

PERP Program – New Report Alert

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Chem Systems' Process Evaluation/Research Planning program has published a new report, *Plants as Plants (00/01S6)*.

This report is about a novel approach to producing specialty and commodity polymers that uses genetically modified plants to directly generate the polymers in microbes and plants through enzymatic processes. This is radically different from separately polymerizing monomers that are derived from petrochemicals or even monomers produced from biological sources. In this report the research and development, commercial and technical precedents and commercialization progress of three important concepts in industrial biotechnology to achieve this goal are assessed:

- Producing “finished” specialty and commodity polymers (specifically, a naturally-occurring class called polyhydroxyalkanoates, or PHAs) directly in biological systems and extracting them from the biomass rather than making only the monomers by biological means
- Genetically modifying or “metabolically engineering” microbes and crops to accomplish this in two distinctly different modes of industrial fermentation and farming
- Adapting large-scale fermentation-based processes, farming and agricultural product processing systems to economically implement these developments

It has been demonstrated that polymers in this class of natural polyesters, PHAs, can be made to match and/or exceed for the same applications practically any commodity or specialty polymer in commerce today. PHAs with the structural qualities of polypropylene as well as ones with the flexibility and resilience of thermoplastic elastomers (TPEs) can be made. This has been demonstrated by: Metabolix, Inc. (the primary developer considered); its predecessors in their development chain, WR Grace, ICI and Monsanto; Procter & Gamble; and many academic researchers. PHAs properties can be varied widely by selecting monomers and co-monomers and by manipulating their molecular structures through selecting and genetically modifying organisms to operate specific enzymatic pathways. Desirable monomers or co-monomers can be added externally,

or can be made internally (at potentially lower cost, but with more difficulty), through selection among a complex set of enzymatic pathways.

Two potential commercial routes to PHAs are examined in this report:

- Fermentation using genetically modified microbes that express PHAs, combined with patented solvent extraction of PHAs from the cell bodies. The process design and process economics were modeled after two commercial fermentation processes: the RHM Mycoprotein process and the L-lysine process. In addition, two glucose feedstock pricing scenarios were examined: commercial grade glucose and a notional, lower priced “industrial” grade of glucose.
- Producing PHAs in the seeds and/or green matter (stems and leaves) of genetically modified large plants, such as corn, soy, or native American perennial switchgrass (“Plants as Plants” route), and using solvent extraction techniques to recover the PHAs.

From our analysis, it is clear that fermentation PHAs have the potential to compete in price with high performance polymers such as the nylons, and that crop-extracted PHAs may compete with the cheapest commodity polymers on the market. Nexant believes that some day low cost “industrial” grade glucose may become available if a PHA facility is integrated with a corn “refinery”, such as may be operated in the future to produce fuel alcohol and co-products by wet corn milling. If this is the feed, then the fermentation products will be even more competitive with incumbent “performance/commodity” polymers.

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