ISSN 2181-8622

Manufacturing technology problems

Scientific and Technical Journal Namangan Institute of Engineering and Technology

INDEX COPERNICUS INTERNATIONAL

Volume 10
Issue 2
2025

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Crossref doi
SLIB.UZ Scientific library of Uzbekistan

ANALYSIS OF THE PHYSICOCHEMICAL PROPERTIES OF POLYVINYL CHLORIDE AND THE IMPORTANCE OF MINERAL FILLERS IN INCREASING ITS FIRE RESISTANCE

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Abstract: This article explores on the role and importance of fire-resistant composite materials in the construction industry, the specific properties of polyvinylchloride (PVC) in fire-resistant composite materials, an analysis of its physico-chemical properties, and the need for mineral fillers and additives to increase the fire resistance of PVC.

Keywords: polymers, polyvinylchloride, composite materials, mineral fillers and additives, fire resistance, synergistic efficiency.

Introduction. Today's construction industry is unimaginable without composite materials. The importance of synthetic polymers in the production of composite materials is enormous. Our research shows that polyvinylchloride (PVC) is one of the most widely produced and widely used synthetic polymers in the world. Its unique properties allow it to be used in a wide range of applications. From this point of view, analyzing the physico-chemical properties of PVC is a key factor in assessing its effectiveness in various fields.

According to the Development Strategy of New Uzbekistan for 2022–2026, important tasks have been set "to double the output of construction materials" [1]. In this regard, it is advisable to create a technology for producing fire-resistant composites from PVC based on mineral fillers. In order to implement the tasks set out in the Resolutions of the President of the Republic of Uzbekistan No. PQ-4992 dated February 13, 2021 "On measures for further reform and financial consolidation of chemical industry enterprises, development of the production of high-value-added chemical products" [2] and No. PQ-99 dated January 24, 2022 "On measures for creating an effective system for developing production and expanding industrial cooperation in the republic" [3], as well as other regulatory legal acts related to this activity, it is a requirement of the time to conduct research in the field of creating a technology for obtaining refractory composites based on mineral fillers from polyvinylchloride. Because in recent years, about 30% of fires observed in housing and communal services in the construction industry in the world economy occur due to short circuits observed as a result of increased load on electrical

equipment, and the short service life of polymer pipes in water supply and sewage systems, which leads to limitations in the use of buildings and structures. Polyvinyl chloride (PVC) is the second largest thermoplastic after polyethylene in terms of volume. Because it has easy processing, impact and fire resistance, and excellent electrical insulation properties.

Methodology. Monographic observation, experimental testing, and IR spectroscopy analysis of a PVC composite sample form the basis of the research methodology.

Literature review. Foreign and domestic researchers, including Hoang Thanh Hai, Cinausero N., Batistella A., Ling Sun, Sertsova A.A., Wennan Li, Yi-Wei Wang, Ruiqing Shen, Qingsheng Wang, Tripolitsin A.A., Yeremina T.Y., Nikolayeva Y.A., Almenbayev M.M., Zubkova N.S., Sabirzyanova R.N., Mikitayev A.K., Djalilov A.T., Samigov N.A., Nabiyeva I.A., Rafikov A.S., Mukhiddinov B.F., Akbarov X.I., Mukhamedgaliev B.A., Turayev X.Kh., Nurkulov F.N., Siddikov I.I., Tojiyev P.J., Beknazarov X.S. and other scientists, conducted scientific research on the production of refractory composite materials from polymers and the creation of their application technology. These scientists studied various methods of obtaining flame retardants in the creation of fire-resistant composite materials, the influence of various technological factors on the process of their production, as well as issues such as improving their structure and properties, and developing technologies for economic and environmental efficiency. In accordance with the requirements of today's modern economy and environmental and international standards, it is advisable to conduct research in the direction of improving the technology for obtaining fire-resistant composite materials based on polyvinylchloride (PVC) with additives and mineral fillers.

Analysis and results. Although PVC has a unique fire resistance property (due to the chlorine in its composition), it is an objective necessity to include various mineral fillers in its composition in order to further increase its fire safety and reduce the amount of smoke and toxic gases released during combustion. In this process, it is advisable to analyze the physicochemical properties of PVC.

The physical properties of PVC are expressed in such indicators as density, mechanical strength, heat resistance, electrical insulation, noise insulation, and light resistance.

The density of PVC is usually from 1.35 g/cm^3 to 1.45 g/cm^3. This indicates a higher density than many other plastics, which increases its weight.

PVC is a hard and strong material, especially without plasticizers (rigid PVC - uPVC). It has high tensile and flexural strengths. When plasticizers are added (soft PVC - f-PVC), its elasticity and flexibility increase, but its strength decreases slightly.

