Development of macroporous geopolymer foams functionalized by a photocatalyst.

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Résumé

Heterogeneous photocatalysis is one of the advanced oxidation processes for treating a wide range of polluants in water (1). Driven by the advancement of technologies based on the use of the solar resource, this technique has gained ground in recent years and has proven to be very effective in removing toxic compounds from water in an economical and clean way, as it uses a renewable energy source and semiconductor materials with limited cost (2). These technologies are based on the production of highly reactive oxidizing species such as the hydroxyl radical, to degrade recalcitrant organic polluants. It consists of using a photocatalyst under UV irradiation to oxidize the pollutants present in the water. This work is part of the development of innovative supported materials. Photocatalytic materials dedicated to a
solar application must meet the constraint of radiation management for the production of radicals. It is essential that the catalyst is homogeneously distributed in order to capture the radiation in the volume of the photoreactor which is the site of photo-oxidation. In the literature, macroporous supports, such as metal foams, are a prime candidate (3). They develop
a macroporosity allowing the distribution of radiation in the volume, their photocatalytic performance is close to that of nanometric powders, which are the reference in this field, but which require a separation step (4). To overcome the high cost of producing metallic foams, it is proposed to design geopolymer foams based on the development technology developed in civil engineering. In a first step, the method of elaboration of the geopolymeric material classically used in the literature will be presented (5). To confer porosity to the material, hydrogen peroxide is added during the polycondensation in order to generate bubbles. Thus, fly ash and metakaolin, the basic constituents of a geopolymer, are mixed, then an alkaline solution based on NaOH and Na2SiO3 is added to activate the polycondensation process (6). The porosity is generated by the production of O2 from the decomposition reaction of hydrogen peroxide which was chosen as the foaming agent. The volume expansion of the foam is monitored during its formation over time. The difficulty lies in the fact that the growth of gas bubbles can become limiting if the polycondensation rate of the geopolymer is faster than the decomposition rate of H2O2. The amount of hydrogen peroxide and the operating conditions allowed to modulate the porosity of the material. The foam was then dried (40∘C, 24h) and calcined (800∘C,2 h) to obtain a mechanically resistant material. The structural properties of the material will be studied (composition, crystallinity, morphology) using scanning and X-ray microscopy techniques. Tensile tests will be used to define the mechanical characteristics (Young's modulus). The pore size distribution of the foams was determined by image analysis of digital micrographs using image analysis software (ImageJ).

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The pore size of the geopolymeric foams ranged from 0.01 to 3.5 mm. Several parameters such as H2O2 concentration, surfactant nature, viscosity will be optimized in order to confer macroporosity and to define the experimental conditions allowing to control the material characteristics.