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INFLUENCE OF THE PENTAERYTHRITOL ESTER OF OIL ACID ON COMPATABILITY OF OCTYLPHENOXYPROPYL PHTHALATE WITH POLYVINYL CHLORIDE

Extended Abstract:

Various chemical additives are used for polyvinyl chloride (PVC) processing. Plasticization is one of the ways to improve the physical and mechanical PVC materials properties and simplify processing of polymer into the corresponding products.

Today certain requirements to PVC-based compositions for environmental compatibility and manufacturability are increasing. Therefore, there is a need to develop new modern plasticizers and enlarge the assortment of them. This paper presents the results of research devoted to the compatibility of a new plasticizer, octylphenoxypropyl phthalate with PVC, with and without addition of pentaerythritol ester of butyric acid. The PVC plasticizers compatibility was evaluated by the critical PVC dissolution temperature in the plasticizer and Shore A durometer hardness change in comparison with the industrial plasticizer dioctyl phthalate. The plasticizer influence on the flow temperature and the glass tran-

sition temperature has also been studied. It was marked that the studied octylphenoxypropyl phthalate as a plasticizer with the addition of pentaerythritol ester of butyric acid possesses sufficiently high plasticizing ability and it is well combined with PVC.

Keywords: compatibility, critical dissolution temperature, dioctyl phthalate, octylphenoxypropyl phthalate, flow temperature, glass transition temperature, pentaerythritol ester of butyric acid, polyvinyl chloride plasticizer, Shore A hardness.

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Such characteristics of chemical structure of polyvinyl chloride (PVC) as high glass transition temperature, wide plastic deformation temperature range, low elasticity, tendency to cracking during storage and operation necessitate to modify them in order to change the properties in the desired direction [1].

One of the most important PVC modification ways is plasticization which can eliminate both mentioned above disadvantages and give new valuable technical properties set to the material [2].

Earlier we described the production methods and some physicochemical properties of plasticizers based on oxialicated alcohols phthalates [3–17].

The purpose of this paper was to study the effect of additives of pentaerythritol ester of butyric acid (PEBA) on the compatibility of octyl-

phenoxypropyl phthalate (OPOPP), proposed as a plasticizer of polyvinyl chloride.

The following substances were chosen for the experiments: C-70 PVC suspension; dioctyl phthalate (DOP) – industrial plasticizer; OPOPP and PEBA, which we synthesized for the first time.

The plasticizer compatibility with the polymer (PVC) parameter was used as the plasticizers effectiveness criterion. The current parameter is characterized, first, by the critical PVC dissolution temperature in the plasticizer, secondly by the Shore A hardness change [18, 19].

To determine the critical dissolving temperature (Tcd), 1g of PVC was mixed with 4g of plasticizer, the mixture was gradually heated at a rate of 2°C per minute and the tube contents appearance was visually determined. The critical dissolving temperature was assumed to be the temperature at which the polymer completely dissolved in the plasticizer and the solution became transparent. The research results in comparison with the industrial dioctyl phthalate analogue are given in the Table 1.

Table 1

Plasticizers characteristics

№	Sample	T_{cd}, °C
1	DOP	118
2	OPOPP*	119
3	OPOPP* + PEBA	118

* n = 1.0

The table data shows, OPOPP plasticizing effect is close to DOP in efficiency in accordance with Tcd indicator, and with the addition of PEBA, the efficiency is at the DOP level. Moreover, the amount of pentaerythritol ester of butyric acid should not exceed 5% of the mass of octylphenoxypropyl phthalate. Probably, the synergistic effect of the plasticizing action of the two types of plasticizers is affected here.

