



**Multi-level Circular
Process Chain for Carbon
and Glass Fibre Composites**

MC4 101057394

Multi-level Circular
Process Chain for Carbon
and Glass Fibre Composites

Deliverable D1.2: Dataset in Repository

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1. OBJECTIVE

The objective of this deliverable is to describe the collection and use of data in the MC4 project and in particular how and which data will be made publicly available to other researchers after the end of the project. According to the “Horizon Europe Programme Guide”¹, we distinguish between two types of open access:

- Open access to peer-reviewed scientific publications: Open access is an obligation for scientific publications in Horizon Europe.
- Open access to research data: If data is needed to validate the results presented in a scientific publication, the publication of this data is obligatory. Additional research data may be published on a voluntary basis.

Open access to scientific publications and research data is regulated in article 17 in the Grant Agreement of the MC4 project.

During the project, data sets mainly became available in the form of process parameters, material specifications, characterizations of materials and products made from recycled carbon and glass fibres. Apart from that personal data like contact information has been acquired at conferences and fairs. All these data will be collected on Profactor’s file server to make them available for all partners during the project. Special care has been taken in case of personal data, that need to be managed in compliance with the general data protection regulation. Data that are very interesting for other researchers are the properties such as tensile strength, bending strength or fracture behaviour of the materials made from recycled carbon and glass fibres. To enable further research in this field we follow the FAIR principles² (FAIR stands for findable, accessible, interoperable, and reusable). Hence, data, including the necessary meta-data, has been made available in the “Zenodo research data repository” (link in chapter 6).

Published data is available in aggregated form to avoid reverse engineering of information about production processes. For other data, especially CAD data of the parts that were produced from the recycled materials, the commercial interests of the industrial partners in the project require that these data do not become available in the public domain.

This document is a living document and has been updated over the course of the project. Whenever new types of data sets have been identified, these have been added to create an updated version of the document.

¹ https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/guidance/programme-guide_horizon_en.pdf (26.7.2022)

² Wilkinson, M., Dumontier, M. Aalbersberg, I. et al. The FAIR Guiding Principles for scientific data management and stewardship. Sci Data 3, 160018 (2016). <https://doi.org/10.1038/sdata.2016.18> (26.7.2022)

2. CHANNELS FOR OPEN ACCESS

Data channels for open access has been considered in two different approaches in the MC4 project. For publication of scientific papers, the focus has been put on conferences and journals that offer open access. For open access data it has to be kept in mind that large storage resources might be required in some cases. The MC4 project aims at taking advantage of the Zenodo research data repository³, a collaboration of the OpenAIREplus project for open access repositories, archives and journals and CERN. This data repository provides the possibility to upload research data and make them publicly accessible for download. It is used for open access in the MC4 project. The maximum size of a single data set for upload to Zenodo is 50GB, which is sufficient for the needs of the MC4 project. All uploads to Zenodo automatically receive a DOI (Digital Object Identifier). The ISO-standardized DOI system is administered by the International DOI Foundation⁴ and implements persistent identifiers for electronic documents. Therefore, it will be easy to reference and find data sets of the MC4 project.

The MC4 project website contains links to all MC4 data sets that are uploaded to Zenodo. This will help researchers from all over the world to get direct access to research data provided by the MC4 project. However, as maintenance of the project website after the end of the project is not guaranteed over a longer period of time, the website itself will not be the major medium to host open access research data. With an upload of data to the Zenodo portal, accessibility of MC4 data is well ensured – even long after the end of the MC4 project.

³ <http://www.zenodo.org> (26.7.2022)

⁴ <http://www.doi.org> (26.7.2022)

3. DATA FORMATS

Initially, data formats used for data representation within the MC4 project (or at individual project partners) may be proprietary and/or of complex structure. However, when preparing data for open access, the goal is to use standard data formats that are well known and easy to handle. Any data that is present in a highly proprietary complicated format must be converted to easily readable data formats before publication. For example, .png-, .pdf- and .xlsx- files are favoured over complex proprietary binary formats. Every data set that is published is accompanied by a simple text file (.txt or .word file format) that provides general information about the data as well as a detailed description of the data format.

