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Abstract

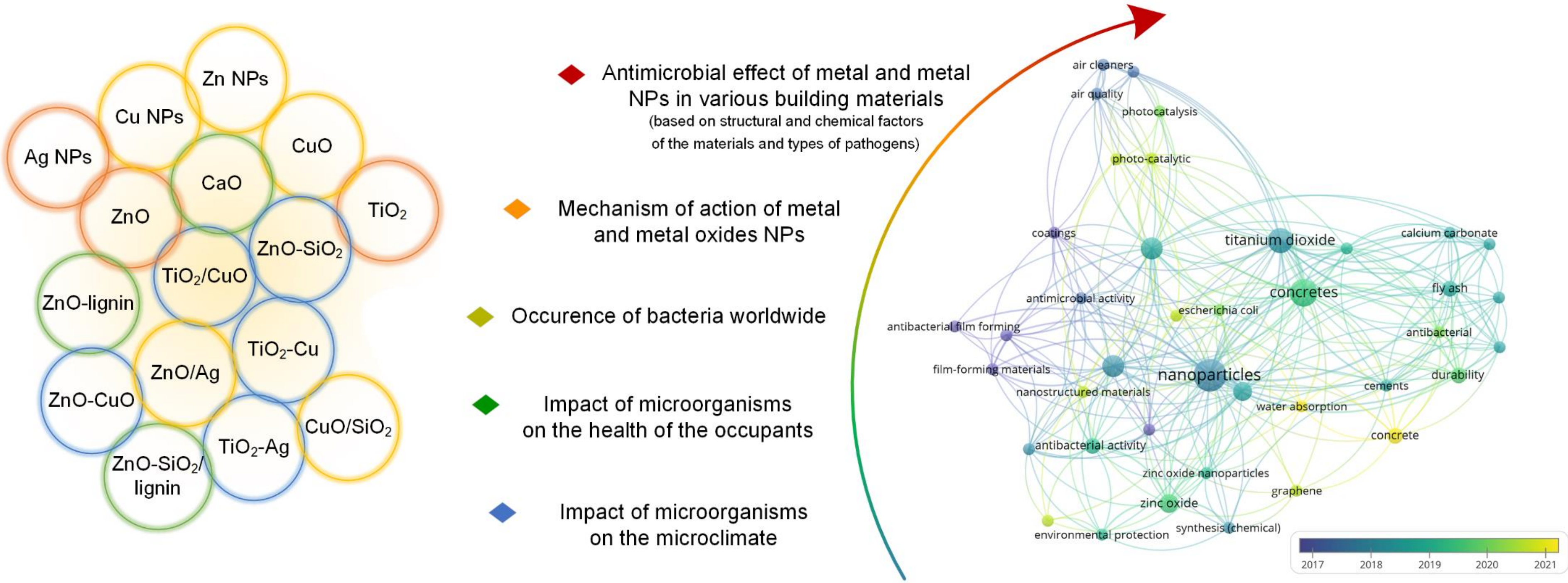
In view of the intensive development of the construction industry and the importance of environmental concerns, in recent years attention has increasingly been paid to the design and fabrication of construction materials that will exhibit not only adequate strength and quality parameters, but also low carbon and water footprints and high durability causing a longer life cycle, which together will lead to the creation of sustainable products. Unfortunately, the production of many construction materials, including concrete in particular, is associated with high atmospheric CO_2 emissions and significant energy inputs, which in the case of concrete are required for its production and its incorporation into construction elements. Materials which may be used to mitigate the environmental impact of concrete include chemical admixtures, especially superplasticizers, which when added even in small quantities can enable significant reductions in quantities of cement and water, while retaining the suitable rheological parameters of the mixture. Reduction of the water–cement ratio also leads to improvement in the compression strength of cement composite, and the replacement of clinker in the structure of concrete with alumino-silicates compounds having pozzolanic and/or hydraulic properties also leads to improvement of the materials' performance and durability. Unfortunately, the need to supplement cement clinker with ever increasing quantities of additives sometimes results in a lack of compatibility with new cements containing superplasticizers, leading to their partial or total deactivation.

