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Additive manufacturing of geopolymeric materials for water treatment

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Abstract

The lack of drinking water in the world is becoming increasingly evident and is expected to grow even more in the coming decades. The small volume of water available for consumption, population growth and pollution, which are the main causes of scarcity, have made the situation alarming. For instance, the discharge of untreated oily wastewater can cause serious environmental and public health problems. Inadequate treatment of oily effluents can compromise the availability of drinking water, agricultural production, and the efficiency of sewage treatment. Therefore, it is essential that there are efficient technologies for oil removal at a low cost, so that not only science benefits from the technology and innovation resulting from this type of study, but also society, which will have better health assured for cleaner water, without increasing costs. Traditional techniques have limitations for treating emulsions with small oil droplets. In these cases, filtration separation processes have proven to be a good alternative for effective oil removal. Although inorganic materials have already been used in the manufacture of filtering structures and present several advantages over organic materials, few studies involve their functionalization to improve process performance. Among the inorganic materials used for oil-water separation, geopolymers (GPs) have stood out. This class of material is considered environmentally friendly as the entire production process has low CO_2 emissions. Additive manufacturing (AM), or 3D printing, of geopolymers is also a growing technique. It can be used by most research fields and is a progressing technology in many industrial companies. GPs are materials that have great versatility in creating ceramic composites for use in different areas. Based on this, this study aims to develop a 3D-printed porous geopolymer structure for the treatment of oily effluents. The geopolymers produced in this work were developed according to the parameters and methodology described in literature [1, 2]. For 3D-printed structures, some formulations were tested with different fillers, such as alumina, quartz, and glass frit, to provide the structures with the best characteristics for their intended purpose. In this case, the filler with best behavior was glass frit and was the chosen one to be used in this work. To obtain the suspension, an alkali-activating solution, together with a silicate, was mixed with metakaolin, additives and fillers. After homogenizing well, the paste was placed in a plastic syringe and attached to the 3D printer. To print, the pastes were extruded at room temperature through a capillary nozzle at varying pressures (between 1 and 5 bar), according to the viscosity of the pastes which changes over time. The printed structures were consolidated at room temperature for 7 days. All structures produced were characterized in terms of porosity and density, by helium pycnometry, specific surface area (SSA) by Brunauere, Emmette, Teller (BET), pore and pore volume by Barrett, Joyner, Halenda (BJH), mechanical resistance by compression test, morphology by scanning electron microscopy (SEM), chemical analysis by energy dispersive X-ray spectroscopy (EDS), crystallinity by X-ray diffraction (XRD) and evaluation of geopolymerization degree of the samples through Fourier transform infrared spectroscopy (FTIR). The 3D-printed geopolymers are going to be tested for the filtration of an oil emulsion (e.g. soybean).

References

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