Investigation of the Activation Efficiency of Powdered Polyvinylchloride

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Abstract – the purpose of these studies is to determine the mechanical activation characteristics of powdered suspension polyvinylchloride with zinc. The studying method of the powdered polymeric raw material's mechanical activation effectiveness with fine metal powders is developed, according to which the influence of the powdered polyvinyl chloride and finely divided zinc ratio, the time of the mixture treatment, as well as the degree of a ball mill loading on the activation efficiency of the polymer surface has been investigated. The optimal processing time of powdered polyvinyl chloride in a ball mill during the activation of fine zinc has been established.

Keywords – polymer composites, activation, PVC, zinc, ball mill.

I. Introduction

The analysis of trends in the development of promising materials and technologies indicates the widespread use of polymer composites, of which the metal-filled polymeric materials are of particular interest. A wide range of practical use of such materials contributes to its inherent complex of valuable properties.

In the simplest case, the metal-filled polymer composite consists of finely dispersed metal particles that are uniformly distributed in the polymer matrix. Traditionally, metal-filled polymer composites are produced by the following methods:

1. Mechanical mixing of a metal filler with powders, solutions or melting of polymers.

2. Thermal or electrolytic reduction of metals from their compounds, that were previously dispersed in liquid resins, solutions or molten polymers.

3. Impregnation of metal harnesses, fabrics or porous metals with solutions or melting of polymers.

The feature of metal filled polymer composites is that at low concentrations of metal particles, they remain isolated from each other and do not contribute to the conductivity of the system, and at the next increased concentration of the filler, the mechanical properties of the system deteriorate sharply.

The creation of metal filled composite materials with high technological and operational properties requires the development of alternative technological solutions for their obtaining. The main disadvantage of traditional technologies for the production of metal-filled composites is a significant reduction in their mechanical properties, as well as high concentrations of reaching the threshold of percolation. A new technology for the production of metal-filled polymeric composites is proposed by metallization of polymeric raw materials and its subsequent processing directly into products [1-3].

As a result, the process of combining of the components is significantly facilitated and the uniform distribution of the metal filler in the polymer matrix is provided (Fig. 1). This technology relates to highly effective, resource-saving technological processes and is characterized by a reduced production cycle.

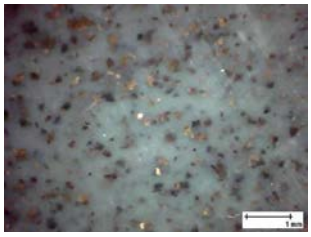

Fig. 1. Microphotography of metal-filled PVC composite (5 mass. % of copper)

II. Powdered PVC activation

The creation of polymeric composites combining good conductive (electrical and thermal conductive) and mechanical properties is a complex task and represents a considerable practical interest. One of the effective methods for solving the problem is the development of new technological solutions for the production of metal-filled polymer composites using a simple technology for activating the polymeric surface.

Powder-like suspension PVC was used for research. Activation of the polymer surface was carried out in a laboratory ball mill with ceramic cylindrical grinding bodies. Suspended PVC and metal activator (zinc powder of the brand PZ-2) was loaded into the mill. During the rotation of the mill there was a metal activator on the polymeric surface.

The use of powdered PVC poses a difficult task for studying of the activation process. Since both the polymer and the metal-activator are powder-like products, it is unclear whether, in the process of processing in a ball mill, there is fixation of metal particles on the polymeric surface (activation), or a mechanical mixture of components is formed.

The formation of a mechanical mixture during processing in a mill is unacceptable, since in this case, during the subsequent metal deposition in chemical recovery solutions [2], there will be no polymeric surface, which eliminates all the advantages of the proposed technology.

Investigation of the activation effectiveness of powdered polymers was carried out using an installation that provides the possibility of transferring the activated polymer powder to a fluidized state with simultaneous vibration exposure (Fig. 2). The need for simultaneous use of vibration and fluidization is caused by the sealing of a powder-like polymer layer due to vibration, which prevents the system from being split into separate density fractions. The transfer of the test mixture to the fluidized state provides the necessary mobility of the components, which contributes to the rapid and maximally complete separation of the system by density.

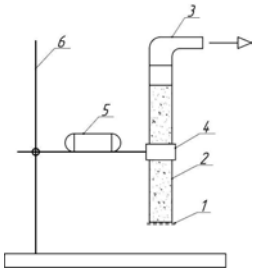

Fig. 2. Installation for separation of the activated powdered polymer on a density fractions
1 – tissue filter, 2 – separation cylinder, 3 – connection of the vacuum pump, 4 – holder, 5 – vibrator, 7 – tripod.

Using only fluidization to separate the system by density is also less effective because of the presence of significant circulation flows, which, due to the small size of the metal particles, contributes to the mixing of individual fractions. The velocity of air flowing through the polymer layer should prevent the compaction and provide the required mobility of the components of the system (polymer, metal, polymer with metal) for the possibility of their separation under the action of vibration and does not cause a significant circulation in the layer, resulting in a density equalization the height of the material layer.

The design of the installation also enables the unloading of individual fractions, which are divided in the height of the cylinder by density. After unloading, the percentages of metal in each fraction were determined. The activation efficiency was estimated by the difference in the content of the metal in the upper and lower fractions.

In order to evaluate the activation efficiency of powdered polymeric raw materials, a number of studies has been conducted on the activation of PVC powder with a different amount of finely divided zinc.

It has been established that the activation efficiency increases with an increase in the amount of zinc in the mixture. This can be explained by the fact that at low zinc levels, it is not sufficient for the uniform activation of all polyvinyl chloride. There is a certain amount of pure polymer that is unbound (not activated) with particles of zinc. With an increase in zinc content in the composition, the proportion of such unactivated PVC decreases, which leads to an increase in the activation efficiency.

Microscopic studies, carried out using a scanning electron microscope in the mode of contrast on the average atomic number (Fig. 3), showed the presence of zinc particles on the surface of polyvinylchloride, and can confirm the activation of the polymer surface by zinc powder.

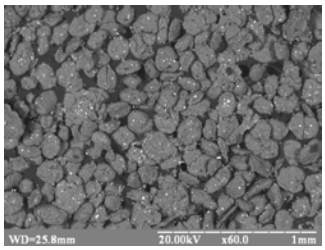

Fig. 3. Microphotographs of zinc activated suspension PVC surface produced in the mode of contrast on the average atomic number

In order to intensify the process of suspension PVC activation, the effect of technological activation parameters was investigated. Namely, the speed of rotation in a ball mill, as well as increased loading of grinding balls and a mixture of polymer with metal activator. The speed of rotation in a ball mill is found to have the greatest influence on the activation efficiency in the range of 60-100 rpm, and the subsequent increase in the speed does not significantly affect the activation efficiency.

In the case of an increase in the degree of ball mills loading, as grinding balls, and the initial mixture, the activation efficiency increases slightly. In addition, it should be borne in mind that with a greater degree of load of the mill with a mixture of polymer with metal, the efficiency of the use of equipment and the reduction of energy costs increases.

Conclusions

Thus, the studies confirm that in the process of mechanical activation of suspension polyvinyl chloride with fine zinc in a ball mill there is a strong interaction between the surface of the polymer and the metal-activator. Such interaction is a prerequisite for the next stage of metallization and the production of metal-filled polymer composites with high performance. The activation efficiency is largely determined by the speed, the degree of loading and the ratio of components, which allows to set the optimal parameters for the process.

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