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Posted: September 16, 2010

From the *Plastics Engineering* Blog:

FIRST COMMERCIAL APPLICATIONS FOR THREE NEW 'ECO' FILLERS

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Processors looking to lower the carbon footprint of their plastics found several intriguing new compounds made with sustainable/recycled fillers presented at the Society of Plastics Engineers� latest GPEC technical conference in Orlando last March. The new eco fillers include micro cellulosic fibers from the waste product from paper recycling, structural lignocellulosic fibers made from corncobs, and high cellulose fibers from wheat straw. All three became fully commercial last year.

These novel reinforcements are being used in petroleum-based polyolefins, both virgin and recycled, but they could be used in biopolymers as well. All are natural fibers sourced from readily available inexpensive byproducts from another process. They�re not only recycled, bio-derived, and sustainable, they don�t compete with food products for land use. Here�s data on the physical properties these unusual new reinforcements impart.

PAPER FIBER & PP COMPOUNDS

Eco Research Institute Ltd. (ERI), a 12-year-old company in Tokyo, Japan (www.er-kankyo.co.jp/eri) has developed technology to pulverize short fibers from recycled paper into micro powder as fine as 50 microns. ERI then compounds this powder into PP at loadings of up to 70% to make opaque injection molding grades commercially in Japan. Feedstock for the filler is the waste product of fluffy short cellulose fibers (specific gravity 0.2) left after paper recycling, which recovers only long cellulose fibers. ERI developed a proprietary cutting edge for a roller mill that can grind this fluff into very fine powder.

Paper/PP composites are designed to compete against PS, but with drastically reduced carbon footprint. ERI�s life cycle data shows CO_2 emissions for the paper/PP composite of 0.6152 kg CO_2/kg vs 2.0825 for PS. Compounds of

30% paper/70% PP have a density of 1.03-1.2 g/cc similar to PS with tensile and flexural strength, Young�s modulus and HDT comparable to general purpose PP. MFR is slower than PP, while shrinkage is greatly reduced.

PAPER/PP COMPOSITE PROPERTIES VS GP PP

Property Paper Composite GP PP

Density, g/cc 1.03-1.20 0.9

MFR. G/10 min 1-20 30

Tensile strength, Mpa 29-35 36

Flexural strength, Mpa 41-54 53

Young�s modulus, Mpa 3000-3700 2000

HDT, C 120-130 130

Shrinkage rate, % 0.4-1.0 1.4

ERI has presented data on the material at previous GPEC�s, but this year reported the first commercial applications. An injection molding grade of 53% paper and 47% PP, called Mapka, is used commercially for DVD and CD cases. Other commercial applications in Japan include toys, combs, stationery goods, filters and food service items like cups, bowls and cutlery. Water resistance is excellent, ERI says. At GPEC ERI reported water absorption of 1%-2% (100 hr soak @ 80 C, but says it has achieved lower numbers since. Mapka composites can also be microwaved at up to 130 C. ERI offers precompounded paper-filled PP.

FUNCTIONAL FILLERS FROM CORNCOBS

Blending structural lignocellulosic fibers from ground corncobs into post-industrial recycled HDPE improves its thermal stability and impact performance and reduces shrinkage, according to data from MCG BioComposites in

Cedar Rapids, Iowa (www.mcgbiocomposites.com). MCG, which partnered with North Dakota State University in Fargo (www.ndsu.edu) to develop formulations, tested composites made with two types of corncob fiber, both commercially available from Best Cob LLC in Independence, Iowa (www.bestcob.com). Best Cob, a nearly 50-year-old firm producing ground corncob products, developed two grades for plastic compounding: a low cellulose �80 grade with 33% strong crystalline cellulose fibers and 37% weaker amorphous hemicellulose, and a high cellulose 20-40 grade with 42.9% cellulose and 40.2% hemicellulose.

