Technology Package
on

Wood Polymer Composites

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Introduction

In recent years, wood fibers have gained significant interest as reinforcing material for commercial thermoplastics. They are now fast evolving as a potential alternative to inorganic fillers for various applications. Wood fiber offers several advantages like low density, high specific properties, low cost, etc. However the primary drawback of using wood fibers for reinforcement is the poor interfacial adhesion between polar-hydrophilic wood fibers and nonpolar-hydrophobic plastics. This results in poor mechanical properties of the final product. The interfacial adhesion can be improved by using compatibilizers or coupling agents. Recent work suggests that the use of maleated polypropylene (MAPP) significantly improves the fiber-matrix bonding. The improvement in mechanical properties is believed to be due to a better dispersion of fibers in the matrix, a more effective wetting of fibers by matrix resin and a better adhesion between the two phases. At Institute of Wood Science and Technology, we have developed a novel coupling agent for wood and other natural fibers filled polypropylene composites. The composites prepared with this coupling agent exhibited much superior mechanical properties when compared to conventional coupling agent like maleated polypropylene.

Twin screw extrusion facility at IWST

Advantages of Wood Fibres

Fillers

In recent years, use of synthetic polymers has grown tremendously because of the capability to mould these thermoplastics into complex shapes and engineer desired properties into them. However plastics have poor mechanical properties, e.g. stiffness, bending strength, etc. To improve the mechanical performance and to reduce the cost, plastics are often reinforced by fibers or particles. Glass and carbon fibers are most commonly used reinforcements for thermoplastics, but are expensive and their production is highly energy intensive. Today, Natural composites are fast emerging as a realistic alternative to glass fiber reinforced composites.

Advantages

Advantages of wood fibers as a reinforcing element for thermoplastics arise from the fact that they are: light weight, non corrosive, and less abrasive to processing equipments. Because of low density of plant fibers, a wood fiber reinforced product will always be thicker and hence stiffer than the one reinforced with the same mass of glass or carbon fiber. Non-abrasive nature of natural fibers permits very high volume of filling (upto 70%) in the composite. Higher filler content will reduces the amount of more polluting polymers used in a given component.

Optical image of wood our

Further, high specific strength and modulus, low cost, and availability in most geographic regions makes wood fibers even more attractive as fillers. The compact design of biological fibers introduces an element of redundancy which is very desirable from the safety point of view. Natural fibers are carbon dioxide neutral in their production (they derive carbon from air and not from oil or natural gas) and require only small energy inputs for processing. Natural fibers cause less dermal and respiratory irritation, and are more pleasant to work with than glass fibers.

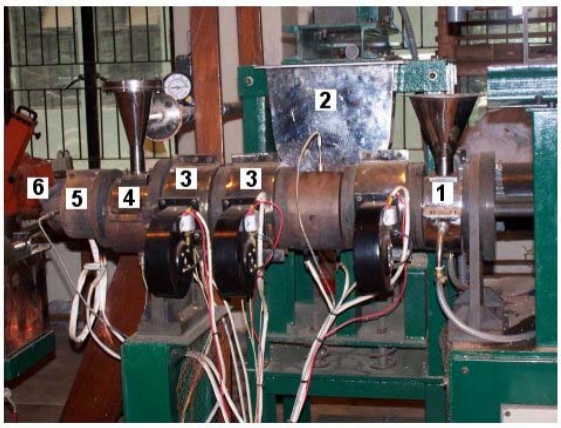
Limitations

Despite of all the advantages mentioned above natural fibers are less frequently used to reinforce common thermoplastics such as polyethylene, polypropylene, polyvinyl chloride, and polystyrene because of difficulties associated with surface interactions between hydrophilic wood fiber and hydrophobic thermoplastics. Such divergent behaviour results in difficulties in compounding these materials, and poor mechanical properties of the end product. A survey of literature reveals that adhesion and chemical affinity between cellulose and polymer matrix can be improved by using coupling agents, which can react with both matrix polymer and reinforcing fiber.

Recent Advances by IWST

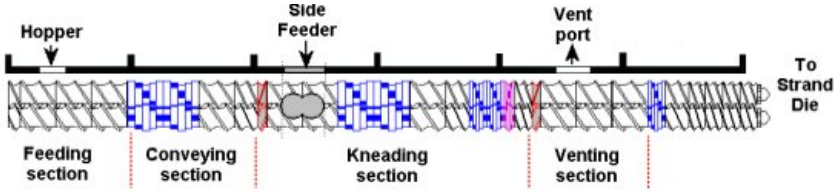
Natural fiber as reinforcements for both thermoplastics and thermosets are one of the fastest growing types of additives in plastics. According to a recent study by Kline & Company, the North American market for wood and agricultural fiber reinforcements was estimated to be in excess of USD150 million in 2000 with average annual growth exceeding 20% in automotive applications and 50% in selected construction applications. Conventionally in India fillers such as clay, calcium carbonate, aluminates, silicates, etc

are used to reduce the cost and to improve stiffness of thermoplastics. As on now, natural fibers filled plastics are not commercially popular in India. The technologies used abroad are expensive and often not suited for machineries, production practices and raw-materials available locally. Institute has undertaken a systematic study to improve the interfacial adhesion between natural fibers and matrix materials. To study natural fiber filled composites, a 28mm co-rotating intermeshing twin screw extrusion system was designed and commissioned.



