MACRAMÉ

Boosting the Knowledge about Micro- & Nano-Plastic
by learning from Research into the Risks of carbon-based Advanced Materials

MACRAMÉ's central Objectives

- **detect, characterise and quantify Advanced Materials** (AdMas)handling and processing the life-cycle,
- **assess impacts on human health and the environment** in intended or unintended situations (i.e. 'Exposure Points') in the product value-chain,
- **Advance** the wide-spread applicability of the developed **test and characterisation methods**, by **their effectiveness and efficiency** in the context of existing, market-relevant industrial AdMas containing products, and
- **prepare and initiate standardisation, harmonisation and technological & regulatory validation** of test- and characterisation-methods.

The MACRAMÉ R&I Approach

5 real-world industrial Use-Cases were selected at the proposal stage to achieve regulatory relevance and broad impact of the MACRAMÉ Project.

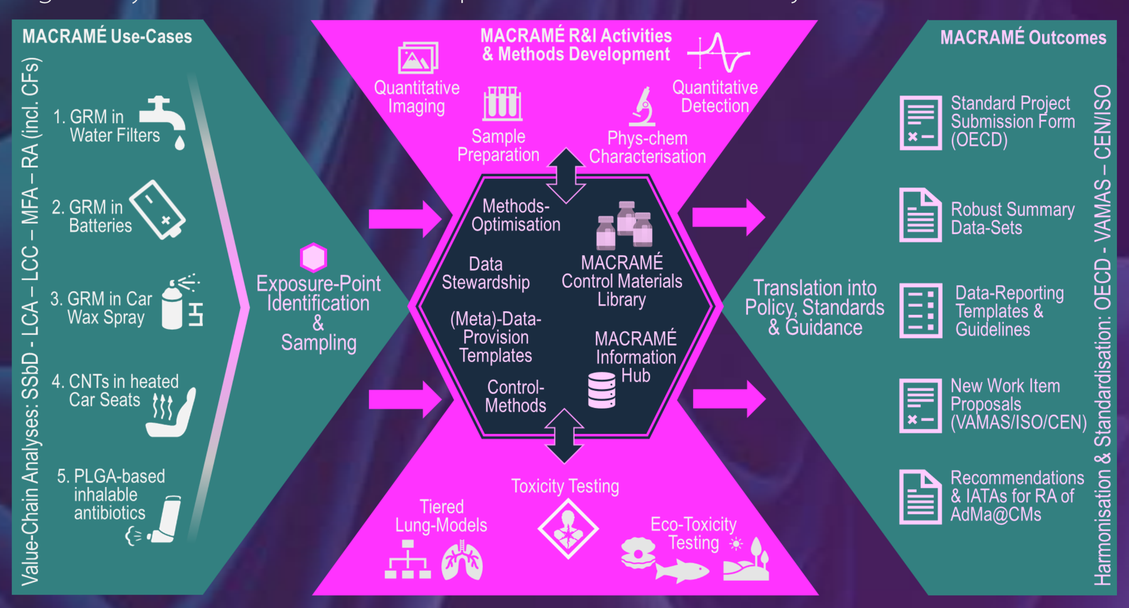
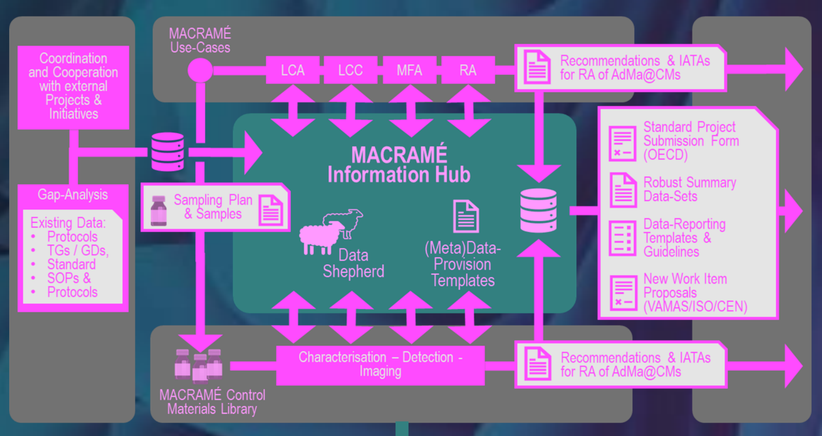


