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Investigation of Mechanical Properties of a New Composite of Corn Leaf/ Polypropylene

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ABSTRACT

Wood-plastic composites are a new type of polymers that have been widely applied in varoius industries based on their efficiency, biodegadability, low costs of production, availability and etc. However, furthure studies over their chemical and mechanical drawbaks are under investigation to improve these caractristics for the improvement of the quality and reduction of the cost of production. To reduce the cost of production for this kind of material and application of corn leaf powder (CLP) that was considered as a resudue of this plant, we studied the effects of CLP addition as a filler into the Polypropylene matrix. In this study, a dried sample of CLP is used as filler to manufacturing of WPC composite. Polypropylene (Arak S30S) with different percentage of 5, 10, and 20 of CLP was used at the presence of coupling agent extruded within screw extruder and some samples have provided for testing process. The results revealed that, similar to usage of wood powder, increase in CLP would cause significant growth in tensile modulus especially for ratios of 5 and 10 % of filler. The results showed that, it would be used as suitable substitute of wood powder to produce WPC composite.

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INTRODUCTION

Wood-fiber composites have many applications including automobile, construction, sport, and military applications. Due to broad variety of applications reported for these materials yet, most of scientist's attentions have been directed toward these materials (Pritchard, 2004), (Smith, and Wolcott, 2006), (Nadir, 2012), (Benthien and Heiko, 2012), and (Hosseinaei *et al*., 2012). Recently, broad variety of researches is done over the corn plant (Safari, 2013), (. khodadadi Dehkordi, 2013), (Ghorbanian and Rejali, 2013), (Monem, 2014), and (Badalzadeh Aghdam, 2013) and there are also other reports focusing over the application of agricultural residues and inorganic fillers into the polymeric bulks for the production of residual-polymeric composite materials (Nur Azni, 2013), (Sakthieswaran, 2014), (Sam, 2013), (Nik Yahya, 2013), (Syed Azuan, 2013), (Syed Bakar, 2013), (Syed Azuan, 2013), (Noriman, 2013), and (Azrem, 2013). There have been a lot of investigations upon the physical and mechanical properties of these materials trying to find a logical relation between these properties and the agents providing these properties such as mixing condition, formulation, kind and structure of wood, kind of coupling agent, modification of polymers, and etc. Moreover, the production of these novel materials, considering higher enforces on the standardization and biodegradability of polymeric contents, represents that the rate of annual application of these material will rise to about 14% with 2015 (Julson, 2004), (Keener, 2004), and (Fabien, 2012). Lower exhausted CO2 gas from the burning of natural fiber enriched polymers isother advantage of these materials. On the other hand, natural fiber enriched plastics are the best environmentally friendly polymeric compounds that are used in biodegradable polymer composites (Yan, 2013), (Kokta, 1989), (Bledzki, 1996), (Bledzki, 2002), and (Cantero, 2003). The effect of coupling agents for polymer (hydrophobic part) - wood (hydrophilic agent) interaction have widely be investigated yet. Additionally, other factors that improve the mechanical and physical properties of these compounds are pervasively studied to gain natural fiber composites with desired properties for application oriented applications (Cantero, 2003), (Danyadi, 2007), and (Bledzki, 1999). There are also other reports especially concentrating over the natural fiber composites and their mechanical and physical properties.Z.L. Yan *et al*. prepared a work namely Reinforcement of polypropylene with hemp fibers (Yan, 2013).

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A. Elkhaoulani and colleagues studied the Mechanical and thermal properties of polymer composite based on natural fibers: Moroccan hemp fibers/polypropylene (A. Elkhaoulani, 2013). A. Hammaa *et al*. prepared a work titled Starch-grafted-polypropylene/kenaf fibres composites. Part 1: Mechanicalperformances and viscoelastic behavior. Recently, other similar studies using natural fibers for the production of natural fiber composites are performed (Hamma, 2013), (Sam-Jung, 2008). Here at the present work, we applied the natural fiber of corn leaf with polypropylene polymer to investigate the mechanical properties of the newly produced composite.

