Deliverable D1.1
First report on project progress

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First report on project progress

Deliverable D1.1

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[1] PU = PUBLIC
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Publishable Executive Summary

Surface finishing treatment bears a significant process applied in many industrial sectors with the view to extend the life of metallic components providing surface properties and functionalities via the application of coatings using electoplating and electroless plating baths.

However, this continuous replenishment of chemical compounds leads to accumulation of by-products and decomposition product that burden the bath from its proper operation. A total amount of 300.000 tons of hazardous waste is produced per year (an average of 16 tonnes per installation). PureNano proposes a novel method for an in-situ purification/regeneration process of plating baths from contaminants and undesirable chemical species hindering the operation of the bath. The concept is based on a real industrial need with a high market demand and will be implemented through the utilization of appropriate functionalized magnetic nanoparticles (MNPs), leading to a significant extension of the lifetime of the baths, up to 10 times. This significant improvement will lead not only to important financial benefits related to the operators of plating baths but also to a great positive environmental impact.

Deliverable 10.1 “First report on project progress” gives an overview of the status of the project covering all the tasks foreseen for this first reporting period.

In the first 18 months of its 36 months planed duration, the PureNano project has generated data on the overall specifications and requirements of the materials and components that will be developed as well as of the overall demonstration activities. Moreover, the MNPs production line was designed and modified in order to achieve the optimal formulation of the starting solution, the mixing device and the control of the aggregation process. The production process has been optimized and validated whereas the next steps for MNPs functionalization have been defined. Regarding the design and development of purification process activities, a mathematical model including the plating processes and all the necessary unit operations for the purification process currently under developed. Moreover, the process for the purification in both electroplating and electroless systems has been defined and the general layout has been established. Activities to assess the sustainability of the recycling routes proposed addressing high-value markets, considering ecological, financial and social aspects are ongoing. Safety and standardization activities related to the early stage adaption of the technology considering the safety and cost analysis are also under development.

All goals for the reported period were achieved and all deliverables and milestones were delivered.

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Abbreviations and acronyms

WP	Work Package
MNPs	Magnetic Nanoparticles
Mo	Months
SM	Social Media
KER	Key Exploitable Result
IPR	Intellectual Property Rights
D&C	Dissemination & Communication
PEDR	Plan for the Exploitation and Dissemination of Results

1. WP1 - Management & Coordination

1.1 Overview of activities in WP1

1.1.1 Task 1.1: Administrative and financial project management

The project management structure was defined during the kick-off meeting in Athens after discussion between the partners. Two levels of project management structure were defined. Administrative and financial project management led by PoliMi and the Project Steering Committee formed by representatives from each entity which is responsible for the overall technical coordination of the project and for the resolution of conflicts. PoliMi has been the contact point for the EC and the partners and has been updating the EC every three months on the project progress.

A mailing list, managed by PoliMi, has been set up and is being updated every time there is a change in the partners' personnel involved in the project.

PoliMi led the administrative activities and coordinated technical activities through regular Teams teleconferences organized according to partners' and project needs.

At the moment, the following project management tools have been established:

- Document section of the PureNano website (https://www.purenano-h2020.eu/documents/) for public deliverables
- One Drive used for file sharing between consortium members
- Microsoft Teams used for hosting teleconferences since it offers features such as screen sharing and chat functions.

Two consortium meetings were organized:

- Kick-off meeting, Athens, 12-13 September, 2019
- 9Mo telematic meeting, 1-2 April, 2020

During these meetings, partners presented the progress of the activities, identified issues and defined tasks to be completed. The kick-off meeting combined WP sessions, live demonstrations and visit to partner premises.

PoliMi transferred the first part of the PureNano budget to each partner. All project partners have an internal Financial Officer who manages the project financial issues. Moreover, partners have their own internal financial management and reporting structure setup and monitor continuously the expenses and personnel effort according to the budget allocated.

The major challenge for the project management so far, has been the COVID-19 emergency that has led to some delays in the technical activities of the project and has postponed visits to partners facilities important for the implementation of some activities. Moreover, the 9Mo meeting originally meant to be carried out physically had been done remotely due to the health emergency. All partners are dedicating effort on monitoring eventual delays in their activities and on identifying mitigation actions and implementation strategies.

1.1.2 Task 1.2: Technical project management

Moreover, PoliMi in close collaboration with the Technical Manager and the Work Package Leaders, has been managing the technical part of the project. Communication and visits to partner premises have been coordinated and carried out according to project needs. Technical risk management was performed by the Technical Manager and the Work Package Leaders and the impact of economical and societal issues was taken into consideration for the planning and execution of the technical activities.
Two technical meetings between partners took place:

- Technical visit of RISE to the facilities of Captive, Gaser, Tecnochimica and PoliMi in order to discuss and plan the activities for the next months on 17-18 December 2019
- Technical visit of Kampakas to CNano premises in order to discuss the design and implementation of the purification system that will be developed within the PureNano Project on 4 March 2020

PoliMi provided support and revision of deliverables before their submission and the progress of the project was presented in deliverables and milestones. PureNano partners submitted all deliverables, with some of them having only minor delay in the submission, and achieved all milestones scheduled so far.

1.2 Achievements and results of WP1

1.2.1 Task 1.1: Administrative and financial project management

PureNano project management structure has been set up and is currently running:

- Administrative and financial project management led by PoliMi
- Project Steering Committee

The project management structure and the monitoring process allowed PureNano consortium to:

- define tasks to be carried out in each WP
- identify possible issues and implement actions
- establish essential collaborations between partners
- meet all aims and objectives as defined in the Grant Agreement in M01-M12

The mailing list provided efficient and reliable communication channels among project partners and management tools such as One Drive and Teams allowed sharing documents, performing teleconferences and collaborating between partners.
Regarding financial management:

- the first part of the project budget has been transferred to PureNano partners
- partners continuously monitored costs and effort using their own financial management and monitoring structure

1.2.2 Task 1.2: Technical project management

Two technical meetings were held:

- visit of RISE to the facilities of Captive, Gaser, Tecnochimica and PoliMi, Milan, 17-18 December 2019
- visit of Kampakas to CNano premises, Athens, 4 March 2020

The technical project management allowed PureNano consortium to:

- submit all deliverables specified in the Grant Agreement in M01-M12
- achieve all milestones scheduled in M01-M12
- provide information during the technical visits and teleconferences necessary for the implementation of activities

Table 1. WP1 Deliverables submitted

Deliverable Number	Deliverable Description	Date
D1.1	First report on project progress	30/05/2020

Table 2. WP1 Milestones

Milestone Number	Milestone Description	Date
MS1	Kick off meeting	12-13/09/2019

2. WP2 - Generation of Specifications & Requirements

2.1 Overview of activities in WP2

2.1.1 Task 2.1: Specification on materials to be used

The activities within this task dealt with all the raw materials that will be involved in the synthesis and the production of aggregates of magnetic nanoparticles (MNPs) during the PureNano Project. The magnetic nanoparticles are made of a ferromagnetic core that allows an easy and fast separation after treatment by applying an external magnetic field combined with methods based on gravity and centrifugal force. The magnetic nanoparticles have an external coating that is the key for attracting different type of pollutants and undesirable species.