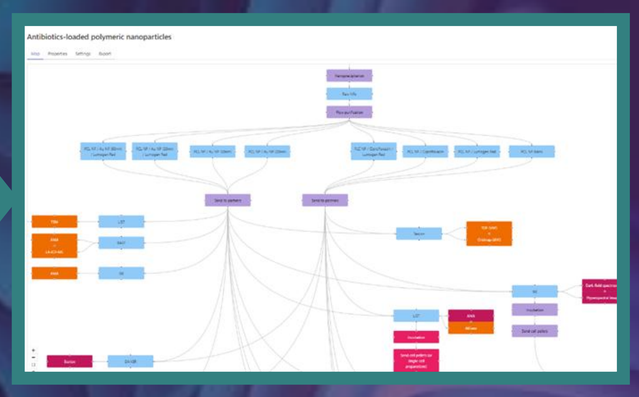
Illustration of the MACRAMÉ R&I Approach (AdMa@CMs: Advanced Materials in complex matrices; CF: Characterisation Factor; GRM: graphene-related material; IATA: integrated approaches to testing and assessment; LCA: Life-Cycle Assessment; LCC: Life-Cycle-Costing; MFA: Material-Flow Analysis; RA: Risk-Assessment; SSbD: Safe-&-Sustainable-by-Design).

The MACRAMÉ Processor

All MACRAMÉ (meta-)data (incl. existing documentation, characterisation- and test-results, images, sample-history information) are collected in a central, flexible data-registry, the **MACRANÉ Information Hub**.



Schematic illustration of the flow- of and value-add to data within the MACRAMÉ Project.



Screenshot of an instance map representing the planning status of the central control material ordering and shipping to the partners.

Complementing established, validated characterisation methods with the advanced MACRAMÉ methods as input for both **regulatory grouping**, **read-across** and **risk assessment** methods, as well as the for the scoping of **Safe and Sustainable by Design (SSbD)** initiatives, has the potential to increase the predictability and reliability of these methods. The new, advanced methods show the quality by providing information on the **robustness**, **reliability** and **validity** of the method in that they **come with highly increased information requirements** to be provided with each data point.

17 real-world Exposure Points were defined across the **5 real-world life cycles**, and **61 Sample Analyses** across **3 independent disciplines** (i.e. (i) detection & characterisation , (ii) human toxicity testing, and (iii) ecotoxicity testing) were planned.

