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Recycling waste as raw material for powder coatings

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Abstract. According to global market analysis, annual production of polymer composites is expected to increase by an average of 6%, reaching a volume of 13-14 million tonnes by 2024, primarily in the building industry and mechanical engineering sectors. Recycling of polymer composites can be achieved through secondary use or recycling of solid waste. In Russia, about 160 out of 343 polymer producers are engaged in polymer recycling, with a focus on thermoplastics. However, recycling of thermoplastics is a complex process due to the strong polymer matrix structure, varying fillers, and resistance to thermal and chemical degradation. Mechanical grinding of waste polymer composites in powder form is a promising way to obtain a secondary product for decorative and protective coatings. Powder coating is a mixture of polymer powders with target and staining pigments, which sprayed onto the surface of a product and then polymerized at 150-220 °C. This paper compares a commercial polymer powder coating with a powder coating derived from recycled glass-reinforced plastic (GRP) on an epoxy binder. The study shows that the polymer powder coating composition obtained from recycled GRP is comparable to commercial powder coatings in terms of uniformity of distribution over the coated surface.

1 Introduction

The problem of recycling and utilization of polymer composite materials (PCM) is included in the list of priority areas of basic and exploratory scientific research for 2021-2030 according to the Decree of the RF Government No. 3684-r of December 31, 2020 "On approval of the Program of basic scientific research in Russia for the long-term period". According to the analysis of the world market of PCM consumption [1], there is a tendency to annual growth of production in an average of 6 %, and reaching in 2024 the volume of 13-14 million tons. This is mainly in the construction and mechanical engineering sectors.

There are two primary methods of recycling PCM: reuse, which involves mechanically treating the polymer to produce pellets with various additives, and utilization, which involves destroying solid waste through thermal decomposition or biodegradation, with the former method releasing toxic gases (Fig.1). Two types of recycling for PCM exist: non-destructive recycling of composite material after pretreatment and destructive recycling of polymer

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material through the crushing into smaller particles [2]. Non-destructive recycling involves mechanically treating the polymer without altering its chemical composition, resulting in pellets of a specific size with various additive modifiers. Currently, the mechanical treatment method is considered the safest and most cost-effective means of recycling.

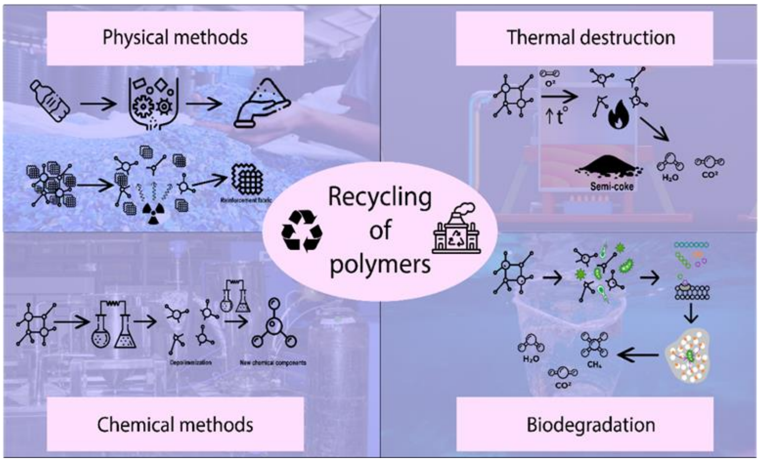

Fig. 1. Main methods of recycling of PCMs.

In the Russian Federation, out of 343 manufacturers of polymer products, approximately 160 companies are engaged in the processing of such products, and most of them are focused on thermoplastics.

The recycling process of thermoplastics is complicated by the strength of the polymer matrix structure, the presence of various fillers and resistance to thermal and chemical decomposition. There are some known methods of dissolution of polymer epoxy matrix in alcoholic solvents, acids and oxidizers with separation of fibrous fillers and their further use as raw material [3-4]. The spent PCM is processed into a powder form that can be used as both a filler for decorative purposes [5] and as raw material for protective coatings [6]. Powder coating is a layer of a mixture consisting of polymer powders with target and staining pigments, which are first sprayed on the surface of the product and then polymerized at 150-220 °C.

The purpose of this study is to develop a composition for a powder protective coating by recycling glass-reinforced plastic using an epoxy binder.

2 Experimental

2.1 Materials

In this work, we used a glass-reinforced plastic based on epoxied binder. The resin was composed of 56.7±0.2% liquid epoxy resin DY-128 (China), while the curing agent was 42.5±0.2% isomethyltetrahydrophthalic anhydride (Russia). To accelerate the curing process, we added 0.8±0.05% 2,4,6-Tris (dimethylaminomethyl) phenol from Russia. We filled with the resin with 18 layers of glass fabric TR-560-30A (Belarus), which served as the filler. The binder/filler ratio was 22.85% to 77.15% of the composite volume. The target additives for this study were residual dust from abrasive materials. This type of waste was chosen because it has the potential to improve the properties of the resulting powder coating, such as hardness, scratch resistance and durability.