Figure 1. *Structure of magnetic nanoparticles.*

Thanks to the possibility to change easily the compounds used for the external coating, during the project, new types of coating were and will be developed and optimized according the specific needs of the different target species.

2.1.2 Task 2.2: Specification on purification systems

The objective of Task 2.2 is the identification and the collection of information on the electroless and electroplating processes. Information collected at this task is essential for the development of the future activities since all the generated information at this stage will be consulted for future activities within the project.

Specifically, in Task 2.2 a thorough investigation has been carried out regarding all the streams involved in each process, including specific information on the main inputs, outputs and intermediate flows of Zinc, Nickel & Ni-P, Ni-P & SiC and Copper electroplating process and of Nickel electroless plating process. Different points have been studied for each process such as a top view of the processes taking into account the main conceptual parts of the system in order to provide a complete list of the main inputs, intermediate flows and outputs of the involved stream. Moreover, in Task 2.2, information on the sub process inside each plating process, as well as information related to the main equipment has been gathered. In deliverable D2.2, for each process where the purification system will be implemented, a detailed description of the sub process has been done, and a simplified block diagram has been generated for a better comprehension of the process. Data on all the sub processes related to the operation and procedures have been also included in D2.2.

Additionally, information on the available equipment in the facilities of the two final Gruppo Gaser and Cnano has been collected. Work done in D2.2, shows a layout plant of Creative Nano's 120L

pilot plant, as well as technical information on the different tanks and equipment that are present in the abovementioned pilot plant. During the kick off meeting of the project, all the consortium partners had the opportunity to visit the pilot plant in site. Similarly, information on Gaser's facilities, including images of the Ni electroless plant and other technical information have been also included in D2.2.

2.1.3 Task 2.3: End users' requirement

This task aims to provide information on the working parameters of Ni-P electroless baths, copper electroplating, and Ni-P electroplating. The descriptions of the processes provide the necessary information to develop the functionalization of NMPs toward specific targets, the design of purification process and the methods for the re-use of the purified solutions.

For the implementation of this task, the end users Gasser, Cnano and Technochimica have provided a detailed description of their production processes. Thus, an analysis and a depiction of the constituents of the operational and spent plating baths was presented. The information that was shared between the partners involved the process parameters of the plating baths, i.e. pH, temperature, volumes, current density applied, and an estimation of the concentration of the undesired species and by-products present in the spent baths. Additionally, the physicochemical properties of the species and the characteristics such as the charge and the type of additives used were described.

The knowledge from this task was presented to PoliMi, CaptiveS and RISE in order to plan the future activities required for the production and functionalization of the MNPs with the intention to increase their capturing efficiency during the purification process.

2.1.4 Task 2.4: Update of Specification deliverables

Due to the complexity of the electrolytes and the physicochemical interactions present during plating, an update of the concentrations and type of undesired species is important. This task was affected from the COVID-19 emergency and a 2-month delay is estimated. The spent plating baths have to be treated accordingly and a series of measurements that can be provided from the consortium of PureNano in order to identify and analyze in depth the physicochemical properties of the undesired species is necessary.

2.2 Achievements and results of WP2

2.2.1 Task 2.1: Specification on materials to be used

In this Task, the selection of all the raw materials for the production of aggregates of magnetic nanoparticles that will be developed and optimized during the process was done according to:

- The needs of Cnano and Gaser Group to remove a series of pollutants and undesirable species from their electroplating baths and wastewater such as metals (i.e nickel, zinc)

and organic compounds. The materials selected for the outer coated are able to attract these compounds by electrostatic force and lipophilic interaction.

- The production process developed by CaptiveS. CaptiveS already had experience in the production and application of specific aggregates of magnetic nanoparticles for the removal of hydrocarbons and organic compounds in wastewater coming from the Oil&Gas sector. The raw materials chosen fit with this synthetic route.
- The availability for purchasing. The raw materials need to be consumer products, easily to purchase from all major chemicals providers and with a cheap cost. Two chemicals providers were contacted with success in order to verify their availability for all raw materials.
- The sustainability of the developed methods in order to provide a greener solution for the market. None of the materials involved in the production process is included in the SVHC list.

2.2.2 Task 2.2: Specification on purification systems

The study of the specification on purification systems in Task 2.2, has made possible the collection a lot of essential inputs for the progress of the project, and in particular for the mathematical model developed in WP5.

With the contributions of partners Gaser, CNano and Tecnochimica, each process has been divided into the main sub processes for a better and detailed understanding. In each sub process the following have been specified:

- the different streams involved
- all the necessary chemical solutions in the process, taking into account capacity volume, concentration of the chemicals, final concentration needs, temperature and pressure as operating values
- pH needs and other operational parameters
- other details on each sub process

Several different possibilities of the purification system that will be implemented in the pilot plant lines have been also studied and presented to the consortium. At the moment, they are conceptual ideas and preliminary designs but will be helpful for the development of the final purification system in electroless and electroplating process.

2.2.3 Task 2.3: End user requirement

The type and concentration of the undesired species present in the spent plating baths was presented, analyzed and discussed between the end-users (Cnano, Gasser) and the purification technology developers (CaptiveS, PoliMi, RISE). During the discussions all aspects of the purification process and the mechanisms present were investigated.

Most of the parameters used during the purification process were also defined, including the filtration performance, the temperature of the solution, the tolerable pH range and the concentration of pollutants remaining in the solutions that is tolerable for the reuse of the solution.

With the specifications provided, IDENER was capable of design the waste treatment plants and to start working on process parameter to maintain. PoliMi, Captive and RISE were also able to start working on the MNPs functionalization, to adapt nanoparticles to the extraction of specific pollutants and their use in specific environment.

2.2.4 Task 2.4: Update of Specification deliverables

Due to the COVID-19 emergency, further studies on the physicochemical properties of the undesired species of the spent plating baths are delayed.

Table 3. WP2 Deliverables submitted

Deliverable Number	Deliverable Description	Date
D2.1	Report on materials to be used	18/11/2019
D2.2	Report on equipment and purification system	29/10/2019
D2.3	Report on end user requirements	03/12/2019

Table 4. WP2 Milestones

Milestone Number	Milestone Description	Date
MS2	Delivery of plating line data to IDE and Kampakas	27/01/2020

3. WP3 - Magnetic NPs development

3.1 Overview of activities in WP3

3.1.1 Task 3.1: Modification of the MNPs production line

The main objective of WP3 was the setup of a pilot production plant with an enhanced production capacity and capable of producing different types of MNPs, such as anionic, cationic and non-ionic. CaptiveS has already a small laboratory production plant with a production capacity of 10 Kg/day. This plant is mostly used for the production of magnetic aggregates of nanoparticles suitable for the removal of hydrocarbons and organic compounds.

