Determination of porosity in supports for ceramic membranes of titanium dioxide by gamma spectroscopy

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Membrane separation processes (MSP) have been widely used to fractionate, concentrate and purify solutions, such as: food industry, pharmaceutical, water desalination, as well as for treatment of the radioactive liquid waste in the nuclear industry [1]. The membranes can be organics (polymers) and inorganics (oxides), such as aluminum oxides (Al_2O_3), silicon (SiO_2), zirconia (ZrO_2), titanium (TiO_2) or a combination of these. The ceramics membranes present greater advantages over polymer membranes, as: high mechanical and thermal resistance, high resistance to chemical attack and greater durability. In general, the inorganic membranes must have porosity around 40%. The measurement of porosity is usually determined by methods geometric, Archimedes and Mercury Intrusion. These methods provide only global information of the sample, and in some cases, underestimate the amount of pores. This way, the porosity by gamma-ray transmission has been very interesting, mainly because it has advantages in relation to conventional techniques, as: fast determination, non-destructive method and providing results more precision [2]. This technique is based on the attenuation that a beam of gamma radiation suffers when crossing a material. Therefore, for the determination of total porosity by this method, it is necessary to calculate the linear attenuation coefficient (Ɛ) of the material analyzed [3].

$$\varepsilon = \left(\frac{\mu_f - \mu_m}{\mu_f}\right) . 100\% \qquad \text{Eq. 1}$$

where: μ_f - linear attenuation coefficient for non porous material ($cm^2.g^{-1}$); μ_m - linear attenuation coefficient of the analyzed material ($cm^2.g^{-1}$). Through the software Gamma Acquisition & Analysis, produced by Genie 2000 VDM, it was possible to perform the acquisition and interpretation of the data.

Table 1: Porosity values by gamma-ray transmission for the supports with: 0, 5 and 10% of potato starch, sintered at 1150 ºC.

Potato starch (%)	Porosity (%)
0	54.096 ± 0.379
5	57.134 ± 0.339
10	54.913 ± 0.364

The porosity values presented in Table 1 were compared with the porosity values obtained by conventional methods (geometric and Archimedes), as shown in Figure 1.

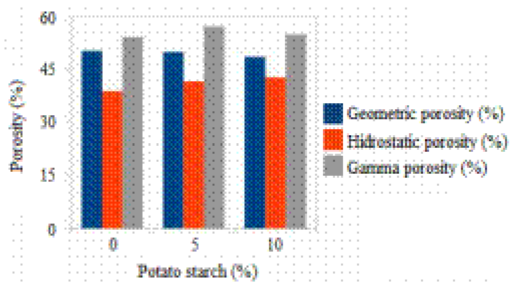

Figure 1. Porosity obtained by conventional methods and the gamma ray transmission.

The Figure 1 shows that the porosity by the gamma-ray transmission method are higher than the values obtained by the Archimedes and geometric. This is due to the higher sensitivity of the gamma-ray transmission method. However, the difference in the value obtained by the method of gamma-ray transmission in relation to the geometric is that the first one provides results with a better characterization for small scales, that is, in relation to heterogeneities of the material, evidenced by the values of the standard deviation in Table 1.

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