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Manufacturing of Wood-Plastic Composite from Completely Recycled Materials

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Abstract. In this study, wastes of wood cutting mills (wood flour) as well as wastes of textile industry (granules of polypropylene) were used in manufacturing wood-plastic composites. Hence, wood flour with weight percent of 30, 35 and 40 was mixed with corresponding amount of polypropylene and coupling agent, polypropylene grafted maleic anhydride in amount of 6 percent was used in whole compounds. Production was done by batch method and with employment of hot press and after preparation and cutting of specimens physical and mechanical properties of them was studied. The results showed that with increase of wood flour up to 35 percent, MOR, MOE, water absorption and thickness swelling increases but further than it mechanical and physical properties decreases. Besides, increase of wood flour up to 40 percent increased the hardness of the specimens.

Introduction

Wood plastic composites (WPCs) are defined as composite materials containing wood (in various forms) and thermoplastic materials. These materials are a relatively new family of composite materials, in which a natural fiber and/or filler (such as wood flour/fiber, kenaf fiber, hemp, sisal, etc.) is mixed with a thermoplastic such as polyethylene (PE), polypropylene (PP), poly (vinyl chloride) (PVC), etc. Compared with the traditional synthetic fillers, natural fibers present lower density, less abrasiveness, lower cost and they are renewable and biodegradable. WPCs are becoming more and more commonplace by the development of new production techniques and processing equipment. Around 100 companies involved in WPC manufacturing have been identified worldwide [1]. In WPC manufacturing, virgin plastics such as high and low density polyethylene (HDPE and LDPE), PP, and PVC are commonly used. As for virgin plastics, any recycled plastic that melts and can be processed below the degradation temperature of wood (lignocellulosic fillers) (200°C) is usually suitable for manufacturing WPCs. Plastic wastes are one of the major components of global municipal solid waste and present a promising raw material source for WPCs (thanks to their large amount of daily generation and low cost). The utilization of recycled plastic for the manufacture of WPCs has been studied by a number of authors [2–4] Applications of such materials include floor parquets, flower vases, waste paper baskets, park benches, picnic tables, and plastic lumbers. Properties of some waste plastics are similar to those made from virgin materials. For instance, only slight changes in mechanical properties of recycled polyethylene have been reported [4]. The use of plastic and wood wastes seems inevitable and the present opportunities are promising [5], [6] Use of the word “waste” projects a vision of material with no value or useful purpose. However, technology is evolving that holds promise for using waste or recycled wood and plastics to make an array of high-performance products that are, in themselves, potentially recyclable. Preliminary research at the USDA Forest Service, Forest Products Laboratory (FPL), indicates that recycled plastics such as polyethylene, polypropylene, or polyethylene terephthalate can be combined with wood fiber waste to make useful reinforced thermoplastic composites. Advantages associated with these composite products include lighter weight and improved acoustic, impact, and heat reformability properties—all at a cost less than that of comparable products made from plastics alone. In addition, previous research has shown that composite products can possibly be reclaimed and recycled for the production of second-generation composites.

The overall goal of this paper is to illustrate the potential that currently exists for manufacturing thermoform able composites from waste materials such as waste wood and plastics

Methods and Materials

Poplar- wood flour (particle size of 40– 60 mesh) was supplied from Kousar Co. (Golestan, Iran). Recycled PP, with the trade name Polinar SF060, was obtained from Polinar Petrochemical Company, Tabriz, Iran. Its melt flow index was 8.5–9.5 g/10 min and density of 0.91 g/cm3. The coupling agent, maleated polypropylene (MAPP) was obtained from Kimiya Javid Company with a melt index of 64g/10 min and 2.0 wt% maleic anhydride.

Composite Processing. The amount of wood flour was varied from 30, 35 and 40 wt % and MAPP was fixed at 6% on the basis of the total weight of PP (table1). The blends were compounded in a twin screw extruder (Borna Pars Mehr, Iran). The barrel temperatures of the extruder were controlled at 165, 170, 175, and 180°C for zones 1, 2, 3, and 4, respectively, whereas the temperature of the die was held at 185°C. The screw speed was 60 rpm. The extruded strand was passed through a water bath and pelletized. The resulting granules were subsequently placed in hot press at 175°C for 10 min. then cooled to room temperature under pressure. The pressure for heating was controlled at 35 bar.

Table1-treatments

treatment	Wood flour (%)	Recycled polypropylene (%)	MAPP (%)
1	30	64	6
2	35	59	6
3	40	54	6

Preparation of the Specimens. The resulting granules removed from the twin screw extruder were then pressed into sheets of 10mm nominal thickness and 20×30 cm^2 nominal dimensions using a laboratory hydraulic hot press at 175 °C. Specimens for mechanical testing were cut out of these sheets.

Mechanical Tests. The mechanical properties of the Wood flour/plastic composites were assessed through flexural and Hardness properties. These properties of Wood flour/waste plastic composites were determined according to ASTM D7031, using an Instron testing machine. All tests were done at room temperature (25°C) and constant relative humidity (65%) and three replicates for each test were performed. The specimens were conditioned at constant room temperature and relative humidity prior to testing.

Fig. 1 and 2 the flexural MOE and MOR of Wood flour/recycled plastic composites, respectively. It can be observed that the MOE and MOR of composites containing 35% Wood flour are higher than those containing 30 and 40% wood flour. When the wood flour content increased up to 35%, MOE and MOR significantly increased, while in switching from 35% to 40% there was slight decreases of MOE and MOR of PP composites.