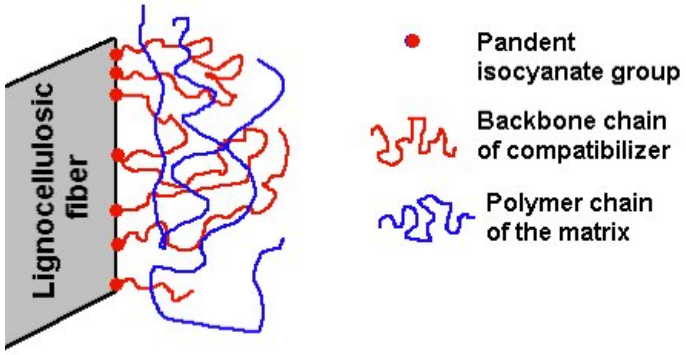
Barrel section of extruder

The system is equipped with two volumetric feeders and a twin screw side feeder. Studies on processes optimization have been completed, and this enabled us to constitute a screw profile for homogeneous dispersion of fillers with least degradation of matrix resin and wood fibers.



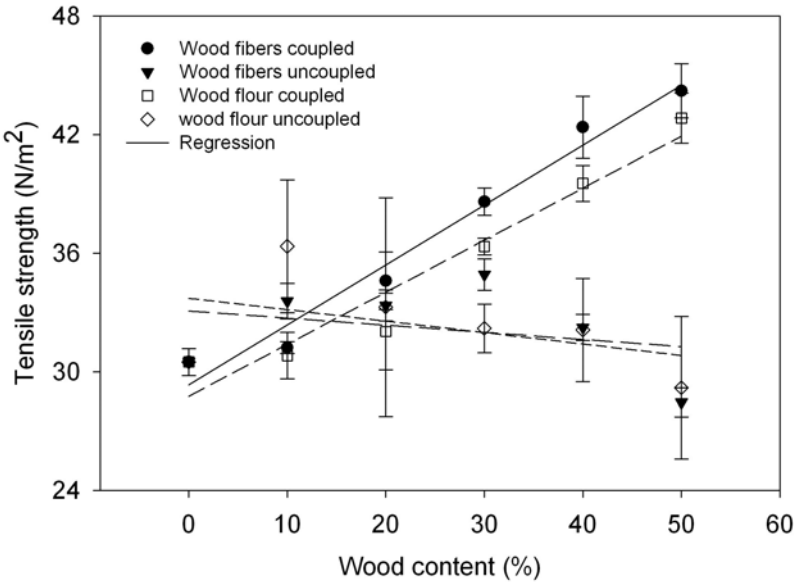
Screw profile

The study on wood polymer composites has shown that biological fibers and synthetic resins like polypropylene and polyethylene can be combined to make composites that are equally strong, but environmentally friendly. By using a suitable coupling agent it is possible to produce advanced composite materials that take advantages of both natural fibers and synthetic resins. A novel vinyl monomer with isocyanate functional group was synthesized. The maximum grafting yield achieved in this new coupling agent is ~9% as against 1-2% reported for maleated polypropylene. The functional group in this coupling agent gets grafted as single monomer unit without any oligomerization, which further improves its efficiency as coupling agent. Also the isocyanate group of this coupling agent is less reactive to water, this is very important, as side reactions with residual moisture in wood can be avoided. Thus this new coupling agent has proved to be superior than most of the commercially available coupling agents.

