



DIFFERENTIAL THERMAL ANALYSIS OF SORBENTS SYNTHESIZED ON THE BASIS OF POLYVINYL CHLORIDE

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ABSTRACT

In this study, the thermal stability and physicochemical properties of sorbents synthesized on the basis of polyvinyl chloride (PVC) were investigated using differential thermal analysis (DTA) and thermogravimetric analysis (TGA). Polymer-based sorbents are widely used in adsorption, ion exchange, wastewater purification, and separation technologies due to their high mechanical strength, chemical resistance, and sorption capacity. Determination of their thermal behavior is important for evaluating their operational stability under industrial conditions. The obtained results demonstrated that the synthesized sorbents undergo a two-stage thermal decomposition process during heating. The first stage corresponds to melting and initial degradation of low-molecular fragments, while the second stage is associated with the destruction of the main polymer chain. The DTA curves revealed characteristic endothermic effects related to thermal transformations occurring in the sorbent structure. The thermal decomposition temperatures, mass loss values, and energy changes confirmed the relatively high thermal stability of the synthesized material within a certain temperature range. The obtained experimental results indicate that PVC-based sorbents can be considered promising materials for sorption and industrial applications requiring thermal resistance.

Keywords: polyvinyl chloride, sorbent, differential thermal analysis, thermogravimetric analysis, thermal stability, polymer materials, thermal destruction, mass loss, DTA, TGA, adsorption materials.

INTRODUCTION

At present, polymer-based sorbents occupy an important place in modern chemical technology, environmental protection, hydrometallurgy, and wastewater treatment processes. Among various polymeric materials, polyvinyl chloride (PVC) attracts significant attention because of its availability, low cost, chemical resistance, mechanical durability, and ease of modification. Modification of PVC with different functional groups allows the synthesis of highly effective sorbents with improved adsorption and ion-exchange properties.

In recent years, increasing environmental pollution caused by industrial wastewater containing toxic metal ions and organic pollutants has intensified the need for efficient sorption materials. Polymer sorbents synthesized on the basis of PVC are considered promising due to their stability in acidic and alkaline media, high porosity, and good physicochemical characteristics. However, the practical application of such sorbents strongly depends on their thermal stability and resistance to thermal degradation.

Thermal analysis methods such as thermogravimetric analysis (TGA) and differential thermal analysis (DTA) are among the most effective techniques for studying the thermal behavior of polymeric materials. These methods provide important information about phase transitions, decomposition stages, thermal effects, and structural transformations occurring during heating. In particular, TGA allows determination of mass loss at different temperature intervals, while DTA makes it possible to identify endothermic and exothermic processes associated with melting, oxidation, and destruction of polymer chains.

Many researchers have reported that PVC-based polymeric materials undergo multistage thermal degradation processes accompanied by dehydrochlorination and destruction of

macromolecular chains. The thermal behavior of modified PVC sorbents depends on the composition of the polymer matrix, the type of modifying agents, intermolecular interactions, and synthesis conditions. Therefore, investigation of thermal properties is necessary for evaluating the stability and practical applicability of newly synthesized sorbents.

The purpose of the present work is to study the differential thermal characteristics and thermal stability of sorbents synthesized on the basis of polyvinyl chloride using DTA and TGA methods. The research focuses on identifying decomposition stages, thermal effects, mass loss behavior, and determining the temperature intervals corresponding to structural transformations of the synthesized sorbent.

Experimental Part:

The experiments were carried out using chemically pure reagents and analytical-grade materials. Polyvinyl chloride-based sorbents were synthesized according to the laboratory procedure under controlled conditions. Thermal analysis was performed in the laboratory of TKTITI using a German-made Netzsch STA 409 RG simultaneous thermal analyzer.

The measurements were conducted in an inert nitrogen atmosphere with a gas flow rate of 50 ml/min. The temperature range of analysis was 25–370°C, while the heating rate was maintained at 5 K/min. For each experiment, approximately 5–10 mg of sample was used. Differential thermal analysis (DTA) and thermogravimetric analysis (TGA) were carried out simultaneously to evaluate the thermal behavior and decomposition characteristics of the synthesized sorbents.

RESULTS AND DISCUSSION:

Thermal Analysis of PVC-Based Sorbents

The obtained TGA curve of the synthesized sorbent demonstrated two main stages of mass loss during heating. The first stage occurred in the temperature range of 68.40–103.2°C, where the sample lost 0.221 mg (3.311%) of its mass. This process can be attributed to the evaporation of physically adsorbed moisture, removal of volatile compounds, and the initial softening of the polymer matrix.

The second stage of mass loss was observed in the temperature range of 250–420°C, corresponding to the thermal degradation of the polymer backbone and decomposition of functional groups. At this stage, a more significant weight reduction was recorded, indicating the breakdown of the main structural framework.

This behavior suggests that the synthesized sorbent possesses moderate thermal stability under elevated temperatures.

The presence of residual mass at higher temperatures indicates the formation of thermally stable char residue. Such residue formation is typical for polymer-based sorbents containing aromatic or crosslinked structures.