MACRAMÉ Exposure Points [Samples & Constituents]		Pristine AdMa Manufacture	AdMa (Un-)Bagging & Transport	Product Manufacture	Reactor/ Machine Cleaning	(Un-)Bagging & Transport	(Professional) Intended Use	End-of-Life: Shredding	End-of-Life: Incineration	End-of-Life: Release/Leakage
		[AdMa]		[AdMa] - [AdMa@CPM] - [CPM]				[AdMa@EoL(CPM)] - [CPM(EoL)]		
MACRAMÉ Use-Cases & Sample-Description @ Exposure Points	UC1: GO in Water-Filters	Pristine GO, polysulfone (matrix)		GO@Polysulfone-Fibre, Water from the spinning-process			~~(filtered water)~~ *	-	Incineration products: Fly-ash, Flue-gas	
	UC2: FLG in BMS	Pristine FLG, epoxy resin		FLG@epoxy (non-reticulated (liquid samples) and reticulated (solid samples))**			FLG@epoxy (overheated)	FLG@epoxy (shredded)		
	UC3: GRM-bearing Sprays			-			GRM@aerosol	GRM@aerosol (in container), EoL according to container material and/or special instructions		
	UC4: CNTs in Polymer Foils	Commercial CNTs (NanoCyl SA), polyurethane (PU) matrix		CNTs@PU (masterbatch & cured composite)			CNTs@PU (overheated, abraded (Taber))	CNTs@PU (shredded)	Incineration products (O_2-depletion): Fly-Ash, Flue-gas	
	UC5: PLGA-based inhal. Antibiotics	PLGA-particles (different sizes) Ciprofloxacin		ciprofloxacine@PLGA controls: Au@PGLA, Fe_3O_4@PLGA, PLGA (labelled with Lumogen red®)				-	ciprofloxacine@PLGA	
Characterisation - Detection – Imaging (by Attributes) [Samples & Constituents]		All UCs: • characterisation; • aerosol generation & characterisation; • stability in environmental & biological matrices; • high resolution imaging in cells		All UCs: • Aerosol generation for *in vitro* exposure • Characterisation of the generated aerosol • Stability and release in environmental & biological matrices				All UCs: • EoL leaking from container/matrix • Aerosol generation for *in vitro* exposure • Stability and release in environmental & biological matrices		
				UC1, UC2, UC4, UC5: • Identification, quantification & characterisation	UC1, UC2, UC4, UC5: • Identification of (form of) release during cleaning	UC3: • Identification: presence of GRM ➢YES: quantification, characterisation	UC2, UC4: • characterisation after mechanical abrasion (Taber) • characterisation of release at heating	UC1, UC2, UC4: • characterisation after mechanical abrasion	UC1, UC2, UC4: • characterisation of flue-gas & fly-ash	UC1, UC2, UC4: • Identification of release of EoL-products (in land-fill)
		[AdMa] - [AdMa@EM] - [AdMa@BM]		[AdMa@CPM] - [AdMa@CPM@EM] – [AdMa@CPM@BM]				[AdMa@EoL(CPM)] – [AdMa@EoL(CPM)@EM]		
Human Toxicity Testing (in-vivo – ex-vivo) [Samples & Constituents]		In case of inhalable release: Scheduled Tiered Lung-Model Approach (see Section 1.2, III.vii)								
		[AdMa@BM]		[AdMa@CPM] [AdMa@CPM@BM]- [AdMa@BM] - [CPM@BM]					[AdMa@EoL(CPM)	
Ecotoxicity Testing [Samples & Constituents]		Ecotox Testing Strategy (see Figure 5)								
		[AdMa@EM]		[AdMa@EM] – [AdMa@CPM@EM] - [CPM@EM]				[AdMa@EoL(CPM)]	[AdMa@EoL(CPM)	

Schematic overview of the identified product-relevant MACRAMÉ Exposure-Points and the sampling, characterisation/imaging/detection and testing to be conducted at these points; *3 GRMs will be processed to a GRM reinforced epoxy composite according to Netkueakul et al. (2020).

Project month 6: the **MACRAMÉ Control Material Library** was launched, to provide reference materials for the Project's laboratories and the wider AdMa testing community.

Project month 14: **MACRAMÉ Sampling & Sample Provision Protocols** were published to harmonise the sampling across the Use-Cases' life-cycles.

> *"[…] a highly topical issue in the science community: that of research data management and FAIR data."*
>
> [Peer-Reviewer 1]

> *"The manuscript is well organised, well written and gives new impulses to the field (as a perspective should do). The authors have done a really good job in collecting important services, standards and ontologies for the FAIRification of nanoscience data and setting this into a big picture with recommendations for the future.'*
>
> [Peer-Reviewer 2]

> *"The field of nanosafety is very complex from the perspective of metadata. This manuscript gives an overview of these complexities, the current state of the art, identifies the main issues, organizes it into two main "hypotheses", defines needs and possible solutions and ends with a possible roadmap.'*
>
> [Peer-Reviewer 1]

Illustrated work-flow of the fabrication of Epoxy-FLG composite plates. Epoxy alone or epoxy-FLG composite are mixed with hardener (Baxxodur EC 301), moulded and then cured in the oven at indicated temperature cycles. The plates obtained after curing were used for abrasion.

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