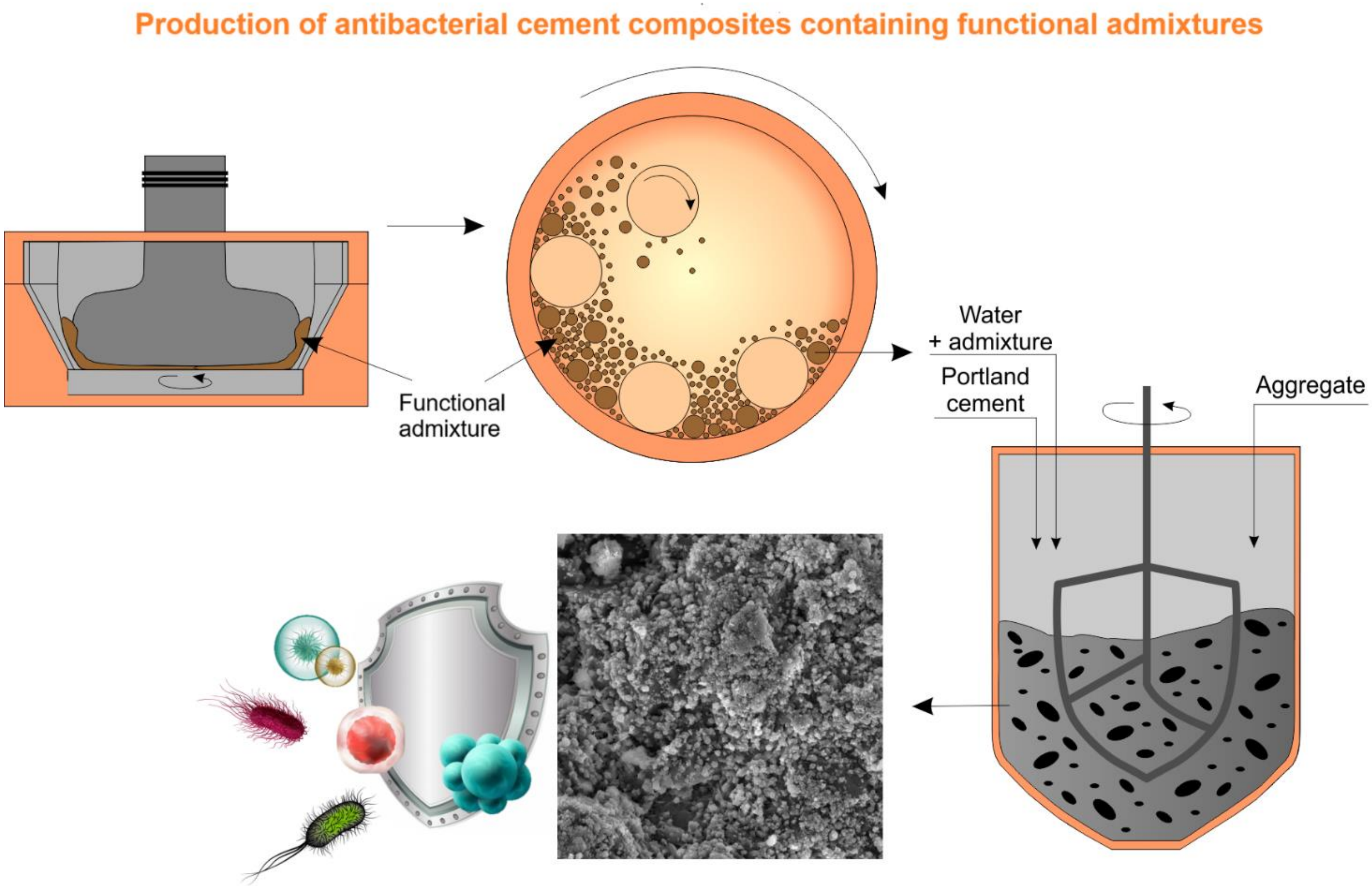
Despite the wide range of materials and/or biomaterials available for various technological applications, there seems a clear need for novel and specially designed hybrid materials with defined, strictly controlled properties. Functional admixtures/additives are crucial in the production of active cement composites for application in modern and sustainable construction.

