidant - ionol is explored. On the basis of our research revealed that the use of antioxidant can effectively inhibit butoxyalkylphenoxyalkylphthalates oxidation process and increase technological and operational properties of PVC films in the formulations of the upper and intermediate layers of linoleum.

Аннотация. Поливинилхлорид (ПВХ) занимает особое место в классе крупнотоннажных хлорорганических соединений, получаемых на основе продуктов нефтехимии. Он обладает хорошими физико-механическими свойствами и отличается сравнительно низкой себестоимостью в сравнении с углеводородными полимерами. Получаемые на его базе материалы отличаются широким диапазоном свойств и применяются в самых разнообразных целях во всех отраслях промышленности, а также сельском хозяйстве и в быту. С развитием производства поливинилхлорида роль пластификаторов, применяемых при его

обработке, значительно возросла. Наиболее практичными в применении считаются сложноэфирные пластификаторы, способные пластифицировать почти все полимеры, особенно поливинилхлорид. В настоящее время промышленность освоила выпуск более трехсот марок пластификаторов, большую часть которых составляют эфиры фталевой кислоты: фталаты занимают более 80% рынка, при этом свыше 90% производимых фталатов используется для пластификации ПВХ. Однако, несмотря на достаточно большой ассортимент пластификаторов, их количество недостаточно для полного удовлетворения потребностей современной промышленности. В этой связи разработка новых пластификаторов для композиций ПВХ-материалов отделочного назначения является актуальной и практически значимой задачей. С другой стороны, вследствие аномально низкой стабильности ПВХ в процессе хранения, переработки и эксплуатации непрерывные темпы роста производства этого полимера чрезвычайно остро ставят проблему стабилизации. С целью повышения термической устойчивости полимерной композиции на основе пластифицированного поливинилхлорида в настоящей работе исследована возможность подбора эффективных химикатов-добавок, необходимых для переработки и эксплуатации полимерных изделий. Разработаны рецептуры ПВХ-пленок верхнего и промежуточного слоев линолеума с использованием новых соединений – бутоксиалкилфеноксилалкилфталатов, предложенных в качестве пластификаторов поливинилхлорида. Изучена возможность повышения термоокислительной устойчивости новых пластификаторов с использованием фенольного антиоксиданта – ионола. На основании проведенных нами исследований было выявлено, что использование антиоксиданта позволяет эффективно ингибировать процесс окисления бутоксиалкилфеноксилалкилфталатов и повысить технологические и эксплуатационные свойства ПВХ-пленок в рецептурах верхнего и промежуточного слоев линолеума.

Key words: antioxidant, butoxyalkylphenoxyalkylphthalates, dehydrochlorination, PVC plasticizers, thermal stability, color stability.

Ключевые слова: антиоксидант, бутоксиалкилфеноксисалкилфталат, дегидрохлорирование, пластификаторы поливинилхлорида, термостабильность, цветостабильность.

In recent years increases volume of production of one of the large polymers – polyvinylchloride, due to its relatively low cost and the possibility of processing to a huge range of hard and soft materials and products (pipes, sheets, profiles, windows, doors, film, cable compounds, linoleum, wallpaper, adhesive tapes, decorative oilcloth, etc.). However, its significant disadvantage, in contrast to other thermoplastic materials, is the low thermal stability. It's practically impossible to process PVC in its pure form because the transition temperature of PVC to viscous-flow state (~170-180 °C) substantially coincides with the temperature of its thermal degradation. It is known that due to thermal, thermo-mechanical, thermal-oxidative and photochemical effects the hydrogen chloride recovery process may start at 70-80 °C and at 150-180 °C process speed increases, rapid degradation of the polymer occurs with liberation of hydrogen chloride and carbon dioxide. In the structure appear labile groups that contribute to its subsequent destruction and structuring, the melt viscosity increase, i.e. deterioration of processability and, ultimately, lower operating performance. In this regard, in the processing of PVC, to achieve the required performance and processing properties of materials and products based on it, various additive chemicals are used. Introduction of chemical additives can modify the physico-mechanical, thermal, optical, electrical, friction and other operational characteristics of the original (base) polymer [1-7].