The formation of aggregates of magnetic functionalized nanoparticles is a one-step process, where chemical co-precipitation is combined with *in situ* surface functionalization with specific molecules. The final dimension of aggregates is controlled by the parameters set during the production and the type and percentage of outer coating. Particles can be synthetized from nanometer range to micrometer. Mainly due to the safety and operational issues related with working with nano-materials, it was decided to set-up the production parameters in a way to obtain micron-aggregates of functionalized magnetic nanoparticles.

The design of the new production plant was done in collaboration with partners Polimi, IDENER and Kampakas, taking into account the need of obtaining a well-controlled process capable to guarantee the optimal size and functionalization of the final aggregates of MNPs. The main characteristic of this pilot plant is its versatility to future changes related to new procedures for coating that could be implemented during the PureNano project. Moreover, discussions with partners IDENER and Gaser took place in order to identify the optimal procedures for the sedimentation and separation systems in order to dehydrate the MNPs for static application.

3.1.2 Task 3.2: Optimization of MNPs production

The core of the production plant is the static mixer in which the co-precipitation reaction, that leads to the formation of aggregates of functionalized magnetic nanoparticles, takes place.

The set-up of the parameters involved in this step is essential since it influences the final dimension of the aggregates. It is important to have a turbulent regime in the tube in order to have an efficient mixing of the reagents. During the scaling up of the production plant, the design of the plant was done in order to guarantee a minimum of turbulent regime in the tube.

Different runs using the new pilot production plant, were done in collaboration with Polimi. A set of runs using appropriate reagents for the productions of MNPs with lipophilic and anionic outer coatings was done in order to verify the capacity of the pilot plant of guaranteeing a standard production and the reproducibility of the production process.

3.1.3 Task 3.3: Optimization of the MNPS aggregation process

The final dimension of the aggregates of magnetic nanoparticles is strictly dependent of both on the process and on the formulation parameters. The pumping rate, the mixing efficiency and geometry of the static mixer influence the dimensions and the shape of the final aggregates. Different types of chemical used for the outer coating and their percentage lead to aggregates with difference sizes. The dependence of the final products according to the chemical formulation of the reagents was investigated.

The first tests for optimizing the aggregation process were done changing the types of the coating and its percentage respect to the ferromagnetic core. It was decided to fix the process parameters (pumping velocity, mixing efficiency and geometry of the static mixing) while changing the chemical composition of MNPs. With the support of CaptiveS, MNPs were produced using three types of coating: anionic, cationic and non-ionic. Moreover, for each type of coating, three different amounts were used. Subsequently, each set of MNPs produced was analyzed by IR-spectroscopy in order to check the presence of the coating on the surface and by particle size analyzer in order to assess the particle size distribution. In addition, bio-based polymeric coating is also being explored for anionic, cationic and non-ionic functionality. This part is being tested in a lab scale by partner RISE, and the pilot production facility will be modified accordingly.

3.1.4 Task 3.4: Characterization of MNPs

The objective of Task 3.4 is to ensure that the developed NMPs will be properly characterized, concerning the properties that are of great importance for the quality of these materials. Therefore, it was deemed important to verify that i) all the listed properties are actually the properties of interest for both the developers and the users and ii) to establish the characterization capacity of each one of the partners in this Task. Following this direction, NTUA created a dedicated questionnaire that was distributed among the partners. The aim of this questionnaire was to gather data regarding all types of characterizations (chemical, thermal, morphological etc.) that each of the participating partners can offer, in order to define which characterizations are necessary and who can provide them. The data were collected and consolidated into a single document and, based on this, the coordination between the different partners regarding the characterization of the produced MNPs is taking place. Data from scanning electron microscopy and particle size analysis were obtained by partner RISE after the production of MNPs using the optimized production plant.

Future actions in this task involve the conduction of in depth characterizations of the produced functionalized MNPs.

3.2 Achievements and results of WP3

3.2.1 Task 3.1: Modification of the MNPs production line

The modification of the MNPs production line resulted in:

- A pilot plant with a production capacity of 50 Kg per day was built.
- A layout that guarantees the production of different types of MNPs.

Additionally, the possible use of a decanter, hydrocyclone with combination of magnetic bars or a centrifuge as tools for dehydrating the MNPs solution and the possible use of spray-drying, freeze-drying and controlled evaporation as techniques for drying the MNPs were evaluated.

Figure 2. *Pilot Production Plant.*

3.2.2 Task 3.2: Optimization of MNPs production

In this Task, the capacity of the pilot plant of guaranteeing a standard production was verified as well as its correct operation. The different set of runs of the MNPs production resulted similar in terms of the size distribution of the aggregates and regarding the presence of the coating on the surface thus verifying a correct operation of the new pilot production plant.

3.2.3 Task 3.3: Optimization of the MNPs aggregation process

The activities of this Task, led to the conclusion that the final dimension of the MNPs aggregates depends on the type of chemical used as coating. Similarly, the final dimension of aggregates of MNPs with a certain type of coating depends on the amount of chemical used. A method for obtaining a targeted size distribution of the final aggregates by changing the types and amount of coating was also developed. Additionally, aggregates with a size distribution from few micron-

meter to hundreds of micrometers were obtained. The presence of the coating on surface was validated by IR the results. The size distribution of the MNPs aggregates shows a low polidispersity indicating a narrow size distribution of the MNPs aggregates.
Lab-scale trials are being carried out by partner RISE in order to develop bio-based polymeric coatings on the MNPs keeping as a goal that this modification should be incorporated into the optimized pilot production plant without significant changes in the configuration. This activity will be continued within WP4 in the coming months.

3.2.4 Task 3.4: Characterization of MNPs

The first MNPs batches prepared at the optimized pilot production plant were sent to partners RISE for an initial characterization. Scanning electron microscopy and particle size analysis was performed (Figure 3).