2.2 Preparation of coating powder

To obtain the polymer powder from GRP, mechanical processing was carried out in a paddle mixer at a speed of 15 thousand revolutions per minute for 5 min. Microphotographs of glass fibre and GRP after machining were taken with a Nikon Eclipse LV100 optical microscope (Nikon, Japan).

2.3 Test methods

Electrostatic spraying is a popular method for the application of powder coatings and has been proven to produce very consistent coatings. In this study, the powder composition obtained from recycled glass-reinforced plastic was subjected to electrostatic spraying under the influence of corona charge, resulting in a highly uniform coating on the metal substrate. Using the coronal charge of the electrostatic spraying process helps to ensure that powder particles are spread evenly and adhere to the substrate in a controlled manner. This process is an effective way to apply powder coatings to complex shapes and surfaces because it allows precise control of the thickness and distribution of the coating.

3 Results

Figure 2 shows the size of a single glass fibre in the GRP and a GRP pellet after machining.

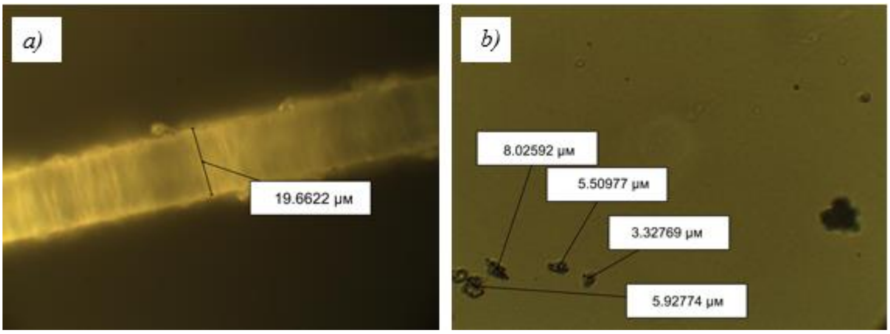

Fig. 2. Optical image of glass fibre dimensions (a), glass fibre after machining (b)

The powder was dried at ambient temperature and humidity before being electrostatically applied to a metal substrate at a distance of 2 cm from the distributor tip. The coating results are shown in the figure 2. As can be seen in figure, the milling was sufficient to obtain the desired dispersion of the GRP composite.

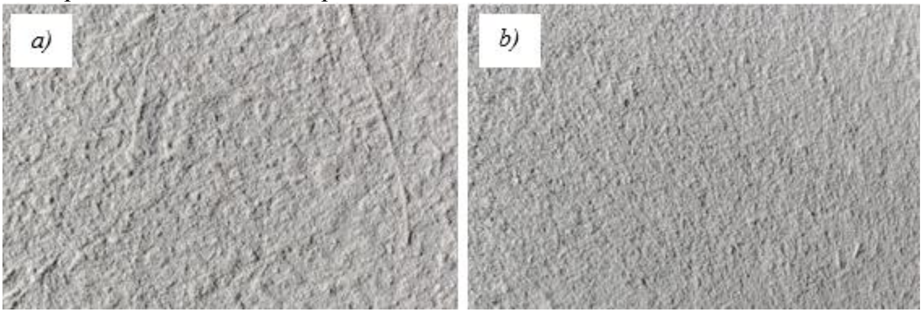

Fig. 3. Image of a metal surface coated with a commercial polymer powder coating (a) and a powder coating obtained from recycled GRP (b)

As shown in Figure 3, the powder produced from recycled GRP can be applied using a process similar to that of commercially available polymer powder coatings. The properties of the resulting coating require further investigation in terms of protection against external influences, adhesion to surfaces of different genesis, hydrophobicity, chemical resistance, etc.

4 Conclusions

In conclusion, this study showed the potential of recycling plastic waste reinforced with fiberglass as a raw material for polymer powder coatings. By careful selection and preparation of GRP waste, a suitable powder composition was obtained and applied using an electrostatic coating method. The coating obtained gave comparable results in terms of uniformity of distribution on the surface of the substrate in comparison with powder coatings of commercially available polymers. This suggests that recycling and reusing GRP waste as a feedstock for coatings has the potential to provide a green and cost-effective solution for industry. However, further research is required to study the properties of the resulting coating, such as protection against external influences, adhesion to different surfaces, hydrophobics, chemical resistance and other factors. All in all, this work represents a step forward in developing environmentally sustainable practices in the polymer industry.

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