AFYREN

GREEN CHEMISTRY

Industry is transitioning to cleaner, greener ways. More than half of companies (51%) say they are committed to sustainability[1] , yet it is clear that reconciling a lower environmental impact with economic success involves a lot of difficult choices — just 21% of companies have a clear roadmap for implementing their sustainability strategy.

A more sustainable enterprise is rooted in **several pillars**, including **responsible financing**, **procurement** and **marketing**. Buyers, marketers, and investors need the right information to navigate an ocean of potential projects, understand their benefits and constraints and stand by their consequences. As recently underlined by Mc Kinsey, "it is not easy buying green".

At AFYREN, we believe that **sharing knowledge** and **experience** can contribute to a more sustainable future. In our blog posts, we seek to share expertise we have developed on our own journey toward a **sustainable**, **circular business model**.

Green chemistry and biobased chemistry are not the same

The chemical industry is one of the **largest industrial consumers** of oil and gas, according to the IEA. For the last 30 years, researchers, big corporations and start-ups in the sector have worked to overcome this dependency on petroleum, reduce the use or generation of hazardous substances and create a cleaner or "greener» chemical industry.

But do you really know what you are buying into when you collaborate with a company that claims to do "green chemistry"? Understanding exactly what that term covers will help you ask the right questions to achieve your environmental objectives.

Green chemistry does not necessarily mean plant-based chemistry

One of the first mistakes is thinking that "green" automatically refers to "vegetal" or "plant". Green chemistry principles do indeed call for using **renewable resources** but there is much more to it than replacing feedstock.

Historically, green chemistry, also called **sustainable chemistry**, is based on 12 principles introduced in 1998 by Paul Anastas et John C. Warner, two scientists and entrepreneurs who are considered to be the fathers of this concept. The green chemistry approach was a "response to the Pollution Prevention Act, which declared that U.S. national policy should eliminate pollution by improved design (including cost-effective changes in products, processes, use of raw materials, and recycling) instead of treatment and disposal"[2].

Prevention and **eco-conception** are the foundation of green chemistry. It marked a real revolution in the chemical industry and a source of inspiration for other sectors. Instead of regulating an acceptable level of hazardous substances or managing them once they had been produced as residues, green chemistry aims to "reduce or eliminate their use or generation in the design, manufacture and application of chemical products."

[1] according to a survey by Sphera: https://sphera.com/sustainability/sustainability-survey-2021/

[2] https://greenchemistry.yale.edu/about/history-green-chemistry

Anastas and Warner believe that green chemistry should lead to many **positive externalities** in addition to minimizing environmental impact, including: increased worker safety, reduced costs for waste handling and disposal litigation, improved efficiency in the use of resources, and minimizing the release of "waste," or non-used molecules, into the environment.

The seventh principle of green chemistry calls for the use of renewable raw materials, including plants (biomass), to replace fossil resources in industrial activities like the manufacture of ingredients, products and materials.

On the other side, plant-based chemistry, a **key component of the bioeconomy**, refers to the production of biobased products. To be sure, plant-based chemistry is not automatically sustainable or "green," and, on the other hand, there are many petrochemical processes that adhere to green chemistry principles.

Still, industrial players in plant-based chemistry or the bioeconomy are, for the most part, practicing green chemistry. Most not only use **renewable feedstocks**, but also strive for waste prevention, energy efficiency, less hazardous chemical synthesis, etc.

Another important point to keep in mind is that using renewable raw materials often means using valuable natural resources that must be carefully managed. Suppliers must prove they have a sustainable sourcing plan to avoid, for example, deforestation or soil depletion.

If you really want to have a clear and rigorous approach, you should keep in mind that green chemistry principles are a great source of guidance, but they are a general code of conduct and not a standardized terminology or a norm. Being a self-declared green chemistry player is not sufficient to guarantee the sustainability performance of a product or a company. On the product level, responsible marketing or procurement should be based on a precise environmental assessment (Life Cycle Analysis) and certified concepts or terminology.

The 12 Principles of Green Chemistry

A framework for designing or improving materials, products, processes and systems

All biobased products are not created equally

If your objective is to **replace fossil resources** in your supply chain and purchase **biobased raw materials** (transition in procurement), it is very important to know the composition of what you are buying. The concept of a biobased product relies on precise terminology, norms and chemical analysis

Only 20% of French consumers have heard about biobased products, and 80% of them would like more information on these products (2018 survey IFOP/ ACDV)**, so a few important distinctions can help companies navigate in this market and inform their consumers.**

A biobased product is a product — material, intermediate, semi-finished or finished product — that is entirely or partially derived from biomass such as that produced from plants, trees or animals. As biomass can have undergone physical, chemical or biological treatment, and that the term «bio-based product» refers to products wholly or partly derived from biomass, it is important to use analysis techniques to determine the amount of biobased components in a given product.

Several methods have been developed to measure the biobased content of a product, and it is crucial that third parties and industrials use the same ones in order to avoid controversy.

