Highly magnified views show how DuPont™ Fusabond® M603 coupling agent (right side panels, above) helps with wood fiber dispersion and internal bonding with PE-based polymer.

Using Fusabond® M603 as a coupling agent in wood-polymer composites (WPCs)
Product Description

DuPont™ Fusabond® M603 resin is an ethylene copolymer, incorporating a monomer which is classified as being a maleic anhydride equivalent for application uses. The exact composition is DuPont proprietary information.

This unique technology can produce both substantial strength improvement and increased moisture resistance in wood/polyethylene composites (WPCs) at significantly lower usage levels than conventional maleic anhydride coupling agents. At higher levels, it provides superior performance for dramatic reduction in water absorption.

Recommended Application of Fusabond® M603 in WPC

1. WPC Compositions
   a.) Type of Bio-Fibers and Concentration:
   Based on the chemical structure and physical properties (e.g., melt viscosity) of the Fusabond® M603 resin, DuPont expects this coupling agent to interact with a variety of biofibers. Studies have been conducted with both hardwood fibers, in particular oak fibers, as well as pine softwood fibers. Fusabond® M603 has also been shown to work well with rice hulls. There are many other cellulosic and organic materials that may also interact with Fusabond® M603.

   The typical concentration of fibers in WPC has been between 40-60 wt%. These could be virgin or recycled fibers. Generally the size of wood fibers used are 40-60 mesh.

   It is strongly recommended that the wood fiber be dried prior to coming in contact with Fusabond® M603. Ideally the moisture content of wood fibers should be below 0.5 wt%. Wood fiber drying is a potentially hazardous process and should be done in consultation with equipment suppliers.

   b.) Type of Polymer Matrix
   Fusabond® M603 is an ethylene copolymer and as such is recommended for use with polyethylene based WPC, although it may have benefits to composites based on other polymers. The polyethylene matrix can be high-, linear-low- or low-density polyethylene (HDPE, LLDPE or LDPE) or any combination of these polymers. The resin can come from virgin, post industrial or post consumer recycled sources as long as it is properly prepared.

c.) Additives
   Fusabond® M603 performance is not affected in the presence of additives typically used in WPC compositions. For example, Fusabond® M603 has been tested in the presence of 5 wt% talc. It is expected that Fusabond® M603 will improve coupling and dispersion of the additive or filler in the polymer matrix.

   Most significantly, lubricants are commonly used in WPC formulations to increase throughput and reduce edge “tear” as the material exits the die. Typical lubricant dosages are between 3-6 wt%. There are generally two classes of lubricants: metal stearate based, and organic based (nonmetal stearate). Metal stearates are the most cost-effective and efficient; however, they interact negatively with traditional maleic anhydride grafted coupling agents. It has been shown that Fusabond® M603 remains effective in the presence of metal stearate based lubricants. Fusabond® M603 can be used with the more expensive organic lubricants, as well, but may not be as effective as when used with the less expensive metal stearate lubricants.

2. Processing and Process Variables
   DuPont™ Fusabond® M603 can be used in processing equipment typically used for WPC processing such as extrusion, compression and injection molding equipment. The most common processes are single-screw and twin-screw extrusion. One should be aware that processing and dosage of Fusabond® M603 may change between single-stage and dual-stage units.

   Fusabond® M603 resin is fed to the processing equipment in a variety of ways, including:
   • independent using a dedicated accurate loss and weigh feeder;
   • dry-blended with the matrix polymer (care must be taken in the uniformity of the dry-blend);
   • fed downstream of the main polymer feed but before the cellulose addition point.

   Fusabond® M603 is used in typical WPC process conditions. The melt temperature for processing wood fiber composite is kept below 200°C (390°F). According to its material safety data sheet, the maximum processing temperature for Fusabond® M603 is 260°C (500°F).
At recommended processing temperatures, small amounts of fumes may evolve from the resins. When resins are overheated, more extensive decomposition may occur. Adequate ventilation should be provided to remove the fumes from the work area.

As stated, it is recommended strongly that the wood fiber is dried (< 0.5wt%) before processing. The water released can negatively impact the reactivity of coupling agents including Fusabond® M603. The presence of a vacuum port is essential to remove other moisture present and other gases evolved during processing, including small off-gases from Fusabond® M603.

3. Recommended Dosage of Fusabond® M603

The recommended dosage of Fusabond® M603 in composite formulation will depend on a number of factors, including the target property goals such as Modulus of Rupture (MOR), Modulus of Elasticity (MOE) and moisture uptake. Other factors include cellulose type, cellulose, additive and filler levels, quality of the matrix polymer(s) and processing equipment.

Due to the high reactivity of Fusabond® M603, DuPont recommends keeping the concentration of Fusabond® M603 below 1.0 wt% when a high intensity, 1-stage process is used to make the WPC profile. An example of such a process is a conical twin-screw process feeding profile die (typically includes a gear pump). In a 2-step process where ingredient mixing and profile extrusion are separated, the loading of Fusabond® M603 can be further increased to 2.0 wt%. In either case for a detailed recommendation, customers should contact their local DuPont representative.

During initial evaluation, DuPont recommends testing at two levels:

- 0.5% and 1.0% Fusabond® M603 for 1-stage systems;
- or 0.75% and 1.5% for 2-stage systems.

If a maleic anhydride grafted polyethylene is currently being used, customers can typically cut the addition levels significantly when using Fusabond® M603.

Fusabond® M603 coupling agent can be used with a variety of lubricants for extruder torque reduction or improved line speeds when making high-strength, high-modulus wood alternatives.
Troubleshooting Guidelines

High amps or torque: If the extruder motor amps or torque increases suddenly, the DuPont™ Fusabond® M603 may have very high reactivity in the system. Stop addition of the Fusabond® M603 (or replace with polyethylene) and restart the test with a lower level of Fusabond® M603. Consult your DuPont representative for additional suggestions.

Disclaimer

This information corresponds to our current knowledge on the subject. It is offered solely to provide possible suggestions for your own determinations. It is not intended, however, to substitute for any testing you may need to conduct to determine for yourself the suitability of our products for your particular purposes. It is the user’s responsibility to determine the level of risk and the proper protective equipment needed for the user’s particular purposes. This information may be subject to revision as new knowledge and experience becomes available. Since we cannot anticipate all variations in actual end-use conditions, DUPONT MAKES NO WARRANTIES AND ASSUMES NO LIABILITY IN CONNECTION WITH ANY USE OF THIS INFORMATION. Nothing in this publication is to be considered as a license to operate under or a recommendation to infringe any trademark or patent right.