



Termokomfort Europe BV
Frank Koster
Neonweg 151
1362 AG Almere
Netherlands

+31 (0)50 363 47 60
cio@rug.nl

Nijenborgh 6
9747 AG Groningen
The Netherlands

www.rug.nl/cio

Date:
23-9-2026

Our Reference:
5256

Your Reference:
BioXbeads®

Dear Frank Koster,

Please find below the results of the biogenic carbon fraction measurement of your samples, based on ^{14}C analysis. We have measured, calculated, and reported the results following the international standard ASTM D6866-21 'Standard Test Methods for Determining the Biobased Content of Solid, Liquid, and Gaseous Samples Using Radiocarbon Analysis'.

Table 1. % Biogenic Carbon content (BioC)

Sample Name	Material	BioC (pMC) $\pm$ total uncertainty
BioXbeads grijs	BioXbeads®	93 $\pm$ 3
BioXbeads wit	BioXbeads®	100 $\pm$ 3

The biogenic carbon content indicates the percentage of biogenic carbon relative to the total carbon fraction that was obtained after combusting a subsample of the material/product to CO_2 at 900°C with an Elemental Analyser. In the appendix, we give additional information about the applied method and the ^{14}C measurement results.

If you have any questions about the results, or would like to receive more information on the methods employed, please let us know.

Best regards,

prof. dr. Michael W. Dee
Associate Professor of isotope Chronology &
Head of Radiocarbon Dating
Centre for Isotope Research (CIO)
University of Groningen

Appendix

Analyses performed

The Centre for Isotope Research (CIO) of the University of Groningen performed the ^{14}C analysis. In this laboratory, no ^{14}C -enriched samples are processed. A subsample of 5-10 mg was weighed in a small tin capsule and combusted at 900°C to pure CO_2 in an Elemental Analyser (Elementar Vario Isotope Cube™). Approximately 4 ml of obtained CO_2 was graphitised, giving approximately 2 mg carbon. This graphite was pressed in a target. The graphite in the target was then measured for relative abundances of ^{12}C , ^{13}C and ^{14}C using a ^{14}C -dedicated Accelerator Mass Spectrometer (AMS; MICADAS, Ionplus AG). The measured abundance of ^{14}C in the sample is calculated relative to the abundance of the ^{12}C isotope and also relative to the measured $^{14}\text{C}/^{12}\text{C}$ isotope ratio in a reference material with standardised ^{14}C amount (Oxalic Acid II; NIST standard SRM 4990C). The measured relative ^{14}C amount is, by standardised international procedure, also corrected for background signal and is corrected and normalised for isotope fractionation using the AMS-measured $^{13}\text{C}/^{12}\text{C}$ ratio. The calculated amount of ^{14}C in a sample is for the bio-based application calculated in the unit 'pMC' (percentage modern carbon).

Validity of the results obtained

Every measurement batch of unknown samples contains a set of calibration standards, background samples and reference materials to verify the accuracy of the calibration. The background samples combusted and measured in the same batch as your samples, were similar to our long-term background values (which are representative for samples without ^{14}C). The spread of the individual ^{14}C measurements on the reference standard in the same combustion and measurement batch as your samples were also within expectation for this material. Both background and reference materials showed that no significant (and/or systematic) carbon contamination was added during the process from combustion to AMS measurement and that the results were calibrated well.

Calculation of the ^{14}C -based biogenic carbon fraction

To calculate the biogenic carbon fraction in a material based on ^{14}C analysis, the measured amount of ^{14}C in a sample material is compared to a reference ^{14}C value (REF) representing 100% biogenic carbon originating from a carbon source that was directly in equilibrium with CO_2 in the atmosphere at the time of carbon uptake.

Fraction of biogenic carbon (in %)

$$= \frac{{}^{14}\text{C value measured in sample material (in pMC)}}{\text{REF } {}^{14}\text{C value}} \times 100 \%$$

Reference ^{14}C value 100% biogenic carbon (REF ^{14}C value)

The ^{14}C reference value for 100% biogenic carbon is not a constant value and varies between different bio-based materials. This is related to annual variability and to what is called 'the Bomb Peak': a large increase of atmospheric $^{14}\text{CO}_2$ values in the time period 1955-1963 caused by above ground nuclear bomb tests and an annual decrease since 1963 after the ban of these tests. Which reference value should be used to verify the amount of bio-based

carbon in a sample material based on ^{14}C value, depends on the bio-based material used and the time period it originates from. Bio-based materials from annual plants will have ^{14}C values comparable with atmospheric $^{14}\text{CO}_2$ values from the time period back to 5 years. Animal-based materials may have values that can go back to 10 years ago and wood-based materials even a longer (average) time-period. If mixtures of plant, wood and/or animal-based materials are used, the ^{14}C value will be a (proportional) mixture.

Because the origin (type and age of plants and/or animal tissue) of the biogenic material that was used in the investigated products is not known, we have taken the REF ^{14}C value for 2020 as mentioned in ASTM 6866-21 (Table 2 of this ASTM standard) as reference ^{14}C value for 100% biogenic carbon. REF (2020) = 100 pMC.

Reference value for 100% fossil carbon

If a material consists of 100% fossil carbon, the amount of measured ^{14}C will be comparable with the amount as measured in ^{14}C -free background samples (^{14}C is 0 pMC). We consider samples with AMS-measured ^{14}C values < 0.30 pMC to be 100% fossil carbon.

^{14}C measurement results

The subsample was weighed and combusted to CO_2 on (09.09.2026). The CO_2 obtained was reduced to graphite on (10.09.2026). The graphite samples were pressed into targets and measured with AMS on (11.09.2026).

Table A.1. ^{14}C Measurement results

Sample Name	Lab Ref.	^{14}C (pMC)	$\pm 1\sigma$ (pMC)
BioXbeads grijs	GrM-43207	92.59	0.26
BioXbeads wit	GrM-43208	99.60	0.28

Table A.2. Additional Measurement Results

Sample Name	%C (Comb.)	$\delta^{13}\text{C}$ (‰, VPDB)	$\pm 1\sigma$
BioXbeads grijs	53.1	-12.16	0.15
BioXbeads wit	49.4	-11.34	0.15

N/B: The Lab Ref. (GrM-No.) is the identification number of the specific ^{14}C AMS measurement performed at the ^{14}C laboratory in Groningen. ' ^{14}C (pMC)' is the ^{14}C value measured in the selected subsample (in pMC). ' $\pm$ ' is the 1σ ^{14}C measurement uncertainty. This measurement uncertainty includes an error correction factor of 1.5x, to account for variation in the results of multiple sample measurements under different conditions (different combustion and measurement batches)