Typically, the PVC materials are multicomponent systems, which in addition to the polymer backbone various additives are present. The content of additives in the PVC composition can vary within very wide limits, the composition may include up to 15-20 individual components: fillers, modifiers, stabilizers,

plasticizers, softeners, antioxidants, lubricants, pigments, fungicides, builders, antistatic agents, etc. Depending on task, the type and nature of the polymer additives it may range from one percent to 95% [2, 3].

As it's known, in recent years requirements to performance and technological properties of materials and products produced on the basis of PVC have steadily increased. Requirements to the additives quality, used during the processing of PVC, continue to grow, since their quality largely determines the properties of the final product. Efficiency of PVC can be realized only by using of combination of appropriate additives, whereby the material acquires the desired properties. Only with the help of finding the right effective additives wide range of characteristics can be obtained. Each of the components gives to material certain properties and has its functional load. Materials and products for various purposes, obtained on its base, have a wide range of physical and mechanical properties: from plastic films and flexible mastic of plastisols, from solid, durable and non-combustible glass to stretch fusible formoplast [3, 8, 9].

Continuous growth of PVC raises the problem of selection of effective chemical additives, without which processing and exploitation of polymer products is impossible. However, despite the huge variety of compounds, used as additives in polyvinyl chloride compositions of finishing appointment, their number is insufficient to meet the requirements of modern industry. It is primarily concerned, of proper selection of plasticizers and antioxidants. [6] Good selection of plasticizer plays an important role in expanding the applications of polymers and lengthening the duration of their service. Most plasticizers are commercially used for PVC plasticizing [10]. The introduction of plasticizers in the PVC compositions allows to obtain materials with a predetermined elasticity, persisting over a wide temperature range, with increased flexural toughness, higher elongation at break [11, 12].

At present time world industry produces a sufficiently large range of plasticizer, among them the major share occupy phthalic acid esters. They have

good plasticising properties and plasticized composition of PVC is widely used in manufacturing various articles and materials.

Dibutylphthalate which is used as a plasticizer in the preparation of materials and products of the finishing appointment, namely, linoleum, cable compounds, polymeric construction profiles, films engineering [11] and has a high volatility, which hinders its widespread use.

Butyl benzyl phthalate also applied in plasticizing PVC and its copolymers to impart improved water resistance and resistance to organic environment [13, 14], is produced in limited quantities. The reason for this is the scarcity of benzyl alcohol.

Phenols, used as plasticizers certain of polymeric materials such as polyamides and cellulose acetate [12, 14] are not suitable for plasticizing PVC. Therefore, despite the great variety of chemical compounds used as plasticizers, finding substances with plasticizing properties is relevant and practically significant problem.

In order to implement this direction we have synthesized butoxyalkylphenoxyalkylphthalates [15-20]. As shown by studies received butoxyalkylphenoxyalkylphthalates are less volatile compounds than industrial plasticizer dibutylphthalate.

The problem of stabilization of plasticized PVC is largely linked to the prevention of oxidative degradation of the plasticizer in the polymer compositions by the use of stabilizers - antioxidants [21-25]. With the effective inhibition of the ester plasticizers oxidation by air oxygen the speed of thermo-oxidative degradation of PVC in their concentrated solutions due to structural and physical stabilization approaches to the speed of degradation of the polymer, which is characteristic for its thermal degradation in the presence of plasticizer (solvent), i.e. decay rate lower in the absence of PVC solvent. In these cases, the inhibition of the solvent oxidation reaction using stabilizers - antioxidants as the "echo" causes stabilization of PVC. This is a fundamental phenomenon of

stabilization of PVC in solution at its thermo-oxidative degradation has been called "echo" - stabilization of PVC [26, 27].

Developing formulations of PVC films of upper and intermediate layers of linoleum with the use of synthesized compounds proposed as PVC plasticizers, we studied the possibility of improving the thermal stability and color stability of films using a widely used in polymer PVC compositions phenolic antioxidant - ionol.

We used samples of PVC suspension stamp PVC-S 6359 M with Fikentcher's constant $C_f = 63$. Further purification of the polymer was carried out by repeated washing with ethanol (bp = 75.4 °C, density = 0.789 g/cm³, refractive index = 1.3542) and diethyl ether (bp = 35.6 °C, density = 0.714 g/cm³, refractive index = 1.3542) followed by drying under vacuum (25 °C, 10 Pa).

