**INTEGRANO Case Study Information Sheet**

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| **Case Study Number and Title** | **Case Study 1.1 – Antimicrobial (medical) textile** |
| **Case Study Owner** | **CNR-ISSMC** |
| **Partners Involved in the Case Study and Their Role(s):** | **CNR-ISSMC:**   * **materials designers (Ag NPs, SiO2 NPs)** * **p-chem and morphological characterization of NMs and NEPs (DLS, ELS, SEM, ICP-OES, XRD, TG-DSC, FTIR, UV-vis, HPLC, BET)** * **incorporation management (Dip coating)** * **functionality assessment of NMs and NEPs (antibacterial test - Supported by an external lab, on demand)**   **Centi:**   * **materials designers (SiO2@TiO2 NPs)** * **incorporation management (Spray coating -available for textile, repeat some trials to check the machine)**   **CNR-ISMN:**   * **p-chem and morphological characterization (XRD, Programmed Reductions and/or Oxidation experiments, BET)**   **UNITO:**   * **materials designers (Egyptian Blue)** * **p-chem and morphological characterization (TEM)**   **AITEX:**   * **functionality assessment**   **BIU:**   * **functionality assessment (antibacterial test)**   **CNR-IAS:**   * **ecotoxicological model**   **UNIMIB:**   * **toxicological model** |

* **Case study aim, scope and goals. Briefly indicate the synthesis and incorporation plans, the applications of the NMs and NEPs, and define the life cycle stages of the nanomaterial:**
  + **Case study objective:** Products and applications where NPs are considered to provide enhanced antimicrobial performances are already present in many sectors such as clothing and textiles, healthcare, filtration systems, and others. This demonstrates the acceptability to both industries who may apply such technology to their products as well as consumers which is key for commercial sustainability and product reach. Nevertheless, despite the enormous need for affordable and broad-spectrum antimicrobial protection nanotechnology solutions and the proven and already exploited capacity to fight infections, in March 2020, the US FDA issued warning letters to companies that were selling fraudulent products, including colloidal silver, claiming to prevent, treat, mitigate, diagnose or cure COVID-19. So, it still needs green, safe, and easily scalable technology and a robust empirical and modeling validation plan. Antiviral and antimicrobial coating properties are significant due to the impact of COVID-19 and the fear that new pandemics can occur. Proven capability of effective killing within specified contact times is of high interest to textile companies and consumers:innovative textile product manufacturers, PPE providers (face masks, medical uniforms, upholstery using woven and not woven textile), final customers of high quality and innovative products for the protection of human health and environment.
    - Development of a textile with antibacterial properties: coating of Ag NPs (AgHEC, AgHEC 6.4 and AgCUR) and engineered SiO2 NPs, provided by CNR-ISSMC, coating of SiO2@TiO2 NMs, provided by Centi, and coating of Egyptian Blue, provided by UNITO. Both NMs SiO2-based materials will be compared with the use of bio-silica from rice husk, provided by Centi. Centi and ISSMC will take care of the incorporation process, respectively Spray coating and dip coating.
  + **Case study strategy:** 
    - **innovation on materials:** 
      * investigating the synthesis variables linked to SiO2 (synthetic and from rice husk)/active ingredients, and encapsulation process;
      * as far as Ag NPs concerned, we will consider the synthesis parameters already optimized in ASINA.
    - **innovation on the process:**
      * investigation of the Spray Coating and Dip Coating application parameters to optimize the deposition yield, washing fastness/ abrasion resistance, and functional durability.
  + **Life cycle stage to be addressed:** synthesis (for new materials), incorporation, and use phase
* **Are there pre-existing data available for this case study?**
  + yes. Ag-based NMs and NEPs will benefit of the data collected in ASINA.
* **List of the (expected/addressed) relevant Key Performance Indicators (KPIs)** **for the case study), which imply experimental characterisation and tests:** 
  + **-**p-chem properties: Z-potential (ELS), nanoparticle size (DSL, TEM, XRD), superficial area (BET, N2 adsorption), elemental composition (ICP-OES), surface chemistry (XPS), nanoparticles loading on the substrate (ICP-OES).
  + functionality tests: antibacterial (MIC against Gram + and Gram – bacteria, MBC), Programmed Reductions and/or Oxidation experiments.
  + Human Toxicity tests: genotox, oxidative stress which endpoint? (e.g. skin, lung).

