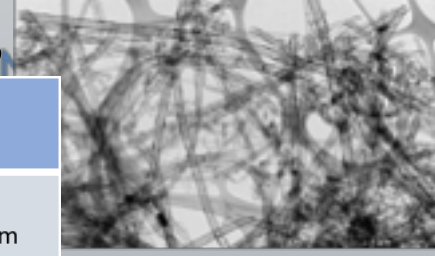
Group Antolin: CNF for automotive applications



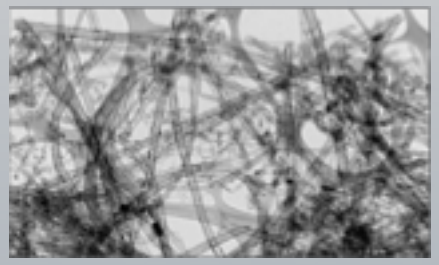
SbD Pillar

Safer NMs
Identify Phys-Chem properties relevant for functionality & risk

PHYSICAL CHARACTERISTICS	GANFg	GANF	GATam
Size Diameter Length	20-80 nm 200-10,000 nm	20-80 nm 200-20,000 nm	20-80 nm 100-10,000 nm
Density (g cm^{-3})	0.08	0.06	0.08
Surface functionalization (O2 content)	1%	5%	10%
Crystallinity (degree of graphitization)	99 %	70 %	60 %
Specific surface Area (BET m^2 g^{-1})	80-120	100-170	70-140
Electrical Resistivity (Ohm m)	1 10^{-4}	1 10^{-3}	1 10^{-3}

SbD Pillar

Safer Process
Identify hot spots to reduce workers exposure

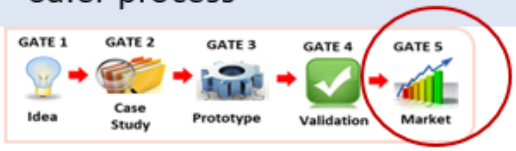


Group Antolin: CNFs for plastics in automotive applications

Scenario

SbD Pillar
- Safer NM (GANFg, GANF, GAtam)
- Safer process

Value Chain Stage



Functionality
- Conductivity after scaling up using the floating catalyst method

Relevant regulation
- CLP (1972/2008/EC)
- H &S at work (1989/391/EEC)
- Industrial Emissions (2010/75/EU)
- International Transport regulations

Risk Evaluation
- Ocuppational exposure
- Human toxicity: citotoxicity, genotoxicity,inlamation, in vivo inhalation
- Ecotoxicity: in vitro (fish & muscles cell lines) and in vivo (algae)

SbD goal
- Reduce exposure to employees
- Select the safest & more sustainable NM for scaling up

