Biobased Product Testing

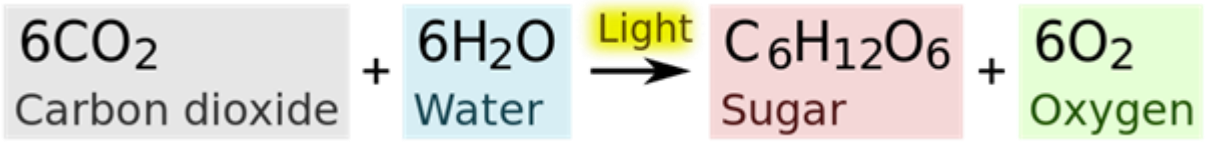
Analytical Background:

The Carbon Cycle

The carbon cycle is a biogeochemical system or cycle through which carbon is exchanged among the biosphere, pedosphere, geosphere, hydrosphere and atmosphere of the Earth. Put more simply, the carbon cycle describes the movement of carbon as it is recycled and reused throughout the biosphere.

Carbon cycling one of the critical biogeochemical systems responsible for sustaining life on Earth and carbon based molecules are the main component of biological compounds and living things. Carbon is also a component of many rock forming minerals and can be found in the atmosphere as carbon dioxide (CO_2).

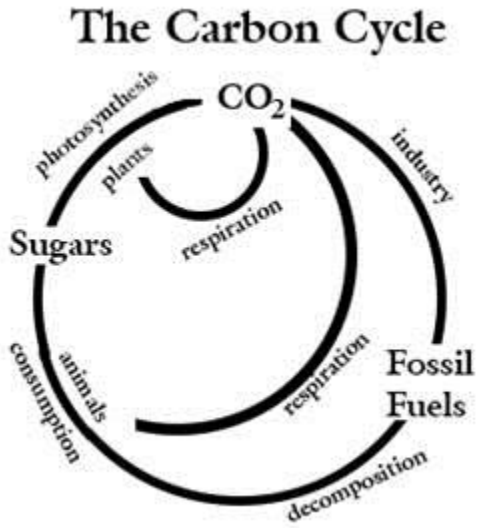
Carbon can enter the cycle through several major processes. Plants convert atmospheric CO_2 and water into sugars using the energy in sunlight (radiant energy). These sugars are, in effect, chemical energy which can be stored and used as needed, commonly referred to as **biomass**. Biomass can be stored in the roots of trees and plants for decades if it is not required by the plant for normal growth and function. A byproduct of photosynthesis is oxygen gas, which is released back into the atmosphere.



A second entry point for carbon into the carbon cycle is the release of carbon through respiration of animals. When animal consume plants, the sugars or biomass is broken down during digestive processes, converting some of the molecular carbon back to CO_2, which is

released into the atmosphere as a gas. The rest of the biomass carbon is used by animals to regenerate their tissues and cells by forming new **biomolecules**, such as proteins, carbohydrates and lipids. Biomolecules make up all life on earth, whether plant or animal.

When living organisms die and decompose, carbon enters the carbon cycle through another pathway in the form of fossil fuels. During **anaerobic decomposition** of organic matter, such as algae, the carbon in the biomolecules is broken down and recombined into **hydrocarbons**. These hydrocarbons take millions of years to form naturally, and so are commonly referred to as fossil fuels.



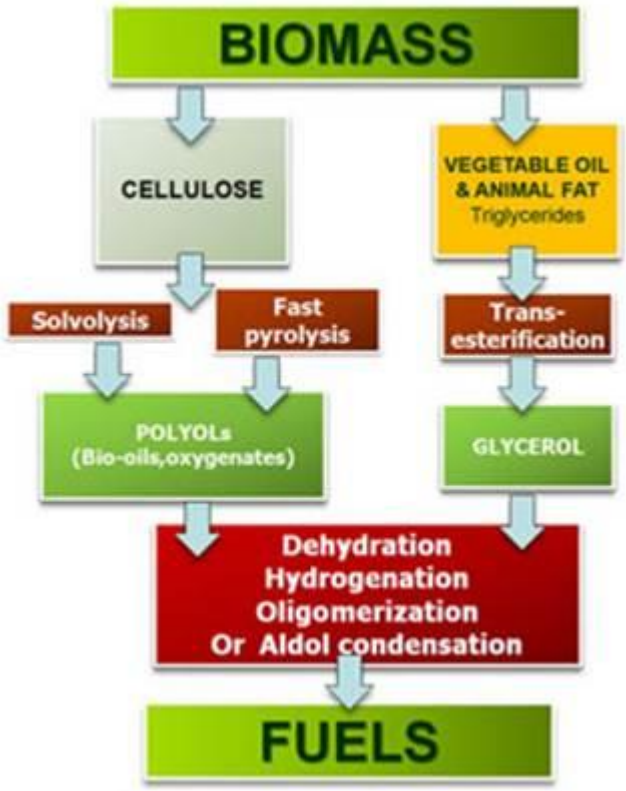
The type of fossil fuel formed is dependent upon the type of organic material present, the conditions in which this material decomposed (temperature and pressure), and the length of time the material was buried. Oil and natural gas, for example, are created from the decomposition of marine organisms buried under ocean and river sediments for hundreds of thousands of years. The heat and pressure created in these environments converts the carbon in the decomposing organisms first into a thick liquid hydrocarbon called oil. Organic decomposition that takes place deeper in the Earth's crust, and therefore at higher temperatures, can continue until the oil has become a natural hydrocarbon gas or natural gas. When these fossil fuels are combusted, they release carbon as CO_2 into the atmosphere.