Butoxyalkylphenoxyalkylphthalates [21-25] were obtained by sequential esterification of phthalic anhydride mark "W" (GOST 5869-77 rev. 1.2) without further purification based on alkoxyated phenols (GOST 23519-93) and butanol (GOST 5208-81 rev. 1-3). As the esterification catalyst p-toluenesulfonic acid mark "W" (TS -6192-52-5) in an amount of 1 wt % sheathe download was used. Base substance content of 99.0 %.

As the antioxidant, phenolic antioxidant was used - ionol mark "chemically pure" (GOST 10894 - 76).

For analytical determination using potassium hydroxide (GOST 4203-65), the content of the basic substance 90%; sodium thiosulfate, acetic acid and potassium iodide - all marks "chemically pure", used without further purification. Indicator: 1 mixture of 0.2% methyl red solution in acetone and 1 part of a 0.1% solution of methylene blue in ethanol. Test paper "Congo red" was prepared by impregnating of filter paper by indicator solution in a mixture of 0.5 ml of distilled water with 200 ml of glycerol.

Heat stability of PVC films were estimated by the induction period before starting of selection of HCl by GOST 14041-91 at temperature 180 °C.

Color stability was determined according to the time of sharp color change after exposure in air bath oven at the temperature of 180 °C.

PVC dehydrochlorination rate was measured during heat exposure of the polymers samples as quantity of allocated HCl by a method of continuous dehydrochlorination in gas carrier current. The degradation of PVC in gas carrier current (nitrogen or air) was carried out in a Vartman's reactor. Hinge plate of polymer was mixed with additives by careful grinding in a mortar within 30 min. As an absorber of HCl a trap with redistilled water was used, where added added is strictly dosed titrant KOH in the presence of a mixed indicator of methyl red-based and methylene. After using alkali in a trap a known amount of KOH solution was again poured and the operation repeated.

The process of thermal-oxidative dehydrochlorination of PVC, plasticized by butoxyalkylphenoxyalkylphthalates, accompanied by autocatalysis [4]. Introduction of ionol in butoxyalkylphenoxyalkylphthalate leads to a drastic decrease of the polymer thermooxidative dehydrochlorination rate, as well as the translation of the autocatalytic process at steady state. Kinetic curves of thermal dehydrochlorination of PVC in the presence of ionol, shown in Figure 1-4, have a linear form. Maximum reduction of the polymer dehydrochlorination rate is observed when the content of plasticizers in ionol is within 0.5-0.9 mmol / mol PVC and does not change with further increase of the amount of antioxidant. It is evident that the used antioxidant slows down the oxidation process of the plasticizer, which in its turn slows down the process of dehydrochlorination of PVC due to solvation stabilization, thereby increasing the thermal stability of the polymer (known effect of "echo – stabilization" PVC) [4, 26, 27]. Effect of anti-oxidizing action of ionol may also be expressed in a decrease of the rate of accumulation of hydroperoxides .

The results of experimental studies of the stabilization of PVC in the conditions of thermooxidizing disintegration have practical value. Stabilized by phenolic antioxidant - ionol synthesized butoxyalkylphenoxyalkylphthalates introduced into the formulation of PVC films. PVC composition for the

preparation of films of the upper and intermediate layers of linoleum milled in laboratory mill at a temperature of 165 °C for 10 minutes. When rolling tracks technological difficulties haven't occurred.