4. SOFTWARE AND INTEROPERABILITY

In some cases, it makes sense to provide data with software that is able to load the data and/or process the data in order to make it easier to work with them. For each data set there is a decision if and how dedicated software can be provided together with the data set. Preferably, we promote Python as programming language to work with scientific open access data from the MC4 project. Since Python has become very popular as the language of choice in research due to its user-friendly syntax, it makes the programming and scripting efforts easy for a large number of researchers to get access to the data and use them.

5. LICENCES FOR DATA

For open access publication of pure data, the Creative Commons Attribution 4.0 International Public License (IPL)⁵ has been considered in the first place. This license essentially provides the right to freely copy and redistribute the material in any medium or format. Re-mixing, transforming, and building upon the material are explicitly permitted. This is granted for any purpose. The licensor cannot revoke these freedoms as long as the license terms are followed.

The use of the IPL is the preferred choice for data publication in the MC4 project. In specific cases a different license might be considered.

⁵ <https://creativecommons.org/licenses/by/4.0/legalcode> (26.7.2022)

6. MC4 DATA SETS

The following list includes the data sets that have been acquired and/or used in the MC4 project. Each data set is defined by:

- Code: a code consisting of “MC4-“ and a 4-letter code (e.g. “MC4-ABCD”).
- Data set full name: a full name for the data set.
- Responsible beneficiary: the main responsible project partner.
- Description: a general description of the data set.
- Data Format: the format of the data.
- Data set size: the size of a single data set instance.
- Data sharing: information about whether the data set is confidential (not published) or published under open access criteria.

Multiple instances of a single type of data set will be tagged with a running number. For example, data sets for code “MC4-ABCD-1”. Additionally, data sets that are uploaded to the Zenodo portal, will receive a unique DOI.

For the data sets listed below the entry, “Data sharing” describes whether data sharing is considered. “Publication” means that the plan is to publish the data set (or at least specific instances). “Confidential” means that the respective data set is not considered for publication. The data sets which are considered for publication can be found at the following link:

<https://zenodo.org/communities/mc4/records?q=&l=list&p=1&s=10&sort=newest>

Listed datasets:

Code	MC4-CIMG
Data set full name	Labelled FScan images
Responsible beneficiary	Profactor
Description	The data set contains the images of the FScan sensor (azimutal-, polar-, diffuse- and specular- image). An additional table contains a label for each image that describes the defect show in the image (none, fuzzball, ...)
Data format	Bitmap images and an .xlsx table for the labels
Data set size	> 1 GB
Data sharing	Publication

Code	MC4-CGRS
Data set full name	Labelled spectroscopy data
Responsible beneficiary	i-RED
Description	Spectroscopic data plus the labels (resin type, fiber composite material, etc.)
Data format	.xlsx and/or .csv files
Data set size	< 100 MB
Data sharing	Publication

Code	MC4-CGSD
Data set full name	Sample descriptions
Responsible beneficiary	i-RED
Description	Descriptions / data sheets of the fiber composite materials provided by project partners
Data format	.xlsx and .pdf files
Data set size	< 10 MB
Data sharing	Publication

Code	MC4-CSFT
Data set full name	Material parameters of semi-finished textiles (nonwovens, slivers, tapes)
Responsible beneficiary	STFI
Description	The data set contains testing results on tensile strength, air permeability, thickness, mass per unit area.
Data format	.xlsx or .pdf file, REM images
Data set size	> 1GB
Data sharing	Confidential

Code	MC4-CFTC
Data set full name	Material parameters of finished textiles (composites)
Responsible beneficiary	STFI
Description	The data set contains testing results on stiffness, tensile strength, bending strength, fracture behaviour, fibre-matrix-adhesion, shear strength, compression strength etc.
Data format	.xlsx or .pdf file, REM images
Data set size	> 1GB
Data sharing	Confidential

Code	MC4-GSFT
Data set full name	Material parameters of recycled fibres material
Responsible beneficiary	3B-Fibreglass
Description	Data sets of mechanical properties of composite made of 3R resins compared with standard reference resins.
Data format	.xlsx table with the data and statistical analysis report