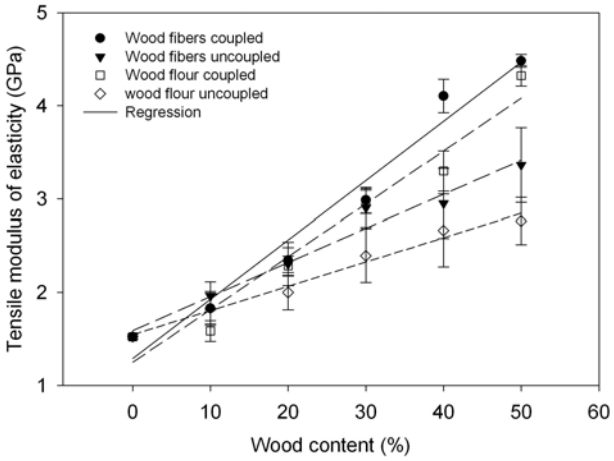


Mechanism of coupling

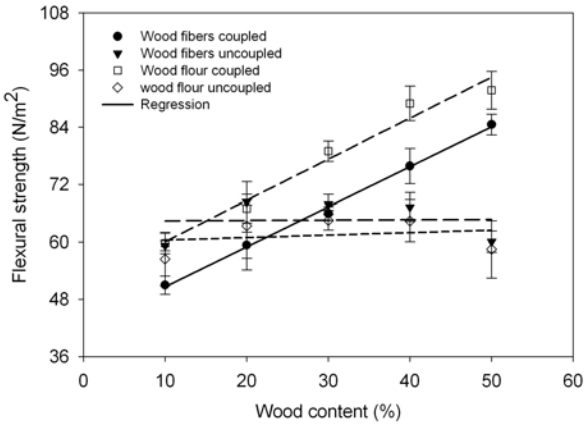
Under the study, we have also done complete characterization of the composites. Mechanical properties, chemical ultra-structure, water absorption, thermal behaviour, non destruction evaluation of mechanical properties and damping behaviour of the composite materials have been systematically studied. The study provides complete understanding of the material. In conclusion, the coupling agent synthesized during the study proved to be a much superior coupling agent than those reported in the literature. Addition of wood fibers at all levels leads to significant improvement in stiffness, tensile strength and flexural strength with some loss of impact strength. As an example, Mechanical properties of wood filled polypropylene composites are shown in figures below.



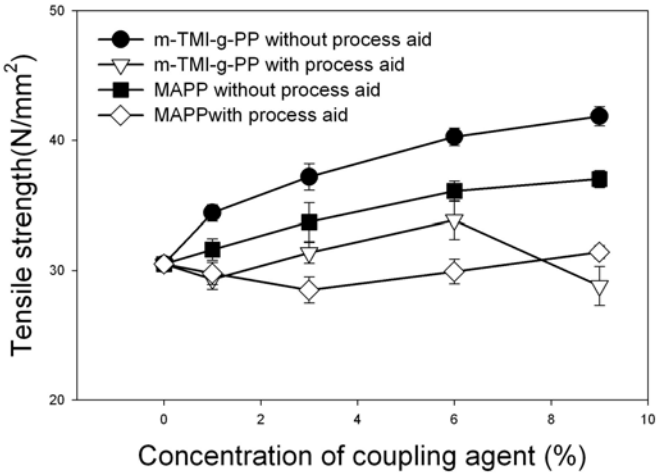
Tensile strength of wood fiber and flour filled PP composites prepared with and without coupling agent



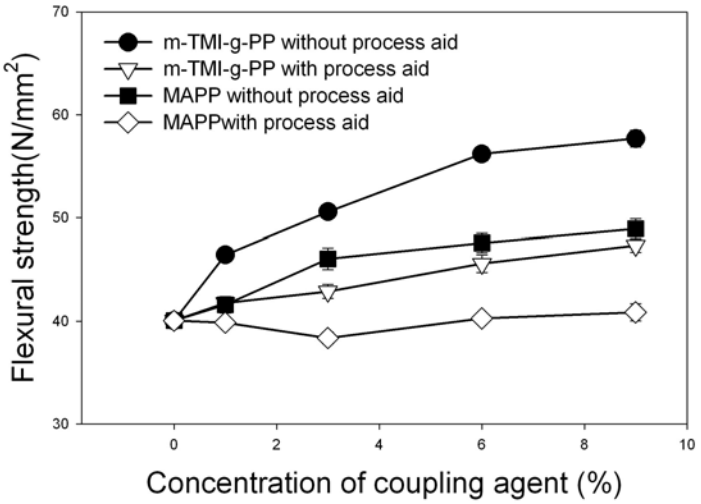
Tensile modulus of wood fiber and flour filled PP composites



Flexural strength of wood fiber and flour filled PP composites



Effect of type and concentration of coupling agent (*m*-TMI-g-PP and MAPP) on tensile strength of 40% wood polypropylene composites



Effect of type and concentration of coupling agent (*m*-TMI-g-PP and MAPP) on flexural strength of 40% wood polypropylene composites

The Institute has expertise on

- ✓ Synthesis of coupling agent
- ✓ Wood, bamboo and jute filled polypropylene composites
- ✓ Wood and bamboo filled polyethylene(HDPE) composites
- ✓ Grafting of styrene on wood fibers using a patented technology
- ✓ Wood filled styrene composites
- ✓ A novel one step method to prepare cellulose fiber filled HDPE composites

Technology Transfer

As a policy, Institute of Wood Science and Technology encourage industries/ entrepreneurs to join hands with the Institute to commercially exploit the technologies developed at the institute. For detailed terms and conditions and negotiation of cost of technology, the interested parties may contact Marketing Cell of IWST. Email Id: groupco_iwst@icfre.org Phone No. 080-23340115. Office Hours- 9.00 A.M. to 5.30 P.M.