Overall, the TGA results confirm the multi-stage degradation mechanism and thermal characteristics of the synthesized material.

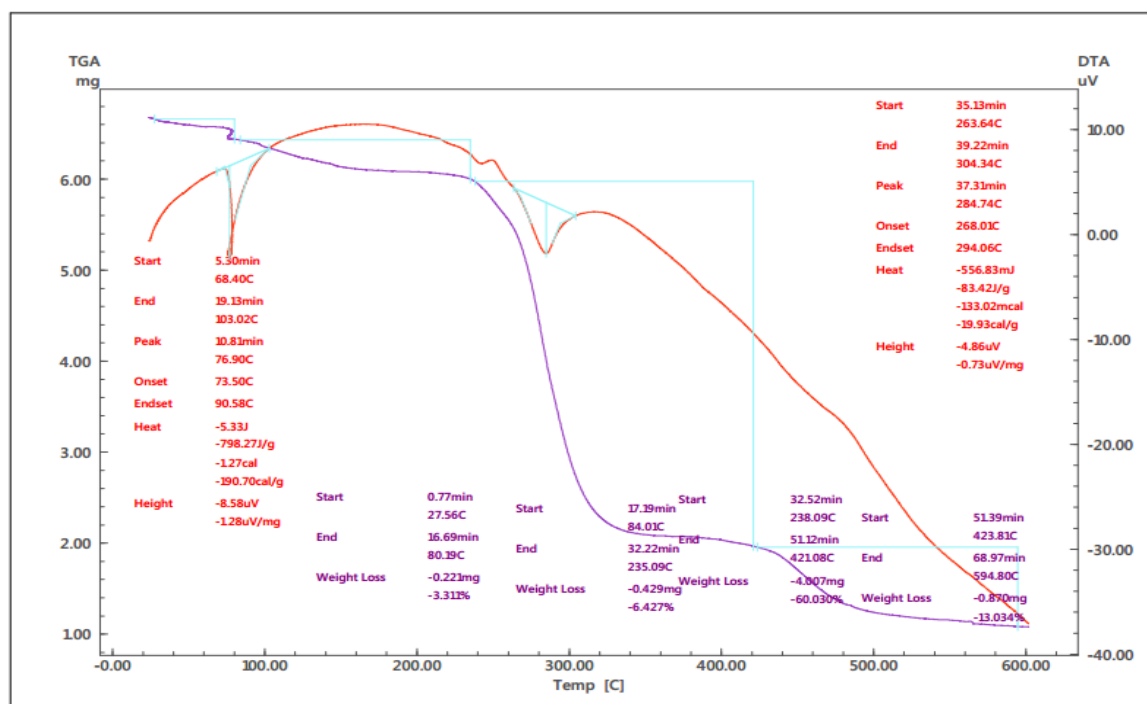


Figure 1. TGA and DTA curves of the PVC-based sorbent.

The second stage of decomposition was observed within the temperature interval of 263.64–304.34°C. At this stage, the mass loss reached 4.007 mg (60.030%), indicating intensive thermal destruction of the main polymer structure. This process is mainly associated with dehydrochlorination reactions and decomposition of the PVC macromolecular chains. The DTA results confirmed the presence of two endothermic effects corresponding to the thermal transformations observed in the TGA analysis. The first endothermic peak was detected within the range of 68.40–103.2°C with a maximum peak temperature at 76.90°C, which corresponds to melting and the beginning of thermal degradation processes. The second endothermic effect appeared in the range of 263.64–304.34°C with a maximum at 284.74°C, indicating the major stage of thermal decomposition of the sorbent.

The obtained results confirmed that the synthesized PVC-based sorbent possesses relatively high thermal stability up to a certain temperature interval. The two-stage degradation mechanism observed during heating is characteristic of modified polymeric sorption materials and agrees with previously reported studies on PVC-containing composites and ion-exchange polymers.

Furthermore, the thermal behavior indicates that the synthesized sorbent can maintain structural integrity under moderate thermal conditions, which is important for its practical application in adsorption and wastewater purification processes. The presence of stable intermolecular interactions within the polymer matrix contributes to improved thermal resistance and stability of the material.

CONCLUSION

The present study demonstrated that differential thermal analysis (DTA) and thermogravimetric analysis (TGA) are effective methods for investigating the thermal stability and decomposition behavior of PVC-based sorbents. The synthesized sorbent exhibited a two-stage thermal degradation process characterized by distinct mass loss regions and endothermic effects.

The first stage corresponded to melting and initial structural transformations, whereas the second stage represented intensive thermal destruction of the polymer matrix. The obtained thermal parameters confirmed that the synthesized sorbent possesses satisfactory thermal stability within a specific temperature range. The results also indicated that the material can potentially be applied in



industrial sorption systems, adsorption technologies, and wastewater treatment processes where thermal resistance is required.

Overall, the study provides valuable information about the physicochemical and thermal properties of PVC-based sorbents and demonstrates their prospectiveness as functional polymeric materials for environmental and industrial applications.

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