Data set size	<1 GB
Data sharing	Publication

Code	MC4-CFMA
Data set full name	Material properties of finished materials: datasheet and product study comparison
Responsible beneficiary	Chomarat
Description	Product description of the composites reinforcement
Data format	.pdf
Data set size	<200MB
Data sharing	Publication

Code	MC4-CPPM
Data set full name	Manufacturing process parameters
Responsible beneficiary	FIDAMC
Description	Parameters of the manufacturing process of recycled carbon parts
Data format	PDF
Data set size	<4GB
Data sharing	Confidential

Code	MC4-CFMR
Data set full name	Waste carbon fibre composite requirements
Responsible beneficiary	GAIKER
Description	Waste carbon fibre composite requirements (e.g.: minimum and maximum sizes, thickness, geometry, resin and hardener types, etc.) for feeding the reaction system and separate recycled carbon fibres and liquids.
Data format	.xlsx spreadsheets, .docx documents, .pptx presentations, .pdf files + pictures .jpg / .png
Data set size	< 4 GB
Data sharing	Publication

Code	MC4-CFMS
Data set full name	Chemical recycling process – Solvolysis parameters

Responsible beneficiary	GAIKER
Description	Reactions parameters (e.g.: time, temperature, pressure, stirring, solvent, catalyst liquid to solid ratio, etc.) to perform waste carbon fibre composite solvolysis and separate carbon fibres and liquids
Data format	.xlsx spreadsheets, .docx documents, .pptx presentations, .pdf files + pictures .jpg / .png
Data set size	< 4 GB
Data sharing	Confidential

Code	MC4-CFMP
Data set full name	Properties of the recycled products
Responsible beneficiary	GAIKER
Description	Characterization of the main product recycled carbon fibres (e.g.: SEM, TGA, FTIR, mechanical properties, etc.) and the by-product liquids derived from resin (water content, pH, organics, etc.)
Data format	.xlsx spreadsheets, .docx documents, .pptx presentations, .pdf files + pictures .jpg / .png
Data set size	< 4 GB
Data sharing	Publication

Code	MC4-CCIU
Data set full name	Characterization of the uncured material
Responsible beneficiary	GAIKER
Description	Characterization of the uncured material (e.g.: size, thickness, resin type, etc.).
Data format	.xlsx tables and .pdf files (if possible, accompanied by pictures (.jpg / .png))
Data set size	< 4 GB
Data sharing	Publication

Code	MC4-CFPU
Data set full name	Recycling process parameters uncured carbon
Responsible beneficiary	GAIKER
Description	Parameters and conditions (e.g.: film removal, stoichiometry between the uncured material and the additional resin, etc.) of the recycling process of uncured material.

Data format	.xlsx tables and .pdf files
Data set size	< 4 GB
Data sharing	Confidential

Code	MC4-CCOU
Data set full name	Characterization of recycled materials from uncured materials
Responsible beneficiary	GAIKER
Description	Characterization and properties (e.g.: tensile and flexural strength, DSC and TGA, etc.) of the output material after recycling process of uncured material.
Data format	.xlsx tables and .pdf files (if possible, accompanied by pictures (*.jpg / *.png))
Data set size	< 4 GB
Data sharing	Publication

Code	MC4-GFMS
Data set full name	Chemical recycling process parameters for glass fibre/3R epoxy composites
Responsible beneficiary	CIDETEC
Description	Parameters of the fibre-matrix separation process of glass fibre/3R epoxy composite parts and characterization of recovered fibre (FESEM micrograph, residue quantification via thermogravimetric analysis) and matrix (glass transition temperature).
Data format	Pictures (.pdf), raw data tables (.xlsx)
Data set size	<100 Mb
Data sharing	Confidential

Code	MC4-GCER
Data set full name	Characterization of 3R epoxy resin.
Responsible beneficiary	CIDETEC
Description	Thermal properties (glass transition temperature, degradation temperature), temperature dependent stress relaxation and mechanical properties.
Data format	Pictures (.pdf), raw data tables (.xlsx)
Data set size	<100 Mb