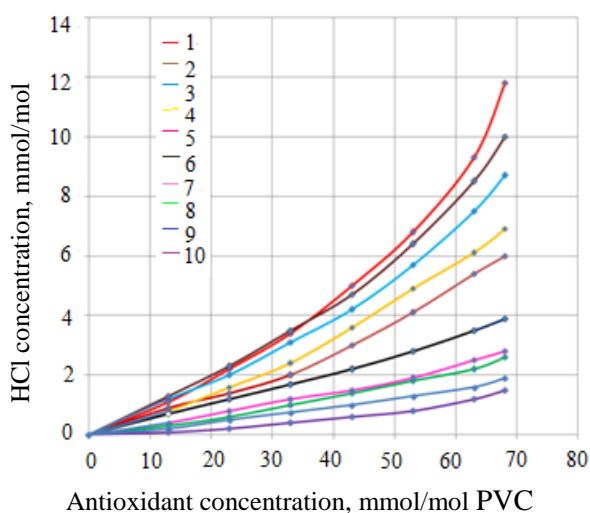


Figure 1. Kinetic curves of dehydrochlorination of PVC, plasticized with butoxyethylphenoxylethylphthalate (40 parts / 100 parts PVC) in the presence of an antioxidant - ionol (antioxidant concentration: 1- 0.0; 2 – 0.1; 3 – 0.2; 4 – 0.3; 5 – 0.4; 6 – 0.5; 7 – 0.6; 8 – 0.7; 9 – 0.8; 10 – 0.9 mmol/mol PVC), (180 °C, carrier gas - air 3.3 l / h)

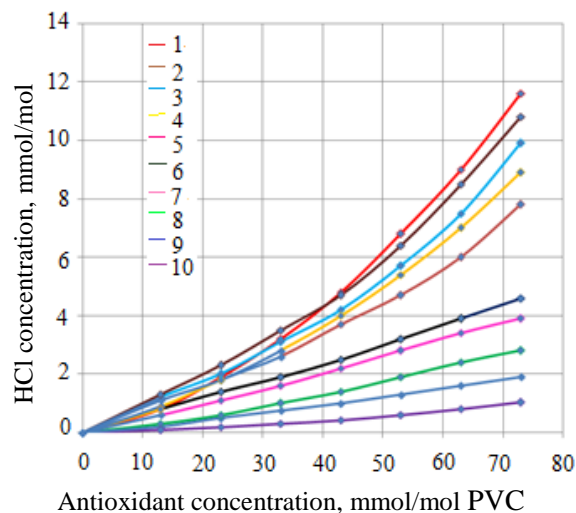


Figure 2. Kinetic curves of dehydrochlorination of PVC plasticized by butoxypropylphenoxypentylphthalate (40 parts / 100 parts PVC) in the presence of antioxidants - ionol (antioxidant concentration: 1- 0.0; 2 – 0.1; 3 – 0.2; 4 – 0.3; 5 – 0.4; 6 – 0.5; 7 – 0.6; 8 – 0.7; 9 – 0.8; 10 – 0.9 mmol/ mol PVC), (180° C, carrier gas - air 3.3 l / h)

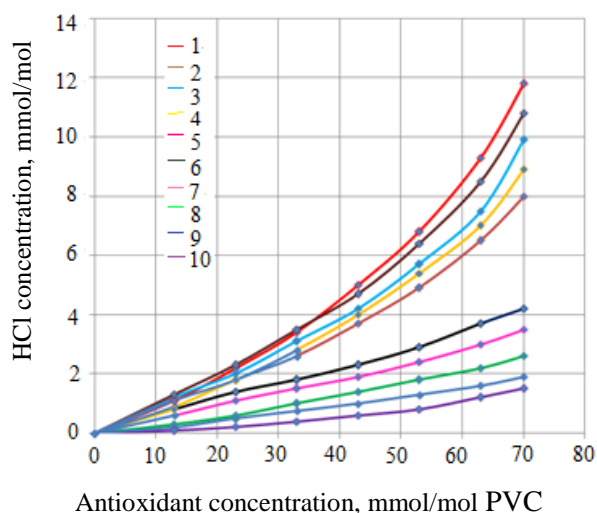


Figure 3. Kinetic curves of dehydrochlorination of PVC, plasticized by butoxyethylphenoxypropylphthalat (40 parts / 100 parts PVC) in the presence of an antioxidant - ionol (antioxidant concentration: 1 - 0.0; 2 - 0.1; 3 - 0.2; 4 - 0.3; 5 - 0.4; 6 - 0.5; 7 - 0.6; 8 - 0.7; 9 - 0.8; 10 - 0.9 mmol / mol PVC), (180 °C, carrier gas - air 3.3 l / h)

