Biobased and Biogenic Carbon Testing Laboratory

ISO/IEC 17025:2005 Accredited

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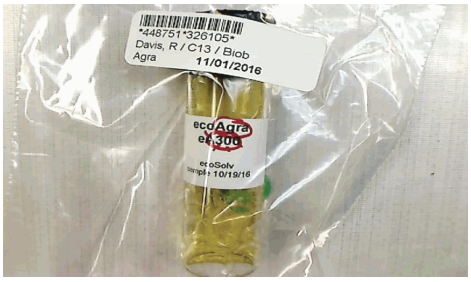
Summary of Results - % Biobased Carbon Content: ASTM D6866-16 Method B (AMS)

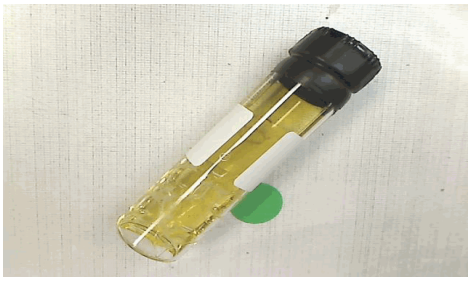
Submitter	Mr. John B. Mchugh
Company	Elemental C, LLC
Date Received	October 27, 2016
Date Reported	November 01, 2016
Submitter Label	**Liquid Carbon Plant Surfactant (USDA Application #1709a3)**

Percent Biobased Carbon 84 %

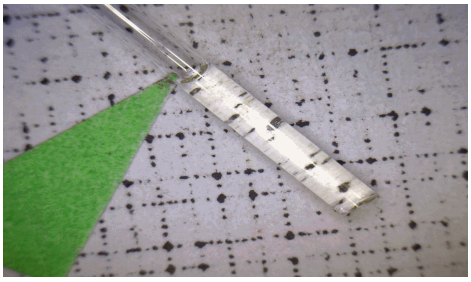
Laboratory Number	Beta-448751
Test Method	D6866-16 Method B(AMS)
Percent modern carbon (pMC)	84.8 +/- 0.3 pMC
Atmospheric adjustment factor (REF)	101.5; =pMC/1.015



Package received - labeling COC



View of content (1mm x 1mm scale)



Representative sample analyzed (1mm x 1mm scale)

Required Disclosures: All work was done at Beta Analytic in its own chemistry lab and AMS. No subcontractors were used. Beta's chemistry laboratory and AMS do not react or measure artificial C14 used in biomedical and environmental AMS studies. Beta is a C14 tracer-free facility. Validating quality assurance is verified with a Quality Assurance report posted separately to the web library containing the PDF downloadable copy of this report.

* ASTM D6866-16 quotes precision on Percent Biobased Carbon as +/- 3% (absolute). The cited precision on the analytical measure (pMC) is 1 sigma (1 relative standard deviation). The reported result only applies to the analyzed material. The accuracy of the % biobased carbon result relies on the carbon present in the analyzed material having been in recent equilibrium with CO2 in the air and/or fossil carbon (from living systems more than 40,000 years old). "Percent biobased carbon" specifically relates % renewable (i.e. non-fossil) organic carbon to total organic carbon, not to total mass. Percent biobased carbon is calculated by dividing pMC by the applicable REF adjustment factor specified in ASTM D 6866-16. % biobased carbon = ([pMC / REF] +/- 3 % absolute).

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Analytical Measure - % Biobased Carbon Content: ASTM D6866-16 Method B (AMS)

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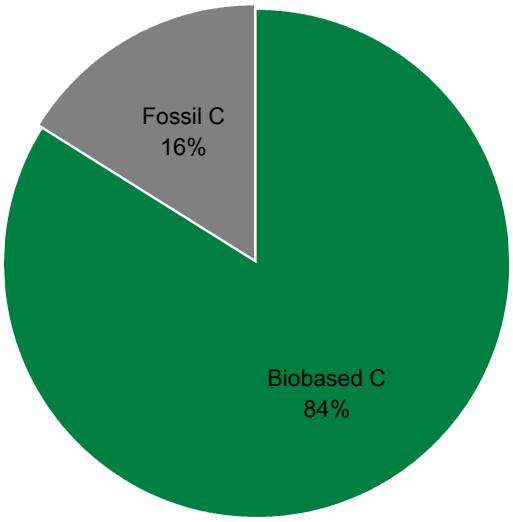
Percent Biobased Carbon 84 % *

