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New Porous Ceramics Based on Natural Clay and Moroccan Oil Shale

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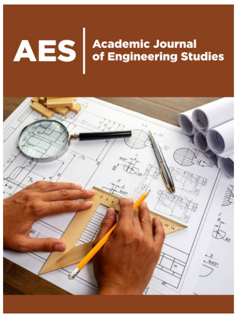

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Abstract

Within the Moroccan natural resources valorization scheme, new porous ceramics have been prepared by mixing abundant Moroccan clay minerals and oil shales. We aim at studying the use of Moroccan oil shale as a porogen for ceramic membrane manufacturing and investigating the effect of oil shale loading on the microstructure and mechanical properties of clay based porous ceramic supports prepared by uniaxial compaction.

Keywords: Porous ceramic; Clay; Oil shale; Mechanical properties

Introduction

Nowadays, technical ceramics are offering specific properties adapted to their use. Their physical, thermal, optical, electrical properties allow providing new opportunities in the field of industrial development, and they open wide domains of applications and utilizations, particularly porous ceramics, whose demand by different industries has become very important, especially as efficient filtration media [1-5]. Because of various industrial applications of ceramics these past years, a lot of research work [6-9] has been reported on their processes of production in order to develop new techniques to obtain high quality ceramics, while meeting the demands and the specifications imposed by the ceramics manufacturers.

Industrial ceramic supports are prepared from expensive compounds, such as Al_2O_3, SiO_2, TiO_2 or SiC, but recently, considerable efforts have been accomplished to prepared ceramics from cheaper materials: cordierite and clay for example [10-12]. Within this context, we have carried out researches to explore the opportunity of producing porous ceramics from Moroccan abundant natural resources, i.e. clays and oil shales, in order to find new applications of the Moroccan oil shales [13,14]. This work consisted in studying the ability of oil shale as an additive to produce porous materials.

Experimental

Materials and Methods

Raw materials

The clay raw material (AR) used in this study came from the natural layer of Safi town located on the West coast of Morocco. This red clay is mainly exploited in the pottery industry.

The Moroccan oil shale samples (Y) used in this work was obtained from Timahdit deposits located in the Middle Atlas Mountain.

Porous ceramic synthesis

The mixtures were prepared at room temperature by dry mixing raw clay and oil shale (1:1 w/w). The mixtures were homogenized using a rotary mixer for 1h. Then the mixed powders were uniaxially pressed at 8MPa in a stainless-steel die (D: 22mm) for 10min. The compacted pellets were heated at 1000, 1050 and 1100 °C. The soak time was 2h and the heating rate was 10 °C·min^{-1}. (Figure 1)

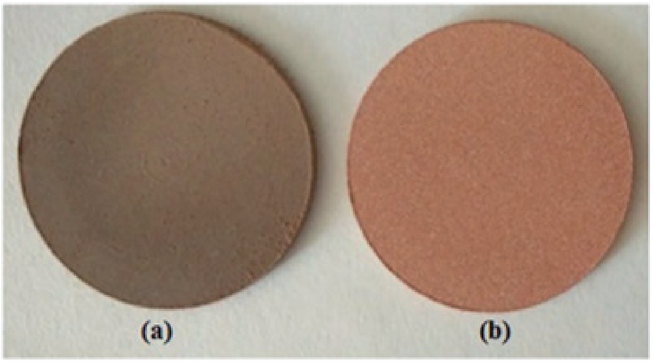

Figure 1: Images of obtained ceramic membrane: Before (a) and after (b) sintering

Results and Discussion

To study the effect of the temperature on the porosity and mechanical resistance of the final materials, we prepared three samples under the conditions described in the experimental part, with increasing temperature: sample 1 sintered at 1000 °C, sample 2 sintered at 1050 °C and sample 3 sintered at 1100 °C. The results of mercury intrusion porosimetry analyses are shown in Table 1.

Table 1: Effect of sintering temperature on densification and porosity.