Shore A hardness change from the plasticizers concentration partially measured per 100 PVC parts has been studied at the next step (Fig. 1). This is a fairly reliable method and it is widely used in practice in order to evaluate the plasticizers effectiveness, expressed as a substitution factor. The

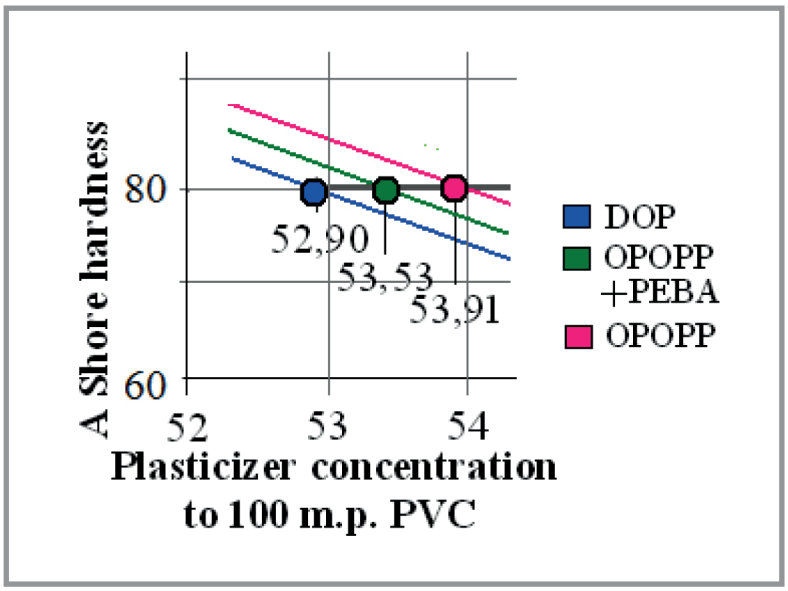

Fig. 1. **A Shore hardness dependence on the Plasticizer concentration**

quantitative replacement factor indicates how much plasticizer should be added to the plastic compound in order to provide the same hardness value as achieved by DOP [18].

It is necessary to add OPOPP with the addition of PEBA only 1.2% , 2% more OPOPP to the PVC composition in order to achieve a Shore A hardness value of 80 provided by the DOP at a content of 52.9 parts, according to the given data.

In order to determine the PVC composition temperature range, we studied the plasticizers effect on the flow temperature (Tf) and the glass transition temperature (Tg). As it is known these parameters largely determine plasticizing action effectiveness.

Preliminary thermomechanical curves were used in order to determine the glass transition temperature and the polymer composition fluidity. Thermomechanical analysis (TMA) is a fairly common method to study polymers. The task of the method is to observe the transitions from the vitreous state to the highly elastic and from the highly elastic to the viscous flow state (for some objects, directly from the vitreous to the viscous flow) with force and thermal action. The method makes it possible to evaluate the temperature ranges of polymer material operability as a plastic or elastomer, to reveal the transition opportunity into a fluid state and the yield temperature value which is necessary for its processing. Thus, TMA is as-

sociated with the main operational and technological polymers and properties of compositions of them [19–23].

The research results (Fig. 2, 3) confirmed the OPOPP with the addition of PEBA is the best effective.