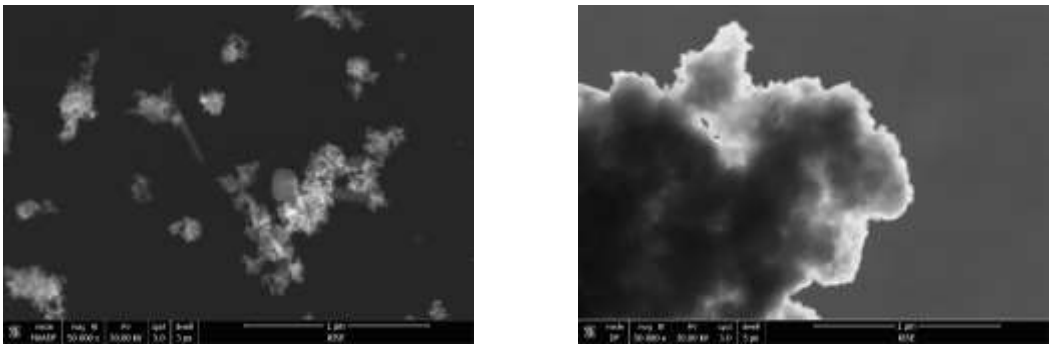

Figure 3. *DF SEM image of the MNPs obtained from the pilot production line.*

Another achievement for Task 3.4, is the listing of the needs of MNP developers and the characterization equipment of the partners. Based on this documentation, a more thorough characterization of functionalized MNPs will be designed, decided and realized.

Table 5. WP3 Deliverables submitted

Deliverable Number	Deliverable Description	Date
D3.1	Pilot line for production of MNPs with mixing equipment and magnetic separation	30/03/2020
D3.2	Definition of baths formulations and process parameters for MNPs	

Table 6. WP3 Milestones

Milestone Number	Milestone Description	Date
MS3	First successful operation of the upscaled MNPs production line	17/02/2020

4. WP5 - Integration of purification system and safe disposal of MNPs

The WP5 is focused on the development of the purification system for the electroplating and electroless processes in the Purenano project.

Within the activities of this WP, a mathematical model including the plating processes and all the necessary unit operations for the purification process is being developed. Moreover, and in a parallel way, an engineering study will be setup for design of the equipment, and a set of documents related to the integration of the purification system will be generated. These are all ongoing activities at the current stage of the project.

4.1 Overview of activities in WP5

4.1.1 Task 5.1: Process model formulation and process optimization

The aim of task 5.1 is to develop a model of electroplating and electroless plating processes, which will be used as a base for carrying out an optimization analysis to minimize capital cost and energy demand.

The elaborated models account for mass and energy balances in order to provide information to develop an economic analysis. Problem formulation and implementation have been carried out using EES and Python to obtain a simplified model able to be used for the optimization process.

At this stage in the project, the simulation of the main equipment involved in the processes (the plating and the adsorption tanks) is being carried out.

Five different plating tanks have been modelled according to the pilot lines of Gasser and Cnano facilities:

- Electroless Ni-P plating (Gasser).
- Zn electroplating (Gasser).
- Ni & Ni-P electroplating (Cnano).
- Ni-P/SiC electroplating (Cnano).
- Cu electroplating (Cnano).

The input data required in the model development, such as the operating conditions of the tanks or the reactions involved in each process, have been provided to IDENER by Gasser and Cnano.

On the other hand, the adsorption tank model, where the contaminants produced in the plating tanks are removed, is still in a preliminary step. Some simulations have been run using some input data found in the literature. Once information from WP3 and WP4 about the functionalization of MNPs is available, a robust model will be elaborated and current assumptions will be validated.

An economic analysis has also been performed. The capital cost and the operating cost of the pilot plants have been estimated, and the NPV (Net Present Value) has been calculated. This parameter is a widely used economic indicator, and its value will be significant to determine the project cost-effectiveness since the highest the NVP the more profitable is the project.

Regarding the optimization process, several scenarios and options of the purification processes are being examined in order to obtain the one with the highest NPV. Nonetheless, these activities are in a preliminary stage as well, and no consistent results have been achieved yet.

4.1.2 Task 5.2: Conceptual and basic engineering

Task 5.2 is an ongoing task of WP5 focused on the engineering of the purification system and the final results will be delivered in D5.2 "Conceptual and Basic engineering".

Activities in this task are actively progressing with the aim to define the final implementation of the purification system in both electroless and electroplating processes.

IDENER has organized several calls with the involved partners in order to present the progress and to receive valuable feedback from the partners. After discussing thoroughly on the preliminary versions of the purification system presented in WP2, several updated versions have been generated as the design progresses, and at the current stage, the consortium has defined the global idea of the necessary equipment to be deployed the purification process. Due to the distinct characteristics of the electroplating and electroless processes, the purification processes of the Gaser and CNano pilot lines will be developed according to the needs of each pilot line still keeping the focus on getting an optimization of the streams and achieving an optimal bath purification using the MNPs. Accordingly, minor differences to the equipment to be used will emerge between the two purification plants.

Since processes have been defined, the work is now focused on the next steps being the definition of each unit operation. Relevant engineering documents will be generated, including Process Flow Diagrams, Mass balance or Equipment datasheets. These documents will contain all the information about the purification system and will be the basis of the demonstration activities in WP6.

4.2 Achievements and results of WP5

4.2.1 Task 5.1: Process model formulation and process optimization

The process model formulation leads to some interesting achievements and results. The model simulations provide information about the electrodeposition of the desired metal in the treated pieces and the mass and heat balance in the plating tanks.

Some results about the equipment involved in the purification process are available but, as it has been mentioned before, only preliminary results have been obtained. There is not any consistent information about the mass and heat balance of this part of the process.

Nonetheless, these preliminary output parameters are provided by the simulations which will be used as inputs in the development of the optimization process.

This optimization process is also in a preliminary stage, some results about the optimization of the operating conditions in the plating tanks have been obtained, but no data about the optimization of the purification system are available yet.

4.2.2 Task 5.2: Conceptual and basic engineering

Up to date, the process for the purification in both electroplating and electroless systems has been defined and the general layout has been established. IDENER is currently working on more specific documents such as the Process Flow Diagrams, mass balance or the design of each unit operation.

5. WP7 - Industrial implementation issues

5.1 Overview of activities in WP7

5.1.1 Task 7.1: Recyclability & Circular economy

This task related to the establishment of an operational and financial model for the development and functioning of networks promoting the circularity of PureNano products will be developed, based on the shared responsibility between manufacturers, distributors, consumers and waste management operators. This model will include technical and management guidelines for the extension of PureNano products life-cycle, through its reuse and/or recycling.

The overall target is to reveal every opportunity that might arise regarding the circular perspectives that are hidden at the PureNano developments observing the overall value chain. To tackle this challenge AXIA strategically proposed a methodological approach as shown in Figure 4. to address recyclability and circular economy aspects within the project frames. The step-by-step approach will enable the identification of current practices in the EoL management of the plating baths, along with the review of alternative circularity models that are applicable at PureNano innovations taking into consideration the regulatory environment.

