A new porous hybrid material to reduce air particulate matter (PM)

Alessandra Zanoletti[1], Fabjola Bilo[1], Laura Borgese[1], Stefania Federici[1], Laura Eleonora Depero[1,2], Elza Bontempi[1,2]

[1]INSTM and Chemistry for Tecnology Laboratory, Mechanical and Industrial Engineering Department, University of Brescia.

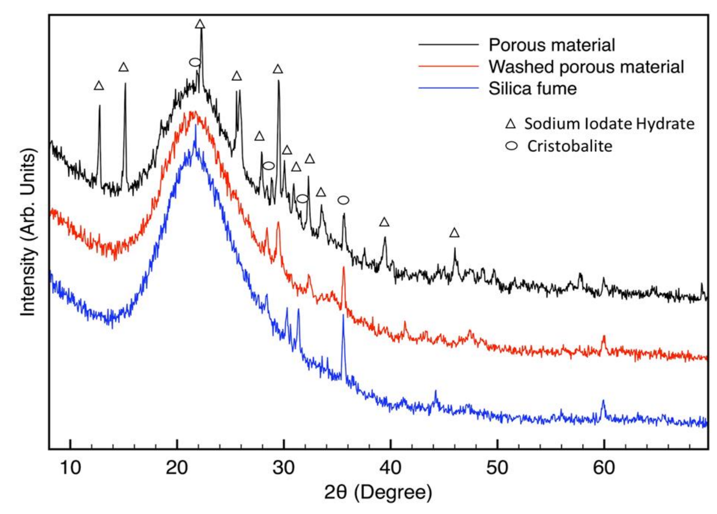
[2]B+LabNet, Laboratorio per l'Ambiente, la Salute e la Sostenibilità, University of Brescia.

e-mail: *a.zanoletti002@unibs.it*; *fabjola.bilo@unibs.it*; *laura.borgese@unibs.it*; *stefania.federici@unibs.it*; *laura.depero@unibs.it*; *elza.bontempi@unibs.it*

Introduction

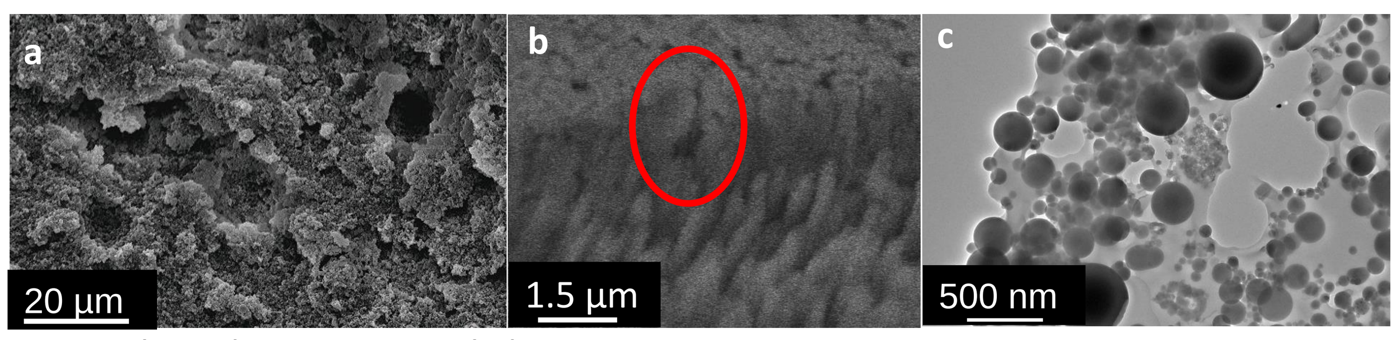
The work presents a new porous-mesoporous hybrid material (named SUNSPACE), which is a well-designed, affordable and sustainable solution for air particulate matter (PM) capture. The proposed innovative porous material is realized by using industrial by-products and low-cost materials. Foliage represents right now the best low-cost and sustainable solution for PM accumulation (for example, in Chicago urban trees, which occupy 11% of the city area, remove about 234 tons of PM_{10} per year). Leaves efficacy in PM accumulation is also due their wide diffusion. Then for SUNSPACE design, it was chosen a low-impact material, that can be applied on wide spaces. It is proposed to apply SUNSPACE, as a coating, on different supports, such as wall, tiles, roof, street borders, and so on, and thus it was designed to be applied by spray and by painting. SUNSPACE contains pores (from micron to nanometer sizes) having ideal shapes and dimensions for ultra-fine PM trap. It is shown that it can accumulate at least 30 g/m^2 of particles, at the cost of 0.02 € per gram of captured PM. As it happens in nature for leaves, SUNSPACE is designed to be regenerated, after PM capture, simply by rainfall. The discharge water can be collected by the urban wastewater collection system (for example with wastewater deriving from street washing) to be conveyed at the urban wastewater treatment plant, with no additional impacts.