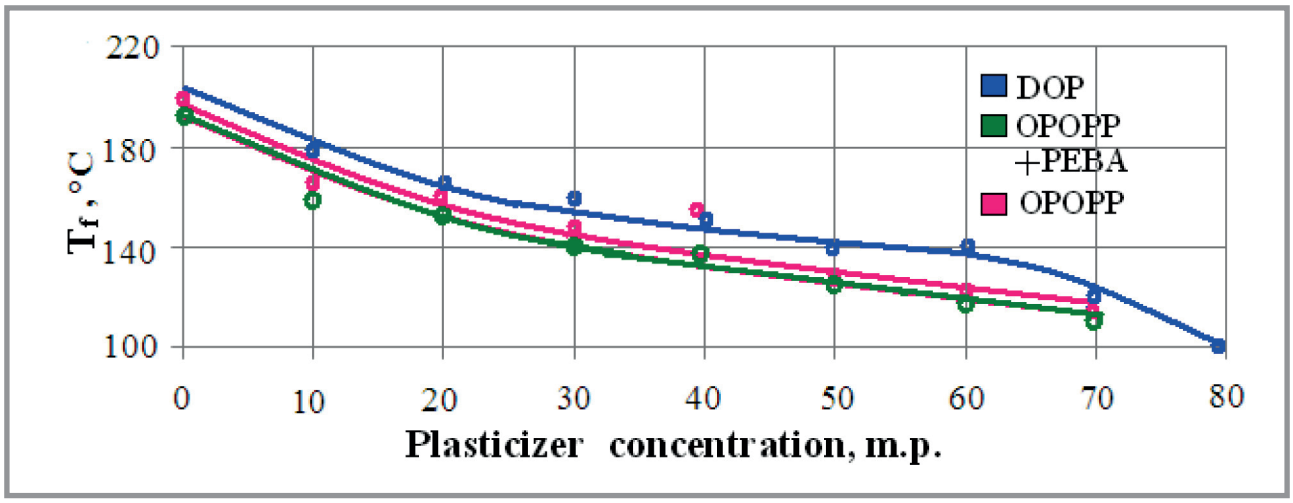

Fig. 2. **Flow temperature dependence on concentration plasticizer**

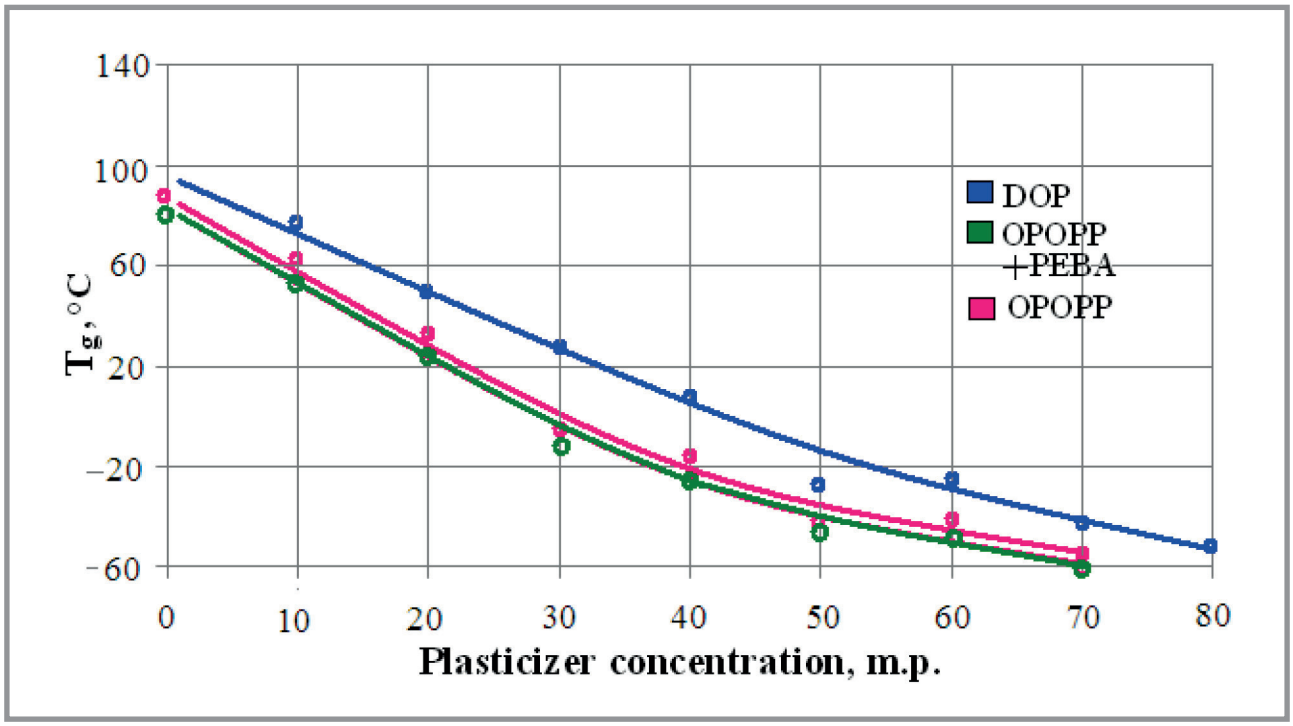

Fig. 3. **Glass transition temperature dependence on the plasticizer concentration**

Thus, in case of OPOPP with the addition of PEBA, the high elasticity (Tm-Tc) interval (Fig. 4) reaches its maximum value at a content of 45 parts by weight; in the case of OPPOP, 50 parts by weight and in the case of DOP, 65 parts by weight. Moreover, most effectively OPOPP with the addition of PEBA reduces the plastic's glass transition temperature.

