Ek Laboratories Response to (RFI) DE-FOA-0001615: Cellulosic Sugar and Lignin Production Capabilities

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EK Laboratories (EK) is the Research and Development center supporting the scale-up and optimization of the patented Cellulose-to-Sugar (CTS) conversion process invented by Dr. Richard G. Blair. The 10,000 sq. ft. Longwood, FL facility has a team of scientists and engineers that have demonstrated the CTS process at laboratory, bench and pilot scale. The facility has demonstrated production of lignocellulose sugar and lignin from over 110 different feed stocks. The laboratory and office areas are outfitted with the latest technology for characterizing incoming feedstock, determining process metrics, and ensuring product quality. EK has also provided laboratory analysis on many feed stocks for many clients.

Category 2: Lignin

Question 1: To which types of research entities are you willing and able to sell or otherwise provide your lignin? (e.g., university researchers, national laboratories, industry/private sector)? Are there any types of research entities to whom you are not willing and able to sell your lignin?

We are willing to sell to any entity whether they are university researchers, national labs, or private industry.

Question 2: What are the maximum and minimum quantities of lignin that you are willing and able to sell (kg)?

We can supply quantities as small as a few milligrams to as large as 1 metric ton.

Question 3: In what units do you sell your lignin and is it packaged (e.g., super sacks), or sold in bulk?

Our lignin is supplied as a dry powder. Samples are packaged in plastic containers ranging from small jars to 55-gallon food-grade plastic drums. We can ship large quantities by freight.

Question 4: How do you ship lignin?

Small samples are shipped via FedEx and larger samples (>75kg) by freight.

Question 5: What is the lignin concentration in your product?

Our typical lignin product is 85% lignin 5% silicates and 10% cellulose/protein/oil. Purer samples can be produced on request.

Question 6: What type(s) of biomass do you use in your process?

We can utilize any type of biomass. We have recovered lignin from several feed stocks listed in Appendix A.

Question 7: What process do you use that produces lignin (dilute acid, ammonium fiber expansion (AFEX), hot water, organosolv, etc.)?

The lignin is a by-product of CTS milling process. It is separated from the product by taking advantage of its difference in polarity from the catalyst, and other biomass constituents. The lignin produced by this process (left) is chemically unmodified and is pale brown to gray in color.

Question 8: What details of the scale of your process are you willing to share (e.g. batch and/or continuous or volumetric productivity)?

We have run the CTS milling process in batch mode to gather data while running separation in batch mode to produce the highest quality lignin, and in continuous mode to capture metrics, including energy consumption and process parameters. Our separation method is scalable, uses mature technology, and can be run continuously.

Question 9: Do you measure the typical composition of your lignin? If so, what method do you use? How consistent is the composition of your lignin?

We measure lignin composition using basic wet lab techniques including material testing, ATR FTIR, TGA, and solid-state NMR. The material can be inconsistent from feedstock to feedstock. Even within a feedstock there can be inconsistencies due to variation in growing conditions. We can maintain consistency by holding a large inventory of feedstock.

Question 10: Do you routinely test your lignin for consistency within and between lots?

Yes, all analytics discussed in question 9 are performed on each lot.

Question 11: What impurities are present in your lignin and what testing do you perform to determine the presence of impurities?

Impurities are typically 5% silicates and 10% cellulose/protein/oil. We use standard wet lab techniques to test them including ash, Soxhlet extraction, biuret, total nitrogen, and mass spectrometry.

Question 12: Does your process include a purification or filtration step?

Yes, the lignin is extracted using its polarity, then centrifuged, and dried.

Question 13: What is the typical concentration in g/L you can provide?

Out lignin is supplied as a powder. Customers can request solutions and we will provide as needed.

Question 14: Have you examined the impacts of transport and storage on lignin? If so, can you please provide any relevant (non-proprietary) details of these impacts?

We have lignin samples that have been stored dry, unrefrigerated in air for 6 months with no measureable change in the product.

Question 15: What additional information are you willing and able to provide to the research community about the lignin? Please provide any non-proprietary cost information you are willing to share.

Our product is the least chemically modified lignin available.

Question 16: Into what markets do you typically sell your lignin? What is a typical application for your lignin?

Customers are interested in the lignin as a feedstock for chemicals, polymer additive, and polymer replacement.

Appendix A

Feedstocks utilized and the quantities of lignin and lignocellulosic sugars recovered as a percentage of initial mass. Hydrolyzed percentage is representative of holocellulose conversion efficiency in a single pass and increases with recycle streams.

Feedstock	Lignin	Hydrolyzed
Algae *Nannochloropsis*	6%	69.20%
Bamboo *Bambusa multiplex*	28%	75.10%
Coastal hay *Cynodon dactylon*	8%	78.40%
Cobs Flint *Zea mays indurata*	18%	81.50%
Spent Coffee Grounds *Coffea arabica*,	27%	45.20%
Big Bluestem Grass, *Andropogon gerardi*	7%	50.10%
Elephant Grass, *Miscanthus giganteus*	26%	64.70%
Switch Grass *Panicum virgatum*	17%	57.90%
Little Bluestem Grass *Schizachyrium scoparium*	8%	48.90%
Bahia Grass *Paspalum notatum*	6%	92.50%
Oat Kernel *Avena sativa*	2%	90.30%
Flint Corn Kernel *Zea mays indurata*	1%	93.40%
Banana Leaf *Musa acuminate*	30%	52.00%
Vidalia Onion *Allium cepa*	22%	87.50%
Paper, newsprint	0%	54.70%

Feedstock	Lignin	Hydrolyzed
Sweet Cherry *Prunus avium*	50%	95.70%
Stover Flint, *Zea mays indurata*	18%	52.10%
Nictotine-free Tobacco	16%	88.20%
Maple Wood *Acer saccharum*,	24%	72.00%
Red Cedar Wood, *Juniperus virginiana*	31%	74.00%
Tulip Poplar Wood, *Liriodendron tulipifera*	23%	66.90%
Douglas Fir Wood, *Pseudotsuga menziesii*	29%	71.10%
Water Oak Wood *Quercus nigra*	26%	68.50%
Yellow Pine Wood *Pinus taeda*	27%	65.30%
Apricot Shell *Prunus armeniaca*	49%	56.83%
Almond Fruit Husk, *Prunus dulcis*	13%	92.37%
Almond Wood, *Prunus dulcis*	5%	84.34%
Dry distiller grain (DDG)	3%	78.24%
Sugarcane Bagasse *Saccharum officinarum*	5%	51.28%