BETO Workshop
September, 2019

Perspectives on Corn Kernel Fiber Commercialization

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Perspectives on Corn Kernel Fiber Commercialization

- ✓ Commercially available **conversion technologies**
  - Both in situ and secondary
- ✓ Commercially available **cellulase enzymes**
- ✓ Commercially available **analytical methodologies**
  - That have been proven to meet the EPA's new definition of "reasonably accurate" using commercially available **representative reference materials** that were specifically formulated to address the EPA's concerns related to resistant starch embedded in cellulose

Perspectives on Corn Kernel Fiber Commercialization

✓ ASTM Standards

- *E1757 Standard Practice for Preparation of Biomass for Compositional Analysis* – published
  - Includes requirements for sample drying to prevent retrograded starch
- *WK63392 Standard Practice for Determination of the Converted Fraction of Starch and Cellulosic Content from a Fuel Ethanol Production Facility* - pending approval and publication
  - Outlines in great detail the criteria for the sampling, testing and calculation methodologies used for the quantification of the converted fraction of starch and cellulosic content used to determine qualification for a D3 RIN under the Renewable Fuel Standard (RFS)
  - Outlines the use of DMSO or KOH to ensure complete access of all starch, including resistant starch
  - Defines “starch” to include soluble C6 glucan mono- and oligosaccharides
  - Codifies EPA’s newest definition of “Reasonably Accurate” (*EPA-420-B-19-022)*

Perspectives on Corn Kernel Fiber Commercialization

- ✓ CARB has over 20 approved kernel fiber pathways
- ✓ Over 30 expected by the end of 2019

  → Approximately 15% of the industry will have commercialized some form of kernel fiber conversion technology by the end of this year

- ✓ CARB vetting process is very technically robust, yet reasonable
  - Requires that any analytical method used be able to ensure that no C5 sugars such as xylose and arabinose and/or C6 sugars such mannose and galactose that are not fermented could be counted as fiber conversion

    → hydrolysis ≠ conversion

- ✓ A growing number of States (CA, OR, and MN) have now disconnected their cellulosic program approval process from the EPA process

EPA's Evolving Definition of "Reasonably Accurate"

- CFR Definition:

Data used to calculate CF must be:

a) **Representative**; and

b) Obtained using an analytical method certified by a VCSB *OR* using a **non-VCSB method that "would produce reasonably accurate results as demonstrated through peer reviewed references provided to the third party engineer performing the engineering review at registration."**

40 CFR 1450(b)(1)(xiii)(B)(3).

day 1

EPA's Evolving Definition of "Reasonably Accurate"

- Rev 2 → Variation Criteria (CV):
  - CV of the certification run (i.e. three Cert sample sets) must be <20%
  - If the CV is >20%, the 95% confidence interval would be reported instead of the mean
  - ✓ Codified in *ASTM WK63392*

EPA's Evolving Definition of "Reasonably Accurate"

- Rev 3 → Starch Reference Material Required:
  - Desire for a reference material for starch analysis articulated
  - Want to ensure retrograded starch is not being measured as fiber (on the BC samples)
  - ✓ NIST and private companies begin work on reference materials
  - ✓ Commercially available representative reference materials that have a documented True Value for cellulosic content and starch

EPA's Evolving Definition of "Reasonably Accurate"

- Rev 4 → Retrograded Starch Concern:
  - Concerns about sample preparation/drying at high temperatures could result in retrograded starch measuring as fiber in the BC samples
  - ✓ Updates made to *ASTM E1757*
    - Ensures sample drying is always below gelatinization temperature of starch
    - Provides an option for freeze drying

EPA's Evolving Definition of "Reasonably Accurate"

- Rev 5 → Resistant Starch and Concern:
  - Concerns about starch embedded in cellulose (i.e. physically resistant starch articulated)
  - ✓ Updates made to *ASTM E1757 and ASTM WK63392*
    - Outlines the use of DMSO or KOH to access all starch present, including resistant starch
    - Outlines a fine grind on samples → 500 µm

day 450

EPA's Evolving Definition of "Reasonably Accurate"

- Rev 6 → May 7, 2019 (*EPA-420-B-19-022*):
  - Reference material pivots to focus on Cellulosic Content instead of starch
  - EPA disregards its regulation stating that reasonable accuracy is to be demonstrated through peer review
  - "Reasonably Accurate" now defined as:

"as a general matter **we currently would consider results within 20 percent of the known value for the cellulosic component of the representative reference material to be reasonably accurate.**"

"Based on our work with NIST, on feedback received from labs such as NREL, the National Corn to Ethanol Research Center, and other technical experts in the ethanol industry, and on EPA's own modeling, **we believe that reasonable accuracy should be demonstrated by validating that the results of a non-VCSB analytical method for calculating the cellulosic converted fraction are within 20 percent of the reported cellulosic value of a representative reference material."**

"Therefore, given our current understanding **we believe that reasonable accuracy is generally achieved for the purposes of 40 CFR 80.1450(b)(1)(xiii)(B)(3) when values are within 20 percent of the reported cellulosic component of representative reference material."**

EPA's Evolving Definition of "Reasonably Accurate"

- Additional Asks → ASTM Standard Needed:
  - ✓ ASTM Task Group formed in August of 2017
  - ✓ Over a two year process to-date; over 40 Task Group meetings
  - ✓ ASTM standard that is pending approval and publication, *WK63392 Standard Practice for Determination of the Converted Fraction of Starch and Cellulosic Content from a Fuel Ethanol Production Facility*
  - ✓ Contains EPA's newest definition of "reasonably accurate" = within 20% of the cellulosic content of a reference material
  - ○ EPA still voting negative on the ballots – the only remaining negative voter

POET In Situ Kernel Fiber Pathway Approval Timeline

EPA Process

- April 19, 2017: Pathway Submitted to EPA
  - 891 (2.4 years) days since original Pathway application…

CARB Process

- March 23, 2018: Pathway Submitted to CARB
- September 28, 2018: CARB Approval Granted
  - 158 days from Pathway application to approval
- Included a very thorough technical vetting process and a scientifically relevant discussion on C5 and C6 sugars

POET also has approval of cellulosic ethanol from Kernel Fiber in OR and MN

Corn Kernel Fiber Commercialization Summary

- ✓ Commercially Available Conversion Technologies
- ✓ Commercially Available Cellulase Enzymes
- ✓ Commercially Available Validated "Reasonable Accurate" Analytics
  - ✓ That have been proven to meet the EPA's new definition of "reasonably accurate" using commercially available representative reference materials that were specifically formulated to address the EPA's concerns related to resistant starch embedded in cellulose
- ✓ Commercially Available Representative Reference Materials
  - ✓ Contains resistant starch and cellulose AND has been proven to highlight the exact issue the EPA is concerned about → resistant starch measuring as fiber
- ✓ ASTM Standard for Sample Prep that Ensures no Retrograded Starch
- ✓ ASTM Standard for Establishing the Converted Fraction*
- ✓ Numerous CARB Approvals (plus OR and MN approvals)
- ○ EPA Approvals…
- ➢ Bottom Line: The EPA just needs to <u>follow the standards set forth in its regulations</u> and stop changing the rules. The only thing that stands between the industry and full commercialization of kernel fiber is the EPA pathway approval process.