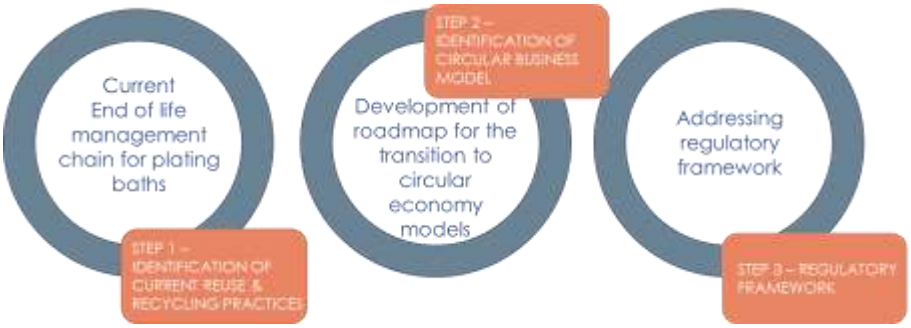

Figure 4. *Methodological Approach.*

5.1.2 Task 7.2: Safe by design

This task aims to contribute to the safety of the PureNano technology, from a safe-by-design perspective, promoting safe practices during production and by identifying product hazards based on the nanomaterials' characteristics (e.g. databases or lab tests done by other WPs). To identify potential risks, a risk management framework, based in ISO 31000:2018 "Risk management — Guidelines" and ISO/TR 13121:2011 "Nanotechnologies — Nanomaterial risk evaluation", has been established. The framework consists of three main phases and five steps: establishing the context, risk assessment (subdivided into 3 steps) and risk treatment (Figure 5).

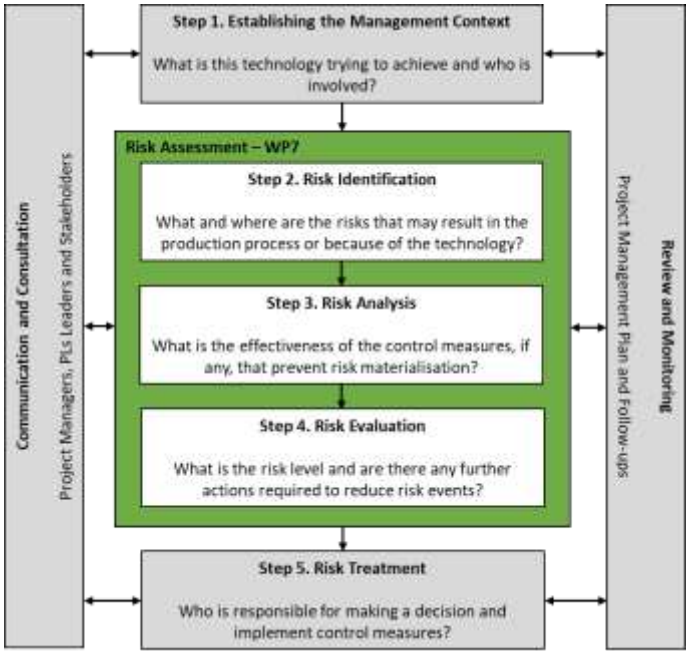

Figure 5. *Risk management framework used to support the SdD process of PureNano technology based on ISO 31000:2018.*

For step 1 "establishing the context", inputs from other WPs were used in order to understand the overall vision, aims and objectives of the PureNano technology (e.g. Deliverable 2.2, meetings: kick-off, 9Mo, etc.). In line with this, the objective of the risk assessment was settled.

Having defined the context, for step 2 "Risk identification", the identification and description of the materials (and nanomaterials) involved in the MNPs production pilot line was undertaken. For this purpose, PL questionnaires, deliverable 2.1, MSDS and chemical substances databases (e.g. ECHA, PubChem, ILO) were used. The information collected was contrasted against different hazard list, such as: Substances Included in the candidate list of SVHC according to Regulation (EC) Nº 1907/2006 (REACH); substances classified as carcinogenic to human by IARC; list categories by ACGIH; NIOSH RELs; DFG MAKs, among others. The next activity to finish step 2 includes the visit to Captive and Gaser pilot lines; unfortunately, due to COVID-19, these visits to the pilot lines have

not taken place and is delaying the development of the task. Further advances of step 2 include the orderly analysis according to the events involved in the processes for the development of technology.

5.1.3 Task 7.3: Safety Lines & Nanosafety issues

This task aims to contribute to the improvement of the safety of all the pilot lines involved in the PureNano project based on the regulatory requirements (e.g. REACH) and standards. ISQ has been working in the identification of the potential risks associated with the operation of the pilot lines. Once the assessment is finished, recommendations and guidelines will be proposed with the aim of reducing risk exposure during processes operation and materials/nanomaterials handling (e.g. engineering control techniques, administrative control systems and use of personal protective equipment).

The main activities carried out in the last twelve months include:

- Development and application of questionnaires with the purposes of: 1) collecting preliminary information on Health, Safety and Environmental aspects (HSE) of the PLs and 2) characterizing the state of development of the PLs and the implemented control measures. This also included Skype Meetings to clarify open questions. Although most of the questions were answered, more details for some aspects are required (e.g. safety controls in place, materials safety data sheets – MSDS, etc.).
- Initiation of technical visits to the pilot lines to understand the process, equipment, the H&S performance, the activities, materials used, and other relevant information related to environmental, safety and health issues. For this reporting period, ISQ has made a visit to Creative Nano pilot line. Unfortunately, due to COVID-19, the visits to Captive and Gaser planned for 11th and 12th March could not take place. This delay is therefore suspending the development of the task, considering that the information needed to be gather is very important for ISQ's good performance.
- Gathering information and characterization of the workplace environment for the different pilot lines (process flow description, different activities, operation procedures, potentially exposes during each task).
- Collection of information on the materials (and nanomaterials) handled in the pilot lines, including the analysis of MSDS and chemical databases.

5.1.4 Task 7.4: Standardization activities

The main objective of this task is to facilitate the acceptance and utilization by the market of the developed materials and processes. Other objectives are to provide starting information for other WPs, to ensure compatibility and interoperability with what already exists in the market through

standards, as well as to use the standardization system as a tool for dissemination of the project results and interaction with the market stakeholders.

In collaboration with ISQ, an initial analysis of the standardization landscape has been performed, starting from needs of other WPs about existing standards that can be related, as well as the related standardization committees and organizations involved.

In order to analyze the standardization landscape and to identify the exiting standards and standard documents under development relating to the project, key concepts of the project were assessed and standardization areas were identified. For this reason, the aims and goals of the project and the levels in which the project should integrate as well as the needs of the end users were considered.

ASFIMET representing the Italian section of European Standardization Committee (UNI - Ente nazionale italiano di unificazione) in the European CEN WG6/TC271 Group, is currently discussing the incorporation of the technology in plating lines according to standards already developed. Another action involves the discussion of the technology with the Nickel Institute, a global organization to promote and support the proper use of nickel in appropriate applications, as potential stakeholders for the use of Purenano technologies in the recovery and recycle of nickel.