Data sharing	Confidential (publication upon evaluation)
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Code	MC4-GCTL
Data set full name	Characterization and thermoforming of optimized glass fiber/3R epoxy laminates
Responsible beneficiary	CIDETEC
Description	Thermal properties (glass transition temperature), fibre volume content (FVC), mechanical data (tensile strength, compression, flexural, interlaminar shear strength).
Data format	Pictures (.pdf), raw data tables (.xlsx)
Data set size	<100 Mb
Data sharing	Confidential

Code	MC4-GVIT
Data set full name	Parameters of the vitrimer resin for shredded material valorisation
Responsible beneficiary	CEA
Description	Synthesis procedures, thermo-mechanical properties (Temperature sweep), mechanical properties (tensile properties) of vitrimer resins and composites.
Data format	Reports and procedures (.docx), pictures (.pdf), raw data tables (.xlsx)
Data set size	<100 MB
Data sharing	Confidential

Code	MC4-GVITC
Data set full name	Characterization of the fractions from chemical recycling
Responsible beneficiary	CEA
Description	Analyses reports and spectra (HPLC-MS, NMR, GC-MS) of recycled organic fractions from chemical recycling.
Data format	Reports and procedures (.docx), pictures (.pdf), raw data tables (.xlsx)
Data set size	<100 MB
Data sharing	Confidential

Code	MC4-CNWP
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Data set full name	Parameters of the nonwoven processes
Responsible beneficiary	STFI
Description	The data set contains parameters of the manufacturing of nonwoven materials (speed, material feeding, mass per unit area, stitching density, stitching depth, needle length, energy consumption data).
Data format	.xlsx or .pdf files
Data set size	> 1 GB
Data sharing	Confidential

Code	MC4-CCMP
Data set full name	Parameters of the composite manufacturing process.
Responsible beneficiary	STFI
Description	The data set contains parameters of the manufacturing of composites (temperature, pressure, heating and cooling rate, energy consumption).
Data format	.xlsx or .pdf files
Data set size	> 1 GB
Data sharing	Confidential

Code	MC4-CDPA
Data set full name	Part Designs
Responsible beneficiary	Amura
Description	The original CAD files were converted into PDF format, preserving all necessary views, layers, and 3D development required for production department interpretation. The PDF also includes descriptions of production methods, types of materials used, manufacturing procedures, technical specifications, detailed design information, and 2D drawings with dimensional plans of the boat roof.
Data format	PDF File (.pdf)
Data set size	Approx. 2 MB
Data sharing	Publication

Code	MC4-GDPV
Data set full name	Part designs
Responsible beneficiary	VDL Fibertech Industries

Description	CAD designs and ply-books of the parts made from recycled materials.
Data format	Ply-books 2D in DXF format (*.dxf) and CAD designs 3D in STEP format (.stp)
Data set size	Approx. 100 MB
Data sharing	Confidential

Code	MC4-CDPM
Data set full name	Part designs
Responsible beneficiary	MANAGING COMPOSITES
Description	CAD designs, 2D Technical Drawings and ply-books of the parts, tooling and auxiliary tooling made from recycled materials. Building books with the post processing. Drilling, machining, finishing.
Data format	CATIA 3D & 2D format (CADPart/CADProduct/.drw) /Step(.stp)/PDF
Data set size	> 1GB
Data sharing	Confidential

Code	MC4-CDPF
Data set full name	Designs of recycled parts
Responsible beneficiary	FIDAMC
Description	CAD designs of the parts made from recycled materials
Data format	.CADPart or .CADProduct
Data set size	<4GB
Data sharing	Confidential

Code	MC4-GDPL
Data set full name	Part designs
Responsible beneficiary	LAB23
Description	CAD designs and ply-books of the parts made from recycled materials
Data format	.stp, .dwg and .pdf files
Data set size	< 2GB
Data sharing	Confidential

Code	MC4-GFPV
Data set full name	Properties of finished parts
Responsible beneficiary	VDL Fibertech Industries
Description	Requirement specification with technical requirements and visual appearance criteria.
Data format	PDF File (*.pdf) and if necessary accompanied by pictures (*.jpg)
Data set size	50 MB
Data sharing	Publication