Porosity (%)		Bulk density (g·cm^{-3})	Average Pore Diameter (nm)
Sample 1	41	1.7	600
Sample 2	39	1.7	500
Sample 3	44	1.5	1200

The results of the porosity and pore size distribution of samples presented in Table 1 shows that sample 3, sintered at 1100 °C, has the highest average pore diameter and porosity. The average pore diameter and porosity of the samples decreases between 1000 and 1050 °C, and then increases at 1100°C. This can be explained by the opening of the pores with temperature between 1050 and 1100°C and by the beginning of the material densification between 1000 and 1050 °C. Similar results were reported by Saffaj et al. [15] during the characterization of microfiltration and ultrafiltration membranes deposited on raw support prepared from Moroccan clay.

The mechanical resistance test was performed using the three points bending strength to control the resistance of the samples fired at different temperatures. The mechanical strength reported in Table 2 increases with increasing sintering temperature and reaches 22.1±2.1MPa at 1100 °C. This value obtained in this work was relatively lower than that given in previous works on porous ceramic prepared from clay [15,16]. Finally, during this work, the best condition to prepare the macroporous ceramic by mixing Moroccan abundant clay mineral and oil shales mixture are established for a firing temperature of 1100°C, at this condition the average pore diameter is 1200nm, the porosity is 44% and the flexural strength is 22.1±2.1MPa. The material obtained under these optimal conditions (sintered at 1100 °C) was used for the treatment of two industrial effluents. Effluent A was collected from a Fes tannery beamhouse. In particular, the beamhouse process features the following phases:

1. soaking (rehydration and desalination of skin),
2. liming (dehumidifi cation by sulfides),
3. washing (water and sodium bisulfide),
4. delimitation (using (organic) acids or mineral salts),
5. bating (enzymatic treatment), and
6. acidification (tanning material penetration),

Table 2: Effect of sintering temperature on flexural strength.

	Flexural Strength (MPa)
Sample 1	15.2 ± 0.9
Sample 2	18.2 ± 2.7
Sample 3	22.1 ± 2.1

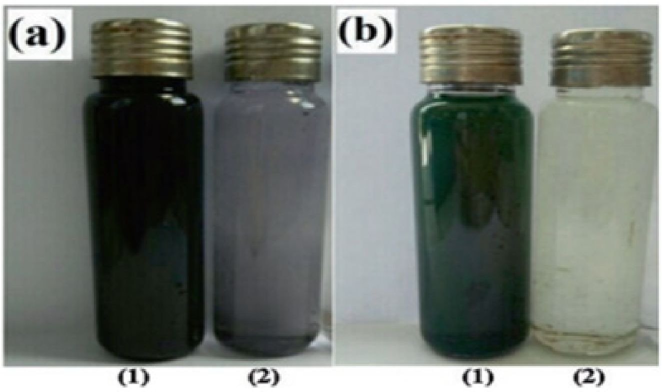

Figure 2: Views of effluents before (1) and after (2) treatment using ceramic support: (a) tannery wastewater and (b) textile effluent.

which generate large amounts of turbid water that needs to be filtered and recycled [17]. Effluent B is the wastewater discharged during the jeans washing process. Since most operations in the textile industry consume significant quantities of water and produce large amounts of poisonous substances and other chemical species, textile effluents are characterized by high concentrations of pollutants and a wide variety of compositions that reflect the variability of the employed technological processes. In particular, colored textile industry sewage typically contains high amounts of dyes, suspended solids, colloids, and dissolved organic carbon [18]. Figure 2 presents the photographs of (a) tannery and (b) textile effluents before (1) and after (2) treatment using ceramic support. As shown in Figure 2, one can note that the filtration of tannery and textile effluents through the ceramic support revealed highly effective contaminant removal and reduced turbidity, residual dye content, and suspended solids.

Conclusion

Within the framework of the development of natural resources, we have carried out a study on the Moroccan oil shales and clay, in order to prepare the new macroporous ceramics. The following conclusions can be drawn from the present investigation on the microstructural and thermomechanical characterization of macroporous ceramics produced from oil shales- clay mixture:

A. The oil shales were a suitable additive to produce the macroporous ceramics with better mechanical properties.

B. The produced ceramic membrane based on the clay and oil shale could be a perfect candidate for prepurification of strongly alkaline industrial waste liquids because of its low cost, easy fabrication, and high turbidity removal efficiency.

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