5.2 Achievements and results of WP7

5.2.1 Task 7.1: Recyclability & Circular economy

The activities of this period are concentrated to the parallel development of Step 1 and 2. Particularly, an assessment of the state of the art EoL management has been identified addressing opportunities and bottlenecks in the management of the material flows. In parallel, the circular economy business models have been studied so far to define the appropriate models to be further analyzed in detail within the purpose of PureNano.

5.2.2 Task 7.2: Safe by design

Main achievements of this task, so far, include:

- Preliminary list of the chemical substances (including nanomaterials) to be used by the PureNano technology, as well as the identification of the main hazards associated to them.
- Progress on the literature review related to the risk assessment of nanomaterials, under a safe-by-design approach; and on the available tools required to carry out this risk assessment.
- Establishment of the framework to advance the risk assessment of the PureNano technology, based on the HSE standardization landscape and applicable standards (see Deliverable 7.1).

5.2.3 Task 7.3: Safety Lines & Nanosafety issues

Main achievements of the task, so far, include:

- Preliminary list of the chemical substances (including nanomaterials) employed in Creative Nano pilot line, as well as the identification of the main hazards associated to them based on MSDS and chemical databases.
- Identification of the significant hazards and hazardous situations, as well as recommendations on control measures, including the validation of the aspirators' airflow that are installed in the Creative Nano tanks, based on "EN 17059:2018 Plating and anodizing lines - Safety requirements".

5.2.4 Task 7.4: Standardization activities

Main achievements of Task 7.4 are:

- identification of several standards relevant to the PureNano project.
- assessment of the incorporation of the technology used in the project in the plating lines based on "EN 17059:2018 Plating and anodizing lines - Safety requirements".
- Feedback from Nickel Institute as stakeholder for nickel recovery and recycle

Table 7. WP7 Deliverables submitted

Deliverable Number	Deliverable Description	Date
D7.1	Report on the standardization landscape and applicable standards	16/01/2020

6. WP8 - LCA/LCC

6.1 Overview of activities in WP8

The aim of this WP is to assess the environmental and economic performance of the PureNano technology to support decision-making, as well as to raise awareness about possible adaptation of the technology to other sectors. The expected immediate or short-term deliverables of WP8 is the "Interim report on Life Cycle Assessments (LCA, LCC) (D8.1)" in month 18. This deliverable will focus on the advancement on the LCA and LCC of the processes and products generated within the project.

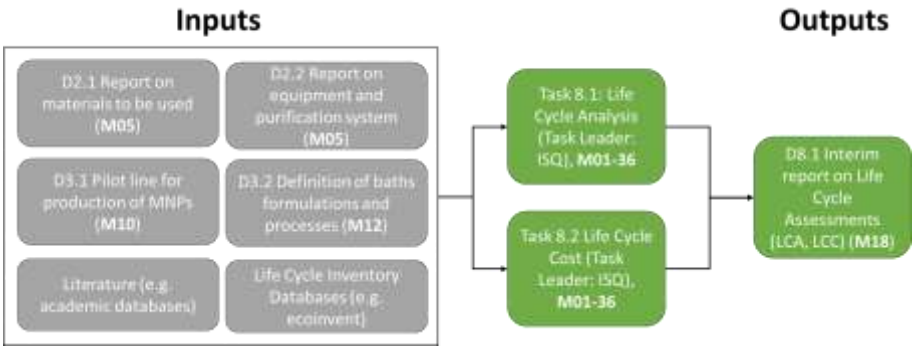

Figure 6. *Relationship of deliverable 8.1 with deliverables from other WPs.*

The progress of WP8 activities for this reporting period is presented below:

6.1.1 Task 8.1: Life Cycle Analysis

A detailed LCA of the PureNano technology, in line with ISO 14040:2006 and 14044:2006, will be performed by ISQ in collaboration with other technical partners. Following the traditional phases of and LCA, the main activities carried out in the last twelve months include:

1. Definition of goal and scope of the study:
    a. Definition of system boundaries and functional unit (based on the Deliverable 2.2).
    b. Ongoing literature review with the objective of gathering information regarding similar projects and identifying potential gaps.
    c. Scenarios definition to compare new technology (PureNano) vs conventional treatment (incineration or underground deposit).
2. Life Cycle Inventory:
    a. Development and application of questionnaires with the purposes of 1) collect preliminary information on inputs (materials, energy, other resources) and outputs (products, by-products, energy, emissions and wastes) of the PLs; and 2) identify the current waste and disposal treatment given to the spent bath. This also include Skype Meetings to clarify open questions. Although most of the questions were answered, more details for some aspects is required (e.g. waste treatment contractor information). ISQ is waiting for the additional requested information.
    b. Analysis of information contained in deliverables 2.1., 2.2 and 3.1.
    c. Collection of some background data/based on existing LCIA databases.
    d. Models of process steps and products, including
3. Life Cycle Impact Assessment:
    a. Selection of environmental impact categories and methods based on ILCD recommendations
4. Interpretation of the results: This phase will be carried out later in the project.

6.1.2 Task 8.2: Life Cycle Cost

This task focuses on the life cycle cost (LCC) of the processes and products involved in the PureNano technology. The aim is to approximately estimate the costs of the selected technical proposal to support decision-making processes for the scaling up. The LCA model is been used as the basis for a life cycle costing analysis to quantify the cost benefit of the new technology. A questionnaire is under development to collect information regarding the capital expenses for installations, operational costs (materials, manpower, waste treatment, etc.), expected down-time and operational risks and end of life costs. Similarly, to the second phase of the LCA analysis, the information from the other partners is key for the successful progress in the LCC.

6.1.3 Task 8.3: Eco-efficiency assessment

This task aims to apply an eco-efficiency evaluation tool (ecoPROSYS©), to improve the environmental and economic performance of the new developed products and processes. The implementation of ecoPROSYS© methodology will be accomplished once task 8.1 and 8.2 have achieved more progress. At this time, progress has been made in reviewing the methodology used by ecoPROSYS© to assess its applicability in this project.

6.2 Achievements and results of WP8

6.2.1 Task 8.1: Life Cycle Analysis

Main achievements of this task, so far, include:

- Stablish the method for the development of life cycle assessment.
- A preliminary literature review of similar LCAs regarding spent bath treatment.
- Definition of the system boundaries and functional unit.
- Construction of preliminary processes and scenarios in SimaPro, which will be fed with the collected data.
- Preliminary list of the chemical substances (including nanomaterials) that will be employed in the PureNano technology.

6.2.2 Task 8.2: Life Cycle Cost

Main achievements of this task, so far, include:

- A preliminary literature review of similar LCCs regarding waste treatment.