Materials and approaches



XRD spectra of SUNSPACE before and after washing and Silica fume

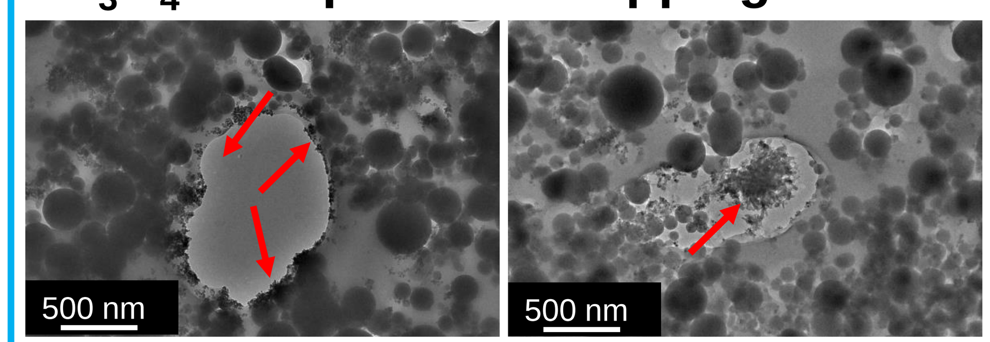
- Material consolidation by gelling properties of alginate and by sodium bicarbonate decomposition;
- Different SUNSPACE applications;
- Material with ink bottle shape pores;



SEM (a, b) and TEM (b) images of SUNSPACE. In red circle a detail of ink bottle shape pore.

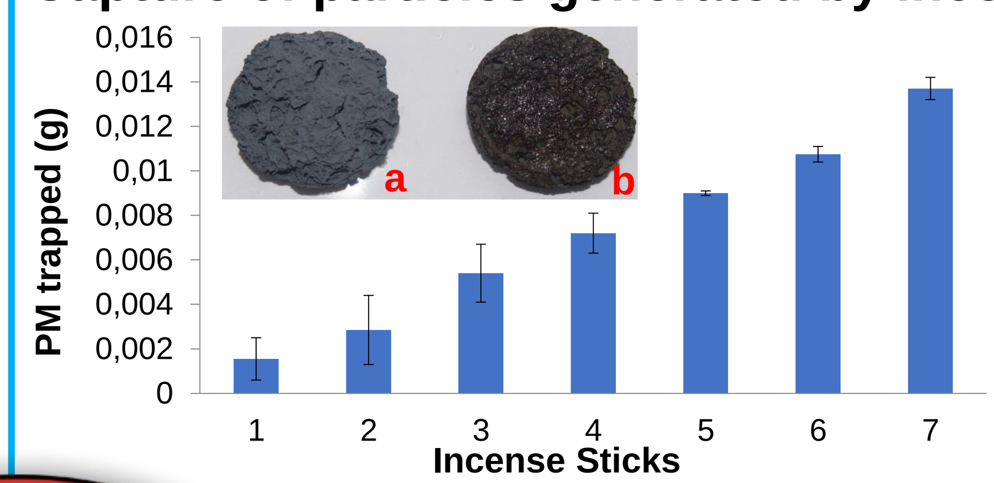
Outcomes

Fe_3O_4 nanoparticles trapping test



✓ TEM images of Fe_3O_4 nanoparticles located on the border and on the center (see arrows) of SUNSPACE pores.

