



Biomass Chemical Products

FACT SHEET 5.9

INTRODUCTION

Numerous opportunities are emerging to expand industrial needs through the production and processing of biological materials. Biological feedstocks can be used as a substitute for petroleum-based feedstocks to make a variety of bulk, intermediate, and specialty chemicals. Biomass-related chemical products typically fall into three general categories: biobased acids, biobased oils, and specialty chemicals. This fact sheet highlights some of the more important bio-based chemicals derived from biological feedstocks.

BIOBASED ACIDS

Acids are a vital component of industrial production. They play an important role in everything from the production of food preservatives and plastics to medical advances. Increasing the feedstock supply for the production of acids is vital if the United States is to stay economically competitive in the global market. As technology advances and the understanding of acid production become clearer, the use of woody biomass to produce specific acids will become a more economically attractive solution than the current petroleum-based and energy intense methods.

Several important bio-based acids recovered from forest residues include acetic acid, fatty acid, and lactic acid.

ACETIC OR ETHANOIC ACID is acid produced from the fermentation of lignocellulosic

material. Uses include foodstuffs, solvents, and fungicides. It is a key component in the production of pharmaceuticals like aspirin. Esters derived from the acid are used to produce vinyl acetate used in paints, glues, and wallboard and cellulose acetate used mainly for rayon and photographic films. Vinegar is 4 to 8 percent acetic acid by volume. PET or polyethylene terephthalate, a thermoforming polymer commonly used for food and beverage containers, is also produced using acetic acid.



source: Corbis Corporation

FATTY ACIDS, readily available from plant oils, are used to make soaps, lubricants, and chemical intermediates such as esters, ethoxylates, and amides. These three classes of intermediates are used to manufacture surfactants, cosmetics, alkyd resins, nylon-6, plasticizers, lubricants and greases, paper, and pharmaceuticals.

LACTIC ACID is produced by the fermentation of starch-derived glucose. In the United States, nearly 72 million pounds are used yearly, mainly in food and beverage service. Chemical companies have invested substantially in identifying potential derivatives of lactic acid that can serve as bio-based alternatives to chemicals currently produced from petroleum. Currently the largest source of lactic acid results from the fermentation of corn.

Ashton, S.; P. Cassidy. 2007. Biomass Chemical Products. Pages 193–196.

In: Hubbard, W.; L. Biles; C. Mayfield; S. Ashton (Eds.). 2007. Sustainable Forestry for Bioenergy and Bio-based Products: Trainers Curriculum Notebook. Athens, GA: Southern Forest Research Partnership, Inc.



BIOBASED OILS

RAW LIQUEFACTION OIL is a free-flowing dark liquid produced by thermochemical liquefaction. A light liquefaction oil, known as TDP-40, is used as refined biodiesel. Some types of liquefaction oil are used as solvents. An example is Cyclohexane, a paint remover also used in making nylon. Another example is Methylethyl benzene, used in the production of rubber and waxes. Liquefaction oil is also blended with gasoline. Toluene, also derived from liquefaction oils, is used in the manufacturing of explosives and added to jet fuel to improve octane.

PYROLYTIC BIO-OIL is a complex, combustible mixture. Pyrolytic bio-oil has been used commercially for industrial heat since the early 1930s. It is currently being tested as a fuel for diesel transportation and stationary turbine and diesel power¹. Pyrolytic bio-oil fuel is a free-flowing, dark brown liquid that can be stored and transported easily. The wood industry relies on petroleum based phenol-formaldehyde resins to produce plywood, oriented strand board, and other wood composites. In addition, extracted additives from bio-oil during the fast pyrolysis process can be used to infuse “smoked”, “roasted”, or “grilled” flavors in food.

SPECIALTY CHEMICALS

Specialty chemicals, which are chemicals produced in small volumes for specific end uses, often mixtures or formulations of different chemicals, play an important role in the economy of the United States. Currently, organic chemicals are primarily synthesized from a petroleum base and used in the

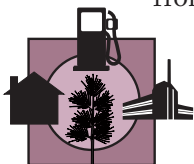
production of paints, solvents, fibers, and plastics. Specialty chemical markets represent a wide range of high-value products. These chemicals generally sell for more than \$2.00 a pound and their market is steadily growing².

Several important specialty chemicals that are produced from woody biomass are enzymes, 3-HP, bio-based fuel gas, syngas, butanol, and glycerin.