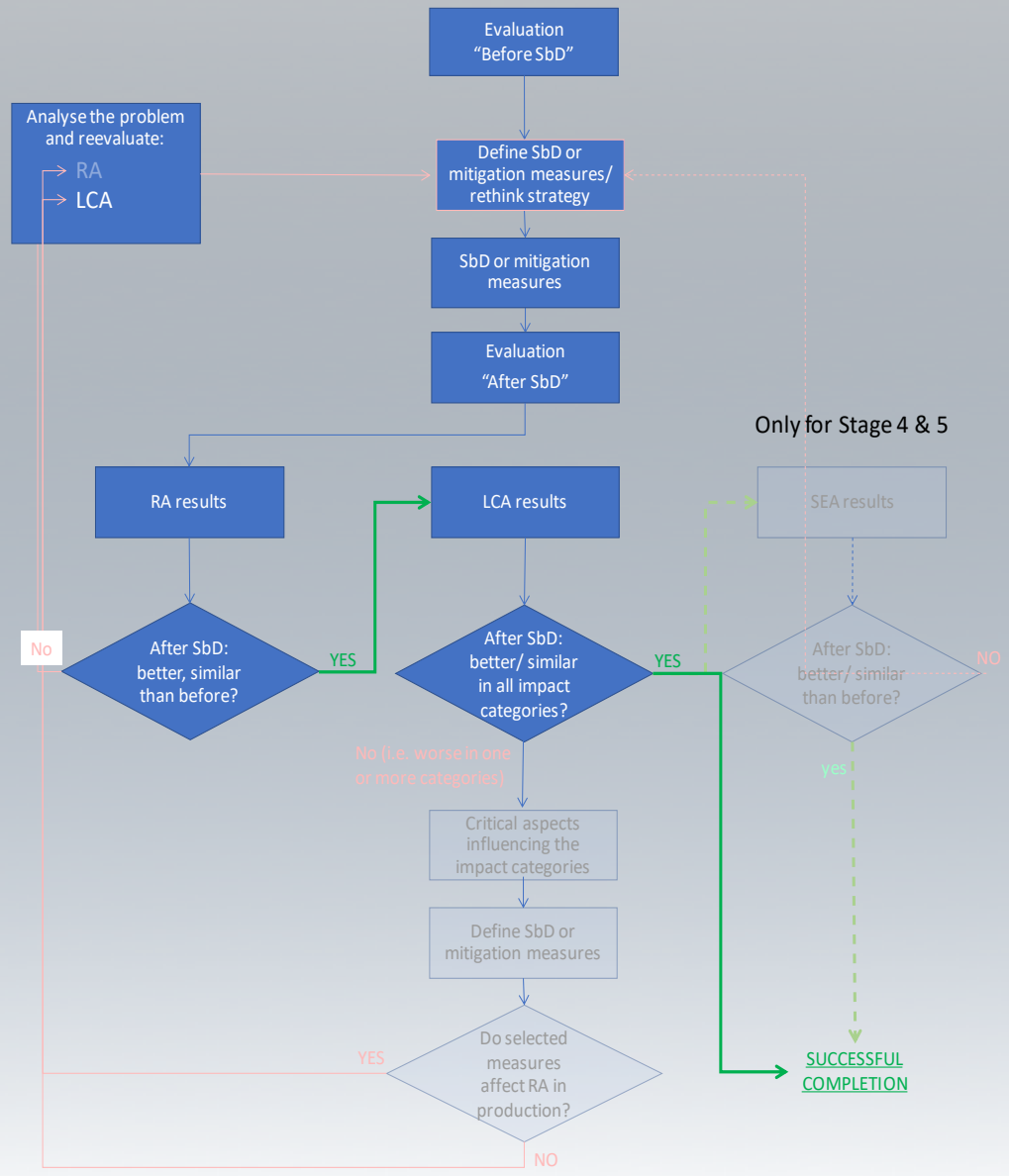
SbD measures
- Optimisation of NM properties (surface area, functionalization & crystallinity)
- Automated penumatic transport & chages in handling and packing methods

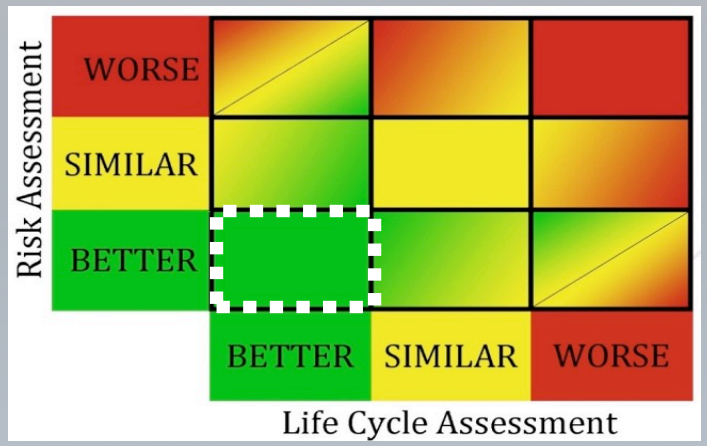
SbD results
- Reduced occupatinal exposure
- Strategy for scaling up a safer & high performance CNF

Group Antolin: CNF for automotive applications

	Description			Conclusion
Human toxicity	redox, ROS, inflammation, cytotoxicity, lung toxicity, stability			Comparable (in vivo studies repeated doses required)
Ecotoxicity				Comparable
Exposure			Exposure during collection	Higher for GATam production
Risk Assessment				Lower risk driven by exposure reduction
Life Cycle Assessment	ENM emission through the life cycle is limited and has low influence in the global impact: production and use show limited outdoor emission and expected destruction in thermal End of Life processes is > 99%.			GATam production more efficient than GANF.

Group Antolin: CNFs for automotive applications





Group Antolin SbD experience

- SbD approach allowed the identification of more proper CNF to scale up production (GAtam).LCA analysis was the main driver for this decision.
- We gained knowledge on the complexities involving the determination of tox/ecotox poperties of NMs
- The behaviour of CNFs was different depending on the dispersion protocols used (genotox procedure with/without BSA)
- Not possible to carry out all the safety assessment without an external experienced expert
- Overall, we see the benefits but the costs of implementation are high