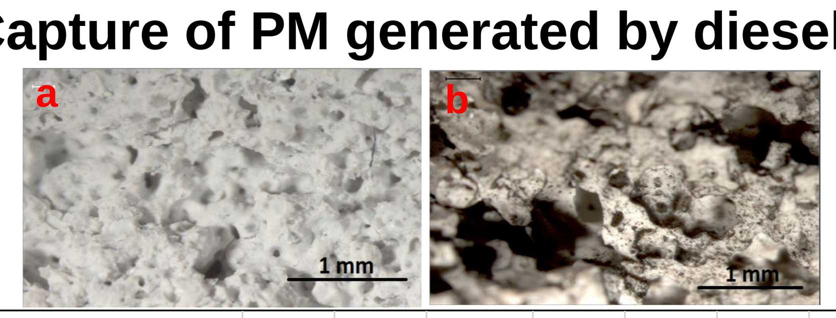
Capture of particles generated by incense



✓ Surface of the sample, with captured incense PM, is covered by a black homogeneous layer;

✓ SUNSPACE adsorbs till to **30 ± 0.8 g/m^2** of PM.

Capture of PM generated by diesel

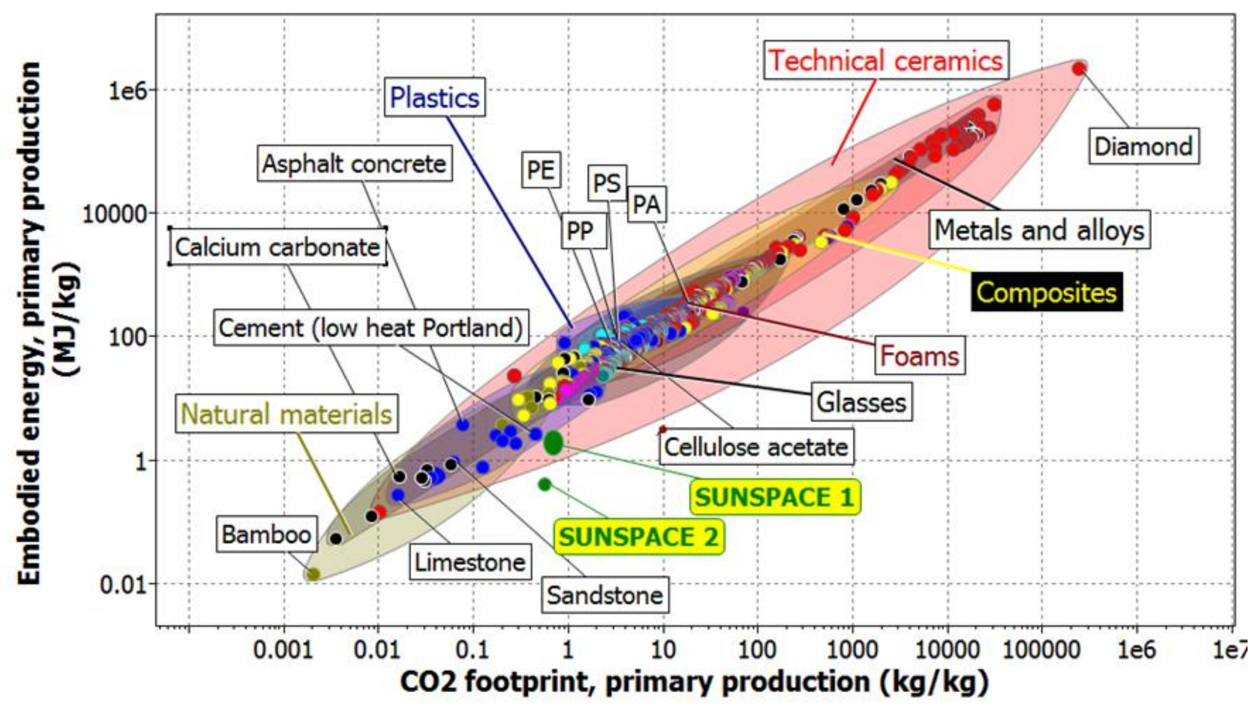


Element (weight%)	C	O	Na	Si	Ca	Ti	I
a(before)	/	39.44	1.44	51.27	1.01	4.98	1.87
b(after)	23.35	39.69	22.97	11.63	/	0.76	1.6

✓ Sample exposed to diesel car contains 23 % of carbon on its surface

Sustainability

- ✓ Synthesis process does not require the use of solvents and precipitating agents;
- ✓ Reuse of waste materials promotes environmental sustainability;
- ✓ To allow the decomposition of bicarbonate it is possible to exploit solar energy (leaving the sample outdoors on a sunny day).