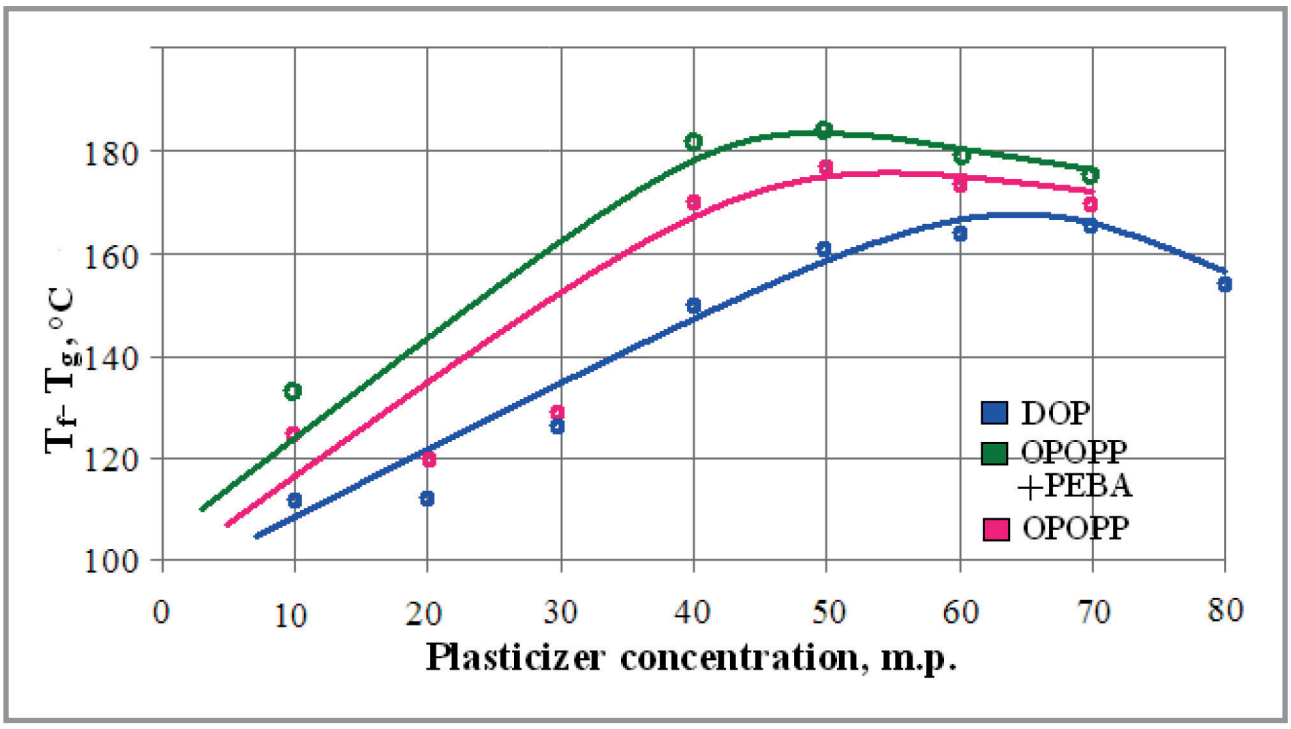

Fig. 4. **High elasticity interval dependence on the concentration**

Thus, it was found that octylphenoxypropyl phthalate with the addition of pentaerythritol ester of butyric acid is better combined with PVC and has a high plasticizing ability. According to the considered parameters (the critical PVC dissolving temperature in the plasticizer, the Shore A hardness change, flow and vitrification temperature), it was determined that OPOPP with an additive PEBA predominates the industrial plasticizer DOP. It should be noted that with a minimum dosage, the pentaerythritol ester of butyric acid can be considered as a nanoadditive.