Biofuel

A **biofuel** is a fuel source derived either directly from plants and agricultural waste or the conversion of biomass directly into energy. Biofuels, unlike fossil fuels, are renewable because the processes and raw materials involved in their manufacture do not require millions of years to form. In response to a US Department of Agriculture (USDA) initiative, fuel purchasers and industrial consumers are increasingly exploring and developing stainable and renewable energy sources and biofuel.

Two of the most common biofuels are **bioethanol** and **biodiesel**. Bioethanol is an alcohol resulting from the fermentation of the sugars in plants, such as corn or sugarcane, or from the cellulose in non-food sources, such as trees and grasses. Both types of bioethanol can be used directly as fuel for vehicles but they are typically mixed with gasoline, a fossil fuel, to increase the fuel's octane and improve vehicle emissions.

Biodiesel is produced from oils and fats rendered during **transesterification**, the process in which the organic R" group of an ester is exchanged for the R' group of an alcohol. Although biodiesel can be used as a fuel for vehicles in its pure form, it is most often used as an additive in fossil fuel based diesel gasolines to reduce the generation of carbon monoxide, hydrocarbons and particulates during combustion.



Radiocarbon

Radiocarbon is a naturally occurring **radioisotope** of carbon with a mass number of 14, commonly referred to as carbon 14 and correctly notated ^{14}C. Radioisotopes are unstable and spontaneously emit radiation (energy) in the form of beta particles in an effort to regain nuclear stability.

The rate at which a radioactive isotope decays is measured as **half-life**, or the time it takes for one half of the radioactive atoms to reach a stable state or isotope. Radiocarbon decays to form nitrogen 14 or ^{14}N with a half-life of approximately 5730 years.

Radiocarbon enters the carbon cycle during photosynthesis, when plants acquire CO_2 from the atmosphere where it gets incorporated into their cellular structure. When plants are consumed by animals, this radiocarbon becomes bioavailable and is incorporated into the living matter of the organism. Since radiocarbon is introduced into this cycle through active processes during an organisms lifetime,

when that organism dies no further radiocarbon is absorbed. (see **Radiocarbon Dating**).

Fossil fuels require millions of years to form; enough time for most if not all of its radiocarbon to decay. Biofuels, on the other hand, can be manufactured days, months or years after the death of the plants or agricultural waste is generated. These fuels, therefore, are radiocarbon active, while fossil fuels are radiocarbon dead. Measurement of the radiocarbon content of a biofuel can facilitate both its identification and authenticity as a biofuel and determine the percentage of bioethanol or biodiesel in a mixed fuel.

Biofuel Sustainability & Biobased Product Certification

While using and developing biofuels has clear environmental benefits, poorly developed or manufactured biofuels can seriously damage the environment because biofuel **feedstocks** are inextricably linked to land, water and wildlife. Many fuel purchasers do not have the resources or experience to analyze the sustainability of biofuels through each stage of the product's life cycle. Therefore, the USDA has called for the development of biofuel sustainability certification systems and a certified biobased product labeling system.

Biofuel sustainability certification systems measure and verify environmental performance of fuels throughout the major stages of the product's life cycle, including feedstock production, fuel production, and end use. Within each stage, the system evaluates criteria that influence environmental sustainability including impacts on water, soil, biodiversity, air, land use, and waste.

The USDA Certified Biobased Product label, displayed on a product certified by USDA, is designed to provide useful information to consumers about the biobased content of the product. This label assures a consumer that the product contains a verified amount of renewable biological carbon (referred to as biobased content). Consumers can trust the label to mean what it says because manufacturer's claims concerning the biobased content are third-party certified and strictly monitored by USDA.

CAIS is one of the few laboratories in the US qualified to determine the biobased content according to ASTM standard method D6866–12. Biobased content is expressed as a percentage of the product's new organic radiocarbon, derived from renewable agricultural resources, to the total organic carbon content, which includes both the new organic radiocarbon and the old organic radiocarbon derived from fossil fuels. The presence and amount of new organic carbon in the product is important for measuring its sustainability footprint.