INTEGRANO Case Study Information Sheet

Case Study Number and Title	**CASE STUDY 4.1: Air Filter**
Case Study Owner	**UNITO / CENTI**
Partners Involved in the Case Study and Their Role(s):	**UNITO (characterisation and production of Egyptian Blue)** **CNR-ISAC (management of the case study and functionality test)** **CENTI (spray coating pilot plant and provider of BIO silica)**

- **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:** (why are we addressing this case study? Which is its relevance? For whom/stakeholder?) e.g. development of a new photocatalytic element / component of device/material

    The case study focuses on **optimizing the synthesis process of Egyptian Blue** (cuprorivaite, $CaCuSi_4O_{10}$) in different formats, initially in micrometer size and base material, and then potentially in nanometer size and/or bio-based material. Based on these results, the possible incorporation -e.g. spray coating process- will be evaluated at a later stage. In relation to the shape of the samples obtained, the following applications will be explored: 1) VOC abatement through photocatalytic degradation; 2) antimicrobial properties for face mask and air filtration applications.

  - **Case study strategy:** innovation, substitution, improvement, accomplishment by studying further life cycle stages, data integration of an already investigated case study….

    Egyptian Blue (EB) is a multi-component material, composed mainly of calcium-copper tetrasilicate, for which several heating phases are necessary, as well as washing/annealing to remove impurities. The number of heating cycles, their duration, as well as the washing stage, are not standardized yet, as they depend on several parameters (e.g. quantity of material inside the oven, type of oven, impurities present, etc.). The two variables "cooking time" and "rinsing" will be explored to determine the best combination for a "lower energy consumption" strategy.

    Depending on the results, at a later stage, the use of rice-husk-derived silica may be explored in order to increase the sustainability of the product with a substitution strategy. Furthermore, the case study may also test an incorporation process, and eventually improve it by reducing the size of the powders from micro to nano scale.
  - **Life cycle stage to be addressed:** (synthesis, and/or incorporation, and/or use phase and/or end-of-life)

    Synthesis

- **Are there pre-existing data available for this case study? E.g.**
    - yes previous life cycle stage(s) data like synthesis (if you are now addressing to the incorporation phase)
    - yes same life cycle stage, incomplete DoE matrix data

      incomplete DoE matrix data.

- **List of the (expected/addressed) relevant Key Performance Indicators (KPIs) for the case study), which imply experimental characterisation and tests:**
    - -p-chem properties: (such as Z-potential, nanoparticle size;…)

      Particles size, Z-potential.

    - functionality tests: (such as antibacterial or photocatalytic activity)

      VOC degradation for powders samples, and antibacterial activity if samples will be incorporated into a fabric/membrane.

    - Human Toxicity tests: which? (e.g. genotox, oxidative stress, ….) which end point? (e.g. skin, lung, intestine,…)

      Micrometer-sized EB is too large to risk inhalation.

    - Eco-tox tests: which? which addressed environmental compartment/ species? Which end point is addressed?

      Not expected for micrometer-sized EB. To be evaluated if samples will be incorporated into a fabric/membrane.

    - Emission sampling campaign: which kind? (e.g. leaching, airborne NP sampling,…) Which environmental compartment? (air, water, soil?)

      Not expected for micrometer-sized EB. To be evaluated if samples will be incorporated into a fabric/membrane, especially in case of a spray coating technique.

List the relevant Key Decision factors (KDFs) (e.g. reagent concentrations, processing parameters, synthesis temperature) for the case study(*):

- **Minimum and sufficient number of KDFs:** e.g. 2 KDFs

  2 KDF for the synthesis of micrometer-sized EB.

- **What KDFs:** (quantity addressed e.g. reagents in a formulation, processing parameters,…etc.)

"heating time" and "rinsing".

- **KDF is it a discrete or continuous variable?** (level / continuous e.g. number of nozzles in spray coating is discrete variable, flow rate is continuous variable)

  "Heating time" is discrete as it can be 32/48/64 hours.

  "Washing cycle" is discrete: washed or unwashed.

- **Unit of measurement of the KDF:** e.g. flow rate ml/min….

  Cooking time is measured in hours.

- **(for continuous) KDF values range:** eg. KDF1 0.5ml/min<flow rate<2.7ml/min, ….

- **(for discrete) KDF levels:** e.g. low, medium, high

  Heating time can be: 32 / 48 / 64 hours.

  Initial heating time of 32 h for a 3 kg batch. Of this: i) 500 g is taken (named sample A); ii) 500 g is taken and rinsed (named sample B); iii) the remaining 2 kg is heated for another 16 h. Considering the 2 kg of powder heated for a total of 48 h: iv) 500 g is taken (named sample C); v) 500 g is taken and rinsed (named sample D); vi) the remaining 1 kg is heated for another 16 h. Considering the 1 kg of powders heated for a total of 64 h: vii) 500 g is taken (named sample E); viii) 500 g is taken and rinsed (named sample F).

(*) 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,….