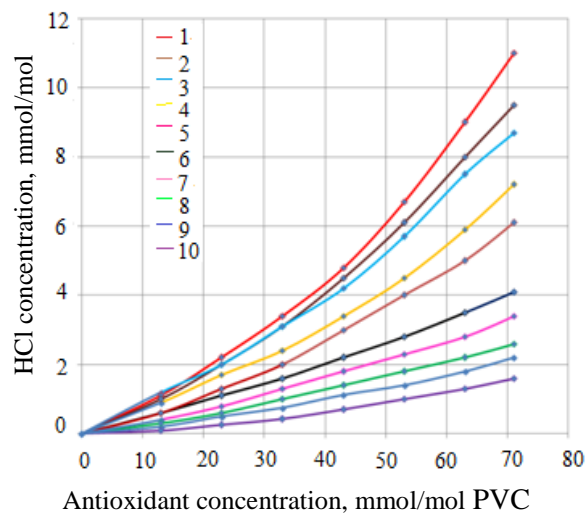


Figure 4. Kinetic curves of dehydrochlorination of PVC, plasticized by butoxypropylphenoxyethylphthalat (40 parts / 100 parts PVC) in the presence of anti-oxidants - ionol (antioxidant concentration: 1 - 0.0; 2 - 0.1; 3 - 0.2; 4 - 0.3; 5 - 0.4; 6 - 0.5; 7 - 0.6; 8 - 0.7; 9 - 0.8; 10 - 0.9 mmol / mol PVC), (180 °C, carrier gas - air 3.3 l / h)

As seen from the results (Tables 1, 2), introduction of ionol in an amount of 0.9 pbw / 100 pbw PVC in plasticized PVC plastic can significantly improve key indicators of polymer compositions – “time thermal stability” and “color stability”.

Table 1. Test results PVC film, plasticized by butoxyalkylphenoxyalkylphthalates in the formulations of the upper and intermediate layers of linoleum

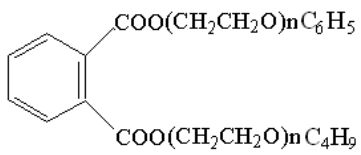
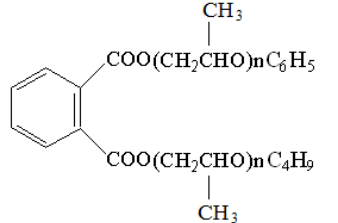
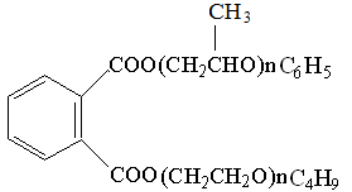
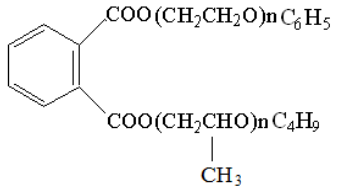















Indicator	Linoleum layer	Plasticizer	Chemical formula	Antioxidant, pbw/100 pbw PVC			
				0,0	0,9		
Thermal stability at 180 °C, min	Intermediate	Butoxyethylphenoxyethylphtalate		120	179		
	Upper			121	180		
Color stability, min	Intermediate			25	36		
	Upper			25	38		
Thermal stability at 180 °C, min	Intermediate			Butoxypropylphenoxypropylphtalate		120	171
	Upper					120	178
Color stability, min	Intermediate	25	30				
	Upper	25	34				
Thermal stability at 180 °C, min	Intermediate	Butoxyethylphenoxypropylphtalat				120	176
	Upper					121	179
Color stability, min	Intermediate			25	36		
	Upper			25	39		
Thermal stability at 180 °C, min	Intermediate			Butoxypropylphenoxyethylphtalat		120	175
	Upper					120	170
Color stability, min	Intermediate	25	34				
	Upper	25	37				

Table 2. Color stability of PVC film plasticized by butoxyalkylphenoxyalkylphthalates in formulations of linoleum upper layer at 180 °C

Plasticizer	Exposure time, min		
	10	30	60
Diethylphthalate			
Butoxyethylphenoxyethylphthalate			
Butoxypropylphenoxypropylphthalate			
Butoxyethylphenoxypropylphthalat			
Butoxypropylphenoxyethylphthalat			

Conclusions

Thus, the use of phenolic antioxidant - ionol can effectively inhibit the butoxyalkylphenoxyalkylphthalates oxidation process and increase technological and operational properties of PVC films of upper and intermediate layers of linoleum.

