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Thermostabilizer for Polyvinyl Chloride-development of Synergistic Compounds

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Abstract: Thermostabilizer-synergistic mixtures with double salts of T-product for PVX were developed and their synergism efficiency phenomena were studied using DTA and TGA methods. The mixtures of thermostabilizers synergics of mixed salts of the product – T for PVCh were worked out by the methods of DTA and TGA and the effect of synergism was studied. This study aims to develop thermostabilizer-synergistic mixtures with double salts of T-product for polyvinyl chloride (PVC) and to investigate their synergistic efficiency using Differential Thermal Analysis (DTA) and Thermogravimetric Analysis (TGA) methods. The research involved synthesizing stabilizers, preparing PVC mixtures, conducting heat resistance tests, and analyzing the data obtained. The efficiency of the synergistic mixtures was evaluated through DTA and TGA to assess their impact on the thermal stability and degradation behavior of PVC. The study found that the synergistic mixtures significantly enhanced the thermal stability of PVC. The results indicated that the mixtures, particularly those involving lead salts of T-product, demonstrated a pronounced synergistic effect, delaying the onset of thermal degradation and improving overall stability. The effectiveness of the stabilizers was 2-3 times higher when used in mixtures compared to individual use. The optimal ratio for maximum stabilization efficiency was found to be 1:1, with specific mixtures showing an induction period of up to 120 minutes. The developed thermostabilizer-synergistic mixtures with double salts of T-product effectively enhance the thermal stability of PVC. The synergistic interactions between the components contribute to improved performance, making these mixtures promising candidates for enhancing the durability and lifespan of PVC materials. This advancement addresses critical issues related to environmental sustainability, performance enhancement, cost reduction, and market expansion, ensuring that PVC remains a viable and valuable material for a wide range of applications.

Keywords: Stabilizers, Calcium, Barium and Lead Salts, Polymer and Polymer Decomposition Products, Strong Inhibitors, Synthesized Stabilizer, Polymer Compositions.

Introduction

Polyvinyl chloride (PVC) is one of the most widely used polymers in various industrial applications due to its excellent versatility, durability, and cost-effectiveness. From construction materials, medical devices, and electrical cables to consumer goods, PVC's applications are extensive and varied (Aripov et al., 1994; Minsker & Fedoseeva, 1979; Ruzieva & Dustmurodova, 2022). However, PVC's inherent susceptibility to thermal and thermo-oxidative degradation presents significant challenges, particularly when exposed to elevated temperatures during processing and end-use (Ruzieva & Dustmurodova, 2023a, 2023b, 2023c). This degradation can lead to discoloration, loss of mechanical properties, and eventual failure of the material, thus limiting its performance and longevity.

Thermostabilizers play a crucial role in enhancing the thermal stability of PVC, preventing degradation, and extending the material's usable life (Romano, 2021). Traditional thermostabilizers, including metal salts and organotin compounds, have been widely used to address these issues (Aisawa, 2019; Hwang, 2020; Kuzma-Kichta, 2020; Muhammed, 2019; Shabaev, 2019). However, these conventional stabilizers often come with drawbacks such as high cost, environmental concerns, and regulatory restrictions. Therefore, the development of new, efficient, and environmentally friendly thermostabilizers is of paramount importance (Aghamaliyev, 2018; Maksimenko, 2018; Maximenko, 2018, 2019; Pathak, 2017).

Recent advancements in the field have highlighted the potential of synergistic mixtures of thermostabilizers, which can significantly enhance the stabilization efficiency compared to individual components. Synergistic interactions between different stabilizers can lead to the formation of more effective modifiers and improve the overall thermal stability of PVC. The exploration of such mixtures, particularly those involving double salts of T-product, presents an opportunity to overcome the limitations of traditional stabilizers (Abdelnabi, 2017; Castro, 2016; Chirikov-Zorin, 2014; Lavrikov, 2017; Pasche, 2017).

The demand for durable and cost-effective materials in various sectors, including automotive, construction, and electronics, necessitates the continuous improvement of polymer stabilization technologies. The ability to produce and maintain high-performance PVC materials is critical for sustaining economic growth and meeting industrial needs. The development of thermostabilizer-synergistic mixtures aligns with these objectives, offering a pathway to enhanced material properties and longer service life (Akcapinar, 2015; Chirikov-Zorin, 2014; Gorelik, 2016; Komarov, 2015).

This research focuses on the synthesis and evaluation of thermostabilizer-synergistic mixtures involving double salts of T-product. By utilizing Differential Thermal Analysis (DTA) and Thermogravimetric Analysis (TGA) methods, the study aims to investigate the synergistic efficiency of these mixtures and their impact on the thermal stability of PVC. The

findings are expected to contribute to the advancement of environmentally friendly and cost-effective stabilization solutions for PVC, supporting its widespread use across diverse applications.

Methodology

In the process of carrying out this research work, we studied the scientific literature on the topic, synthesized stabilizers, prepared PVC mixtures, conducted heat resistance tests, analyzed the data obtained and formed conclusions and proposals for our work. The research was carried out in the laboratories and premises of the Karshi engineering-economicқ ıınstitute.

Result and Discussion

Currently, in our republic, there are opportunities to create new types of stabilizers that affect the operational properties of the product based on secondary raw materials for production of polyvinyl chloride (PVX).

Usually, the stabilization efficiency of stabilizers (the phenomenon of synergism) increases significantly when using their mixtures. The emergence of synergism efficiency is important in the creation of stabilized polymer compositions in a number of cases. Therefore, the influence of the mixture of stabilizers on the thermal and thermooxidation mechanism and kinetics of PVC is undoubtedly of interest.