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References:

1. *Hebole M., Tomus K.* Polyvinilchloride. Mach.Des. 1987. Vol. 57. no. 8. pp. 164–165.
2. *Gotlieb E.M.* Plastifikaciya polyarnyh kauchukov, linejnyh i setchatyh polimerov: monografiya [Plastification of polar rubbers, linear and cross-linked polymers: monograph]. Kazan: Izdatel'stvo Kazanskogo gosudarstvennogo tekhnologicheskogo universiteta [Publishing house of Kazan State Technological University], 2008. 286 p. (In Russian).
3. *Mazitova A.K., Aminova G.K., Nafikova R.F., Deberdeev R.Ja.* Osnovnye polivinilhloridnye kompozicii stroitel'nogo naznachenija [Main polyvinylchloride compositions for building purposes]. Ufa, 2013. 130 p. (In Russian).
4. *Mazitova A.K., Nafikova R.F., Aminova G.K.* Plastifikatory polivinilhlorida [Plasticizers of polyvinylchloride] / Nauka i jepoha: monografija. Pod obshhej redakciej professora O.I. Kirikova [Science and epoch: monograph. Under the General editorship of Professor O.I. Kirikova]. Moscow; Voronezh, 2012. pp. 276–296. (In Russian).
5. *Maskova A.R.* Polivinilhloridnye kompozicii stroitel'nogo naznachenija, plastificirovannye ftalatami oksialkilirovannyh spirtov [Polyvinylchloride compositions for construction, plasticized by phthalates of alcohols oxyalkylated]: Dissertacija ... kand. tehn. nauk [The thesis for PhD in Engineering]. Ufa, 2012. 143 p. (In Russian).
6. *Fajzullina G.F., Gabitov A.I., Maskova A.R., Ahmetova I.I.* Plastifikacija polivinilhlorida novymi plastifikatorami [Plasticization of polyvinylchloride with new plasticizers]. Neftegazovoe delo [Oil and gas business]. 2017. Vol. 15, no. 3. pp. 106–111. (In Russian).
7. *Mazitova A.K., Aminova G.K., Maskova A.R., Yagafarova G.G., Mazitov R.M.* New plasticizers for PVC-compositions in construction. Nanotehnologii v stroitel'stve = Nanotechnologies in Construction. 2017, Vol. 9, no. 4, pp. 48–63. DOI: dx.doi.org/10.15828/2075-8545-2017-9-4-48-63.
8. *Mazitova A.K., Aminova G.K., Maskova A.R., Zentsov V.N., Nedopekin D.V. and Rayzer Ju.S.*, 2017. Development of Oil-Benzen-Resistant PVC-Plastics. Journal of Engineering and Applied Sciences, 12: 7865-7869. DOI: 10.3923/jeasci.2017.7865.7869.
9. *Mazitova A.K., Aminova G.K., Maskova A.R., Sabitov I.N., Nedoseko I.V.* New polyvinylchloride plasticizers. Nanotehnologii v stroitel'stve = Nanotechnologies in Construction. 2017, Vol. 9, no. 6, pp. 168–180. DOI: dx.doi.org/10.15828/2075-8545-2017-9-6-168-180.
10. *Mazitova A.K., Aminova G.K., Gabitov A.I., Maskova A.R., Rahmatullina R.G.* Novye plastifikatory PVH-kompozicij special'nogo naznachenija [New plasticizers of PVC compositions for special purposes]. Bashkir chemical journal. 2015. Vol. 22, no. 3. pp. 23–26. (In Russian).
11. *Mazitova A.K., Aminova G.F. Gabitov A.I., Maskova, A.R., Khusnutdinov B.R., Fattakhova A.M.* Razrabotka novyh plastifikatorov polivinilhlorida [Development of new plasticizers of polyvinyl chloride]. Jelektronnyj nauchnyj zhurnal «Neftegazovoe delo» [Electronic scientific journal «Oil and gas business»]. 2014. no. 12-1. pp. 120–127. (In Russian).
12. *Mazitova A.K., Aminova G.K., Maskova A.R., Builova E.A., Nedopekin D.V.* Difenoksijetilftalaty i butoksijetilfenoksijetilftalaty – novye plastifikatory polivinilhlorida [Diphenoxylate and butoxyethoxyethanol – new plasticizers of polyvinylchloride]. Jelektronnyj nauchnyj zhurnal «Neftegazovoe delo» [Electronic scientific journal «Oil and gas business»]. 2015. no. 5. pp. 376–397. (In Russian).
13. *Mazitova A.K., Stepanova L.B., Aminova G.F., Maskova A.R.* Razrabotka funkcional'nyh dobavok dlja polivinilhloridnyh kompozicij stroitel'nogo naznachenija [Development of functional additives for polyvinylchloride compositions for construction purposes]. Promyshlen-