Code	MC4-GFPM
Data set full name	Properties of finished parts
Responsible beneficiary	MANAGING COMPOSITES
Description	Visual appearance, quality zones depending if the area is visible or not, dimension reports.
Data format	PDF File (.pdf) and .jpg for the pictures
Data set size	100 MB – 500 MB
Data sharing	Publication

Code	MC4-CFPF
Data set full name	Properties of finished parts
Responsible beneficiary	FIDAMC
Description	Mechanical testing of samples from the aerospace part obtained, such as visual inspection or nondestructive testing (NDT).
Data format	.pdf
Data set size	<4GB
Data sharing	Publication

Code	MC4-GFPL
Data set full name	Properties of finished parts
Responsible beneficiary	LAB23
Description	Results of the mechanical testing, visual inspection, nondestructive and destructive testing of the final products.
Data format	.pdf files

Data set size	< 4GB
Data sharing	Confidential

Code	MC4-CMSA
Data set full name	Material Specifications and Properties of finished parts
Responsible beneficiary	Amura
Description	The dataset contains the technical requirements for carbon fibre materials used in the demonstrator's manufacturing, specifying fabric types, weights, mechanical properties, and commercial presentation. It also includes details on the infusion process with epoxy resin and the use of recycled PET as interior reinforcement, along with finishing options such as exposed carbon or polyurethane-based coatings.
Data format	PDF File (.pdf)
Data set size	Approx. 250 KB
Data sharing	Publication

Code	MC4-LCID
Data set full name	Life Cycle Inventory (LCI) Data
Responsible beneficiary	Amura
Description	The dataset includes two Life Cycle Inventory (LCI) datasets detailing the manufacturing processes of a fibreglass roof produced via hand lay-up and a recycled carbon fiber roof manufactured through infusion technology. Each dataset contains a comprehensive assessment of material inputs, energy consumption, packaging and storage, product outputs, packaging and storage outputs, upstream emissions, and upstream waste, providing a detailed evaluation of the environmental impact and resource utilization associated with each manufacturing method.
Data format	Excel (.xlsx)
Data set size	Approx. 0.5 MB
Data sharing	Confidential

Code	MC4-RESA
Data set full name	Report Samples
Responsible beneficiary	Amura
Description	The dataset consists of reports on samples produced for the project, documenting key parameters of the manufacturing process. Each report includes machine specifications,

	processing conditions (pressure, temperature, humidity), resin and fabric references, infusion and curing details, and material quantities used. Additionally, observations and conclusions regarding the manufacturing outcomes are provided to support the project's technical development.
Data format	PDF File (.pdf)
Data set size	Approx. 2 MB
Data sharing	Publication

Code	MC4-GMSV
Data set full name	Material specification for parts made of recycled materials
Responsible beneficiary	VDL Fibertech Industries
Description	Technical datasheet containing: color, mechanical properties, machinability and other characteristics.
Data format	PDF File (*.pdf) and if necessary accompanied by pictures (*.jpg)
Data set size	50 MB
Data sharing	Publication

Code	MC4-CMSA
Data set full name	Dimensioning of product made of re-shapeable resin (3R)
Responsible beneficiary	MANAGING COMPOSITES
Description	Mechanical Properties, numerical simulation
Data format	PDF File (.pdf)
Data set size	100 MB
Data sharing	Confidential

Code	MC4-PCSM
Data set full name	Process simulation
Responsible beneficiary	MANAGING COMPOSITES
Description	Numerical simulation of kayak infusion
Data format	PDF File (.pdf)
Data set size	100 MB
Data sharing	Confidential

Code	MC4-CMSF
Data set full name	Technical characterization of the scrap material
Responsible beneficiary	FIDAMC
Description	Characterization of the material to be recycled in order to get information about the format and size of the parts as well as other relevant parameters during the manufacturing process.
Data format	.xlsx tables and .pdf
Data set size	<4GB
Data sharing	Confidential (depends of data providers)

Code	MC4-GMSL
Data set full name	Recycled material specification for production use
Responsible beneficiary	LAB23
Description	Identification of the recycled material that will be suitable for use: dimensions, format
Data format	.xlsx and/or .pdf files
Data set size	< 1GB
Data sharing	Confidential