References

- 1 PVC stabilizers / Aminova G.K. [and other], Nauka i epoha: monograph. Voronezh: VSPU, 2012. Book 9. P. 275-295. [in Russian].
- 2 Nizamov R.R. Polyvinyl chloride compositions for construction purposes with multifunctional excipients. Extended abstract of PhD dissertation. Kazan, 2007. 45 p. [in Russian].
- 3 Maslova I.P. Chemical additives to polymers. Handbook. M.: Khimiya, 1981. 264 p. [in Russian].
- 4 Ahmethanov R.R. Sulphur as a stabilizer of polymers of vinyl chloride. PhD dissertation. Ufa. 2007. 131 p. [in Russian].
- 5 Minsker K.S., Kolesov S.V., Zaikov G.E. Aging and stabilization of polymers based on vinyl chloride. M.: Nauka, 1982. 272 p. [in Russian].
- 6 Minsker K.S., Fedoseyeva G.T. Degradation and stabilization of PVC. M.: Khimiya, 1979. 272 p. [in Russian].
- 7 Grassi N., Scott J. Degradation and stabilization of polymers. M: Mir, 1988. 246 p. [in Russian].
- 8 Key achievements in the field of production and use of PVC /Voronkov I.A. [and other] // Plastics. 1994. № 2. P.26 -30. [in Russian].
- 9 Osipchik V.V. Materials for construction purposes with improved operational properties on the basis of filled PVC. PhD dissertation. Moscow. 1989. 131 p. [in Russian].
- 10 Wilkie C., Summers J., Daniels C. Polyvinylchloryde. St. P.: Professiya, 2007. 728 p. [in Russian].
- 11 Bartshteyn R.S., Kirillovich V.I., Nosovskii Yu.E. Plasticizers for polymers. M.: Khimiya, 1982. 196 p. [in Russian].
- 12 Kozlov P.V., Papkov S.P. Physico-chemical basis of plasticizing polymers. M.: Khimiya, 1982. 224 p. [in Russian].
- 13 Mazitova A.K., Nafikova R.F., Aminova G.K. PVC plasticizers. Nauka i epoha: monograph. Voronezh: VSPU, 2011. Book 7. P. 276-296.

14 Plasticizers for polyvinyl chloride compositions for construction purposes /Aminova G.K. [and other] // Industrial production and use of elastomers. 2012. № 4. P. 29-32. [in Russian].

15 Dehydrochlorination of PVC compositions during thermal degradation /Lipik V.T. [and other] // Eurasian Chem.-Technol. J. 2002. Vol. 4. № 1. P. 25-29. [in English].

16 Thermal degradation of PVC as a typical macromolecular reaction / Kolesov S.V. [and other] // Polym. Comm. 2003. A. Vol. 1. 45. № 7. P. 1053-1063. [in Russian].

17 The mechanism of initiation and growth of polyene sequences with thermal degradation of PVC /Yanborisov V.M. [and other] // Polym. Comm. 2005. A. Vol. 47. № 8. P. 1478-1490. [in Russian].

18 Thermal aging and stabilization of PVC /Troickiy B.B. [and other] // Polym. Comm. 1978. Vol. 20. № 7. P. 1443-1456. [in Russian].

19 Thermal decomposition and stabilization of PVC / Troickiy B.B. [and other] // Chemical Reviews. 1985. № 8. P. 1287-1311. [in Russian].

20 Minsker K.S., Pethrick A. Polymer Yearbook. Harwood. Acad. Publ. 1994. P. 229-241. [in English].

21 The effect of “echo – stabilization” during the degradation of PVC /Minsker K.S. [and other] // Reports of the USSR. 1982. Vol. 263. № 1. P. 140-143. [in Russian].

22 New types of composite PVC materials finishing appontmant /Aminova G.F. [and other] // Izvestiya KGASU, 2013. 3 (25). P. 80-85.