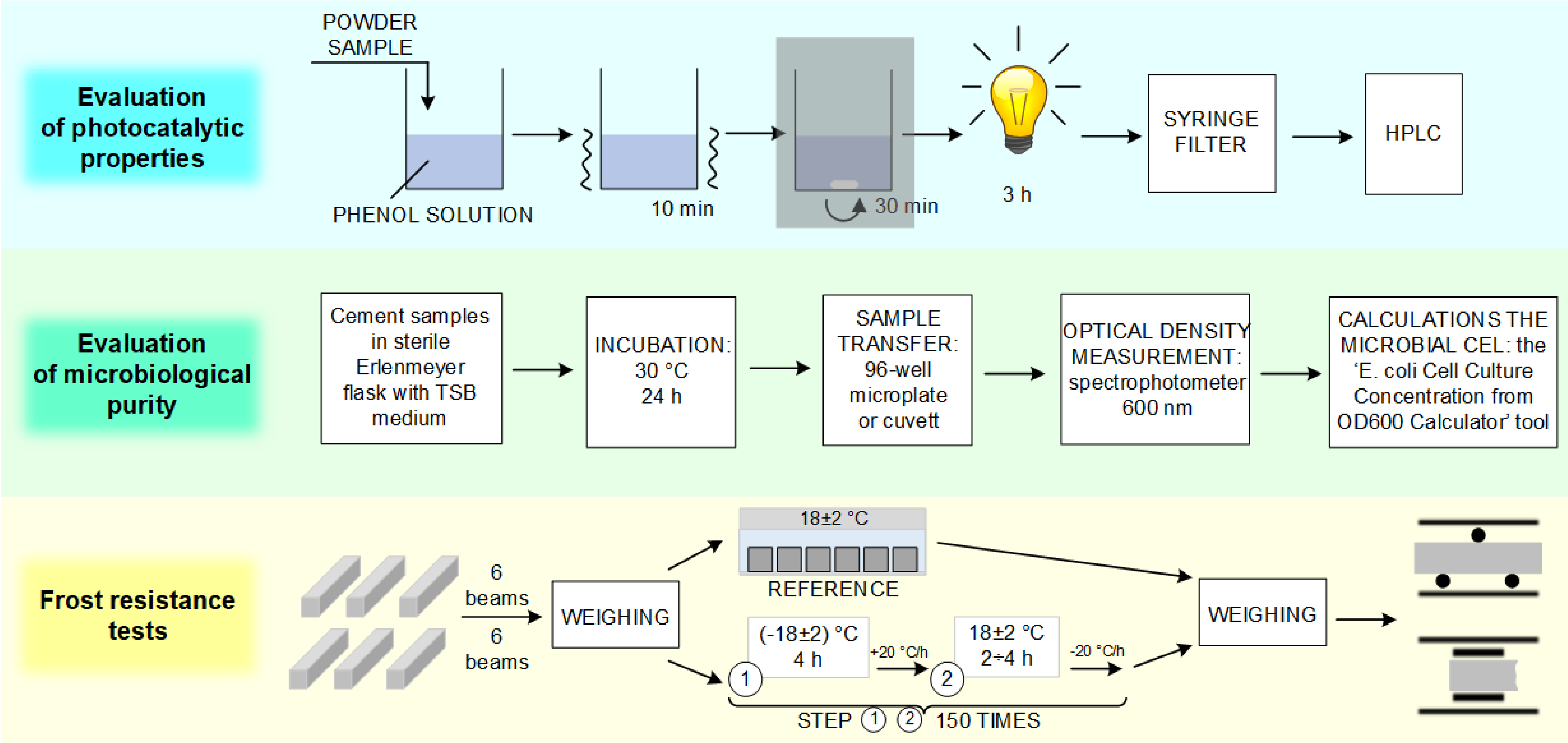
The primary goal of the research is the design of functional inorganic-organic hybrid materials formed using selected oxides, multi-component oxides or silicate oxide systems and biopolymers (lignin and/or its derivatives) as admixtures in cement composites. It is vital to carefully consider the type and amount of cement binder, the composition of the aggregate and the water-cement ratio enabling the selective operation of newly developed, advanced admixtures.

Due to ever worsening environmental pollution, an important goal is to determine the self-cleaning properties of the obtained mortars, which are mainly result from the presence of nanocrystalline TiO_2 in their structure, enabling the occurrence of photocatalytic processes and affecting the light-induced superhydrophilicity of the surface. Verifying the ability of the obtained composites, which include appropriate admixtures, to inhibit the growth of selected model species of microorganisms (Gram-positive and Gram-negative bacteria, and fungi), algae and mosses is an extension of these tests.

Building materials modified with metal and metal oxide NPs against microbial multiplication and growth




Production of antibacterial cement composites containing functional admixtures
Functional
admixture
Water
+ admixture
Portland
cement
Aggregate


Evaluation of photocatalytic properties
POWDER SAMPLE
PHENOL SOLUTION
10 min
30 min
3 h
SYRINGE FILTER
HPLC
Evaluation of microbiological purity
Cement samples in sterile Erlenmeyer flask with TSB medium
INCUBATION: 30 °C 24 h
SAMPLE TRANSFER: 96-well microplate or cuvett
OPTICAL DENSITY MEASUREMENT: spectrophotometer 600 nm
CALCULATIONS THE MICROBIAL CEL: the 'E. coli Cell Culture Concentration from OD600 Calculator' tool
Frost resistance tests
6 beams
6 beams
WEIGHING
18±2 °C
REFERENCE
(-18±2) °C 4 h
+20 °C/h
18±2 °C 2÷4 h
-20 °C/h
STEP ① ② 150 TIMES
WEIGHING