Development of Novel Biopplastics *Nodax*™ by Using 2D IR Correlation Spectroscopy

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Plastics are wonderful and versatile materials and have permanently changed our lifestyle in the last 70 years. One of the major issues with plastics is its longevity and persistence over time. Once created and spread throughout the environment, they are difficult to reclaim and can linger for a very long time with as yet unknown long-term consequences. Today we produce over 300 million tons of plastics every year, and about 8% of them may end up in the ocean. It would be useful if plastics had a well-defined lifetime and then would disappear and safely return to nature after the intended use. Fully bio-based and biodegradable plastics replacement *Nodax*™, which has recently been commercially introduced by MHG, Inc. in Bainbridge, Georgia may provide the much needed answer.

Nodax™ is a new generation of poly(hydroxyalkanoate) or PHA copolymers produced by bacterial fermentation with a very unique and proprietary molecular design which has medium-chain-length (*mcl*) side branches. While certain PHAs have been known as aerobically and anaerobically biodegradable aliphatic polyesters, historically they have had many severe shortcomings to be considered as a serious replacement of conventional petroleum-based plastics. Traditional PHAs were often associated with 1) disappointingly poor materials properties for both processing and end uses due primarily to their excessively high melt temperature and crystallinity, 2) prohibitively high cost of production due to inefficient fermentation and purification processes, and 3) consequently very limited availability to support the robust industrial supply chain.

In contrast, MHG's *Nodax*™ type *mcl*-branched PHAs have a much lower melt temperature and crystallinity to avoid thermal decomposition during processing, as well as dramatically improved mechanical properties, such as toughness and ductility which are immediately useful in numerous applications. MHG's proprietary fermentation and purification processes combined with a judicious choice of a carbon source based on locally harvested non-GMO canola oil brings down the cost of PHA production to a level that is comfortably competitive with conventional plastics. Replacing a large portion of petroleum-based plastics with this new class of materials should constitute one of the promising solutions for an important environmental issue, the proliferation of plastics in the world.

In my talk I will describe the historical development of *Nodax*™ type *mcl*-branched PHAs originally carried out at the Procter & Gamble Company in Cincinnati, Ohio. The design of the new class of PHAs was actually inspired by the critical insight obtained from the analysis of existing PHAs by using a technique called two-dimensional infrared (2D IR) correlation spectroscopy. Features appearing in the 2D IR correlation spectra provided an important clue to the strategy for modification and improvement of known biopolymers to produce much more useful plastics. In other words, *Nodax*™ was developed based on the sound scientific principle and deliverate research effort instead of fortuitous discovery.