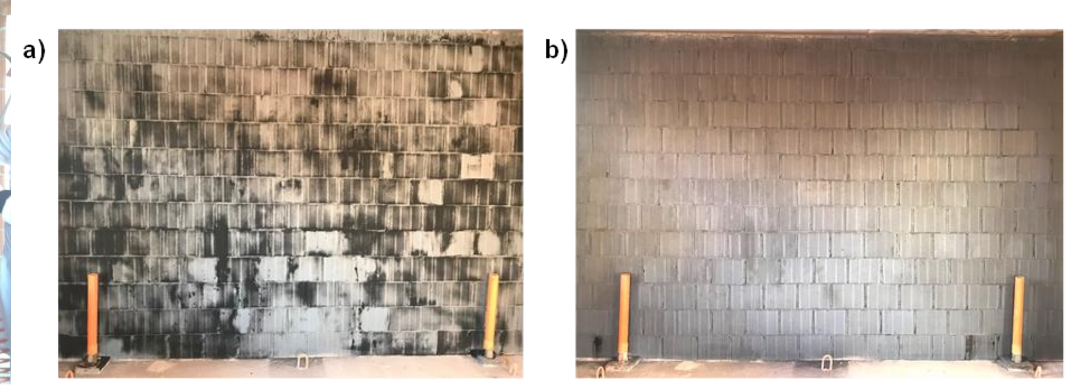


Embodied energy and CO_2 footprint of SUNSPACE (obtained by thermal annealing- SUNSPACE 1, and without thermal annealing -SUNSPACE 2). As comparison also energies and emissions involved in the production of materials used as filters such as polyethylene (PE), polypropylene (PP), polyamide (PA), polystirene (PS) and glass are reported.

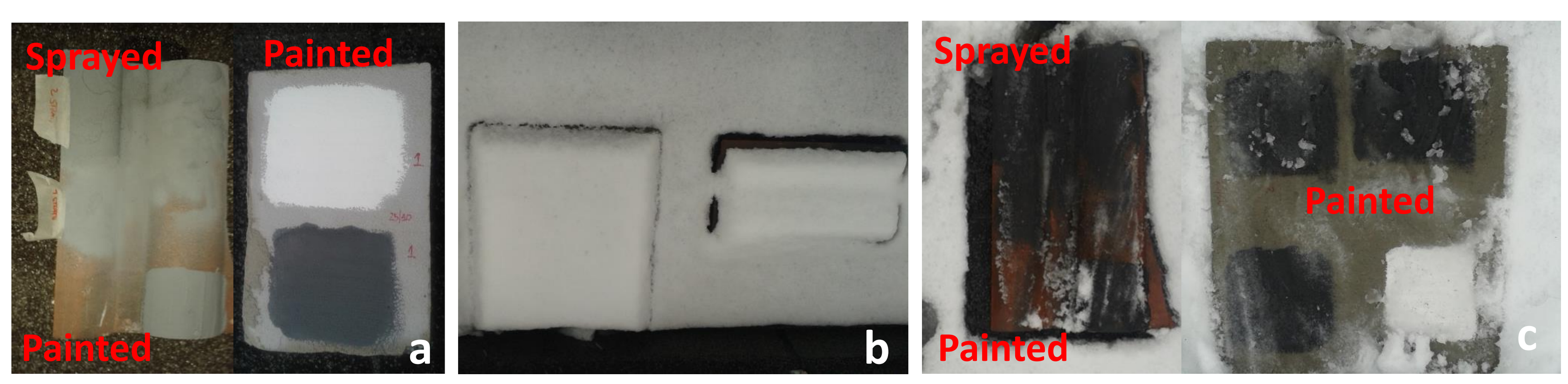
Transferability

Demonstration of a development version of SUNSPACE material, in the operational environment (TRL level 7), realized by deposition of the new materials as a coating.

Building realized at University of Brescia (Delta Phoenix) (a), where SUNSPACE was applied as plaster (b)



SUNSPACE applied indoor during (a) and after (b) the drying process.



Application of SUNSPACE onto a roof tile and a part of a wall (a). SUNSPACE sample after 2 months of exposition on the University roof (b and c).