Tensile and flexural strength with both fiber types are either unaffected by compatibilization (with 1%-2% maleic anhydride grafted HDPE) or improve slightly. Interestingly, however, neither the type of corncob fiber (high or low cellulose) nor use of 1%-2% compatibilizer had much effect on compressive failure or Izod impact performance. Unnotched Izod impact strength actually improves slightly without compatibilizer for both corn cob fiber types vs neat HDPE. Notched Izod is 6.56 and 6.81 J/m respectively for uncompatibilized composites with low cellulose �80 and high cellulose 20-40 fibers respectively vs 5.72 J/m for neat HDPE. This suggests high potential for corncob fiber in recycled HDPE for high impact applications, MCG says. MCG commercialized an injection molding grade in pellet form with 20% corn cob fiber and 80% recycled HDPE called MCGB rHDPE2009 XP279 in June 2009 for garden markers. A more recent custom grade MCGB-2010rHDPE-X100 also with 20% corncob filler achieves higher properties with lower density. Larger applications are being commercialized now including agricultural parts and components.

PROPERTIES OF CORNCOB FIBER/HDPE COMPOSITE VS NEAT HDPE

Property XP279 X100 HDPE

Corn cob fiber % 20 20 0

Specific gravity, g/cu m 1.05 0.97 0.90

Unnotched Izod impact, ft-lbs/in 3.66 0.123 0.107

Notched Izod impact,, ft-lbs/in 1.11 0.129 0.123

Tensile strength, kpsi 3.380 2.87 2.57

Flexural strength, kpsi 6.710 4.27 3.61

Flexural modulus, kpsi 225 170.1 127.3

Elongation @ break, % 7.02 10 25

Tensile modulus, kpsi 195 197.8 140.0

WHEAT STRAW FIBER IN LGHT WEIGHT AUTOMOTIVE COMPOUNDS

Compounder A. Schulman in Akron, Ohio (www.aschulman.com), presented detailed data on its commercialization of a 20% wheat straw fiber/80% PP injection molding compound for Ford Motor Co., designed to match existing Ford material specifications. (In addition to the GPEC presentation, the wheat straw fiber program was also a finalist for the SPE�s Innovations Award last fall.)

R&D on the new filler started with a grant from the Ontario government to the University of Waterloo in Canada to promote use of bio filler materials in automotive applications. The university worked with a supplier of wheat straw fiber, Omtec Inc. in Mississauga, Ont. (www.omtecinc.ca) to develop process controls to insure consistent supply and quality of wheat straw fiber, sourced from specific farmers in the region. Wheat straw fiber, which contains 35%-40% cellulose, comes from the stem or straw product left after grain harvesting. Omtec then cleans, chops, mills, and screens the fiber for the required size. Omtec now offers five grades of wheat straw fiber, based on length or aspect ratio.

Schulman tested formulations of wheat straw powder and wheat straw fiber of different lengths in homopolymer PP. It also tested wheat straw fiber in combination with glass. The resulting wheat straw compounds performed comparably to wood- and talc-filled PP in tensile strength, flex modulus, and notched Izod impact, but were dramatically lower weight, weighing 5%-10% less than talc/PP and 10-15% less than glass-and-mica-filled PP. A 20% wheat straw/80% PP homopolymer compound (AgriPlas BF20H-31) has a density of only 0.96 g/cc vs 1.01 g/cc for a 20% talc PP compound. (Elongation properties for the wheat composite are poorer, but elongation wasn�t required for the material specifications Schulman was matching.)

WHEAT STRAW/PP PROPERTIES VS TALC/PP

Property 20% Wheat Straw/PP 20% Talc/PP

Density, g/cc 0.96 1.01

Tensile strength @ yield, MPa 23.2 25.5

Flexural modulus, MPa 1962 2107

Notched Izod (23 C), kJ/m2 4.6 4.2

HDT, 0.45 MPa C 114 100.6

Shrink, % in 48 hours @ 23 C 0.75 0.94

The injection molding grade processes in existing machinery and tooling at 20-30 degrees C lower temperature, which saves energy and reduces cycle time 8%-12%, Schulman reports. Testing showed that 100% regrind could be reused for up to five passes. The wheat straw compound was commercialized in a third row quarter storage bin and cover liner for the 2010 Ford Flex. New wheat straw formulations have been developed since for other interior, exterior and under hood applications to come, Schulman says. Ford notes that this isn�t its first wheat straw composite. The steering wheel of the first Model-T was reinforced with straw from Henry Ford�s farm.