# Silane modification of wood flour and its application into a polymer matrix

S. Božeková, Z. Mičicová, P. Skalková, I. Labaj, J. Vršková, D. Ondrušová

Wood flour, obtained during wood processing, is often used as a filler in polymer composites. However, its hydrophobicity and low adhesion to polymer matrices can limit its effectiveness in these applications. To improve these properties, wood flour was modified in three different ways using (3-aminopropyl)triethoxysilane (APTES). The biowaste - wood flour (W) derives from the production of wood pellets of the company ECPU, s.r.o. was used for research. The wood flour sample was dried due to the elimination of excess moisture and was prepared particle sizes between 25-40 μm (Fig. 1).
The shape of the wood flour was characterized by scanning electron microscope instrument. Particles of wood flour appear as long and thin with layered wood-like structures rather bundles than individual fibers Fig. 2. The elemental composition of wood flour sample was analyzed using EDX, and the results are shown in Tab. 1. The most represented element in the samples is carbon (C), which is attributed to wood material.
Silane modification of wood flour was done in three ways (Fig. 3):
For first way of silane modification, wood flour was treated at room temperature (25 °C) with an aqueous solution of 3-Aminopropyltriethoxysilane (APTES). The APTES was added gradually, drop by drop at a concentration of 3 wt% based on the weight of the wood flour, into a solvent mixture of ethanol and distilled water in a 9:1 ratio and filler (wood flour). The solution and stirring at 3 000 rpm for 30 minutes to get modified wood flour.
For the second way of modification, the APTES was added at a concentration of 3 wt% based on the weight of the wood flour, into a solvent mixture of ethanol and distilled water in a 9:1 ratio. The stirring time was 30 min. The wood flour was added into solution and stirred in a water bath at 60 °C and at 3 000 rpm for 2 h.
For the third way of modification, the APTES was added at a concentration of 3 wt% based on the weight of the wood flour, into a solvent mixture of ethanol and distilled water in a 9:1 ratio. The stirring time was 30 minutes. The wood flour was added into solution. Prepared dispersion was modified under the vigorous stirring in microwave reactor FlexiWAVE at a constant temperature of 60°C for 2 h.
All three dispersions were washed three times with ethanol and then they were centrifuged for 10 min at 3000 rpm and obtained three forms of modified wood flours. Subsequently, all modified samples were dried at 60°C for 24 h. The modified forms of wood flour were then incorporated into a polymer matrix and analyzed. Five rubber blends were prepared using a Brabender mixer. The mixing was carried out in a single-step process (Fig. 4). The modified forms of wood flour were compared with blend filled with unmodiefied form of wood flour. Among the selected rheological properties (Tab. 2), the M2W sample shows the best properties.
However, incorporating modified wood flour into the polymer blend led to an improvement in tensile strength and led to a decrease in value of elongation at break (Fig. 5) primarily because of the enhanced dispersion of the filler within the matrix. The higher reinforcement restricts the mobility of polymer segments that finally result in a reduction in elongation. The tensile strength can be transformed to a degree of reinforcement, provided by the filler to polymer corresponding to the αf value. The highest value of αf indicates the strongest filler–matrix interaction and, consequently, the most pronounced reinforcing effect, especially for M2W sample.
Samples with modified forms of wood flour showed a slight increase in hardness in comparison with sample filled unmodified form of woof flour (Fig. 6). The slight increase in hardness could be due to a small amount of filler.
The results indicate that the modification of wood flour with APTES affects the interaction between the filler and the polymer matrix, which leads to the improvement of selected properties of the composites. Comparing different modification methods allowed for the identification of the most effective way to modify wood flour. The superior properties observed in sample M2W confirm the second modification approach as the optimal method for modifying wood flour.