Elkhaoulani 2013 Hamma 2013 Sam-Jung 2008 Azizi 2008 Shakeri 2005 El-Sabbagh 2014

Exprimental:

Material:

As illustrated in Table 1, Polypropylene, S30S was supplied by Arak Petrochemical Co (Iran). A mixture of CLP with the particle size of 100meshes (referring previous reports) was applied (Azizi, 2008) as filler using a meshed industrial sieve. Maleic anhydride polypropylene (MAPP) provided by NingboCo with 6-8 % of acid weight was used as coupling agent.

Table 1:

Material	Producer company	Brand	Density(g/cm^3)	Melt Flow Index(g/10min)
Polypropylene, S30S	Arak Petrochemical Co (Iran)	X30S	0.9	8

Composite preparation:

Prior to the preparation of samples, CLP was dehydrated in an oven at 80 ± 2ºC for 24 h. Then, polypropylene and CLPwere weighed and bagged according to formulations given in Table 2. Including different weights for CLP. Mixing was carried out by a twin screw extruder ZK50(Werner Pfliderer Co) and subsequently the output melt was converted into granule using a pellet mill. This extruder contains 6 thermal areas whose temperature from under the feed hopper to the output section ranges of 175, 180, 185, 190, 195, and 200ºC, respectively. To be dehydrated, granules were heated in a dryer at 85$^{\circ C}$ for 4 hours before use and then converted into samples using a heat press machine and compression molding technique at 200$^{\circ C}$ and 15 MPa. Moreover, in order to assimilate the final properties of raw polymer materials and draw comparisons between raw polymer and composites, raw polymer materials underwent the same processing stages as composite production.

Table 2:

Sample code	Polymer type	Polymer Content (%)	Filler Content (%)	Coupling Agent	StabilizerMA-PP
1	X30S	100	0	0	1
2	X30S	95	5	1	1
3	X30S	90	10	2	1
4	X30S	80	20	4	1
5	X30S	70	30	6	1

Mechanical testing:

Flexural and tensile tests were performed based upon ASTM D790 and D638, respectively, via an Instronuniversal (Model 1121). The tests were prepared at crosshead speeds of 50 mm/min. A Zwick impact tester (Model 5102, Germany) was applied for the impact test. All the samples were notched in the center of one longitudinal side according to ASTM D256. For each treatment level, five replicate samples were tested and the average values of the tests were reported. For morphology observations, the samples were broken in liquid nitrogen and the braked surface were pictured via electronic microscope (model XL30).

Scanning electron microscopy:

Scanning electron microscopy (SEM) was used to study the distribution of corn leaf particles in the composite. The prepared sample was examined by a Scanning Electron Microscope (model Philips XL 30) at an acceleration voltage of 25 kV.

RESULTS AND DISCUSSION

Tensile properties:

Improvement and enforcement of the mechanical and physical properties of composites are two major implications of the application of natural fibers in composite materials. These characristicsdepend on other factors such as the amount of fiber per percent, dispersion of fiber powder, and the performance of coupling agent (Yan, 2013) and (Kokta, 1989). In the most of reports over the mechanical properties of natural fiber composites, the modulus is increased after the addition of natural fiber to the pure polymeric bulk (Hamma,

2013) and (Sam-Jung, 2008). We expected to observe similar results for our study as the higher modulus for CLP along with its thickness are evidence of this claim. As it is clear from the Table. 2, the modulus of the prepared composited is grown with the increase in weight percent of CLP (in presence of coupling agent). The values of tensile properties, such as tensile modulus and tensile strength of composites coupling agent MAPP are presented in Fig. 1 and 2, respectively. Fig. 1 illustrates a gradual upwardtrend in the value of tensile modulus of the composites, reaching a peak in the value of 1122MPa for PP/MAPP/ CLP up to at 20 wt. % of filer content compared to the neat PP (1016 MPs). Tensile strength was gradually increased with the growth in the amount of fiber content (with more noticeable increases in between 10 to 30 % of fiber content). Shakeri *et al*. show that, the tensile module for the composite with 29.34 and 39.12 % of wheat straw has higher increases compared with other considered composites (Shakeri, 2005). Noticeably, the interactions between the hydroxyl groups on cellulosic fibers and the PP matrix are improved when the fiber weight percentage is grown.