ENZYMES. The primary source of current and future enzymes is the fermentation of biological materials³. Enzymes function as catalysts in industrial systems to produce feed additives and chemicals. In addition, they function as detergents, reagents, diagnostics, and health aids. Expectations are that enzyme sales will increase 10 percent annually as new markets and needs emerge. Enzyme-derived products have replaced water-polluting phosphate detergents and allowed wash waters to be cooler. They are used to coagulate milk



source: Corbis Corporation





proteins for cheese production, as sweeteners for sodas, and in lactose-free milk. Xylanase enzymes are beginning to replace chlorine in the pulp and paper industry and cellulase in the textile industry.

3-HP is perhaps the most well known intermediate chemical produced by lignocellulosic fermentation behind lactic acid. Research has shown that the intermediate chemical can be produced at a theoretical yield of 100 percent from glucose⁴. With the addition of chemical processing, 3-HP is transformed into a variety of marketable chemicals such as PDO, acrylic acid, acrylonitrile, and acrylamide. When transformed into acrylic acid, the polymer is used in coating, adhesive, superabsorbent, and detergent. In addition, it is used to make acrylic fibers for carpets and clothing, pipes, furniture, automobiles, nitrile rubber and the resin in latex.

FUEL GAS AND SYNGAS are products of either black liquor gasification or biomass gasification. The mixture of raw product gases varies according to the feedstock and the gasification approach utilized. Bio-based fuel gas is also known as “producer gas” or “wood gas” and contains a relatively low energy density. Low energy fuel gas is most suitable for combustion to produce thermal energy. Medium energy syngas, once cleaned, can be used as fuel in boilers or to fuel electricity and steam generation via gas turbines or fuel cells. By-products of fuel gas and syngas fermentation are microorganisms that can directly affect hydrogen and carbon monoxide production.

BUTANOL is an organic chemical that can be broken down into several large-volume derivatives. Butanol could be used as a bio-based oxygenated fuel for blending with gasoline, although it is not in use currently. Butanol has several advantages over methanol and ethanol, such as having energy content closer to that of gasoline with few to no mechanical and chemical compatibility issues⁵. In 1999, about 925,000 tons of butanol were used domestically. Projections are that the usage will increase 3 percent per year, expanding demand significantly when blended with gasoline⁶.

GLYCERIN is a sweet, viscous alcohol that is produced as a byproduct of the manufacturing of biodiesel. The ratio of glycerin to biodiesel produced is one to 10⁷. Selling for \$600 to \$900 per ton, glycerin is used in soaps, solvents, and industrial lubricants that perform on par with or better than petroleum-derived relatives⁷.

In 2006, an estimated 220,000 tons of glycerin were used in the United States⁷. Small home-based soap companies use glycerin in their products. The glycerin market in the United States is currently for more “boutique” products, but glycerin is also used as a humectant, a food additive that keeps foodstuff moist in packaging.

SUMMARY AND CONCLUSIONS

Today’s bio-based products include both commodity and specialty chemicals. Some of these products result from the direct physical or chemical processing of biomass—cellulose, starch, oils, protein, lignin, and

terpenes. Others are indirectly processed from carbohydrates by biotechnologies such as microbial and enzymatic processing. The gross annual sales are in the billions of dollars and continue to grow each year².

For more information, please refer to the Encyclopedia of Southern Bioenergy at <http://www.forestencyclopedia.com/Encyclopedia/bioenergy>.

ENDNOTES

- 1 Diebold, J.P. 2000. A review of the chemical and physical mechanisms of the storage stability of fast pyrolysis bio-oils. National Renewable Energy Laboratory Subcontract Report. January 2000. NREL/SR-570-27613.
- 2 Datta, R. 1994. Potential and Implications of Biotechnology for the Food and Agriculture Industry. Michigan Biotechnology Institute, Michigan Department of Agriculture.
- 3 Ahmed, I. 1993. Industrial utilization of agricultural materials: Energy, economic, and environmental benefits of bioprocessing. 14th Capital Metals and Materials Forum, Agricultural Commodities: Competing with Traditional Metals and Materials. Washington DC: US Bureau of Mines and the US Department of Treasury.
- 4 Zyosec, R. 2003. 3-hydroxypropionic Acid-A new intermediate platform. Wayzata, MN: Cargill, Inc.
- 5 Brown, R. C. 2003. Biorenewable Resources Engineering New Products from Agriculture. Ames, IA: Iowa State Press.
- 6 Energetics Incorporated. 2003. Industrial bioproducts: Today and tomorrow. Washington DC: US Department of Energy, Office of Energy Efficiency and Renewable Energy, Office of Biomass Program.
- 7 DeGuzman, D. 2003. Global glycerin prices pressured on market fundamentals. Chemical Market Reporter, February 2003.