6.2.3 Task 8.3: Eco-efficiency assessment

Main achievements of this task, so far, include:

- Analysis of the current status of the ecoPROSYS tool (v. July2019) in order to identify the suitability to assess the PureNano technology and inform the need for adjustment in the tool or methodology.

7. WP9 - Dissemination & Exploitation

7.1 Overview of activities in WP9

7.1.1 Task 9.1: Exploitation activities

The main objective of this task is related to the development of exploitation and commercialization strategy that comprise different phases such as product identification, market analysis, preparation of product launch and strategic alliances. The exploitation strategy targets to plan market uptake, using specific business case studies for each partner and Key Exploitable Result (KER) as well as continuously monitor the market situation and assess arising business opportunities.

7.1.2 Task 9.2: Dissemination & Communication activities

The plan for dissemination and communication includes the following aspects: target messages and relevant audience, operative elements of promotion, valorization of results and awareness-raising with their timing, responsible partner, budget, and performance indicators. The C&D strategy has already been developed ensuring efficient project visibility and that communication actions are measurable, in order to divulge the project. The strategy also provides channels for scientific dissemination, guidelines, graphics, and template to allow coordinated dissemination of results and news.

7.1.3 Task 9.3: Knowledge management and IPR protection

AXIA is responsible for the management and IPR protection of the knowledge and technology. This encompasses result ownership, access rights to background and results, and transfer of results. These actions will enable the partners to exploit the results generated to their fullest potential.

Within this task, PoliMi collected all necessary information through a specific questionnaire and developed a first version of the Data Management Plan that was outlined in D9.2. Data Management Plan outlined how PureNano consortium collects, processes, publishes and stores data at project and work package level. Moreover, it outlined a framework for managing PureNano data in order to assure full lifecycle data management both during and beyond the project's lifetime.

7.1.4 Task 9.4: Innovation management

Innovation management, that is the main target of this Task has been used as a holistic overview of the actions related to the exploitation activities. A comprehensive exploitation plan is under developed since the early stage of the Project including all prerequisite actions that have been taken to reinforce the Exploitation Strategy with qualitative and quantitative measures. Innovation management works in parallel to the dissemination activities of project results to raise the awareness of stakeholders and the public.

Innovation management includes processes and structures, in order to manage and control activities that, starting from end users' needs, aim to continuously identify and check new ideas with the final objective of developing new products or services which can satisfy the needs of the electroplating industry.

7.2 Achievements and results of WP9

7.2.1 Task 9.1: Exploitation activities

The exploitation planning activities started at the beginning of the project, by setting up a comprehensive exploitation strategy oriented towards the project scope and the business orientation of the industrial partners. The exploitation strategy is built on the effective update and refocus of KERs. To this end, AXIA started to clarify and update the already defined KERs from the proposal stage. Furthermore, in order to better focus the exploitation plan and connect it to the existing list of KERs they have been categorized into 3 new groups according to the type of KER: Group A: Product Development, Group B: method of the purification process and Group C: Consulting. In this context, AXIA as responsible for the exploitation activities of PureNano has already prepared and distributed timely among the partners a questionnaire in order to acquire information that is connected to the exploitation and Dissemination & Communication activities of the entities in relation to each KER as included in the GA. All information acquired from the partners are being analyzed and will be included in the Deliverable 9.3 ''MidPlan for the Exploitation and Dissemination of Results – PEDR''.

7.2.2 Task 9.2: Dissemination & Communication activities

Website:

The website is the project's showcase and aims to increase public awareness of the project by providing visual and easy to comprehend information about PureNano. The Website (https://www.purenano-h2020.eu/) was published in October 2019 in order to disseminate information and engage the public from the beginning of the project. Social media have been setup and connected at an easy accessible position within the project webpage (top right) and all project news are also distributed towards these channels.

Figure 7. *PureNano website.*

The PureNano website is being continuously updated as far as the news-events and activities sections are concerned. The website also includes announcements about the project and allows visitors to download documents, such as publications, public deliverables, and project documents (newsletter, press release, flyer, etc.). Moreover, a Newsletter subscription tab was added in order to allow visitors to receive the latest activities of the Project (Figure 8).

Figure 8. *PureNano Newsletter subscription form.*

Website statistics:

Audience: The PureNano H2020 website is a website of world interest with visitors from 34 countries around the globe. The main bulk of visitors are from the European continent (nearly 71%), the American (nearly 16%) and Asian (nearly 13%). From the 270 unique visitors that visited the website nearly 15% are returning visitors that often check for news and updates in the website.

Figure 9. *Visitors around the globe.*

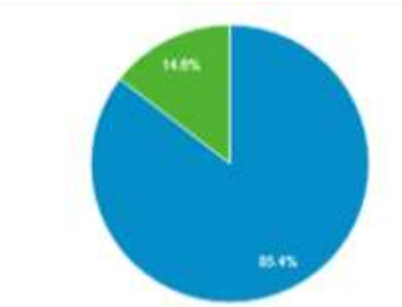

Figure 10*. New vs returning visitors.*

Social Media:

PureNano supports accounts in three major Social Media (SM) channels: Facebook, Twitter, LinkedIn. The project profiles serve as a complementary dissemination and communication channel in addition to the project website. They include general project information with the aim to proactively promote the project and its results, permitting a two-way exchange. Social media profiles are constantly updated with news, events and dissemination information related to the project.

Social media statistics:

PureNano Facebook page has currently 133 followers. From the beginning of the project until now, we 18 posts with 2739 reactions have been made in total. LinkedIn page has a total of 56 followers, and 575 post impressions that represent the total number of times our posts were seen and is one of the indicators of our project presence. Finally, Twitter account has 8 followers with 1351 impressions.