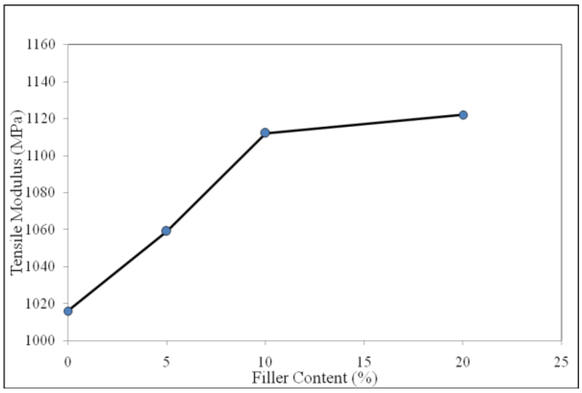

Fig. 1:

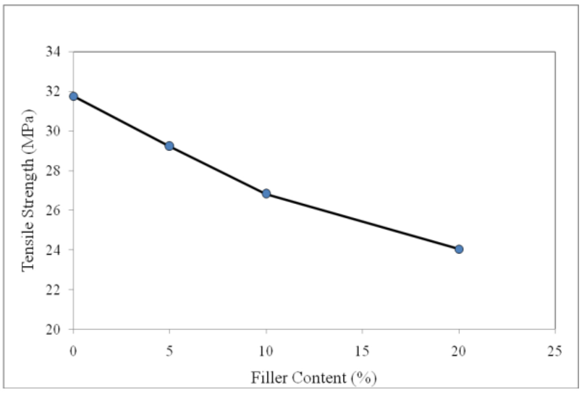

Fig. 2:

A. Elkhaoulani represented that the highest values for young's modulus and tensile strength are at 25 and 20 % of hemp fiber with polypropylene while the highest values for the young's modulus and tensile strength of pp-(SEBS-g-MA)-fiber composites, where maleic anhydride (SEBS-g-MA) plays the role of a compatibilizer, are at 20 and 10 % filer content, respectively (A. Elkhaoulani, 2013). S.-J. Kim and coworkers revealed that, the tensile strength is increased for PP-cotton fiber as the fiber content grown reaching to a peak at 350Kgf/m2 for 30wt. % filer content (Kim, 2008). In terms of Impact strength, the incorporation of fibers to the polymer at the presence of MA as compatibilizer resulted to a moderatedecrease as the fiber content percentage increases (See Fig 3).

Moreover, we have studied theElongation at break for the prepared specimens as presented in Fig.4, the results reveal a noticeable decrease from 15% for the pure polypropylene to 6.9% for composite with 5wt. % of filer content (where the overall trend is downward). El-Sabbagh and colleagues represented that, the values of Elongation at break per percent are decreased as the content of natural fibers of Flax, Hemp, and Sisal increased (El-Sabbagh, 2014). Reinforcement of polypropylene with hemp fibers is a study prepared by Z.L. Yan *et al*., finding that, generally the tensile and impact stringent diminishes while the flexural strength as the fiber content (per percent) increases in composite matrix, where the most changes have occurred in the range of 10 to 30 % of fiber content [Yan, 2013].

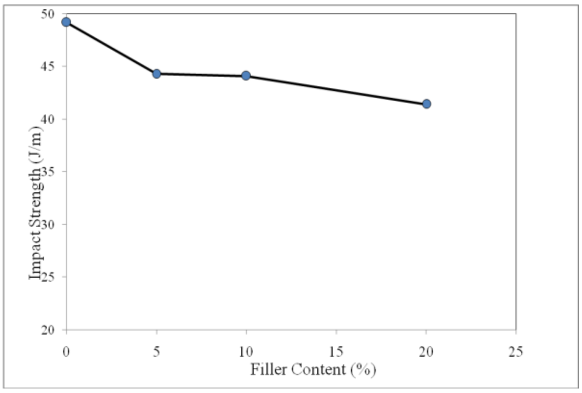

Fig. 3:

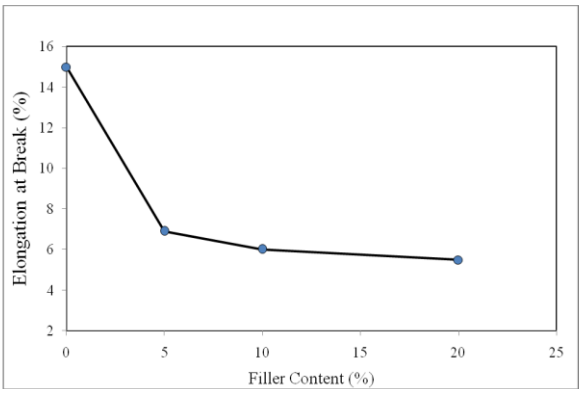

Fig. 4:

*Scanning electron microscopy*tests:

In order to observe the surface of prepared composite, the SEM observation was prepared using Scanning Electron Microscope (model Philips XL 30). Fig. 6A and B illustrates SEM fracture surface of the CLP/PP composite at 5 and 20 of fiber content inside the PP matrix, respectively, and 1MA ratio. Sufficient cohesion between polymer and wood flour stemmed from the coupling agent may remarkably affect the final properties of the composite. As it is clear from the SEM plot, there is a unique distribution of fiber particles all over the PP bulk. The fracture shows no pulled out of fiber length from the pp bulk. The SEM plot also elaborates for the positive effects of MA regarding the good adhesion between the fibers and PP.

Concluding remarks:

The application of corn leaf powder as filler within polypropylene produced by Arak Petrochemical Company (ARPC) for the production of a natural fiber composite and consequent investigation over its mechanical properties is performed. Since the tensile strength relies on the weakest segment of the composites and the interfacial interaction between PP and corn leaf powder is weak, the tensile strength of the PP/ corn leaf powder composites decreases as the corn leaf wt. % increased. The result expresses increase in tensile modulus and decrease in. The results revealed that polypropylene X30S can represent better properties to be applied for general applications tensile strength, impact strength and elongation at break.ch as auto parts based on their more moderate decreases in impact strength, tensile strength and elongation comparing with other composites.

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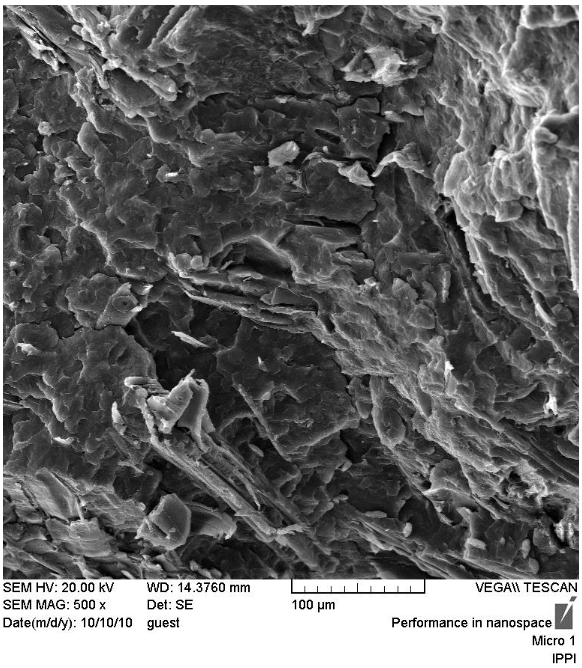

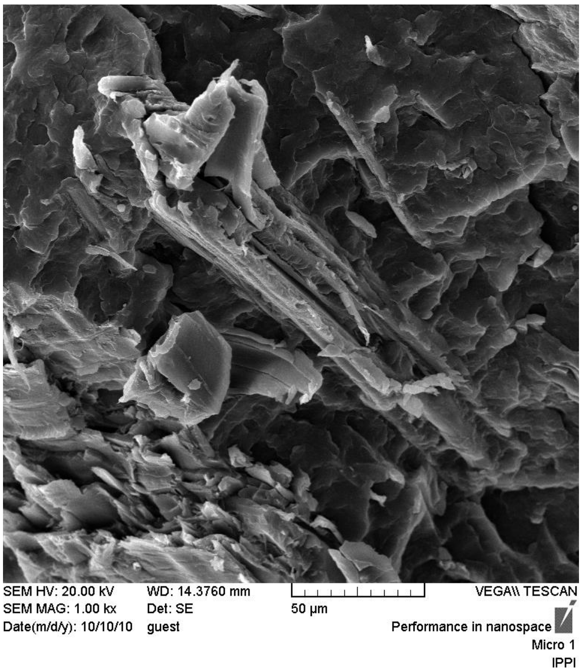

Fig. 5: A and B.

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