noe proizvodstvo i ispol'zovaniejelastomerov [Industrial production and use of elastomers]. 2015. no. 2. pp. 27–31. (In Russian).
14. *Maskova A.R., Stepanova L.B., Aminova G.F., Rol'nik L.Z., Abdrahmanova L.K.* Ispytanie receptur PVH-kompozicij stroitel'nogo naznachenija na osnove novyh dobavok [Testing of formulations of PVC-compositions for construction purposes on the basis of new additives]. Promyshlennoe proizvodstvo i ispol'zovanie jelastomerov [Industrial production and use of elastomers]. 2015. no 3. pp. 11–15. (In Russian).
15. *Aminova G.F., Gabitov A.I., Maskova A.R., Yagafarova G.G., Rolnik L.Z., Klyavlin M.S.* New composite PVC-material for finishing purposes, plasticized by butoxyalkylphenoxyalkyl phthalates. Electronic scientific journal «Oil and gas business». 2013. no 5. pp. 353–362.
16. *Mazitova A.K., Aminova G.K., Maskova A.R.* Research of thermostability of phthalates of oxyalkylated alcohols. Nanotehnologii v stroitel'stve = Nanotechnologies in Construction. 2018, Vol. 10, no. 2, pp. 157–170. DOI: dx.doi.org/10.15828/2075-8545-2018-10-2-157-170. (In Russian).
17. *Maskova A.R., Mazitova A.K., Aminova G.K., Rolnik L.Z., Faizullina G.F.* Investigation of the rheological properties of PVC compositions containing phthalate plasticizers. Nanotehnologii v stroitel'stve = Nanotechnologies in Construction. 2018, Vol. 10, no. 3, pp. 127–137. DOI: dx.doi.org/10.15828/2075-8545-2018-10-3-127-137.
18. *Shtarkman B.P.* Plastifikatory PVH [PVC Plasticizers]. Moscow. Himija [Chemistry], 1975. 248 p. (In Russian).
19. *Grossman F.* Rukovodstvo po razrabotke kompozicii na ocnove PVH [Guidline for development of PVC compositions]. Moscow. Nauchnye ocnovy i tehnologii [Scientific foundation and technologies], 2009. 550 p. (In Russian).
20. *Askadskiy A.A., Matveev Yu.I.* Himicheskoe stroenie I fizicheskie svoistva polimerov [Chemical structure and physical properties of polymers]. Moscow. Himija [Chemistry], 1983. 248 p. (In Russian).
21. *Tager A.A.* Fiziko-himiya polimerov. 4-e izd., pererab., dop. [Physicochemistry of polymers. 4th ed., revised., add.]. Moscow: Nauchnij mir [The scientific world], 2007. 573 p. (In Russian).
22. *Chernousan A.I.* Fizicheskie svojstva processa steklovaniya [Physical properties of the vitrification process]. Sorosovskij obrazovatel'nyj zhurnal [Soros Educational Journal]. Vol. 7. no. 3. 2001. pp.103–109. (In Russian).
23. *Sorokin G.A., Kutsenko A.I., Merzlikina V.P., Abramova R.A., Chirikova A.V.* Vliyanie himicheskoj prirody plastifikatora na temperaturu steklovaniya [Influence of the plasticizer chemical nature on the glass transition temperature]. Plastmassy [Plastics]. 1974. no. 7. pp. 55–56. (In Russian).

