INVESTIGATION OF THE RHEOLOGICAL PROPERTIES OF PVC COMPOSITIONS CONTAINING PHTHALATE PLASTICIZERS

EXTENDED ABSTRACT:

Polymer materials based on polyvinyl chloride (PVC) are processed in the form of multitudinous compositions. One of the main indicators in the processing of polymer compositions is manufacturability. It is known that in the processing of polyvinyl chloride compositions manufacturability is estimated by rheology of melts. The determine polymer processability the melt flow index (MFI) is the most widespread and almost universally used value. The melt flow index of the polymer material is the mass of polymer in grams extruded through the capillary at a certain temperature and pressure overfall in 10 minutes. It allows us to take decisions on the necessary conditions of processing the polymer composition and to determine the temperature limits of converting.

In fact, PVC compositions are characterized by high viscosity and various chemical additives. For example, plasticizers are used to improve the processing conditions. This research studied how oxyalkylated alcohol phthalates developed by the authors influence on the MFI polymer. The results show that the synthesized esters, in a greater degree respect to the industrial plasticizer di-
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Additives of various functional purposes – plasticizers, stabilizers, fillers, fire retardants, etc. – allow achieving the meaningful change in the characteristics of polymers. The choice of the type and dosage of the initial components is determined by the conditions of processing the polymer composition and the necessary complex of operational properties of the products obtained.

Plasticizers have great impact on the structure and properties of polymers. Physical, mechanical and rheological properties of polymeric materials can be changed in a guided way with help of plasticizers. Successful selection of plasticizer expands the polymers scope of use and extends their lifespan. Most plasticizers produced in industry are used for plasticizing of polyvinylchloride (PVC).

The widely used method for analysis of rheological properties of polyvinylchloride melt is capillary viscometry, which helps to determine melt

**Keywords**: oxyethylated alcohol, oxypropylated alcohol, PVC, melt flow index, flow temperature, oxyalkylated alcohol phthalates.

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flow index (MFI), that characterizes the speed of flowing of melt through the standard size capillary at given temperature and pressure. The value of MFI is the parameter, which largely determines the choice of processing conditions of polymer compositions. In addition, MFI can be used for the quality control of raw materials (components) of polymeric compositions. Thus, the melt flow index of composition is the important parameter, which determines the processability of PVC-compositions [1–7].

The aim of the work was to study properties of PVC-compositions containing proposed plasticizers and to estimate efficiency of plasticizers in comparison with commercial prototype.

Previously we described phthalates of oxyalkylated alcohol, especially: symmetrical and unsymmetrical phthalates of oxyethylated and oxypropylated butanol and phenol. In the papers [8-18] the results of investigation of methods of their obtaining and some physico-chemical properties are presented. In the present case we focused on investigation of the influence of developed compounds on the technological properties of PVC-materials.

**Experimental part**

We used model PVC compositions containing a thermal stabilizer (calcium and zinc stearates – 3 parts by weight of PVC / 100 parts by weight of PVC) and a plasticizer – prototypes of esters of oxyethylated alcohol – butoxyethylphenoxyethylphthalate (compound I), mixed esters of oxyethylated and oxypropylated alcohol – butoxyethylphenoxypropylphthalate (compound II), esters of oxypropylated alcohol – butoxypropylphenoxypropylphthalate (compound III) or commercially available analogue of dioctylphthalate (DOP) in the experiments.

The influence of oxyalkylated alcohol phthalates on the melt flow index was determined by capillary viscometry at 195°C and at the load 2.16 kg on the apparatus IIRT-AM according to the GOST 11645-73 [19].

**Results and discussion**

From the experimental results one can see (fig. 1) that with increasing of temperature and quantity of introduced plasticizer the melt flow index of PVC-composition increases.
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**Fig. 1.** The influence of quantity of oxyalkylated alcohol phthalates (1, 3, 5) and DOP (2, 4, 6) on MFI of PVC-compositions.

The content of plasticizer, weight part of PVC: 1, 2 – 80; 3, 4 – 60; 5, 6 – 40
(I–III – symbols of oxyalkylated alcohol phthalates)

It was found out that for PVC-compositions with same amount of plasticizer at the same value of MFI the main parameters that influence on the rheological properties, namely, temperature and content of plasticizer are linked linearly (fig. 2).

**Fig. 2.** The dependence of flow temperature of PVC-composition from the content of plasticizer in mixture:
1 – oxyalkylated alcohol phthalates; 2 – DOP) at constant value of MFI, 5g/10 min
(I–III – symbols of oxyalkylated alcohol phthalates)
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For quantity estimation of influence of plasticizer on the flow of polymer melt, the index of effectivenes $\theta$, which equal to the slope ratio of the obtained experimental straight lines to the $x$ – axis, was used. The value of index $\theta$ corresponds to changing of flow temperature of PVC-composition when in its formulation 1 weight part of plasticizer is introduced in case of constant value of the melt index of composition. From the experimental results (fig. 1) follow that proposed plasticizers in a greater degree than DOP increase the flow of melt of PVC-composition and decrease its processing temperature.

It is found that the flow of the melt of PVC somewhat depends from chemical nature of used plasticizer. According to the obtained results due to the influence on the flow of melt of polymer, phthalates of oxyalkylated alcohol can be arranged in the following series: esters of oxyethylated alcohol $>$ mixed esters of oxyethylated and oxypropylated alcohol $>$ esters of oxypropylated alcohol. In the case of introduction of developed plasticizers within compatibility with PVC, the flow of the melt increases proportionally that indicates on better compatibility with PVC.

Conclusion

Thus, the nature of plasticizer influences on the melt index. The presence of the plasticizer with specific structure to a greater or lesser degree increases the flow of the melt of PVC-composition, this allow us to suppose that their using in the composition of PVC-compounds improves their processing characteristics.

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Аннотация к статье (авторское резюме, реферат):

Полимерные материалы на основе поливинилхлорида (ПВХ) перерабатываются в виде многочисленных композиций. Одним из основных показателей при переработке полимерных композиций является технологичность. Известно, что технологичность при переработке поливинилхлоридных композиций оценивают по реологии расплавов. Наиболее распространено на практике и используется практически повсеместно определение технологичности переработки полимеров по величине показателя текучести расплава (ПТР). Показатель текучести расплава полимерного материала — масса полимера в граммах, выдавливаемая через капилляр при определенной температуре и перепаде давления за 10 минут. Он позволяет судить о необходимых условиях переработки полимерной композиции и определить температурные пределы переработки.

Известно, что ПВХ-композиции характеризуются высокой вязкостью и для улучшения условий их переработки используют различные химикаты-
добавки, например, пластификаторы. В данной работе приведены результаты исследования влияния разработанных нами фталатов оксиалкилированных спиртов на ПТР полимера. Показано, что синтезированные сложные эфи-ры в большей степени, чем промышленный пластификатор диоктилфталат (ДОФ), повышают текучесть расплава ПВХ-композиции и снижают темпера-туру ее переработки, т.е. улучшают технологичность получения пластикатов.

Ключевые слова: оксиэтилированные спирты, оксипропилированные спирты, ПВХ, показатель текучести расплава, температура течения, фталаты оксиалкилированных спиртов.

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