There are two that you should know about:

• **Bio-based content**: this is a measure of the amount of biomass in a product. It takes into account four key components: carbon, hydrogen, oxygen and nitrogen. The bio-based content is expressed as a percentage of the overall weight of the product in question.

• **Bio-based carbon content**: this measure focuses on carbon and is generally expressed as a percentage of the biogenic carbon the product contains (organic carbon or total carbon).

Both approaches are based on European or international standards, and each has its advantages and drawbacks. To be clear with suppliers, producers or buyers, you can refer to the norm **EN 16785** (expressed in dry matter by the ratio biobased fraction (C, H, O and N) / total mass of the product) for biobased content, or the norm **EN 16640** (expressed by the ratio biogenic carbon / total carbon) for biobased carbon content.

At AFYREN, we make biobased products AND follow the 12 green chemistry principles.

We are committed to producing 100% biobased products from renewable raw materials through a fully dedicated process that follows the segregated biobased chemistry approach. The biobased content of our products has been verified via the method **ASTM6866**.

Our zero industrial waste process **uses renewable feedstock** (biomass co-products). We adhere to the **waste prevention** and **atom economy** principles, as all products at the end of the fermentation process are valorized; the sole residue is sold as fertilizer and there are **no other derivatives**. The process uses **enzymatic catalysis** from natural micro-organisms. **It is less hazardous** than the existing processes used to make the equivalent petro-based products (usually made from oxo synthesis). The process uses **benign solvent** (aqueous phase) and produces **benign chemicals**. The production process involves inherently benign chemistry and uses modern **accident prevention methods**. It also designed for **energy efficiency** (with a heat recovery system). Our final products have an **equivalent end of life** to similar on the market and are naturally biodegraded in most applications (food/feed/perfumes and fragrances). **Pollution prevention** on the site is ensured via real-time analysis.

In addition, the environmental impact of our products has been evaluated via LCA analysis.

If you know biogenic carbon, you know your biobased products

Now you have the essentials you need to discuss green chemistry, as well as the tools to better select biobased products. Perhaps it is time to deepen your scientific knowledge by learning more about what biogenic carbon is, and why it is important.

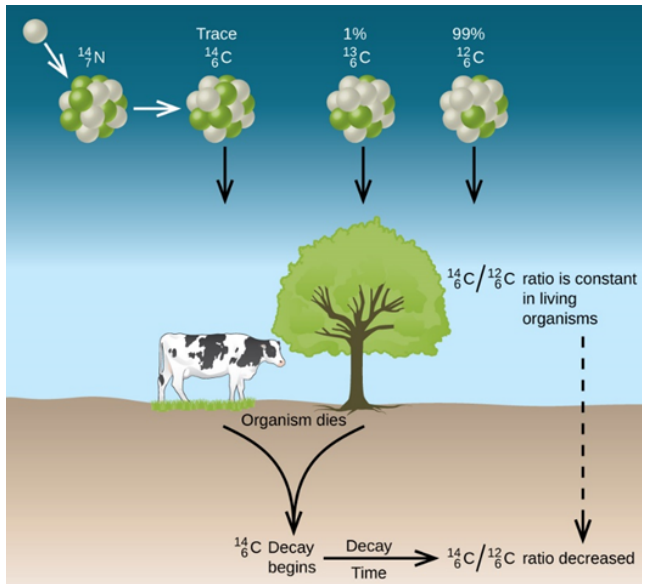
Biogenic carbon refers to **all the carbon that is stored in, sequestered by and emitted through organic matter**. The most common biogenic feedstocks include trees, plants and soil, which absorb carbon as a natural part of their life cycles, during photosynthesis.

Biogenic carbons are derived from the atmosphere and arrive via a short cycle in the finished product. However, radiation from the atmosphere causes the appearance of a small but perfectly known and measurable percentage of the radioactive isotope Carbon-14.

Radiocarbon (carbon 14) is an isotope of the element carbon that is unstable and weakly radioactive. The stable isotopes are carbon 12 and carbon 13. It is rapidly oxidized in air to form carbon dioxide and enters the global carbon cycle.

By contrast, non-biogenic carbons refer to the carbon stored in fossil fuels, such as oil, coal and gas. Fossil carbons had this Carbon-14 at the beginning of their fossilization, but have totally lost it through radiation over millions of years of fossilization.

Measuring the percentage of C-14 in products (called the radiocarbon method) evaluates the share of fossil-based carbon versus biogenic carbon in the product. You probably have heard of this method in another context — it's a great way to determine the age of bones, mummies and other ancient artifacts. Indeed, the biogenic carbon in plants, trees and other vegetation has a cycle of up to 100 years, while that stored in soil can last as long as 500 years.



Along with stable carbon-12, radioactive carbon-14 is taken in by plants and animals, and remains at a constant level within them while they are alive. After death, the C-14 decays and the C-14:C-12 ratio in the remains decreases. Comparing this ratio to the C-14:C-12 ratio in living organisms allows us to determine how long ago the organism lived (and died).

Source: https://opentextbc.ca/chemistry/chapter/21-3-radioactive-decay/