Facebook: https://www.facebook.com/PureNanoProject/

Figure 11. *PureNano Facebook page.*

LinkedIn: https://www.linkedin.com/company/purenano-project

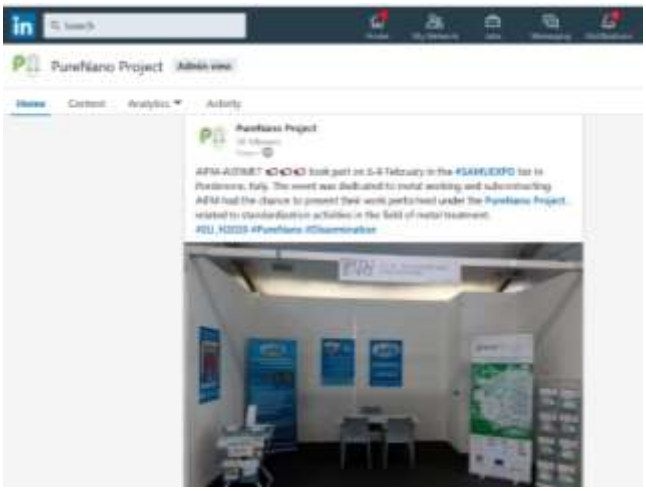

Figure 12. *PureNano LinkedIn page.*

Twitter: https://twitter.com/PureNanoProject

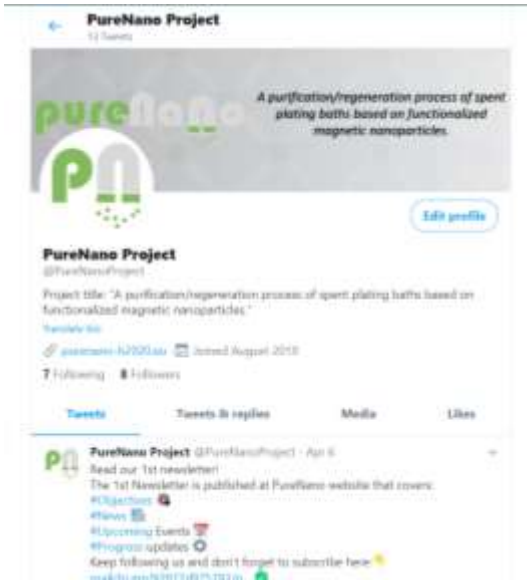

Figure 13. *PureNano Twitter account.*

Communication and Dissemination kit:

AXIA is responsible to monitor and prepare all the communication activities of the project. Accordingly, the following activities have been implemented:

- Design of the PureNano Corporate Identity
- Development of the projects´ dissemination & communication kit which includes templates for agendas & presentations and for word documents, a folder, a leaflet, a roll-up, and a barcode
- Press release and Newsletter

Press Release: The aim of the press releases is to attract media attention and increase public awareness of the PureNano project and its outcomes and events. The first project press release was published in October 2019 to inform about the kick-off meeting of the project and its objectives.

Newsletter: The 1st issue of the PureNano newsletter that was developed by AXIA, was published in February 2020 and included an overview of project objectives, news, upcoming events related to the sector and the progress of the project up to that date.

Figure 14. *PureNano 1st Newsletter issue.*

Figure 15. *PureNano Press release.*

Dissemination plan:

PureNano dissemination plan will address different target groups such as stakeholders related to surface finishing industry and nanomaterial production, engineering companies related to plating systems, waste recycling companies, sector associations, investment groups, Academia, Research institutes, applied technology, policy makers, European and regional authorities, general public and media. The dissemination plan targeting these groups and strategic impact of the project has been designed and will be coordinated on a regular basis between partners.

In order to keep track of dissemination activities, two questionnaires are circulated periodically to identify all past and potential upcoming events to be attended by each partner (Figure 16). Additionally, a third questionnaire has been prepared regarding the publications of each partner involved in PureNano. All this information based on the partner's contribution is gathered in excel files (Figure 17).

Figure 16. *PureNano Questionnaires on D&C activities, upcoming events, and publications.*

No.	Conference	Acro	Date	Location	Website	Contact	Frequency
1	SurfaceTechnology		16/06/2020	Stuttgart	https://www.surface-	Asfimet	Biannual
2	Eurocar Conference -		03/06/2020	Barcelona	http://www.eurosurfas	Asfimet	Every 3 years
3	EuroSciCon		11-12/5/2020	Frankfurt	https://nanotechnolog		
4	Eurocar		3-4/6/2020	Barcelona	http://www.eurosurfas		
5	Nanotechnology Rome		4-5/5/2020	Rome	https://scientonline.or		
6	32nd Nano Congress for		12-13/6/2020	Frankfurt	https://nanocongress.		
7	ACHEMA		14-18/6/2020	Frankfurt	https://www.achema.d		
8	Nanomaterials and		15-16/6/2020	London	https://nanomaterials.i		
9	SurfaceTechnology		16-18/6/2020	Stuttgart	https://www.surface-		
10	Materials Science and		22-23/6/2020	Rome	https://materialsscien		
11	16th Coatings Science		22-26/6/2020	Noordwijk	https://coatings-		
12	Euro Nano Mat 2020		26-27/6/2020	Paris	https://nanoscience.e		
13	Nanotech Expo 2020		9-10/7/2020	Geneva	https://nano.nanotech		
14	Euro Marerials 2020		27-28/7/2020	London	https://materialscienc		
15	European Technical		2-4/9/2020	Krakow	https://etcc2020.org/		
16	Materials Science,		21-22/9/2020	Milan	https://material-		

Publications | Dissemination Activities | Plan for dissemination

Figure 17. *D&C activities database.*

7.2.3 Task 9.3: Knowledge management and IPR protection

AXIA has already distributed a questionnaire in April 2020 in order to agree on the Initial ownership levels between partners, analyze the market segments and the business environment towards the development of individual business plans for each partner in the final exploitation plan. The contribution from each partner will provide information for both Exploitation and IPR management as such.

Moreover, the first version of the PureNano Data Management Plan has been elaborated and published.

7.2.4 Task 9.4: Innovation management

Innovation management covers all aspects related to Exploitation, Dissemination and Communication activities. Initially, innovation management activities ensure the effective deployment of the Exploitation plan. AXIA is in progress to monitor and collect market needs and customer requirements as well as to identify any mismatch between the project values and market/customer needs. Innovation management also encompasses the dissemination activities, and thus a comprehensive strategy has already developed in order to increase the awareness of the public through social media and focus on the communication channels as described in Task 9.2.

Table 8. WP9 Deliverables submitted

Deliverable Number	Deliverable Description	Date
D9.1	Project Web-portal, Blog and Social Media Groups	30/10/2019
D9.2	Data management Plan	20/01/2020

8. WP10 - Ethics requirements

8.1 Overview of activities in WP10

The ethics requirements that the project must comply with were defined in this WP. Documentation confirming the GDPR compliance of all partners including relevant systems and privacy practices were collected. Data Processing Agreement for personal data between the consortium was drafted and signed by all partners.
Authorizations for partners' facilities and documentation on the measures that taken to mitigate the risks of possible harm to the environment caused by the research were collected. Authorizations on appropriate health and safety procedures, conforming to relevant local/national guidelines/legislation, to be followed for staff involved in this project were also collected and kept on file.

8.2 Achievements and results of WP10

The following documentation regarding processing of personal data (POPD) was collected drafted and signed by all partners:

- GDPR compliance statement of each partner
- Data Processing Agreement for personal data
- DPO assignment letter

Regarding environmental risks and health and safety procedures, partners provided certifications of compliance with relevant local/national guidelines/legislation regarding:

- waste management
- occupational health and safety policy and procedures

Table 9. WP10 Deliverables submitted

Deliverable Number	Deliverable Description	Date
D10.1	POPD - Requirement No.1	13/01/2020
D10.2	EPQ - Requirement No. 2	08/12/2019