Human toxicity test will be conducted, on relevant and selected NPs, in in vitro model of the lung (alveolar and brochial cells in mono- and co-culture with THP-1 derived macrophages). The following endpoints will be addressed: cell viability, release of inflammatory mediators (ELISA), oxidative stress (oxidative potential through acellular test and cellular ROS), DNA damage, expression of genes related to response pathways..

* + Eco-tox tests: ecotox tests will be conducted by using bacteria, microalgae and the larval stages of several invertebrates belonging to the aquatic compartment (including either freshwater and marine environment). The following endpoints will be addressed: bacteria bioluminescent inhibition, microalgal growth inhibition, mortality/immobility/fertilization rate/embryotoxicity/behavioural alteration of aquatic invertebrates (i.e. crustaceans, rotifers, echinoderms, jellyfish).
  + Emission sampling campaign: only for the best implemented sample (Ag NPs)
    - use release (washing fastness, abrasion resistance) in the water compartment.
    - workers exposure during the incorporation process Ag-based NMs and NEPs will benefit of the data collected in ASINA
* **List the relevant Key Decision factors (KDFs) (e.g. reagent concentrations, processing parameters, synthesis temperature) for the case study(\*):**

For the synthesis for Ag NPs:

Is already optimized

For the synthesis for SiO2 NPs/ active ingredients:

* + **Minimum and sufficient number of KDFs:** 2 KDFs
  + **What KDFs:** ratio matrix/active ingredient; active ingredient composition.
  + **KDF is it a discrete or continuous variable?** both continuous and discrete variables possible.
  + **(for continuous) KDF values range:** Mass ratios (0.1< x < 10).
  + **(for discrete) KDF levels:** different composition

For the incorporation Spray coating: for Ag NPs and SiO2@TiO2 NPs (only on one NMs type, es. AgHEC and SiO2@TiO2 NPs)

* + **Minimum and sufficient number of KDFs:** 3 KDFs for the deposition step and 2 KDFs for the curing step
  + **What KDFs:** 
    - 1a) flow rate, 1b) belt speed, 2) nozzle distance, 3) nanomaterials concentration,
    - 4) curing temperature, 5) curing time.
  + **KDF is it a discrete or continuous variable?** KDF1a KDF1b KDF2 KDF3 KDF4 KDF5 are continuous.
  + **Unit of measurement of the KDF:** KDF1a – mL/min, KDF1b – m/min, KDF2 – cm, KDF3 - wt%, KDF4 – °C, KDF5 – min.
  + **(for continuous) KDF values range:** KDF1a (50<x<200), KDF1b (0.5<x<6), KDF2 (20<x<35), KDF3 (0.01 <x< 1), KDF4 (80<x<120), KDF5 (5 <x<15).

For the incorporation Dip coating: for AgNPs and Egyptian Blue

* + **Minimum and sufficient number of KDFs:** 3 KDFs for the deposition step and 2 KDFs for the curing step
  + **What KDFs:**
    - soaking time, 2) number of impregnation steps, 3) nanomaterials concentration,
    - 4) curing temperature, 5) curing time,
  + **KDF is it a discrete or continuous variable?** KDF1 KDF2 KDF3 KDF4 KDF5 are continuous.
  + **Unit of measurement of the KDF:** KDF1 – min, KDF2 – #, KDF3 – wt%, KDF4 – °C, KDF5 – min,.
  + **(for continuous) KDF values range:** KDF1 (5 <x<10), KDF2 (1<x<5), KDF3 (0.01 <x< 1), KDF4 (80<x<120), KDF5 (5 <x<15).

(\*) please note that:

* the KDF selection is primarily addressed to the targeted functionality level of the solutions (e.g. Nano material functionality, product functionality,….)
* KDFs may be selected based on process experience / use phase or end-of life options analysis ….
* KDF number is strongly affecting the number of experiments: e.g.
  + # **2** KDFs imply a minimum number of **6** measured samples with average value and uncertainty
  + #**3** KDFs imply a minimum number of **10** measured samples with average value and uncertainty
  + **….**
* KDF selection may be based on:
  + Process experts
  + Available previous (primary=specific and owned) data on process and its effects on experiment results
  + Available data from the literature, databases,….