23 Aminova G.F., Maskova A.R. Synthesis butoxyethylphenoxyethylphthalates /64th Scientific Conference of Students and Young Scientists. Ufa: Izd USPTU. 2013. P. 261-263. [in Russian].

24 Composite PVC finishing materials on the basis of destination butoxypropylphenoxypropylphthalates /Aminova G.F. [and other] // Nauka i Mir. 2013. 2 (2). P. 40-42. [in Russian].

25 New composite PVC-material for finishing purposes, plasticized by butoxyalkylphenoxyalkylphthalates /Aminova G.F. [and other] // Electronic scientific journal "Oil and Gas Business". 2013. № 5. P. 353-362. URL: http://www.ogbus.ru/eng/authors/AminovaGF/AminovaGF_1.pdf. [in English].

26 Producing of linoleum with improved physical and mechanical properties /Aminova G.F. [and other] // Electronic scientific journal "Oil and Gas Business". 2013. № 6. P. 508-537. URL: http://www.ogbus.ru/eng/authors/AminovaGF/AminovaGF_2.Pdf. [in English].

27 Oxidative thermal degradation of plasticized PVC /Minsker K.S. [and other] // Polym. Comm. 1980. A. Vol. 22. № 9. P. 2131-2136. [in Russian].

Список используемых источников

1 Стабилизаторы поливинилхлорида / Аминова Г.К. [и др.]. Наука и эпоха: монография. Воронеж: ВГПУ, 2012. Кн. 9. С.275-295.

2 Низамов Р.Р. Поливинилхлоридные композиции строительного назначения с полифункциональными наполнителями: автореф....дис.... докт. техн. наук. Казань. 2007. 45 с.

3 Маслова И.П. Химические добавки к полимерам. Справочник. М.: Химия, 1981. 264 с.

4 Ахметханов Р.Р. Сера как стабилизатор полимеров винилхлорида: дис....канд. техн. наук. Уфа. 2007. 131 с.

5 Минскер К.С., Колесов С.В., Заиков Г.Е. Старение и стабилизация полимеров на основе винилхлорида. М.: Наука, 1982. 272 с.

6 Минскер К.С., Федосеева Г.Т. Деструкция и стабилизация поливинилхлорида. М. Химия, 1979. 272 с.

7 Грасси Н., Скотт Дж. Деструкция и стабилизация полимеров. М.: Мир, 1988. 246 с.

8 Основные достижения в области производства и применения ПВХ /Воронкова И.А. [и др.] // Пласт. массы. 1994. № 2. С. 26-30.

9 Осипчик В.В. Материалы строительного назначения с улучшенными эксплуатационными свойствами на основе наполненного ПВХ. Дис...канд. техн. наук. МХТИ им. Д.И. Менделеева. М., 1989. 131 с.

10 Уилки Ч., Саммерс Дж., Даниелс Ч. Поливинилхлорид. СПб.: Профессия, 2007. 728 с.

11 Бартштейн Р.С., Кириллович В.И., Носовский Ю.Е. Пластификаторы для полимеров. М.: Химия, 1982. 196 с.

12 Козлов П.В., Папков С.П. Физико-химические основы пластификации полимеров. М.: Химия, 1982. 224 с.

13 Мазитова А.К., Нафикова Р.Ф., Аминова Г.К. Пластификаторы поливинилхлорида. Наука и эпоха: монография. Воронеж: ВГПУ, 2011. Кн. 7. С. 276-296.

14 Пластификаторы для поливинилхлоридных композиций строительного назначения /Аминова Г.К. [и др.] // Промышленное производство и использование эластомеров. 2012. № 4. С. 29-32.

15 Dehydrochlorination of PVC compositions during thermal degradation /Lipik V.T. [and other] // Eurasian Chem.-Technol. J. 2002. Vol. 4. № 1 . P. 25-29. [in English].

16 Термическая деструкция поливинилхлорида как типичная макромолекулярная реакция /Колесов С.В. [и др.] // Высокомолек. соед. 2003. А. Т.45. № 7. С. 1053-1063.

17 Механизм инициирования и роста полиеновых последовательностей при термической деструкции поливинилхлорида /Янборисов В.М. [и др.] // Высокомолек. соед. 2005. А. Т.47. № 8. С. 1478-1490.

