for 1 hour. The powder was characterized by means of X-ray diffraction, laser granulometry and scanning electron microscopy (SEM). SEM observations were done also on screen-printed films.
Results and discussion: $BaTiO_3$-CuO thick-film screen-printed sensors were successfully produced through a simple solid-state method. The adhesion of the powder was good only for the higher temperature thermal treatment, at 1.100°C. To unravel the potentialities of this mixed oxide for CO_2 detection, the sensors were tested in a wide CO_2 concentration range (from environmental actual concentration to few thousand ppmv) at the temperature of 250°C. Very preliminary tests carried on some sensors showed a limited sensitivity to CO_2 in the adopted experimental conditions: improvements to increase sensors response and sensitivity like photo-activation of $BaTiO_3$-CuO films are ongoing.

COMPUTATIONAL TOOLS AND METHODOLOGIES FOR THE SUSTAINABLE USE OF MATERIALS IN ENGINEERING AND DESIGN

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Introduction: Sustainability is a broad topic that engineers need to consider when developing new products as well as improving existing products. It involves resources, material and energy flows, alongside societal and economic aspects. Increasingly, sustainability is of concerns among professionals, researchers, and educators from any engineering field, making it an interdisciplinary but complex topic.
Materials and methods: In this talk, we present an interactive computational tool and unique database of material properties that enables rational and sustainable material selection in engineering design. These are based on a methodology developed by Prof. Mike Ashby at the University of Cambridge and enable cost, manufacturability, mechanical performance, and eco-properties such as embodied energy or CO_2-footprint to be taken into account in a visual and interactive way. Life-cycle implications can be estimated at the early design stage and guidance provided to the designer or the student on ways to change the design for improved environmental performance.
Results: Examples based on a recently developed Sustainability Database and Eco Audit function will be used to show how these tools can be used to support resource and criticality aspects in teaching as well as product development.
Discussion: This computational tool now provides an initial framework for sustainable assessment in product development. The database and tools, alongside a set of teaching resources are used today in a growing number of universities worldwide to educate the engineers of the future.

INORGANIC BINDERS BASED ON FIRED LIMESTONE-CLAY RAW MATERIALS

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Introduction: Limestone-clay based natural or artificial mixtures are investigated as inorganic materials for the production of sustainable inorganic binders as hydraulic lime or belite cement. From preliminary tests it has been found that it necessary to pay much attention to both the nature and composition of the starting material in order to maximize the content of hydraulic active components. This because some mineral phases among them mainly the gehlenite have been mistakenly considered and computed as an active component of the fired product by others researchers.
Materials and methods: Calcium carbonate, aluminum hydroxide kaolin and amorphous silica pure for analysis reagents (Sigma-Aldrich) and non-commercial types of natural raw materials classified as limestone, siliceous limestone, clay marl and calcareous marl were used in this study. The first set of reagents were employed to prepare binary and ternary mixtures of pure chemicals with a widely weight ratio ranging from 90/10 to 20/80. Characterization procedure by thermal analysis and powder X-ray diffraction techniques were made both before and after the thermal treatment performed in a platinum crucible at 1000 ÷ 1100 Celsius degree for a reaction time of 2-3 hours.
Results: Experimental findings have clearly shown that thermal treatment of both pure mixtures of limestone and kaolin with largely variable $CaCO_3$/$Al_2(OH)_4Si_2O_5$ weight ratios and natural raw materials based on these two minerals gives rise to the formation of a mixture of several minerals always including besides lime and larnite the gehlenite. The same has also found in the fired products derived from raw materials characterized by the presence of kaolinite clays. Gehlenite and other calcium silicate and calcium aluminosilicate as wollastonite and anorthite, respectively were not found when Al_2O_3 and SiO_2 are provided from two separate sources.
Discussion: The study proposed has highlighted that sustainable firing cycle on raw materials such as clayed limestone, marl and marly clays can lead to feebly hydraulic binders characterized by a content of active part (lime + belite) ranging from 15 to 65%. Otherwise ternary mixtures of calcite, aluminum hydroxide and amorphous silica processed under the same experimental conditions can lead to strong hydraulic limes and belite cement.

MECHANICAL CHARACTERIZATION OF BIORESORBABLE PHOSPHATE OPTICAL FIBERS

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Introduction: Phosphate glasses can be properly engineered to fabricate bioresorbable optical fibers. Such fibers have been employed for diffuse optics experiments and dissolution in simulated body fluids was demonstrated with a rate of 2 μm/day. In the present work, step-index 125 μm diameter optical fibers were manufactured by rod-in-tube technique starting from two slightly different bioresorbable phosphate glasses. The prepared fibers underwent morphological and optical characterization, followed by the measurement of their mechanical properties.
Materials and methods: The investigated phosphate glass compositions included the following components: P_2O_5, CaO, Na_2O, SiO_2, MgO. The core and cladding glasses were fabricated by melting a powder batch of high purity chemicals inside an alumina crucible at a temperature of around 1200°C, followed by casting into preheated brass molds. The core glass was cast into a cylindrical mold to form a rod, while for the cladding glass rotational casting was carried out to obtain a tube. Capillary fibers were obtained by directly drawing the cladding glass tubes. The optical fiber was characterized by measuring the optical loss by cut-back method at the wavelength of 1300 nm. Mechanical tests on the fibers included tensile tests both in dry and humid environments with the aim of determining their elastic moduli and tensile strengths.
Results: The prepared fibers were homogeneous and in the case of the optical fiber a very good core/cladding interface was observed, leading to an optical loss of 3.4 dB/m. Tensile tests were carried out on fibers with gage length from 10 to 150 mm, this allowing the determination of a failure stress ranging from ~200 MPa to ~400 MPa and an elastic modulus of about 53 GPa. This latter was also determined on capillaries produced by the glasses constituting the core and cladding. This provided the evidence of higher stiffness of the cladding glass composition, whose elastic modulus (around 53 GPa) determines the stiffness of the entire fiber.
Discussion: The core and cladding glasses and fibers were successfully fabricated, and the tensile tests carried out revealed a surprising limited fatigue susceptibility although the fibers are relatively soluble in water based solutions.

EFFECT OF COMMERCIAL AND WASTE CARBONACEOUS FILLERS ON THE MECHANICAL AND ELECTRICAL PROPERTIES OF INNOVATIVE MORTARS

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