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ВЛИЯНИЕ ПЕНТАЭРИТРИТОВОГО ЭФИРА МАСЛЯНОЙ КИСЛОТЫ НА СОВМЕСТИМОСТЬ ОКТИЛФЕНОКСИПРОПИЛФТАЛАТА С ПОЛИВИНИЛХЛОРИДОМ

Аннотация к статье (авторское резюме, реферат):

Для переработки поливинилхлорида (ПВХ) используют различные химикаты-добавки. Одним из способов улучшения физико-механических свойств ПВХ-материалов и упрощения процесса переработки полимера в соответствующие изделия является пластификация.

В настоящее время возрастают требования к ПВХ-композициям по экологичности и технологичности. Поэтому возрастает необходимость разработки новых современных пластификаторов и повышение их ассортимента. В данной работе приведены результаты исследования совместимости нового пластификатора – октилфеноксипропилфталата с ПВХ с добавкой пентаэритритового эфира масляной кислоты и без него. Оценка совместимости пластификаторов с ПВХ производилась по критической температуре растворения ПВХ в пластификаторе и изменению твердости по Шору А в с сравнении с промышленным пластификатором диоктилфталатом. Также было изучено

влияние пластификатора на температуру текучести и температуру стеклования. Было отмечено, что исследуемый нами в качестве пластификатора октилфеноксипропилфталат с добавлением пентаэритритового эфира масляной кислоты обладает достаточно высокой пластифицирующей способностью и хорошо совмещается с ПВХ.

Ключевые слова: диоктилфталат, критическая температура растворения, октилфеноксипропилфталат, пластификатор поливинилхлорида, совместимость, твердость по Шору А, температура стеклования, температура текучести.

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Библиографический список:

1. *Hebole M., Tomus K.* Polyvinilchloride // Mach.Des. – 1987. – Vol. 57. – №. 8. – pp. 164–165.
2. *Готлиб Е.М.* Пластификация полярных каучуков, линейных и сетчатых полимеров: монография. – Казань: Изд-во Казан. гос. технол. ун-та, 2008. – 286 с.
3. *Мазитова А.К., Аминова Г.К., Нафикова Р.Ф., Дебердеев Р.Я.* Основные поливинилхлоридные композиции строительного назначения. – Уфа, 2013. – 130 с.