18 Термическое старение и стабилизация поливинилхлорида /Троицкий Б.Б. [и др.] // Высокомолек. соед. 1978. Т. 20. № 7. С. 1443-1456.

19 Термический распад и стабилизация поливинилхлорида / Троицкий Б.Б. [и др.] // Успехи химии. 1985. № 8. С. 1287-1311.

20 Minsker K.S., Pethrick A. Polymer Yearbook. Harwood. Acad. Publ. 1994. P. 229-241. [in English].

21 Эффект «эхо-стабилизации» при деструкции поливинилхлорида /Минскер К.С. [и др.] // Доклады АН СССР. 1982. Т. 263. № 1. С. 140-143.

22 Новые типы композиционных ПВХ-материалов отделочного назначения /Аминова Г.Ф. [и др.] // Известия КГАСУ. 2013. 3(25). С.80-85.

23 Аминова Г.Ф., Маскова А.Р. Синтез бутоксиэтилфеноксипропилфталатов /64-я науч.-техн. конф. студентов, аспирантов и молодых ученых. Уфа: Изд-во УГНТУ, 2013. С. 261-263.

24 Композиционные ПВХ-материалы отделочного назначения на основе бутоксипропилфеноксипропилфталатов /Аминова Г.Ф. [и др.] // Наука и Мир. 2013. 2 (2). С. 40-42.

25 New composite PVC-material for finishing purposes, plasticized by butoxyalkylphenoxyalkylphthalates /Aminova G.F. [i dr.] // Jelektronnyi nauchnyi zhurnal "Neftegazovoe delo". 2013. № 5. P. 353-362. URL: http://www.ogbus.ru/eng/authors/AminovaGF/AminovaGF_1.pdf. [in English].

26 Producing of linoleum with improved physical and mechanical properties /Aminova G.F. [i dr.] // Jelektronnyi nauchnyi zhurnal "Neftegazovoe delo". 2013. № 6. P. 508-537. URL: http://www.ogbus.ru/eng/authors/AminovaGF/AminovaGF_2.Pdf. [in English].

27 Окислительная термодеструкция пластифицированного поливинилхлорида /Минскер К.С. [и др.] // Высокомолек. соед. 1980. А. Т. 22. № 9. С. 2131-2136.

Сведения об авторах

About the authors

A.K. Mazitova, Doctor of Chemical Sciences, Professor of the Chair “Applied Chemistry and Physics” FSBEI NPE “Ufa State Petroleum Technological University”, Ufa, the Russian Federation

Мазитова А.К., д-р хим. наук, проф. кафедры «Прикладная химия и физика» ФГБОУ ВПО УГНТУ, г. Уфа, Российская Федерация

L.B. Stepanova, Lecturer of the Chair “General Chemical Technology”, Branch of FSBEI NPE “Ufa State Petroleum Technological University”, Sterlitamak, the Russian Federation

Степанова Л.Б., преп. кафедры «Общая химическая технология», филиал ФГБОУ ВПО УГНТУ, г. Стерлитамак, Российская Федерация

G.F. Aminova, Postgraduate Student of the Chair “Applied Chemistry and Physics”, FSBEI NPE “Ufa State Petroleum Technological University”, Ufa, the Russian Federation

Аминова Г.Ф., аспирант кафедры «Прикладная химия и физика» ФГБОУ ВПО УГНТУ, г. Уфа, Российская Федерация

A.I. Gabitov, Doctor of Engineering Sciences, Professor of the Chair “Building Construction” FSBEI NPE “Ufa State Petroleum Technological University”, Ufa, the Russian Federation

Габитов А.И., д-р техн. наук, проф. кафедры «Строительные конструкции» ФГБОУ ВПО УГНТУ, г. Уфа, Российская Федерация

A.R. Maskova, Candidate of Engineering Sciences, Associate Professor of the Chair “Applied Chemistry and Physics” FSBEI NPE “Ufa State Petroleum Technological University”, Ufa, the Russian Federation

Маскова А.Р., канд. техн. наук, доцент кафедры «Прикладная химия и физика» ФГБОУ ВПО УГНТУ, г. Уфа, Российская Федерация

e-mail: asunasf@mail.ru