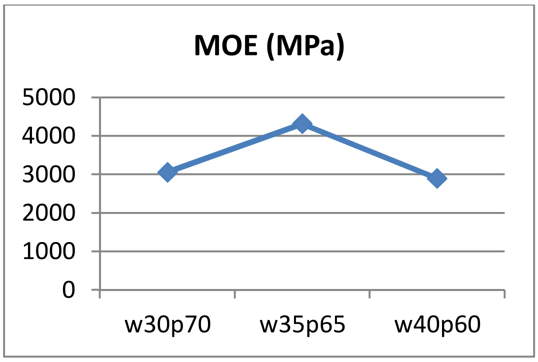

Fig. 1: MOE of Wood flour/ recycled polypropylene composites.

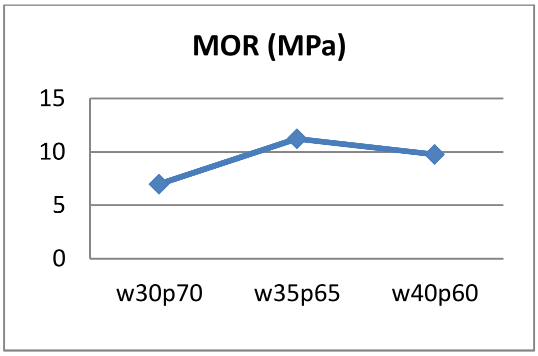

Fig. 2: MOR of Wood flour/ recycled polypropylene composites.

Hardness of wood flour/ recycled polypropylene composites is shown in Fig. 3. Increase of wood flour up to 40 percent increased the hardness of the specimen.

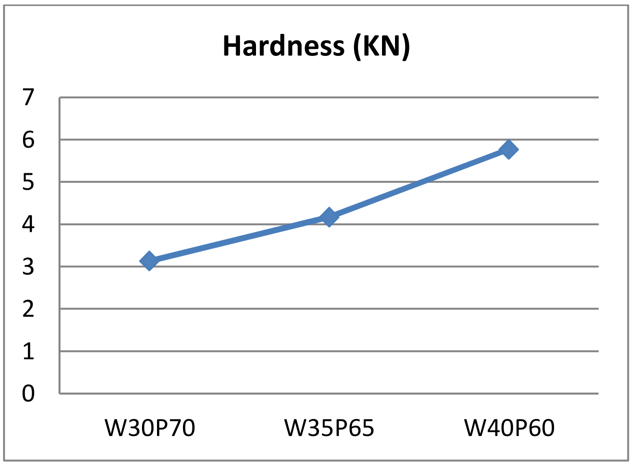

Fig. 3: Hardness of Wood flour/recycled polypropylene composites.

Physical Tests. The water absorption test was carried out according to ASTM D 570. The samples were immersed in distilled water at 23 ± 1°C for 2 and 24h intervals. Before testing, the weight and thickness of each sample were measured. Samples were removed at certain periods of 2 and 24h, wiped with tissue paper to remove the excess water on the surface, and immediately weighed and measured. WA was calculated according to the following Eq. 1:

$$WA(\%) = \frac{(m_t - m_0)}{m_0} \times 100 \quad (1)$$

One of the important properties that we evaluated for the WPCs was WA because it can limit their application. The fact that cellulosic fibers easily absorb water is actually one of the reasons for fiber surface treatments. The treated fibers may absorb less moisture and, thus, favor adhesion with the polymer matrix and also present better performance in humid environments.

Fig. 4 shows the percentages of the water uptake for the Wood flour/recycled polypropylene composites at different periods of immersion (2 and 24h), which varied depending on the wood flour content. The WA of the 60% polypropylene, however, was very low (~ 0.5%) because of its hydrophobic nature. In general, polymers absorb very little moisture; when polymers do slightly absorb moisture, this indicates that moisture is being absorbed by the cellulosic material in the composite.

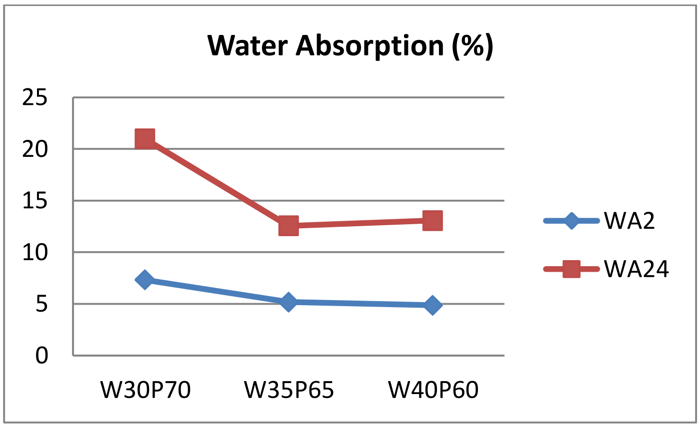

Fig. 4: Water absorption after 2 and 24 hours

Summary

Mechanical and physical properties of WPCs manufactured from Wood flour and recycled plastic (PP) were studied in this research. The following conclusions can be drawn from the results and discussions presented above:

- With increase of wood flour up to 35 percent mechanical and physical properties, increases but further than it decreases MOR, MOE, and physical properties.
- Generally the mechanical properties of specimens containing recycled plastics were statistically comparable with and even to somehow better than those of composites made from virgin plastics. This was considered as a possibility to expand the use of recycled plastics in the manufacture of WPCs.(Kazemi et al,2005)
- When polymers do absorb moisture slightly, this indicates that moisture is being absorbed by the cellulosic material existed in matrix of the composite.

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