4. *Мазитова А.К., Нафикова Р.Ф., Аминова Г.К.* Пластификаторы поливинилхлорида // Наука и эпоха: монография. – под общей ред. проф. О.И. Кирикова. – Воронеж, 2011. – С. 276–296.
5. *Маскова А.Р.* Поливинилхлоридные композиции строительного назначения, пластифицированные фталатами оксиалкилированных спиртов: дис. ... канд. техн. наук. – Уфа, 2012. – 143 с.
6. *Файзуллина Г.Ф., Габитов А.И., Маскова А.Р., Ахметова И.И.* Пластификация поливинилхлорида новыми пластификаторами // Нефтегазовое дело. – 2017. – Т. 15, № 3. – С. 106–111.
7. *Mazitova A.K., Aminova G.K., Maskova A.R., Yagafarova G.G., Mazitov R.M.* New plasticizers for PVC-compositions in construction. Nanotehnologii v stroitel'stve = Nanotechnologies in Construction. 2017, Vol. 9, no. 4, pp. 48–63. DOI: dx.doi.org/10.15828/2075-8545-2017-9-4-48-63.
8. *Mazitova A.K., Aminova G.K., Maskova A.R., Zentsov V.N., Nedopekin D.V. and Rayzer Ju.S.*, 2017. Development of Oil-Benzen-Resistant PVC-Plastics. Journal of Engineering and Applied Sciences, 12: 7865-7869. DOI: 10.3923/jeasci.2017.7865.7869.
9. *Mazitova A.K., Aminova G.K., Maskova A.R., Sabitov I.N., Nedoseko I.V.* New polyvinylchloride plasticizers. Nanotehnologii v stroitel'stve = Nanotechnologies in Construction. 2017, Vol. 9, no. 6, pp. 168–180. DOI: dx.doi.org/10.15828/2075-8545-2017-9-6-168-180.
10. *Мазитова А.К., Аминова Г.К., Габитов А.И., Маскова А.Р., Рахматуллина Р.Г.* Новые пластификаторы ПВХ-композиций специального назначения // Башкирский химический журнал. – 2015. – Т. 22, № 3. – С. 23–26.
11. *Мазитова А.К., Аминова Г.Ф., Габитов А.И., Маскова А.Р., Хуснутдинов Б.Р., Фаттахова А.М.* Разработка новых пластификаторов поливинилхлорида // Нефтегазовое дело. – 2014. – Т. 12, № 1. – С. 120–127.
12. *Мазитова А.К., Аминова Г.К., Маскова А.Р., Буйлова Е.А., Недопекин Д.В.* Дифеноксиэтилфталаты и бутоксиэтилфеноксиэтилфталаты – новые пластификаторы поливинилхлорида // Нефтегазовое дело. – 2015. – № 5. – С. 376–397.
13. *Мазитова А.К., Степанова Л.Б., Аминова Г.Ф., Маскова А.Р.* Разработка функциональных добавок для поливинилхлоридных композиций строительного назначения // Промышленное производство и использование эластомеров. – 2015. – № 2. – С. 27–31.
14. *Маскова А.Р., Степанова Л.Б., Аминова Г.Ф., Рольник Л.З., Абдрахманова Л.К.* Испытание рецептур ПВХ-композиций строительного назначения на основе новых добавок // Промышленное производство и использование эластомеров. – 2015. – № 3. – С. 11–15.
15. *Aminova G.F., Gabitov A.I., Maskova A.R., Yagafarova G.G., Rolnik L.Z., Klyavlin M.S.* New composite PVC-material for finishing purposes, plasticized by butoxyalkylphenoxyalkyl phthalates // Electronic scientific journal «Oil and gas business». – 2013. – № 5. – P. 353-362.
16. *Mazitova A.K., Aminova G.K., Maskova A.R.* Research of thermostability of phthalates of oxyalkylated alcohols. Nanotehnologii v stroitel'stve = Nanotechnologies in Construction. 2018, Vol. 10, no. 2, pp. 157–170. DOI: dx.doi.org/10.15828/2075-8545-2018-10-2-157-170.

17. *Maskova A.R., Mazitova A.K., Aminova G.K., Rolnik L.Z., Faizullina G.F.* Investigation of the rheological properties of PVC compositions containing phthalate plasticizers. Nanotehnologii v stroitel'stve = Nanotechnologies in Construction. 2018, Vol. 10, no. 3, pp. 127–137. DOI: dx.doi.org/10.15828/2075-8545-2018-10-3-127-137.
18. *Штаркман Б.П.* Пластификация ПВХ. – М.: Химия, 1975. – 248 с.
19. *Гроссман Ф.* Руководство по разработке композиций на основе ПВХ. – М.: Научные основы и технологии, 2009. – 550 с.
20. *Аскадский А.А., Матвеев Ю.И.* Химическое строение и физические свойства полимеров. – М.: Химия, 1983. – 248 с.
21. *Тагер А.А.* Физико-химия полимеров. 4-е изд., перераб., доп. – М.: Научный мир, 2007. – 573 с.
22. *Черноуцан А.И.* Физические свойства процесса стеклования // Соросовский образовательный журнал. – Т.7, № 3. – 2001. – С. 103–109.
23. *Сорокин Г.А., Куценко А.И., Мерзликина В.П., Абрамова Р.А., Чирикова А.В.* Влияние химической природы пластификатора на температуру стеклования // Пласт. массы. – 1974. – № 7. – С. 55–56.

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