Proportions Biobased Carbon vs. Fossil-Based Carbon indicated by 14C content



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% Biobased Carbon Analysis: ASTM D6866-16 Method B (AMS)

Explanation of Results

ASTM D6866-16 cites the definition of biobased as containing organic carbon of renewable origin like agricultural, plant, animal, fungi, microorganisms, marine, or forestry materials living in a natural environment in equilibrium with the atmosphere. "Renewable" is defined as being readily replaced and of non-fossil origin, specifically not of petroleum origin. Therefore, % biobased carbon in manufactured products most commonly indicates the amount of non-petroleum derived carbon present. It is calculated and reported as the percentage renewable organic carbon to total organic carbon (TOC) present.

Two methods of analysis are described in ASTM D6866-16 - Method B (AMS) and Method C (Liquid Scintillation Counting (LSC). Method B is the most accurate and precise and was used to produce this result. The methods determine % biobased carbon content using radiocarbon (aka C14, carbon-14, 14C). The C14 signature is obtained relative to modern references. If the signature is the same as CO2 in the air today, the material is 100 % biobased carbon, indicating all the carbon is from renewable sources and no petrochemical or other fossil carbon is present. If the signature is zero, the product is 0 % biobased carbon and contains only petrochemical or other fossil carbon. Values between 0% and 100% indicate a mixture of renewable and fossil carbon.

The analytical term for the C14 signature is percent modern carbon (pMC) and will typically have a cited error of 0.1 – 0.4 pMC (1 RSD) using Method B. Percent modern carbon is the direct measure of the product's C14 signature to the C14 signature of modern references. The modern reference used was NIST-4990C with a C14 signature approximating CO2 in the air in AD 1950. AD 1950 is chosen due to the "BOMB CARBON EFFECT". This effect is a consequence of atmospheric thermonuclear weapons testing between 1952 and 1963. During this period, the 14CO2 content in the air increased by 90%. This means that a plant living in 1963 would measure about 190 pMC. Since the signing of a test ban treaty in 1963, this signature declined to about 140 pMC by 1975, 120 pMC by 1985, and 102 pMC by 2015. For example, to obtain the % biobased carbon content of a product relative to living biomass in 2015, the pMC value needs to be divided by 1.02. ASTM D6866-16 cites a constant decline in this value of 0.5 pMC per year and provides requisite values to be used according to the year of measurement. The adjustment factor is termed "REF".

The consequence of bomb carbon is that the accuracy of the % biobased carbon content will depend on how well REF relates to when the biobased material in the product was last part of a respiring or metabolizing system. The most accurate results will be derived using biobased material from short-lived material of very recent death such as corn stover, switch grass, sugar cane bagasse, coconut husks, flowers, bushes, branches, leaves, etc. Accuracy is reduced in materials made from wood contained within tree rings. The rings within trees each represent the previous growth season with the previous year's 14CO2 signature. The center most ring of a tree living today but planted in 1963 would be about 190 pMC whereas the outermost ring/bark would be the present day air pMC (e.g. 102 in 2015). If this tree is harvested and used in manufacturing a biobased product, the % biobased carbon of the product will depend on where the carbon came from within the tree. ASTM D6866-16 cites to use average values of past carbon pMC for REF when values greater than 100 pMC are measured. For more details the Standard can be purchased from the ASTM International website (www.astm.org).

ASTM D6866-16 also cites requirements for materials of known aquatic origin and options for analyzing materials for which a single C14 measurement cannot produce a % biobased carbon content value (complex products). Also, reporting requirements are cited.

The result provided in this report is unique to the analyzed material and is reported using the labeling provided with the sample. Although analytical precision is typically 0.1 to 0.4 pMC, ASTM D6866 cites an uncertainty of +/- 3 % (absolute) on each % biobased carbon result. The reported % biobased carbon only relates to carbon source, not mass source.