The mechanism of action of the components is based on chemical interactions, the formation of more effective modifiers as a result of the reactions of the components in the mixture with each other (santanox and diphenylolpropanes with calcium, barium and lead salts of the T-product, which have such an effect for PVX); individual effects (each of the components affects the modification effect individually); activation (one component activates another); including polymer and polymer interactions with degradation products.

Conducted studies on double systems in the oxidation of PVX: lead salt of T-product - santanox, barium salt of T-product - santanox, calcium salt of T-product - santanox and lead salt of T-product - diphenylolpropane, barium salt of T-product - diphenylolpropane, T - was carried out with the calcium salt of the product - diphenylolpropanes. In all cases, the phenomenon of synergism was observed, especially when the lead salts of T-product were used, its effect on breaking down hydroperoxide was the highest. Here, -product T salts are weak inhibitors and act like strong inhibitors in the presence of synergists, oxidation process remains stationary even after complete consumption of T product salts. It can be concluded from the fact that the product is consumed as a result of decomposition of hydroperoxides in the presence of salts: synergists, that is, decomposers of hydroperoxides, do not allow the

part occupied by phenol to be consumed until the other part is exhausted, which leads to the formation of the initial part of hydroperoxides in the polymer.

Figures 1 and 2 show that the mixture of antioxidants has a positive effect on the thermodestruction of PVX. Compounds of substances -react with each other to form even more effective stabilizers.

The mechanism of synergistic action in this form is of great interest, which means that the "forces" created by these compounds can be several tens of times higher than those used separately.

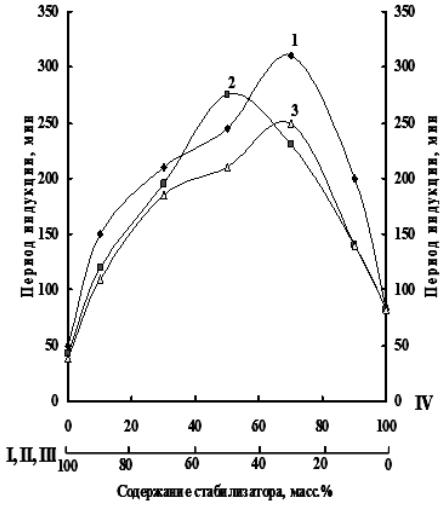

Figure 1. As a result of the oxidation of PVC at 1750C, the graph of dependence of the induction cycle on the amount of stabilizer mixtures: 1- lead salt of product T-santanox; Barium salt of 2-T product - san-tanox; Calcium salt of 3-T product - santanox

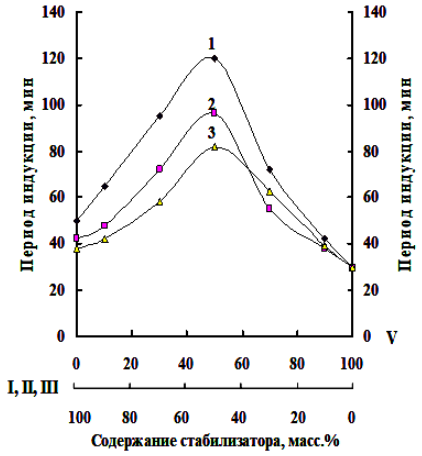

Figure 2. Oxidation of PVC at 1750C

As a result of the stabilization of the induction cycle to the amount of mixtures of lyzers dependence graph: 1-T product lead salt - diphenylolpropane; Barium salt of 2-T product - diffe-nilolpropane; 3 - T product calcium

Diphenylolpropane salt

It can be seen from the pictures that the stabilizers obtained in the above amounts lead to a significant increase in the thermal stability of PVC, that is, their effectiveness -can be seen to be 2-3 times higher than when the stabilizers were used individually. In this case, the maximum stabilization efficiency corresponds to the value of 1:1 ratio in the samples stabilized according to the "thermal stability time" indicator (Fig. 2). It can be seen that when the total concentration of antioxidants is equal to 0.5 mol/kg, the maximum "composition - induction period" coordinates of the curve is -120 minutes for the lead salt of product T - diphenylolpropane and, accordingly, 96 minutes for the barium salt of product T, diphenylolpropane, calcium salt of product T, diphenylolpropane compositions and for 82 minutes, as well as 1.0 mol/kg, the maximum in the length of the induction period shifts to the side of the component with relatively stronger efficiency in the lead salt of Tproduct - santanox mixtures, where the efficiency is 3 times higher.

Often, when obtaining polymer materials based on PVC, it is required to add various components to it: fillers, plasticizers, stabilizers, anti-oxidation additives, etc. These substances -can interact with each other in different ways and affect the speed of polymer thermal oxidation.

Thus, an increase in the synergistic effect of the synthesized stabilizers can be observed during the thermal and thermooxidative decomposition of PVC. Synergistic mixtures have a positive effect not only on the increase of thermal stability, but also on the volatility of polymer compositions.

Conclusion

The relevance of developing synergistic compounds for the thermostabilization of PVC is multifaceted, addressing critical issues related to environmental sustainability, performance enhancement, cost reduction, and market expansion. As industries continue to evolve and face new challenges, the innovation in stabilizer technology will play a pivotal role in ensuring that PVC remains a viable and valuable material for a wide range of applications. The ongoing research and development in this field are not only crucial for overcoming current limitations but also for paving the way for future advancements in polymer science and technology.

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