PVC has relatively low heat resistance. Its softening temperature (Vikat softening temperature) is around 75-80°C, which limits its use at high temperatures. At temperatures above 140-160°C, it can decompose and release hydrogen chloride (HCl) gas, which changes the color of the material and deteriorates its properties. For this reason, stabilizers are used in processing and in high-temperature environments.

PVC has very good electrical insulating properties. This allows it to be widely used in electrical cables, wires and other electrical components. PVC, especially in thicker and multilayered forms, can have good sound insulation properties, making it suitable for use in window profiles and floor coverings.

When exposed to direct sunlight for long periods of time, especially under UV light, PVC can yellow and become brittle. For this reason, UV stabilizers are added to PVC products intended for outdoor use.

The chemical properties of PVC include its chemical stability, water resistance, flammability, solubility, decomposition, etc.

Figure 1 below presents a systematic summary of the chemical properties of PVC.

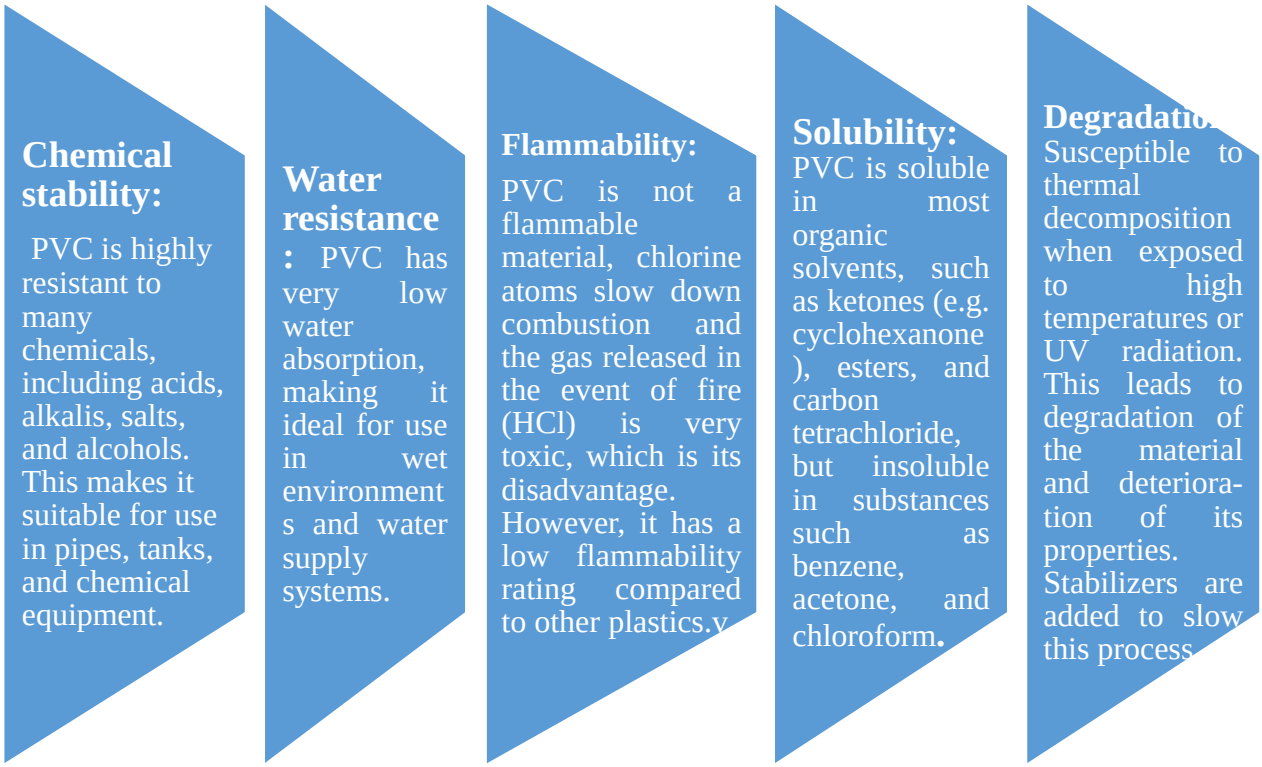

Figure 1. Systematic composition of the chemical properties of PVC

These physicochemical properties of PVC ensure its widespread use in piping systems, cable insulation, window profiles, floor coverings, medical devices and many other products. Its low cost, strength, chemical resistance and electrical insulating properties have made it an indispensable part of modern industry. In particular, its heat

resistance is of particular importance, but this also raises problems that are waiting to be solved. Because the HCl gas released during the combustion of PVC is a major problem for human life and safety in general. It cannot be ignored.

In particular, the flame resistance of polyvinylchloride (PVC) is an important property associated with the presence of chlorine (Cl) atoms in its composition. These chlorine atoms give PVC its flame-retardant properties, which distinguishes it from many other plastics.

We will consider the mechanism of PVC flame resistance below and it is appropriate to divide it into the following stages:

1. The role of chlorine atoms: PVC contains approximately 57% chlorine molecules. When PVC decomposes under the influence of fire or at high temperatures, it releases hydrogen chloride (HCl) gas.

