Recycled Thermoplastic Concrete Aggregates from Water-Assisted Compounding: A Short Review

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ABSTRACT: The plastic industry is one of the biggest and essential industries in this world. It has become a crucial part of our modern life. Along with the industrial growth, the amount of plastic waste generated has become a major global issue. A recent article by World Wide Fund (WWF) found that Malaysia is the top plastic polluter compared to other Asian Countries. Water-assisted compounding represents the solid-state mixing with the presence of water which provides good material dispersion and affects the properties of the composites. In this article, the feasibility of using water-assisted melt compounding to produce recycled thermoplastic reinforced with clay material for their use as plastic aggregates in construction is reviewed.

Keywords: *Water assisted Melt Compounding; Thermoplastic polymer; Water Assisted*

1. INTRODUCTION

The abundance of waste plastic is a major issue for the sustainability of the environment. International plastic consumption has significantly increased, and plastic goods have become one of the most significant parts of our daily life [1]. The level of plastic wastes in households increases as time goes by. Polyethylene is the largest component of plastic waste, followed by polypropylene, polyethylene terephthalate, and polystyrene [2]. This plastic materials application is snowballing due to the low cost and ease of manufacture [3].

The water-assisted melt compounding technique has the best dispersal compared to conventional melt mixing. The latter usually produces the poorer filler's dispersion. No surface alteration, no decomposition, reduced health risk, and improved filler dispersion are the main advantages of the water-assisted technique [4]. The properties of a recycled polymer matrix can be enhanced using a low amount of clay nanofiller loading with the help of water-assisted melt compounding for better dispersion [5].

Almeshal et al. [6] summarize the potential use of plastic waste aggregate (PWA) as fine aggregate from previous studies until 2019. The use of PWA offers various advantages, such as lightweight, reduced costs, reduced handling and production times and increased structural thermal insulating performance. Therefore, this article reviews and analyzes the feasibility of producing plastic waste aggregates by utilizing water-assisted melt compounding and their potential.

2. THERMOPLASTIC POLYMER COMPOSITES

Thermoplastics are a group of polymers that can be repetitively remade, remelted, and resolidify. These attributes, which give their name thermoplastics, are reversible. Once subjected to enough heat, thermoplastics will melt and harden again when allowed to cool. Polystyrene (PS), polyethylene terephthalate (PET), polyethylene (PE), polycarbonate (PC), fluoropolymers, polyarylsulfone, and polyvinyl chloride are all examples of thermoplastics (PVC).

The majority of plastic, or polymer, is designed to be discarded after a single use, especially in packaging applications. As a consequence, packaging materials account for about half the world's plastic waste. Figure 1 shows that the global generation of plastic waste between the 1950s and 2015. In previous research, polyvinyl chloride (PVC), polyethylene terephthalate (PET), polystyrene (PS), and low-density polyethylene (LDPE) are the widely used plastic aggregates in concrete. However, there is still limited research as construction aggregates for other types of plastic.

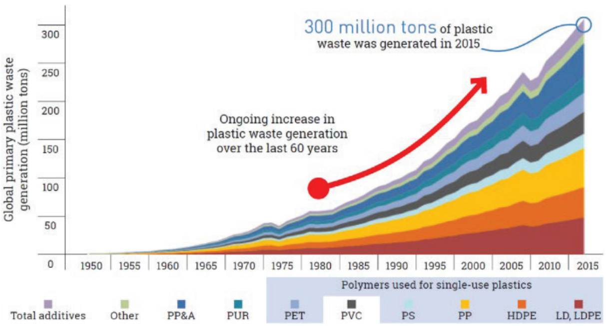

Figure 1 Global primary plastics waste generation, 1950 – 2015 [6]

3. WATER-ASSISTED MELT COMPOUNDING

Polymer composites are materials composed of polymer and other materials. The continuous phase is the matrix, while the discontinuous phase is referred to as the filler. The second phase is added to the polymer to improve its physical and mechanical properties or incorporate new functions. Different approaches have been followed to prepare polymeric composites, such as melt compounding, solvent-induced mixing, water-assisted compounding, and in-situ polymerization. The water-assisted (WA) compounding represents a mixture of solution-assisted, often producing the best dispersal and conventional melt mixing, usually producing the lowest nanofiller dispersion. Figure 2 shows the mechanism of water-assisted melt compounding.

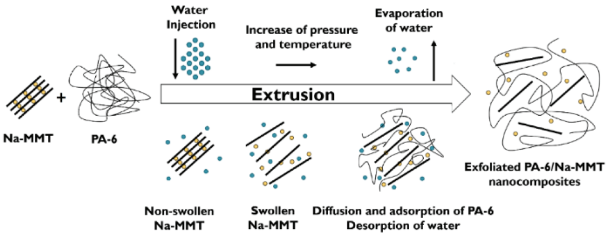

Figure 2 Mechanism of water-assisted melt compounding [7]

The water acts as a plasticizer and a suppressor of melting temperature and crystallization through a cryoscopic effect. Due to cryoscopy, the melting temperature at a constant processing temperature is reduced, followed by reduced viscosity per second. Besides, organophilic alteration of cationic clays could be performed in situ during the melt compounding. In the study by Karger-Kocsis et al. [7], in the presence of dimethyl dioctadecylammonium bromide, virgin MMT (with Na+ cation, Na-MMT) was compounded with ethylene-vinyl acetate copolymer (EVA) (cationic surfactant, modifier, intercalant). In the "one-pot reactive" process, the surfactant has substituted the initial Na^+ cations in the MMT and aided intercalation through the associated enlargement of the clay gallery.

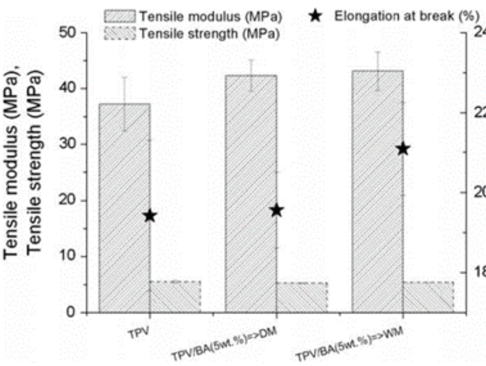

Figure 3 Tensile properties of thermoplastic dynamic vulcanizate (TPV) composites for water-mediated (WM) and direct compounding (DM) [8]

Numbers of research have demonstrated that the form and processing conditions influence the clay's dispersal in polymer matrices [5,7,8]. These factors are crucial in improving the physical, mechanical, and thermal properties of composites. Figure 3 shows higher tensile properties observed in TPV composites prepared via WM than DM [8]. The dispersion condition of fillers is highlighted as the primary contributor.

4. CONCLUSIONS

Overall, the composite development technique might modify the structure and properties of polymer-clay. It is known that the water-assisted melt compounding method provides good material dispersion and improves physical and mechanical qualities while reducing processing temperature. Hence, from this short review, it can be claimed that future polymer-clay investigation using water-assisted processing methods is promising and can contribute to a better solution to manufacture greener concerete aggregates.

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