Code	MC4-CMSS
Data set full name	Material specification for carbon fibres
Responsible beneficiary	STFI
Description	The data set contains testing results on fibre fineness, fibre length, fibre diameter, tensile strength, fibre surface etc.
Data format	.xlsx or .pdf file, REM images
Data set size	> 1 GB
Data sharing	Confidential

Code	MC4-CMSC
Data set full name	Material specification for recycled raw materials of STFI for Chomarat
Responsible beneficiary	Chomarat
Description	Textile construction (non woven, UD, sliver) defined in area weight, width, fiber type, binder type, fiber length, fiber

	orientation, packaging, mechanical properties (Tensile Modulus and strength, elongation)
Data format	.pdf
Data set size	<200MB
Data sharing	Confidential

Code	MC4-CGLC
Data set full name	Life cycle analysis and life cycle costing data inventory and impact assessment results
Responsible beneficiary	IRES
Description	The dataset contains inventory data for input/output material, energy and waste flows for defined system boundaries of each case study and impact assessment results.
Data format	.xlsx tables
Data set size	<5 MB
Data sharing	Confidential (depends on data providers if data can be published or not)

Code	MC4-CGCD
Data set full name	Contact data
Responsible beneficiary	Techtera
Description	Contact details (first name, name, position, phone number, email address, organization) of persons interested in the MC4 technologies (met during events).
Data format	.xlsx table
Data set size	< 1MB
Data sharing	Confidential

Code	MC4-PCMC
Data set full name	Parameters of the composite manufacturing containing rGFRP
Responsible beneficiary	NOMA
Description	The data set contains parameters of the manufacturing of composites (temperature, pressure, heating and cooling rate, energy consumption).
Data format	.xlsx or .pdf files
Data set size	<1 GB

Data sharing	Confidential
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Code	MC4-FOLM
Data set full name	Formulations of liquid modifiers
Responsible beneficiary	NOMA
Description	The data set contains parameters of the synthesis of liquid modifiers, functional groups and their properties (chemical compositions, time, temperatures, NMR, FTIR)
Data format	.xlsx or .pdf files
Data set size	<1 GB
Data sharing	Confidential

Code	MC4-EPRF
Data set full name	Epoxy resins formulations
Responsible beneficiary	NOMA
Description	The data set contains parameters of the resins (characteristic temperatures and mechanical properties).
Data format	.xlsx or .pdf files
Data set size	<1 GB
Data sharing	Data sheets

Code	MC4-MCFM
Data set full name	Method for carbon fibres modification
Responsible beneficiary	NOMA
Description	The data set contains parameters of the carbon fibres modifications (type of modifiers, time of exposition, temperature of drying)
Data format	.xlsx or .pdf files
Data set size	<1 GB
Data sharing	Confidential

7. ALLOCATION OF RESOURCES

The costs of providing FAIR data in the MC4 project is not extensive. Due to the use of the Zenodo repository, no additional costs for infrastructure concerning storage and online availability of the data has occurred. All partners defined clear interfaces within the project to prepare the data for easy reuse. The definition of internal interfaces eased preparations for data publication.

As a coordinator, Profactor will was responsible for keeping an overview and guiding data management across the whole project. However, individual partners are associated to data sets and declared “responsible beneficiary” as specified in the tables above. As such, partners supervised data acquisition, storage, and documentation for “their” data sets. When specific versions of data sets that allow interesting (scientific) insights have been, these have been presented and discussed in the regular telephone conferences or at general meetings. The respective responsible beneficiaries drove activities for publication of data sets (preparation of scientific publications, upload to online repository, etc.)

8. DATA SECURITY

Open Data in the MC4 project is uploaded to the Zenodo repository. Zenodo stores its data in the CERN Data Center. We consider this a highly trustable host. Loss of data – even in a long-time perspective – is very unlikely.

9. CONCLUSIONS

Open access is obligatory for scientific publications and corresponding data that is required for validation of these publications. The data management plan for the MC4 project listed all data sets that were expected to be generated over the duration of the project. This Dataset in Repository deliverable lists all data sets that have actually been generated. A total of 46 types of data sets was identified, of which 16 data sets is publicly available on the Zenodo platform. While the project website is be used to promote publications, the Zenodo repository will be used as the major host for publicly available research data.