2. Fire-stopping gas: The evolved HCl gas competes with oxygen in the combustion zone and binds radicals, slowing down or completely stopping the combustion reaction. This prevents the spread of fire.

Flame retardancy: As a result, PVC does not burn easily, self-extinguishes when removed from the fire or burns very slowly. This property allows it to be widely used in electrical cables, building materials (window profiles, floor coverings) and other applications where fire safety is important. PVC has a low flammability rating. It often corresponds to the V-0 level (according to the UL94 standard), which means that it burns vertically and self-extinguishes in less than 10 seconds when the flame is extinguished and does not produce molten droplets. At the same time, the shortcomings and safety problems of PVC regarding its fire resistance require scientific research. Because by adding halogen-free additives and mineral fillers to PVC, it is possible to increase its fire resistance as well as ensure its safety.

Our analyses show that, although PVC has high fire resistance, its combustion (if exposed to high temperatures for a long time) leads to the following negative consequences:

Toxic gases: When PVC burns, as mentioned above, hydrogen chloride (HCl) gas is released. This gas is highly toxic and a severe respiratory irritant. It can be fatal in high concentrations.

Black smoke: PVC burns produce dense, black smoke. This smoke can limit visibility and make evacuation difficult.

Corrosive effects: HCl gas reacts with moisture to form an acid, which can have a corrosive effect on nearby metal equipment and building structures. For this reason, special attention is paid to fire safety regulations and ventilation systems in areas where PVC products are used.

In general, due to the unique chemical composition of PVC, it has an advantage over many other polymers in terms of fire resistance. This is one of the main reasons for its widespread use in a number of industries, especially in the construction and electrical industries. In the production of fire-resistant composite materials from PVC, a composite

material was obtained, saturated with halogen-free additives, melamine, melamine cyanurate, and mineral fillers, talc.

In our experiment, a PVC composite with halogen-free melamine was prepared. The process was carried out in a single-screw extruder granulator.

The following figure 2 shows the IR spectroscopy analysis of the PVC composite sample.

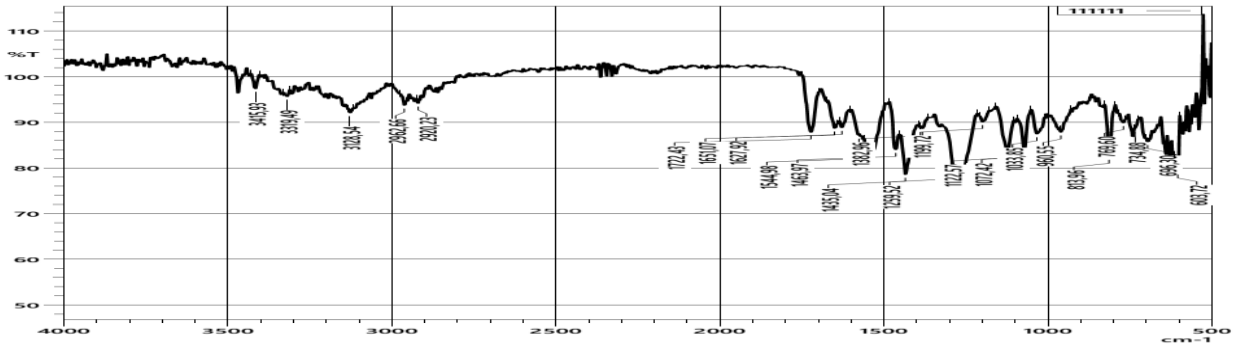

Figure 2. IR spectroscopy analysis of a sample of PVC composite obtained in the experiment

Conclusion. Our research shows that the increasing demand for new types of high-quality, energy-efficient and fire-safe materials in the construction industry, as well as reforms in the field of localization, i.e. the production of fire-resistant materials using local raw materials (for example, mineral fillers), reduces dependence on imports and reduces the cost of products. The presence of research potential in our country in the field of polymer chemistry, materials science and building materials allows us to create a technology for obtaining fire-resistant composites based on mineral fillers from polyvinylchloride. There is also an opportunity to study the experience of developed countries (for example, the use of halogen-free flame retardants and intumescent systems) and adapt it to local conditions. Today, the urgent need to create fire-resistant composite materials based on PVC using mineral fillers is also confirmed by standardization issues. For example, the need to bring national standards for fire safety of building materials closer to international standards (e.g. ISO, EN) increases the demand for fire-resistant materials.

The service life of PVC pipes alone is 40 years, and new developments in this area prove that their service life can be extended to 100 years. This is because PVC is cheaper, lighter and has a much longer service life than other polymer building materials. However, studies show that improving the fire resistance of polyvinylchloride (PVC) in the construction and automotive industries is one of the priority areas of the industry in ensuring compliance with environmental safety requirements.

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